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BIBLIOGRAPHY OF THE GEOLOGY OF THE COLUMBIA BASIN AND SURROUNDING AREAS OF WASHINGTON WITH SELECTED REFERENCES TO COLUMBIA BASIN GEOLOGY OF IDAHO AND OREGON

By

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INTRODUCTION

The bibliography was prepared by the Washington Division of Geology and Earth Resources (WDGER) in partial fulfillment of the provisions of a contract with the U.S. Department of Energy. The contract, administered through Rockwell-Hanford Atomic Operations, Richland, Washington, is part of a study to determine the feasibility of storing nuclear wastes within the Columbia River Basalt Group. This study, called the Basalt Waste Isolation Program, will examine the stratigraphic, structural, tectonic, seismic, and hydrologic aspects of the Columbia Basin to provide criteria for specific site selection of the proposed waste repository.

A thorough review of all previous geological investigations in the Columbia Basin is the initial objective of WDGER portion of the study. This bibliography, a comprehensive collection of Columbia Basin geologic references, makes such a review possible.

The bibliography is a compilation of all known published, unpublished, and open-file references dealing with the geology and geophysics of the Columbia Basin of eastern Washington. Bibliographic entries were obtained primarily from the WDGER and Washington State libraries. The "Geo-Ref" bibliographic system was also utilized. Although all fields of geology have been included, the emphasis of the literature search was placed on the basalt stratigraphy of the Columbia Basin, Quaternary sediments overlying the basalt, structural geology, tectonics, and seismicity.

Because the WDGER portion of the study includes preparation of a geologic map of Quaternary deposits in the Columbia Basin, references dealing with this subject have been annotated to increase their usefulness (note: some of the references are not annotated due to their unavailability to the authors). Many abstracts in the annotated section have been copied directly from their respective publications without author credit in the text.

Every effort has been made to see that the bibliography is complete. The authors take full responsibility for any errors or omissions, and would appreciate having them brought to their attention. The sections on Idaho and Oregon are known to be incomplete, as the focus of the bibliographic search was on Washington State.

The authors wish to express their thanks to the secretarial, editorial, and library members of the WDGER staff who devoted much time in support of this project.

Bibliographic Format

The bibliography is presented in topical format, alphabetized by author's last name within each category. Refer to the table of contents for a listing of the categories.

The numbered notations before some references (as A1, B3, etc.) correspond to the identical notations appearing on an index to geologic mapping in the Columbia Basin under preparation by the authors.

Annotated entries provide information according to the following format:

1. Type of publication.
2. Subject.
3. Location of study area.
4. Geologic units involved.
5. Method of investigation.
6. Type of information gathered.
7. Illustrations (geologic maps, cross-sections, tables, charts).
8. Abstract.

COLUMBIA BASIN GEOLOGY

PRE-PLATEAU BASALT GEOLOGY

Alexander, Frank, 1956, Stratigraphic and structural geology of the Blewett-Swauk area, Washington: Unpub. M.S. thesis, Univ. of Washington, 62 p.

Bressler, C. T., 1951, The petrology of the Roslyn arkose, central Washington: Unpub. Ph.D. thesis, Pennslyvania State Univ., 147 p.

Chappell, W. M., 1936, Geology of the Wenatchee quadrangle, Washington: Unpub. Ph.D. thesis, Univ. of Washington, 249 p.

Clayton, D. N., 1973, Volcanic history of the Teanaway Basalt, east-central Cascade Mountains, Washington: Univ. of Washington M.S. thesis, 55 p.

Foster, R. J., 1957, The Tertiary geology of a portion of the central Cascade Mountains, Washington: Unpub. Ph.D. thesis, Univ. of Washington, 186 p.

_____, 1958, The Teanaway dike swarm of central Washington: American Jour. Sci., v. 256, p. 644-653.

_____, 1960, Tertiary geology of a portion of the central Cascade Mountains, Washington: Geol. Soc. America Bull., v. 71, p. 99-126.

Griggs, A. B., 1973, The Belt Supergroup in the Spokane quadrangle (abs.). In Bishop, D. T.; Powell, J. D., co-chairmen, Belt Symposium 1973, v. 1: Univ. of Idaho Dept. Geol., and Idaho Bur. Mines Geol., Moscow, p. 76.

Huntting, M. T.; Bennett, W. A. G.; Livingston, V. E., Jr.; Moen, W. W., 1961, Geologic map of Washington: Washington Div. Mines Geol., scale 1:500,000.

Johns, W. S., 1961, Pre-lava geomorphology of the lower Coeur d'Alene and St. Joe River valleys, Kootenai and Benewah Counties, northern Idaho: Univ. of Kansas M.S. thesis, Manhattan.

Lofgren, D. C., 1973, The bedrock geology of the southwest part of the Kachess Lake quadrangle, Washington: M.S. thesis, Portland State College.

Lupher, R. L., 1949, Stratigraphic aspects of the Blewett-Cle Elum

iron ore zone, Chelan and Kittitas Counties, Washington: Washington Div. Mines Geol., Report Invest. 11, 63 p.

McKee, B.; Whetten, J. T., 1972, The Chiwaukum Graben: Northwest Sci. Assoc. 45th Ann. Mtng. Abstracts, p. 9.

Newman, K. R., 1971, Age ranges of strata mapped as Swauk Formation, central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 6, p. 397-398.

Ozier, Ron, 1971, Pre-Miocene geomorphology and the Tertiary-pre-Tertiary unconformity, Grand Canyon of the Snake River, Oregon and Washington (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 4, p. 273-274.

_____, 1971, Pre-Columbia River basalt boulder bed deposits in the Grand Canyon of the Snake River, Oregon and Washington (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 4, p. 273.

Peterson, D. W., 1955, The pre-basalt surface in the vicinity of Peck, Idaho: Northwest Sci., v. 29, no. 1, p. 1-9.

Rector, R. J., 1962, Geology of the east half of the Swauk Creek mining district: Unpub. M.S. thesis, Univ. of Washington, 73 p.

Russell, I. C., 1893, A geological reconnaissance in central Washington: U.S. Geol. Survey, Bull. 108, p. 5-108.

_____, 1899, Geology of the Cascade Mountains in northern Washington: U.S. Geol. Survey, 20th Ann. Report, pt. 2, p. 83-310.

Simmons, G. C., 1950, Russell Ranch Formation: Washington State College M.S. thesis, 26 p.

Smith, G. O., 1903, Contributions to the geology and physiography of central Washington: U.S. Geol. Survey Prof. Paper 19, p. 9-39.

_____, 1904, Description of the Mount Stuart quadrangle, Washington: U.S. Geol. Survey Atlas, Folio 106, 10 p.

Smith, G. O.; Calkins, F. C., 1906, Description of the Snoqualmie quadrangle, Washington: U.S. Geol. Survey Atlas, Folio 139, 14 p.

Southwick, D. L., 1966, Petrography, chemistry, and possible correlations of the Camas land sill and Teanaway dike swarm,

central Washington: Northwest Sci., v. 40, no. 1, p. 1-16.

Stout, M. L., 1959, Geology of a part of the south-central Cascade Mountains, Washington: Ph.D. thesis, Univ. of Washington, 183 p.

_____, 1961, Diabasic and gabbroic intrusions in the Frost Mountain area, south central Cascade Mountains, Washington: American Jour. Sci., v. 259, p. 348-352.

Waters, A. C., 1926, Petrography of Corbaley Canyon: Univ. of Washington B.S. thesis, 77 p.

Weaver, C. E., 1937, Tertiary stratigraphy of western Washington and northwestern Oregon: Univ. of Washington Pub. in Geol., v. 4, 266 p.

Weissenborn, A. E., 1969, Geologic map of Washington, lat 46° to 49°, long 118° to 124°: U.S. Geol. Survey Misc. Geol. Invest. Map I-583, scale 1:2,000,000.

ADDITIONAL REFERENCES - PRE-PLATEAU BASALT GEOLOGY

Burnet, F. W., 1976, Felsic volcanic rocks and mineral deposits in the Buck Mountain Formation andesites, Okanogan County, Washington: Univ. of Washington M.S. thesis.

Buza, J. W., 1977, Dispersal patterns of lower and middle Tertiary sedimentary rocks in portions of the Chiwaukum graben, east central Cascade Range, Washington: Univ. of Washington M.S. thesis.

Hyndman, D. W.; Talbot, J. L., 1976, The Idaho Batholith and related subduction complex: Geol. Soc. Am., Cordilleran Section Mtg., Pullman, Washington, Field Guide No. 4, April 1976.

Morrison, R. F., 1963, The Pre-Tertiary geology of the Snake River Canyon between Cache Creek and Dug Bar, Oregon-Idaho boundary: Oregon Univ. Ph.D. thesis, 195 p.

Peterson, D. W., 1955, The pre-basalt surface in the vicinity of Peck, Idaho: Northwest Sci., v. 29, no. 1, p. 1-9.

Vallier, T. L.; Hooper, P. R., 1976, Geologic guide to Hells Canyon, Snake River: Geol. Soc. Am., Cordilleran Section Mtg., Pullman, Washington, Field Guide No. 5, April 1976.

Chappell, W. M., 1931, Endogenetic alteration of the Camas Land irruptive, Chelan County, Washington: Univ. of Washington M.S. thesis, 37 p.

McKague, H. L., 1960, Petrology of the Hatchery Creek serpentinite, Chelan County, Washington: Washington State Univ. M.S. thesis, 42 p.

Oles, K. F., 1956, Geology and petrology of the crystalline rocks of the Beckler River-Nason Ridge area, Washington: Univ. of Washington Ph.D. thesis, 192 p.

Pratt, R. M., 1954, Geology of the Deception Pass area, Chelan, King, and Kittitas Counties, Washington: Univ. of Washington M.S. thesis, 58 p.

Southwick, D. L., 1962, Mafic and ultramafic rocks of the Ingalls-Peshastin area, Washington, and their geologic setting: Johns Hopkins Univ., Ph.D. thesis, 287 p.

PLATEAU BASALT GEOLOGY

Airlog: Kalispell — Ephrata: In Voight, Barry; and others, eds., Rock Mechanics: The American Northwest: Pennsylvania State Univ. Press, University Park, Pennsylvania, p. 265-268 (incl. geol. sketch map).

Allen, J. E., 1932, Contributions to the structure, stratigraphy, and petrography of the Lower Columbia River Gorge: University of Oregon M.S. thesis, 96 p. Map, 1:125,000.

_____, 1958, Columbia River Gorge - Portland to The Dalles: University of Oregon Guidebook for Field Trip Excursions of the Geol. Soc. America Cordilleran Section, p. 4-23. Figure 2, 1:633,600.

Alto, B. R., 1955, Geology of a part of the Boylston quadrangle and adjacent areas in central Washington: Seattle University M.S. thesis, 38 p.

Anderson, A. L., 1923, Geology and ore deposits of the Silver Hill districts, Spokane County, Washington: University of Idaho M.S. thesis, 100 p. Plate 1, 1:12,000.

Avent, J. C., 1969, Correlation of the Steens-Columbia River basalts: Some tectonic and petrogenetic implications. In Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, p. 133-156.

_____, 1969, Reinterpretation of the origin of some basalt magmas of the Pacific Northwest (abs.): Geol. Soc. America Spec. Paper 121, p. 13.

Bacon, C. S., Jr., 1923, Geologic history of the Spokane region, Washington: Univ. of Chicago M.S. thesis, 43 p.

Baksi, A. K.; Watkins, N. D., 1973, Volcanic production rates: Comparison of oceanic ridges, islands and the Columbia Plateau basalts: Science, v. 180, p. 493-496.

Baldwin, E. M., 1966, Geology of the Columbia River Gorge: Northwest Sci., v. 40, no. 4, p. 121-128, illus.

Barnes, V. E., 1927, Geology of the Oakesdale quadrangle, Washington: Washington State College M.S. thesis, 51 p. Plate 2, 1:316,800.

Beaulieu, J. D., editor, 1973, Geologic field trips in northern Oregon and southern Washington: Oreg. Dept. Geol. Mineral Ind. Bull. 77, 206 p., illus.

Beck, G. F., 1935, Fossil-bearing basalts, more particularly the Yakima basalts of central Washington: Northwest Sci., v. 9, no. 4, p. 4-7, 3 figs.

_____, 1940, Late Tertiary stratigraphy and paleontology of south-central Washington and adjacent Oregon: Geol. Soc. America Bull. v. 51, no. 12, pt. 2, p. 2018.

_____, 1941, Fossil-bearing basalts: Mineralogist, v. 9, no. 12, p. 462-464.

Becraft, G. E., 1956, Geological mapping, Pacific region-Turtle Lake quadrangle, Washington: U.S. Atomic Energy Commission Report Tel-640, p. 146-150. Figure 36, 1:138,600.

_____, 1956, Turtle Lake quadrangle, Washington: U.S. Geol. Survey Rept. TEl-640, p. 146-150 incl. geol. map.

Becraft, G. E.; Weis, P. L., 1957, Preliminary geologic map of part of the Turtle Lake quadrangle, Lincoln and Stevens Counties, Washington: U.S. Geol. Survey Min. Inv. Field Studies Map MF-135, 1:48,000.

_____, 1957, Turtle Lake quadrangle, Washington: U.S. Atomic Energy Commission Report Tel-700, p. 98-110. Figure 22, 1:190,080.

Becraft, G. E., 1959, Geology of the southern part of the Turtle Lake quadrangle, northeastern Washington: University of Washington Ph.D. thesis, 95 p. Plate 1, 1:48,000; Plate 2, 1:2,400; Plate 3, 1:1,200.

Becraft, G. E.; Weis, P. L., 1963, Geology and mineral deposits of the Turtle Lake quadrangle, Washington: U.S. Geol. Survey Bull. 1131, 73 p. Plate 1, 1:62,500; Plate 3, 1:1,200; Plate 4, 1:1,200; Plate 5, 1:1,200.

Beddow, J. H., 1963, Lower Snake River development: Western Construction, v. 38, no. 1, p. 45-50.

Beeson, M. H.; Bentley, R. D.; Moran, M. R., 1976, Preliminary correlation of lower Yakima basalt flows in western Oregon with the type area in central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 353-354.

Bentley, R. D., 1976, Stratigraphy of the Yakima basalts and structural evolution of the Yakima ridges in the western Columbia River Plateau: Field Trip by Bentley, Central Washington State College, Ellensburg, Washington.

_____, 1977, Stratigraphy of the Yakima basalts and structural evolution of the Yakima ridges in the western Columbia Plateau (Field Trip no. 12). In Geological excursions in the Pacific Northwest: Geol. Soc. America 1977 Annual Meeting, Seattle, Washington, p. 339-389.

Bingham, J. W.; Grolier, M. J., 1965, Geologic map and sections of parts of Grant, Adams, and Franklin Counties, Washington: U.S. Geol. Survey Open-File Report, map scale 1:60,000.

Bingham, J. W.; Walters, K. L., 1965, Stratigraphy of the upper part of the Yakima Basalt in Whitman and eastern Franklin Counties, Washington: U.S. Geol. Survey Prof. Paper 525-C, p. 87-90. Figure 1, 1:7,920,000.

Bingham, J. W.; Grolier, M. J., 1966, The Yakima Basalt and Ellensburg Formation of south-central Washington: U.S. Geol. Survey Bull. 1224-G, 15 p. Figure 2, 1:7,000,000.

Bingham, J. W.; Londquist, C. J.; Baltz, E. H., 1970, Geologic investigation of faulting in the Hanford region, Washington: U.S. Geol. Survey Open-File Report, 103 p.

Bingham, J. W., 1970, Several probable source vents for the Roza and Priest Rapids type basalts in Whitman and Adams Counties, Washington. In Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, p. 171-172.

Bingham, J. W.; Grolier, M. J., 1978, Geology of parts of Grant, Adams, and Franklin Counties, east-central Washington: Washington Div. of Geology and Earth Resources Bull. 71, 91 p.

Blume, J. A.; and Associates, Engineers, 1970, Seismic and geologic siting evaluation, fast flux test facility near Richland, Washington: John A. Blume and Assocs., Engrs., Report No. JABE-WADCO-03, 90 p.

_____, 1971, Supplementary geologic investigations for seismic evaluation for the fast flux test facility site near Richland, Washington: John A. Blume and Assocs., Engrs., Report No. JABE-WADCO-04, 162 p.

_____, 1971, A summary report, seismic evaluation and development of ground acceleration and response spectra for the fast flux test facility site: J. A. Blume and Assocs., Engrs., Report No. JABE-WADCO-03.

_____, 1971, Subsurface geologic investigations for the fast flux testing facility project in Pasco Basin: John A. Blume and Assocs., Engrs., San Francisco, Calif., 228 p.

Bogue, R. G., 1932, A petrographic study of the Mount Hood and Columbia River basalt formations: Univ. of Oregon M.S. thesis, 88 p.

Bond, J. G., 1969, The eastern Columbia Plateau: A study in isostatic response and post extrusion adjustments: Internat. Assoc. Volcanol. Chem. Earth's Interior, Oxford Univ., Dep. Geol. Mineral., 1969, in Symposium on volcanoes and their roots, Oxford 1969, v. Abs., p. 154-155.

Braile, L. W.; Keller, G. R.; Martin, W. R.; Mazzella, F. E., 1977, Crustal structure of the Columbia Plateau and Snake River plain (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 908. "Surface wave dispersion analysis for two-station paths in the Columbia Plateau (CP) and seismic refraction profiles in the western and eastern Snake River Plain (SRP) were used to determine crustal models for the CP and SRP. The models indicate a thick, primarily 'basaltic' (compressional velocity 6.8 km/s) crust in the Columbia Plateau which thins considerably toward the east to the eastern SRP where a relatively thin crust (30km) is suggested. The presence or absence of a 'granitic' upper crustal layer (compressional velocity 6.0 km/s) in the eastern SRP has not yet been established. The structure of the crust in the Columbia Plateau and Snake River plain is consistent with the tectonic model for the SRP which suggests the migration of a crustal heat source northeastward along the axis of the eastern SRP over the last 15 million years."

Bretz, J. H., 1921, Stratigraphic problems in the Columbia Valley between Snake River and Willamette River (abs.): Geol. Soc. America Bull., v. 32, no. 1, p. 36-37.

_____, 1924, The Dalles type of river channel: Jour. Geology, v. 32, p. 139-149.

_____, 1930, Relation of Yakima Valley to the Channeled Scabland: (abs.) Geol. Soc. America Bull. v. 41, no. 1, p. 93; (abs.) Pan-American Geologist, v. 53, no. 2, p. 135, 1930.

Brooks, W. E., 1974, Stratigraphy and structure of the Columbia River basalt in the vicinity of Gable Mountain, Benton County, Washington: University of Washington M.S. thesis, 39 p.

Brown, D. J., 1959, Subsurface geology of the Hanford separation areas: Hanford Laboratories Operation Report HW-61780, 21 p.

_____, 1962, Geology underlying Hanford Reactor areas: Hanford Atomic Products Operation, Rept. HW-73337, p. 212-218.

Brown, D. J.; Ledgerwood, R. K., 1973, Stratigraphy and structure of Yakima Basalt in the Pasco Basin, Washington. In Beaulieu, J. D., ed., Geologic field trips in northern Oregon and southern Washington: Oregon Dept. Geology and Mineral Ind. Bull. 77, p. 171-181.

Brown, J. C., 1976, Tectonic significance of subsurface chemical-stratigraphic correlation, Pullman/Moscow Basin, Washington and Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 357-358.

Brown, R. E., 1953, Geology of the Columbia Basin, Washington: Pacific Northwest Fertilizer Conf., 4th Ann., Pullman, Washington, Proc., p. 112-115.

Brown, R. E.; Brown, D. J., 1958, The surface of the basalt bedrock beneath the Hanford Works: Hanford Atomic Products Operation Report HW-57935.

_____, 1959, The surface of the basalt series in the Pasco Basin, Washington: Geol. Soc. Oregon Country News Letter, v. 25, no. 4, p. 23-27.

_____, 1963, Geologic features and ground water flow: Hanford Atomic Products Operation Report HW-77609, p. 4.43-4.44.

Brown, R. E., 1965, An immensity of basaltic lava: Lake Wallula Reflections, no. 6, p. 1-3.

_____, 1966, The stratigraphy of the uppermost part of the basalt sequence and its implications: Battelle Memorial Institute, Pacific Northwest Laboratory Report BNWL-235-3, p. 1-4.

_____, 1968, The Yakima Basalt Formation and its relationships to the Columbia River in aquifer development: Battelle Memorial Institute, Pacific Northwest Laboratory Report BNWL 481-3, p. 1-5.

Brown, R. E., and others, 1968, Geology and hydrology of the Pasco Basin: U.S. Atomic Energy Comm.

Brown, R. E., 1968, A study of reported faulting in the Pasco Basin: Battelle Memorial Institute, Pacific Northwest Laboratories Rept. 662, 55 p.

Brown, R. E.; Brown, D. J., 1969, The geology of the Pasco Basin: Battelle Memorial Institute, Pacific Northwest Laboratory Report BNWL-947.

Brown, R. E., 1970, Some suggested rates of deformation of the basalts in the Pasco Basin, and their implications. In Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, p. 179-187.

_____, 1970, Interrelationships of geologic formations and processes affecting ecology as exposed at Rattlesnake Springs, Hanford, Project: Battelle-Northwest Laboratory Report BNWL-B-29, 42 p.

Bush, J. H.; Siems, B. A., 1973, Basalt stratigraphy of the Jameson Lake area, Douglas County, Washington (abs.): Geol. Soc. America Abs. with Programs v. 5, no. 1, p. 19.

Buwalda, J. P.; Moore, B. N., 1930, The Dalles and Hood River Formations and the Columbia River Gorge: Carnegie Inst. Wash. Pub. 404, p. 11-26.

_____, 1928, Age of Dalles beds and "Satsop" Formation and history of Columbia River Gorge: Pan-American Geologist, v. 49, no. 4, p. 313; (abs.) Geol. Soc. America Bull., v. 40, no. 1, p. 176-177, 1929.

_____, 1936, Postulated peneplanation in central Washington: Geol. Soc. America Proceedings for 1935, p. 331-332.

Calkins, F. C., 1905, Geology and water resources of a portion of east-central Washington: U.S. Geol. Survey Water-Supply Paper 118, 96 p.

Camp, V. E., 1975, Structure and basalt stratigraphy of the "Lewiston Downwarp", Idaho-Washington: Geol. Soc. America Abs. with Programs, v. 7, no. 3, p. 300-301.

_____, 1976, Petrochemical stratigraphy and structure of the Columbia River basalt, Lewiston Basin area, Idaho-Washington: Washington State University Ph.D. thesis, 201 p.

Campbell, C. D., 1956, Geology of the site and surrounding areas — late Cenozoic history of the region. In Daugherty, R. D., Archaeology of the Lind Coulee site, Washington: Am. Philos. Soc. Proc., v. 100, no. 3, p. 260-262.

Campbell, C. D.; Runcorn, S. I., 1956, Magnetization of the Columbia River basalts in Washington and northern Oregon: Jour. Geophys. Research, v. 61, p. 449-458.

Campbell, Newell, 1975, A geologic road log over Chinook, White Pass, and Ellensburg to Yakima highways: Washington Div. Geology and Earth Resources Inf. Circ. 54, 82 p.

_____, 1976, Preliminary geologic map of Yakima area: Washington Div. Geology and Earth Resources Open-File Report No. OF 76-11, Scale 1:24,000.

_____, 1976, Relative slope stability of the Yakima core area and surrounding slopes, Yakima County, Washington: Washington Div. Geology and Earth Resources Open-File Report No. OF 77-2, Scale 1:24,000 (Modified by Artim, E. R., 1977).

_____, 1977, Geology of the Selah area, Yakima County, Washington: Washington Div. Geology and Earth Resources Open-File Report No. OF 77-5, Geologic Map 1:24,000, Flood Hazards Map 1:24,000, Slope Stability Map 1:24,000.

_____, 1977, Geology of the Snipes Mountain area, Yakima County, Washington: Washington Div. Geology and Earth Resources, Open-File Report No. OF 77-8, Slope Stability and Flood Hazards Maps 1:24,000.

Carter, G. L., 1974, Varieties of siderite occurring in vesicular basalt between Moscow, Idaho, and Pullman, Washington: The Mineralogical Record, v. 5, no. 4, p. 157-159.

Chappell, W. M., 1936, The effect of Miocene lavas on the course of Columbia River in central Washington: Jour. Geology, v. 44, p. 379-386.

_____, 1936, Geology of the Wenatchee quadrangle, Washington: Univ. of Washington Ph.D. thesis, 249 p., pl. 1, 1:62,500.

Clem, R., 1966, The distribution of "Intracanyon" basalt flows in the Snake River Canyon, Washington between mile 41 and 86: An attempt to verify a textural method of distinguishing the "intracanyon" basalt (abs.): Northwest Sci., v. 40, no. 1, p. 37-38.

Cline, D. R., 1969, Ground water resources and related geology of north-central Spokane and southeastern Stevens Counties, Washington: Washington Dept. Water Res. Water-Supply Bull. 27, 195 p., illus., tables, geol. map.

_____, 1976, Reconnaissance of the water resources of the upper Klickitat River basin, Yakima Indian Reservation, Washington: U.S. Geol. Survey Open-File Report No. 75-518, 54 p.

Culver, H. E., 1926, Abstract of the report (by Solon Shedd) on the geology and resources of the Pasco and Prosser quadrangles: Washington Dept. Conserv. and Devel., Div. of Geology Rept. Inv. 1, 7 p., Accompanied by geol. map of Pasco and Prosser quadrangles, Bull. 32, pl. 1 (text not published).

_____, 1956, Preliminary statement of the geologic age of the beds in lower Lind Coulee, Washington. In Daugherty, R. D., ed., Archaeology of the Lind Coulee site, Washington: Am. Philos. Soc. Proc., v. 100, no. 3, p. 26.

Danehy, E. A.; Swanson, O. E.; Hitchcock, D. M., 1976, Structural elements of the Pasco Basin, south-central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 366-367.

Davis, O. K.; Kolva, D. A.; Mehringer, Jr., P. J., 1977, Pollen analysis of Wildcat Lake, Whitman County, Washington: The last 1000 years: Northwest Sci., v. 51, no. 1, p. 13-30.

Dayharsh, F. L., 1969, Distribution of ring dike-like structures near Odessa, Washington. In Gilmour, E. H.; Stradlings, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, p. 176-178.

Dayharsh, F. L.; Norberg, J. R., 1969, A Reconnaissance of ring dikes and related features in the upper Crab Creek drainage area: Northwest Sci., v. 43, no. 1, p. 34.

Dennis, T. E., 1938, Structure of the Horse Heaven Hills of Washington: Washington State College M.S. thesis, 35 p.

Diery, H. D., 1967, Stratigraphy and structure of Yakima Canyon between Roza Gap and Kittitas Valley, central Washington: University of Washington Ph.D. thesis, 116 p. Plate 1, 1:24,000.

Diery, H. D.; McKee, Bates, 1968, Stratigraphy of the Yakima River Canyon (abs.): Northwest Sci., v. 42, no. 1, p. 32.

_____, 1969, Stratigraphy of the Yakima Basalt in the type area: Northwest Sci. v. 43, no. 2, p. 47-64.

Easterbrook, D. J.; Baker, V. R.; Waitt, R., 1977, Glaciation and catastrophic flooding of the Columbia Plateau, Washington (Field Trip No. 13). In Geological excursions in the Pacific Northwest, Geol. Soc. America 1977 Annual Meeting, Seattle, Washington, p. 390-414.

Eddy, P. A., 1971, Geology and ground water availability, Selah area, Washington: Washington Dept. Ecology, no. 71-15, 7 p.

_____, 1971, Geology and ground water resources in vicinity of the Columbia River and Interstate 5, Clark County, Washington, No. 2 : Washington Dept. Ecology, Office of Technical Services, 13 p.

Farkas, S. E., 1971, Stratigraphic and structural analysis of Columbia River Basalt flows, Umtanum Ridge, Yakima and Benton Counties, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 6, p. 380.

_____, 1972, Structural relationships of folds and faults in Yakima Basalt and Ellensburg Formation, central Washington (abs.): Geol. Soc. America Abs. with Programs v. 4, no. 6, p. 375-376.

Farkas, S. E.; Bentley, R. D.; Movseyan, S. A., 1973, Stratigraphy of the Frenchman Spring Member, Columbia River Plateau (abs.): Geol. Soc. America Abs. with Programs v. 5, no. 1, p. 40.

Farooqui, S. M.; Kienle, C. F., Jr., 1976, Structural implications of the Yakima Basalt in north-central Oregon and south-central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 372-373.

Fernquist, C. O., 1941, The geology and paleontology of Spokane and vicinity: Mineralogist, v. 9, no. 3, p. 83-84.

Fischer, A. G.; Wheeler, H. E.; Mallory, V. S., 1954, Arbitrary cut-off in stratigraphy, discussion and reply to discussion: Am. Assoc. Petroleum Geologists Bull., v. 38, no. 5, p. 926-931.

Foster, R. J., 1958, The Teanaway dike swarm of central Washington: Am. Jour. Sci., v. 256, no. 9, p. 644-653, Figure 2, 1:405,504.

Fowler, C. S., 1931, Radial columnar structure in Columbia River Basalt: Washington State College B.S. thesis, 9 p.

Foxworthy, B. L., 1962, Geology and ground water resources of the Ahtanum Valley, Yakima County, Washington: U.S. Geol. Survey Water-Supply Paper 1598, 100 p. Plate 1, 1:62,500.

Free, M. R., 1976, Evidence for magmatic assimilation in several diorites of the middle Columbia River gorge: Univ. of Utah M.S. thesis, 65 p.

Freeman, O. W., 1937, Curious surface markings on basalt near McCall, Washington (abs.): Northwest Sci., v. 11, no. 3, p. 75.

_____, 1938, The Snake River Canyon: Geog. Rev., v. 28, no. 4, p. 597-608. 14 figs. incl. index map.

_____, 1942, Columbia lava basins and plateaus. In Freeman, O. W.; Martin, H. H., eds., The Pacific Northwest: New York, Wiley and Sons, p. 59-79, illus. incl. index map.

Fruchter, J. S.; Baldwin, S. F., 1975, Correlations between dikes of the Monument Swarm, central Oregon, and Picture Gorge Basalt flows: Geol. Soc. America Bull., v. 86, p. 514-516.

Fryxell, Roald ; McIntyre, D. H., 1963, A possible vent breccia in basalt at Lyons Ferry, Washington (abs.): Northwest Sci., v. 37, no. 4, p. 168.

Fuller, R. E., 1925, The geology of the northeast part of the Cedar Lake quadrangle: Univ. of Washington M.S. thesis, 96 p.

_____, 1928, The Asotin craters of the Columbia River Basalt: Jour. Geology, v. 36, no. 1, p. 56-74; (abs.): Revue de Geologie et des Sciences connexes v. 9, no. 4, p. 170, 1928.

_____, 1931, The aqueous chilling of basaltic lava on the Columbia River Plateau: Am. Jour. Sci. (5), v. 21, p. 281-300; (abs.) Geol. Soc. America Bull., v. 42, no. 1, p. 301, 1931; (abs.): Pan-American Geologist, v. 54, no. 1, p. 76-77, 1931.

Fuller, R. E.; Hoffman, M. G., 1934, Structural features in the Columbia River lavas of central Washington: Jour. Geology, v. 42, no. 3, p. 311-328, 5 figs.

Fuller, R. E., 1950, Structural features in the Columbia River Basalt: Northwest Sci., v. 24, no. 2, p. 65-73.

Gard, L. M., Jr., Geology of the Benge quadrangle: U.S. Geol. Survey unpublished map, 1:62,500.

_____, Geology of the Washtucna quadrangle: U.S. Geol. Survey unpublished map, 1:40,000.

_____, Geology of the Endicott quadrangle: U.S. Geol. Survey unpublished map, 1:62,500.

_____, Geology of La Crosse quadrangle: U.S. Geol. Survey unpublished map, 1:62,500.

Gard, L. M., Jr.; Waldron, H. H., 1954, Geology of the Starbuck quadrangle, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-38, 1:62,500.

Gibson, I. L., 1966, The Grande Ronde dike swarm and its relation to the Columbia River Basalts (abs.): Geol. Soc. America Spec. Paper 87, p. 205.

_____, 1966, Crustal flexures and flood basalts: Tectonophysics, v. 3, no. 5, p. 447-456.

_____, 1969, A comparative account of the flood basalt volcanism of the Columbia plateau and eastern Iceland: Bull. Volcanologique, Tome XXXIII-2, p. 419-437.

Gilmour, E. H.; Stradling, Dale (eds.), 1970, Proceedings of the Second Columbia River Basalt Symposium: East. Wash. State Coll. Press, Cheney, Wash., 333 p. (Proceedings of the Symposium held at the Northwest Scientific Association Meetings, 21-23 March, 1969).

Gottfried, David, 1958, Uranium in basalts from Washington and Oregon: U.S. Geol. Survey Report TEI-740, p. 283, 285 incl. table.

Graham, C. E., 1949, Structure of the western portion of the Lewiston downwarp in southeastern Washington: Washington State College M.S. thesis, 36 p.

Gray, I. B., 1955, Correlation of the upper flows of the Columbia River basalts between Moses Coulee and Yakima, Washington: University of Washington M.S. thesis, 52 p.

Greeley, R., 1972, Formation of multiple lava tubes (abs.): EOS (Am. Geophys. Union, Trans.), v. 53, no. 3, p. 276.

Gresens, R. L., 1975, Geologic mapping of the Wenatchee area: Washington Div. Geology and Earth Resources Open-File Report, No. OF 75-6, scale 1:1,000.

_____, 1976, A new tertiary formation near Wenatchee, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 372-373.

Griggs, A. B., 1965, Stratigraphic relationships between the Columbia River Basalt and the Latah Formation in Spokane area, Washington (abs.): Geol. Soc. America Spec. Paper 82, p. 328.

_____, 1966, Geology - Columbia Basin, In Mineral and water resources of Washington: U.S. Cong., 89th, 2nd Sess., Comm. Interior and Insular Affairs, Comm. Print, p. 22-27, illus.

_____, 1966, Reconnaissance geologic map of the west half of the Spokane quadrangle, Washington and Idaho: U.S. Geol. Survey Misc. Geol. Inv. Map I-464, 1:125,000.

_____, 1973, Geologic map of the Spokane quadrangle, Washington, Idaho, and Montana: U.S. Geol. Survey Misc. Geol. Inv. Map I-768, map and text on one sheet, 1:250,000.

_____, 1973, The Belt Supergroup in the Spokane Quadrangle (abs.): In Belt Symposium 1973, v. 1, p. 76.

_____, 1976, The Columbia River Basalt Group in the Spokane quadrangle, Washington, Idaho, and Montana, with a section on petrography by D. A. Swanson: U.S. Geol. Survey Bull. 1413.

Grolier, M. J.; Foxworthy, B. L., 1959, Geology of the Moses Lake North quadrangle, Washington: U.S. Geol. Survey Open-File Report.

_____, 1961, Geology of the Moses Lake North quadrangle, Washington: U.S. Geol. Survey Misc. Geol. Invest. Map I-330, 1:24,000.

Grolier, M. J.; Bingham, J. W., 1962, Geologic map and sections for parts of Grant, Adams, and Franklin counties, Washington: U.S. Geol. Survey Open-File Report.

Grolier, M. J.; 1965, Geology of part of the Big Bend area, in the Columbia Plateau, Washington: Ph.D. thesis, Johns Hopkins University, 163 p.

Grolier, M. J.; Bingham, J. W., 1965, Geologic map and sections of the Columbia Basin Project area, Washington. U.S. Geol. Survey Open-File maps, 1:62,500.

_____, 1969, Geology of parts of Grant, Adams, and Franklin counties, east-central Washington: U.S. Geol. Survey Open-File Report.

Grolier, M. J., 1971, Volcanic investigations - Basalts of the Columbia River Group: U.S. Geol. Survey Prof. Paper 750-A, p. 189.

Grolier, M. J., Bingham, J. W., 1971, Geologic map and sections of parts of Grant, Adams, and Franklin counties, Washington: U.S. Geol. Survey Misc. Geol. Invest. Map I-589, 6 sheets, 1:62,500.

Hague, A.; Iddings, J. P., 1883, Notes on the volcanoes of northern California, Oregon and Washington Territory: Am. Jour. Sci., v. 126, p. 222-235.

Hammond, P. E., 1973, Quaternary basaltic volcanism in the southern Cascade Range, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 49.

Hammond, P. E.; Pederson, S. A.; Stricklin, C. R., 1975, Geology and gravimetry of the Quaternary basaltic volcanic field, southern Cascade Range, Washington (abs.): U. N. Symposium Dev. Use Geotherm. Resour., Abs., no. 2, unpaginated.

Haverland, M. L.; Butler, G. L., 1974, Shear and sliding resistance tests of rock joints for Forebay Dam, Grand Coulee Third Powerplant projects: In Voight, Barry; and others, eds., Rock Mechanics: The American Northwest: Penn. State Univ. Press, University Park, Penn., p. 258-261.

Hershey, O. H., 1912, Some Tertiary and Quaternary geology of western Montana, northern Idaho, and eastern Washington (abs.): Geol. Soc. America Bull., v. 23, p. 75.

Hodge, E. T., 1931, Columbia River fault-scarp (abs.): Pan-American Geologist, v. 55, no. 1, p. 64; (abs.): Geol. Soc. America Bull., v. 42, no. 1, p. 185-186.

_____, 1932, History of Columbia River gorge (abs.): Pan-American Geologist, v. 57, no. 1, p. 62; (abs.): Geol. Soc. America Bull., v. 43, no. 1, p. 131-132.

_____, 1933, Age of Columbia River and lower canyon (abs.): Geol. Soc. America Bull., v. 44, no. 1, p. 156-157; (abs.): Pan-American Geologist, v. 58, no. 1, p. 70.

_____, 1938, Geology of the lower Columbia River: Geol. Soc. America Bull., v. 49, p. 831-930.

Hodges, C. A., 1976, Basaltic ring structures of the Columbia Plateau: (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 382.

Hoffer, J. M., 1967, The Rock Creek flow of the Columbia River Basalt: Northwest Sci., v. 41, p. 23-31.

Hoffman, M. G., 1932, The geology of Bald Butte Ridge, Washington: Jour. Geology v. XL, p. 634-51, 1 fig.: (abs.): Revue de Geologie et des Sciences Connexes, v. 13, no. 11, p. 650, 1933.

_____, 1932, Several phases of geology of the Moses Coulee area (Washington): Northwest Sci., v. 6, no. 4, p. 120-123, 129.

_____, 1933, Structural features in the Columbia River lavas of central Washington: Jour. Geology, v. 41, no. 2, p. 184-195, 5 figs.; (abs.): Revue de Geologie et des Sciences Connexes, v. 13, no. 10, p. 558, 1933.

Holden, G. S., 1973, Multiple vent in the Columbia River Basalt: Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 55.

_____, 1967, The Yakima-Ellensburg unconformity, central Washington: University of Washington M.S. thesis, 69 p., Plate 1, 1:142,560; Plate 2, 1:42,768; Plate 3, 1:96,000; (abs.): Northwest Sci., v. 42, p. 34-35, 1968.

Holmgren, D. A., 1968, Origin of sub-horizontal platy jointing in the Yakima Basalt (abs.): Northwest Sci., v. 42, no. 1, p. 35.

_____, 1969, Columbia River Basalt stratigraphic patterns near Yakima, Washington and The Dalles, Oregon (abs.): Geol. Soc. America, Abs. with Programs for 1969, Part 3, p. 26.

_____, 1969, Columbia River Basalt patterns from central Washington to northern Oregon: University of Washington Ph.D. thesis, 55 p.; (abs.): Diss. Abs. Int., v. 31, no. 2, sec. B., p. 759.

Hooper, P. R.; Camp, V. E.; Kleck, W. D.; Reidel, S. P.; Sandstrum, C. E., 1976, Magnetic polarity and stratigraphy of the southeastern part of the Columbia River basalt plateau; Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 383.

Houghland, Everett, Description of Saddle Mountains, Frenchman Hills, and Badger Mountains area in general: State of Washington - General, Div. of Geol. Area Files, Washington Div. Geology and Earth Resources.

Howell, P. W., 1963, The Columbia River Basalt - Another hypothesis: Geol. Soc. Oregon Country Geol. News Letter, v. 29, no. 1, p. 3-4.

_____, 1970, The geology of the Columbia River Basalt: Geol. Soc. Oregon Country Geol. News Letter, v. 36, no. 11, p. 81-82.

Hoyt, C. L., 1961, The Hammond sill - An intrusion in the Yakima Basalt near Wenatchee, Washington: Northwest Sci. v. 35, no. 2, p. 58-64.

Huff, L. C., date unknown, Spokane, Greenacres, Medical Lake, Clayton, Deerpark, and Mt. Spokane quadrangles: U.S. Geol. Survey Ground water branch, Tacoma, unpub. maps, scale 1:62,500.

Hull, L. M., 1929, A history of central Washington: Shaw and Borden Press, Spokane, Washington.

Huntting, M. T., 1942, Geology of the middle Tucannon area: Washington State College M.S. thesis, 33 p. Figure 4, 1:96,000.

_____, 1942, Preliminary report of geology along part of Tucannon River Washington: Northwest Sci., v. 16, no. 4, p. 103-104.

Huntting, M. T.; Bennett, W. A. G.; Livingston, V. E., Jr.; Moen, W. M., 1961, Geologic map of Washington: Washington Div. Mines and Geology, scale 1:500,000, 2 sheets.

Irwin, W. H., 1938, Geology of the rock foundation of Grand Coulee Dam, Washington: Geol. Soc. America Bull. v. 49, p. 1627-1650.

Irwin, W. H.; Aherns, T. P., 1946, Geology and ground-water hydrology of the South Dam, Columbia Basin project, Washington (abs.): Geol. Soc. America Bull., v. 57, no. 12, pt. 2, p. 1207-1208; (abs.): Annot. Biblio. Econ. - Geology, v. 19, no. 2, p. 156, Dec. 1946.

Irwin, W. H., 1946, Engineering geologic problems of the Grand Coulee area, Columbia Basin project, Washington (abs.): Geol. Soc. America Bull., v. 57, no. 12, pt. 2, p. 1207; (abs.): Annot. Biblio. Econ. Geology v. 19, no. 2, p. 156, Dec. 1946.

Jaske, R. T., 1964, Large scale quarry blasting on the Hanford Reservation: Hanford Atomic Products Operation, Report HW-79614, 63 p.

Jenkins, O. P., 1922, Geological investigation of the Grand Coulee: Washington Dept. of Conserv. and Dev., Div. of Geology Report, geol. map, scale 1:62,500.

Jones, F. O., 1945, Geological report on Potholes damsite and vicinity, Columbia Basin Project, Washington: U.S. Bur. Reclamation unpublished report.

Jones, F. O.; Deacon, R. J., 1966, Geology and tectonic history of the Hanford area and its relation to the geology and tectonic history of the state of Washington and the active seismic zones of Western Washington and western Montana: Douglas United Nuclear, Inc., Consultant agreement CA-00056, Spokane, Washington, 21 p.

Jones, R. W., 1969, Comparison of Columbia River Basalts and Snake Plains Basalts, In Gilmour, E. H.; Stradling, D., eds., Proceedings of the second Columbia River Basalt Symposium: Eastern Washington State College Press, p. 209-221, (abs.): Northwest Sci. v. 43, no. 1, p. 37, Feb. 1969.

Keppler, B. H., 1954, Structural variations in a single basalt flow of southeastern Washington: Washington State College M.S. thesis, 41 p.

Kienle, Clive, 1971, The Yakima Basalt in western Oregon and Washington: University of California, Santa Barbara, Ph.D. thesis, 171 p.; (abs.): Geol. Soc. America Abs. with Programs, v. 4, no. 7, p. 561-562, 1972.

Kienle, C. F., Jr.; Newcomb, R. C., 1973, Geologic studies of Columbia River Basalt structures and age of deformation, The Dalles-Umatilla region, Washington and Oregon: Shannon and Wilson, Inc., Portland, Ore., 55 p.

Kinnison, H. B.; Sceva, J. E., 1963, Effects of hydraulic and geologic factors on stream flow of the Yakima River Basin, Washington: U.S. Geol. Survey Water-Supply Paper 1595, 134 p. Plate 1, 1:250,000.

Kirkham, V. R. D., 1931, Snake River downwarp: Jour. Geology, v. 39, no. 5, p. 456-482, 11 figs., 1 pl. map.

Ko, Chong An, 1974, Geology and groundwater resources of the Hangman Creek drainage basin, Idaho-Washington (abs.): Washington State Univ. Ph.D. thesis; (abs.) Diss. Abs. Int., v. 35, no. 6, p. 2824B-2825B.

Kuno, H., 1962, Frequency distribution of rock types in oceanic, orogenic, and kratogenic volcanic associations. In MacDonald, G. A.; Kuno, H., eds., The crust of the Pacific Basin: Am. Geophys. Union Geophys. Monograph 6 (National Academy of Science-National Research Council Publication 1035), p. 135-139.

Landes, H., 1930, Geology of the Columbia River, In Columbia River and minor tributaries, v. 2: Cong. Doc., 23d Cong., 1st Sess., House Doc. 103, U.S. Dept. of War, p. 1197-1198.

Lasmanis, R., 1971, A Dana locality, Spokane, Washington: Rocks and Minerals, v. 46, no. 6, whole number 381, p. 372-374.

Laursen, J. M.; Hammond, P. E., 1974, Summary of radiometric ages of Oregon and Washington rocks, through June 1974: Isochron. West, no. 9, 32 p.

Laval, W. N., 1956, Stratigraphy and structural geology of portions of south-central Washington: Univ. of Washington Ph.D. thesis, 223 p. Plate 21, 1:62,500; Plate 23, 1:126,720; Plate 24, 1:62,500, Plate 27, 1:62,500; Plate 28, 1:62,500; Plate 29, 1:62,500; Plate 30, 1:62,500; Plate 31, 1:62,500.

_____, 1957, Primary structures of the Columbia River basalt flows, south-central Washington (abs.): Geol. Soc. America Bull., v. 68, p. 1867.

_____, 1958, Anticlines of the southwestern Columbia Basin (Washington) (abs.): Geol. Soc. America Bull., v. 69, no. 12, pt. 2, p. 1734.

_____, 1966, Engineering geology of Tertiary formations and structures, south-central Washington. In Engineering geology and soils engineering symposium, 4th Ann., Moscow, Idaho, 1966, Proc.: Boise, Idaho, Idaho Dept. Highways, p. 91-111, illus.

_____, 1966, Miocene-Pliocene formations of south-central Washington (abs.): Northwest Sci., v. 40, no. 1, p. 38-39.

LeConte, J. L., 1873 and 1874, On the great lava flood of the Northwest: and on the structure and age of the Cascade Mountains: Calif. Acad. Sci. Proc., v. 5, p. 214-220 (1873); Am. Jour. Sci., v. 3, no. 7, p. 167-180, 259-267 (1874).

Ledgerwood, R. K.; Brown, D. J.; Waters, A. C.; Meyers, C. W., 1973, Identification of Yakima Basalt flows in the Pasco Basin: Draft copy of a field guide published by ARHCO, Richland, Washington.

Lefebvre, R. H., 1966, Jointing variations in the flows and interbeds of the Columbia River basalts (abs.): Georgia Acad. Sci. Bull., v. 24, no. 2, p. 77.

_____, 1966, Variations of flood basalts of the Columbia River Plateau, central Washington: Northwestern Univ. Ph.D. thesis, 211 p.

_____, 1968, Formation of flood basalts, central Washington (abs.): Geol. Soc. America Spec. Paper 101, p. 120.

_____, 1968, Lava flow correlation in a flood-basalt province (abs.): Geol. Soc. America Spec. Paper 101, p. 367.

_____, 1969, Columbia River Basalts of the Grand Coulee area. In Gilmour, E. H.; Stradling, E., eds., Proceedings of the Second Columbia River Basalt Symposium: Cheney, Washington, Eastern Washington State College Press, p. 1-30; (abs.) Northwest Sci., v. 43, no. 1, p. 38, 1969.

Livingston, V. E., Jr., 1957, Reconnaissance map of the Clyde-Alto area, Columbia and Walla Walla Counties: Washington Div. Mines and Geology unpublished map, 1:125,000.

Lowry, W. D.; Baldwin, E. M., 1952, Late Cenozoic geology of the lower Columbia River valley, Oregon and Washington: Geol. Soc. America Bull., v. 63, pt. 1, p. 1-24.

Lynch, M. B., 1976, Remanent paleomagnetism in the miocene basalts of north Idaho: Univ. of Idaho M.S. thesis, 150 p.

Mackin, J. H., 1940, Review of geology of the lower Columbia River, by E. T. Hodge, 1938: Jour. Geomorph., v. 3, p. 70-75.

_____, 1955, Geology of the Priest Rapids development; Priest Rapids Hydroelectric Development, Columbia River, Washington: Grant Co. Public Utility Dist., 43 p.

_____, 1960, Geology of the Priest Rapids and Wanapum dam sites on the Columbia River in south-central Washington 9abs.): Geol. Soc. America Bull., v. 71, no. 12, pt. 2, p. 2066.

_____, 1961, A stratigraphic section in the Yakima Basalt and the Ellensburg formation in south-central Washington: Washington Div. Mines and Geology Rept. Inv. 19, 45 p.

Mac Nish, R. D., 1976, Mathematical model of an aquifer system in the Columbia River Basalt Group in southeastern Washington and northeastern Oregon (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 391-392.

Maddox, G. E., 1976, A proposed structural control of surface and ground water in the eastern portion of the Columbia River Basalt, Washington (abs.): Geol. Soc. Am., Abs. with Programs, v. 8, no. 3, p. 392.

Mason, G. W., 1953, Interbasalt sediments of south-central Washington: Washington State College M.S. thesis, 116 p.

McConnell, Duncan, 1956, An unusual palagonite tuff (Washington): Am. Mineralogist v. 41, nos. 1-2, p. 153-156, illus.

McDonald, R., 1974, Third powerplant rock mechanics and instrumentation. In Voight, Barry; and others, eds., Rock Mechanics: The American Northwest: Pennsylvania State Univ. Press, University Park, Pa., p. 257.

McDougall, Ian., 1976, Geochemistry and origin of basalt of the Columbia River Group, Oregon and Washington: Geol. Soc. America Bull., v. 87, no. 5, p. 777-792.

McKee, Bates, 1968, The northwestern part of the Columbia Plateau. In Assoc. Eng. Geologist, 1968 Natl. Mtg., Seattle, Wash., 1968, Guidebook to field trips: Sacramento, Calif., Assoc. Eng. Geologists, p. 4-10.

_____, 1968, The Olympic-Wallowa lineament in western and central Washington (abs.): Geol. Soc. America Spec. Paper 115, p. 340.

_____, 1969, Regional stratigraphic study of the Yakima Basalt (abs.): Geol. Soc. America Spec. Paper 121, p. 530.

McKee, Bates; Stradling, Dale, 1970, The sag flowout-a newly described volcanic structure: Geol. Soc. America Bull., v. 81, p. 2035-2043.

McKee, Bates, 1974, The northwestern part of the Columbia Plateau. In Voight, Barry; and others, eds., Rock Mechanics: The American Northwest: Penn. State Univ. Press, University Park, Penn., p. 241-246.

McKee, E. H., Swanson, D. A.; Wright, T. L., 1977, Duration and volume of Columbia River basalt volcanics, Washington, Oregon, and Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 4, p. 463-464.

Monahan, C. J., 1962, Geologic features at McNary Dam, Oregon-Washington: U.S. Army Corps Engrs. Pub., p. 33-38.

_____, 1962, John Day lock and dam: foundation investigations: Jour. Power Division, Proc. Soc. Civil Engineers, v. 3344, PO4, p. 29-45.

_____, 1969, Reservoirs in volcanic terrain: Assoc. Engineering Geologists Bull., v. 6, no. 1, p. 53-60.

Mundorff, M. J., 1964, Geology and groundwater conditions of Clark County, Washington with a description of a major alluvial aquifer along the Columbia River: U.S. Geol. Survey Water-Supply Paper 1600, 268 p.

Myers, C. W.; Brown, D. J., 1973, Stratigraphy of the Yakima Basalt in the Pasco Basin, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 80-81.

Myers, C. W., 1973, Yakima Basalt flows near Vantage, and from core holes in the Pasco Basin, Washington: Univ. California, Santa Cruz, Ph.D. thesis, 147 p.

Neal, V. T., 1972, Physical aspects of the Columbia River and its estuary. In The Columbia River estuary and adjacent ocean water bioenvironmental studies, p. 19-40.

Neff, G. E., 1940, Structure contour map of feldspar basalt flow, Coulee City-Long Lake-Soap Lake area: Unpublished map of the U.S. Dept. Int., Bur. Reclamation, Columbia Basin Project, Wash., Drawing no. 222-117-11514.

_____, 1962, The Warden-Othello dike system (abs.): Northwest Sci., v. 36, no. 1, p. 20-21.

Neff, George, 1974, Roadlog: Ephrata - Coulee Dam: In Rock Mechanics: The American Northwest: Penn. State Univ. Press, University Park, Penn., p. 269-270.

Nering, L. G., 1956, Stratigraphic, mechanical, chemical, and petrographic analysis of the Lind Coulee site. In Daugherty, R. D., ed., Archaeology of the Lind Coulee site, Washington: Am. Philos. Soc. Proc., v. 100, no. 3, p. 263-266, tables.

New, W. R., 1940, Origin of Goose Egg Mountain, Yakima County, Washington: Washington State College M.S. thesis, 40 p.

Newcomb, R. C.; Strand, J. R., 1953, Geology and ground water characteristics of the Hanford Reservation of the Atomic Energy Commission, Washington: U.S. Geol. Survey WP-8., p. 12-53.

Newcomb, R. C., 1958, Corral Canyon, Coyote Rapids, Hanford, and Richland quadrangles: U.S. Geol. Survey unpublished maps, 1:62,500.

_____, 1961, Storage of ground water behind subsurface dams in the Columbia River Basalt, Washington, Oregon and Idaho: U.S. Geol. Survey Prof. Paper 383-A, p. 1-15. Figure 1, 1:3,752,000.

_____, 1961, Structural barrier reservoirs of ground water in the Columbia River Basalt: U.S. Geol. Survey Prof. Paper 424-B, p. 213-215. Figure 1, 1:3,752,000.

_____, 1965, Geology and ground-water resources of the Walla Walla River Basin, Washington-Oregon: Washington Div. Water Resources, Water-Supply Bull. 31, 151 p. Plate 1, 1:95,040.

_____, 1966, Lithology and eastward extension of The Dalles formation, Oregon and Washington: U.S. Geol. Survey Prof. Paper 550-D, p. 59-63. Figure 1, 1:1,267,200.

_____, 1967, The Dalles-Umatilla syncline, Oregon and Washington: U.S. Geol. Survey Prof. Paper 575-B, p. 88-93.

Newcomb, R. C.; Strand, J. R.; Frank, F. J., 1966, Geology and ground-water characteristics of the Hanford Reservation of the Atomic Energy Commission, Washington: U.S. Geol. Survey draft report.

Newcomb, R. C., 1969, Geologic map of the proposed Paterson Ridge pumped-storage reservoir, south-central Washington: U.S. Geol. Survey Open-File Report, 1 sheet accompanied by 8 pages of text.

_____, 1969, Effect of tectonic structure on the occurrence of ground-water in the basalt of the Columbia River Group of The Dalles area, Oregon and Washington: U.S. Geol. Survey Prof. Paper 383-C, 33 p., 19 illus.

_____, 1969, The Columbia River Group: Its tectonic structure in Washington, Oregon, and Idaho. In Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Cheney, Washington, Eastern Washington State College Press, p. 173-175.

_____, 1970, Tectonic structure of the main part of the basalt of the Columbia River Group, Washington, Oregon and Idaho: U.S. Geol. Survey Misc. Geol. Inv. Map I-587.

_____, 1971, Geologic map of the proposed Paterson Ridge pumped-storage reservoir, south-central Washington: U.S. Geol. Survey Misc. Geol. Inv. Map, no. I-653. Scale 1:31,680, sections, explanatory text (4 p.).

Newcomb, R. C.; Strand, J. R.; Frank, F. J., 1972, Geology and ground-water characteristics of the Hanford Reservation of the U.S. Atomic Energy Commission, Washington: U.S. Geol. Survey Prof. Paper 717, 78 p.

Newcomb, R. C., 1976, Some characteristics of aquifers in the Columbia River Basalt (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 399-400.

Newman, K. R., 1969, Palynology of Interflow sediments from the Standard Oil Company of California Rattlesnake Hills No. 1 well, Benton County, Washington. In Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Cheney, Washington, Eastern Washington State College Press, p. 201-208.

Nowakowski, R. F., 1965, Many lava flows centered on Pasco Basin 30 million years ago. In Tri-City Herald newspaper, 13 June, 1965, p. 33.

Oestreich, Karl, 1915, Die Grande Coulee (Washington): Am. Geol. Soc. Mem. Vol. of Transcontinental Excursions of 1912, p. 257-273, 2 pls., 3 figs.

Olson, T. M.; Gilmour, E. H.; Bacon, Marion; Daggy, J. L.; Robinson, G. A.; Parker, O. J., 1975, Geology, groundwater, and water quality of part of southern Spokane County, Washington: Office of Water Research and Technology Project Completion Report, Eastern Washington State College, 139 p., 17 tables, 2 plates.

Olson, T. M., 1975, The geology and groundwater resources of part of the Hangman and Marshall Creek drainage basins, Spokane County, Washington: Eastern Washington State College M.S. thesis, 70 p.

Ouellette, C., 1971, Frenchman Springs, out of the ordinary but not out of the way: The Seattle Times Pictorial, 28 Mar. 1971, p. 30-35.

Pardee, J. T.; Bryan, Kirk, 1925, Origin of fossiliferous Latah clays and associated basalts near Spokane (abs.): Pan-American Geologist, v. 43, no. 5, p. 369-370.

_____, 1926, Geology of the Latah formation in relation to the lavas of the Columbia Plateau near Spokane, Washington: U.S. Geol. Survey Prof. Paper 140-A, p. 1-16, 7 pl, 3 fig: (abs.) Revue de Geologie et des Sciences Connexes, v. 7, nos. 2-3, p. 152, 1926.

Pardee, J. T., 1928, Geology of reservoir sites near Washtucna and Kahlotus, Washington: U.S. Geol. Survey Open-File Report, 15 p. Figure 4, 1:125,000.

Parson, D. L., 1973, The Snake River Basin: Its characteristics and problems: Coll. Idaho, Snake River Reg. Stud. Cent., Occas. Paper, no. 1, 12 p.

Peacock, M. A.; Fuller, R. E., 1928, Chlorophaeite, sideromelane and palagonite from the Columbia River plateau: Am. Mineralogist, v. 13, p. 360-382.

Peterson, D. E.; Brown, R. E., 1966, Gravity anomalies and geologic structures of the central part of the Columbia River Basalt Plateau (abs.): Am. Geophys. Union Trans., v. 47, no. 4, p. 630.

Piper, A. M., 1932, Geology and ground-water resources of The Dalles region, Oregon: U.S. Geol. Survey Water-Supply Paper 659B, p. 107-189.

Price, S. M., 1977, An evaluation of dike-flow correlations indicated by geochemistry, Chief Joseph swarm, Columbia River Basalt: Univ. of Idaho, Ph.D. thesis, 320 p.

Price, W. H., 1972, The Rattlesnake Ridge Project - A Progress Report: Atlantic Richfield Hanford Company, Richland, Washington, Report no. ARH-2657.

Purves, W. J., 1969, Stratigraphic control of the ground water through Spokane Valley: Washington State Univ. M.S. thesis 213 p.

Rahm, D. A., 1969, Post-Miocene erosion of basalt in southeastern Washington (abs.). In Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, Cheney, Washington, p. 328.

Raisz, Erwin, 1945, The Olympic-Wallowa lineament: Am. Jour. Sci., v. 243A, p. 479-485.

Raymond, J. R.; Tillson, D. D., 1968, Evaluation of thick basalt sequence in south-central Washington: Battelle Northwest Laboratories BNWL-776.

Reed, J. C., 1941, The firey floods that formed the Inland Empire: Nat. History v. 47, no. 4, p. 200-210, illus.

Reidel, Steve, 1978, Stratigraphy of Grande Ronde basalt: Washington State Univ. Ph.D. thesis.

Ritchie, A. M., 1950, Highway problems in basalt: Northwest Sci., v. 24, no. 2, p. 88.

Robinson, C. F., 1966, Stratigraphy and structural geology of Ahtanum Ridge, Yakima, Washington: Univ. of Washington M.S. thesis, 35 p. Plate 1, 1:72,412.

Robinson, P. T., 1973, Columbia River Basalt. In Geologic Field Trips in northern Oregon and southern Washington: Trip 1, Cretaceous and Cenozoic, north-central Oregon: Oregon Dept. Geol. Miner. Ind. Bull., no. 77, p. 22-23.

Rosenmeier, F. J., 1968, Yakima Basalt stratigraphy and faulting in the Wenatchee Mountains (abs.): Northwest Sci., v. 42, no. 1, p. 43.

Ross, M. E., 1975, The structure of Yakima basalts in a portion of the Grande Ronde River region of northeastern Oregon and southeastern Washington (abs.): Geol. Soc. America Abs. with Programs, v. 7, no. 5, p. 638-639.

Russell, I. C., 1893, A geological reconnaissance in central Washington: U.S. Geol. Survey Bull. 108, 108 p.

_____, 1897, Principal features of the geology of southeastern Washington (abs.): Am. Jour. Sci., series 4, v. 3, no. 15, p. 246-248; (abs.) Jour. Geology, v. 5, no. 1, p. 107-109, 1897: (abs.) Mining, v. 3, no. 6.

_____, 1897, A reconnaissance in southeastern Washington: U.S. Geol. Survey Water-Supply Paper 4, 96 p.

_____, 1901, Geology and water resources of Nez Perce County, Idaho: U.S. Geol. Survey Water-Supply Paper 53, p. 28.

Savage, C. N., 1973, A Geological field trip in Benewah and Whitman Counties, Idaho and Washington, respectively. In Bishop, D. T.; Powell, J. D., Co-chairmen. Belt Symposium 1973, Volume 1: Univ. of Idaho Dept. Geology, and Idaho Bur. Mines and Geology, Moscow, Idaho, p. 253-320.

Schmauch, S.; Conyac, M., 1978, Mineral resources of the Snake River drainage, Washington and Oregon: U.S. Bureau of Mines Bull. ___, (in press).

Schief, V. E., 1947, Excelsior surface, an intra-Columbia River basalt weathering surface (abs.): Northwest Sci., v. 21, no. 1, p. 34; Geol. Soc. America Bull., v. 58, no. 12, pt. 2, p. 1224-1225.

Schmidt, R. G., 1962, Aeroradioactivity survey and areal geology of the Hanford Plant area, Washington and Oregon (ARMS-1): U.S. Atomic Energy Commission, Rept. No. CEX-59.4.11. (abs.) Geoscience Abstracts, v. 5, no. 5, p. 40, 1963.

Schmincke, H. U., 1964, Petrology, paleocurrents, and stratigraphy of the Ellensburg Formation and interbedded Yakima Basalt flows, south-central Washington: The Johns Hopkins Univ., Ph.D. thesis, 426 p.

_____, 1964, Petrology, current directions and history of the Upper Late Yakima Basalt flows and interbedded sediments, south-central Washington (abs.): Fourth Ann. Grad. Student Symposium in the Geol. Sci., Univ. Calif., Los Angeles, Calif., 1964, p. 14-15.

_____, 1965, Tracing a basalt flow on the Columbia River Plateau, south-central Washington (abs.): Geol. Soc. America Spec. Paper 82, p. 275-276.

_____, 1967, Stratigraphy and petrography of four upper Yakima Basalt flows in south-central Washington: Geol. Soc. America Bull., v. 78, p. 1385-1422.

_____, 1967, Flow directions in Columbia River basalt flows and paleocurrents of interbedded sedimentary rocks: Geol. Rundschau., v. 56, no. 3, p. 992-1020.

_____, 1968, Flow directions in Columbia River basalt flows and paleocurrents of interbedded sedimentary rocks, south-central Washington (abs.): U.S. Geol. Survey Abs. North American Geology, p. 95.

_____, 1967, Fused tuffs and peperites in south-central Washington: Geol. Soc. America Bull., v. 78, p. 319-330.

Shaw, H. R.; Swanson, D. A., 1967, Some limitations of flow velocities during eruption and flooding of the Columbia Plateau by lavas of the Yakima Basalt (abs.): Geol. Soc. America Spec. Paper 115, p. 202.

_____, 1969, Eruption and flow rates of flood basalts. In Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Cheney, Washington, Eastern Washington State College Press, p. 271-300.

_____, 1970, Speculations on the fluid mechanical history of Yakima basalt flows (abs.): In Columbia River Basalt Symposium, 2d, 1969: Eastern Washington State College Press, Cheney, Washington, p. 330.

Shedd, Solon, 1923, Topography and geology of the Okanogan Highlands and Columbia Plateau of Washington (abs.): Geol. Soc. America Bull., v. 34, p. 75.

_____, 1926, Abstract of report on geology and resources of the Pasco and Prosser quadrangles: Washington Div. Geology Rept. Invest. 1, pl. 1, 1:125,000.

Sheppard, R. A., 1962, Iddingsitization and recurrent crystallization of olivine in basalts from the Simcoe Mountain, Washington: Am. Jour. Sci., v. 260, no. 1, p. 67-74.

Shumway, R. D., 1960, Geology of the Lime Hill area, Asotin County, Washington: Washington State Univ. M.S. thesis, 54 p. Figure 11, 1:15,600.

Simons, W. D., et. al., 1953, Spokane-Coeur d'Alene River basin, Washington-Idaho: Chap. 10 of U.S. Cong. House Comm. Interior and Insular Affairs, Subsurface facilities of water management and patterns of supply-type area studies, p. 162-185, illus.

Skehan, J. W., 1965, A continental-oceanic crustal boundary of the Pacific Northwest: Air Force Cambridge Research Lab., Scientific Rept. 3, AFCRL-65-904.

_____, 1965, The Olympic-Wallowa lineament: A major deep-seated tectonic feature of the Pacific Northwest (abs.): Am. Geophys. Union Trans., v. 46, no. 1, p. 71.

Smith, G. O., 1901, Geology and water resources of a portion of Yakima County, Washington: U.S. Geol. Survey Water-Supply Paper 55, 68 p.

_____, 1903, Geologic folio of the Ellensburg quadrangle, Washington: U.S. Geol. Survey Geol. Folio 86, 7 p., 3 maps, scale 1:125,000.

_____, 1903, Anticlinal mountain ridges in central Washington: Jour. Geology, v. 11, p. 166-177.

_____, 1903, Geology and physiography of central Washington: U.S. Geol. Survey Prof. Paper 19, p. 1-39.

Snavely, P. D., Jr.; MacLeod, N. S.; Wagner, H. C., 1971, Consanguinity of Miocene basalts in coastal Oregon and Washington and on the Columbia Plateau (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 2, p. 197-198.

_____, 1973, Miocene tholeiitic basalt of coastal Oregon and Washington and its relation to coeval basalts of the Columbia Plateau: Geol. Soc. America Bull., v. 84, no. 2, p. 387-424.

Sorem, R. K., 1963, Central Washington field trip led by A. C. Waters: The XI Transactions of Sigma Gamma Epsilon, XI Chapter, Washington State Univ., v. 1, no. 1, p. 7-8.

Souther, J. G., 1977, Late Cenozoic volcanism and tectonics of the west central Cordillera of North America (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1185.

"Miocene and younger volcanism in the Canadian Cordillera was restricted to six well-defined linear belts. The four belts south of latitude 55° are related to subduction of the Juan de Fuca and Explorer plates. The late Miocene, Pemberton Volcanic Belt (PVB) is a calc-alkaline front above the subduction zone whereas the alkaline Plateau lavas (PL) of Central British Columbia

were erupted in a back-arc environment and coeval eruption of alkaline to peralkaline lavas in the east-west Anahim Volcanic Belt (AVB) was initiated by deep fractures along the north edge of the downgoing plate. The younger, calcalkaline Garibaldi Volcanic Belt (GVB) bears a similar relationship to alkaline centres of the Alert Bay Belt (ABB).

North of latitude 55^{o} post early Miocene movement between North America and Pacific Plate has been transcurrent and peralkaline volcanism in the adjacent Stikine Volcanic Belt (SVB) is related to incipient north-south rifting of the continental margin. Farther north, where the continental margin swings west into the Alaska Peninsula the Wrangell Volcanic Belt (WVB) forms a calcalkaline front above the downgoing slab of Pacific crust."

Staatz, M. H.; Morris, R. H., 1976, Resume of the regional geology of the Grand Coulee area, Washington: U.S. Geol. Survey Open-File Report 76-782, 34 p. 4 Figures.

Steele, J. L., 1975, A heat flow study in the Turtle Lake Quadrangle, Washington, Southern Methodist Univ. M.S. thesis.

Stewart, C. A., 1922, The geological history of eastern Washington: Washington State College B.S. thesis, 94 p.

Strand, J. R., 1949, Structural geology of pre-Tertiary rocks in southeastern Washington and adjacent portions of Idaho: Washington State College M.S. thesis, 25 p.

Suchanek, Ron, 1974, The Columbia River Gorge; the story of the river and the rocks: Ore Bin, v. 36, no. 12, p. 197-214, illus. (incl. sketch map).

Sullivan, Irma, 1965, Yakima basalt: Geol. Soc. Oregon Country Geol. Newsletter, v. 31, no. 7, p. 65-66.

Summers, K. V., 1975, Palagonite and pillow basalts of the Columbia River Group, Washington: Washington State Univ. M.S. thesis.

_____, 1976, The clay component of the Columbia River palagonites: Am. Mineralogist, v. 61, nos. 5-6, p. 492-494.

Suppe, John; Powell, Christine; Berry, Robert, 1975, Regional topography, seismicity, Quaternary volcanism, and the present-day tectonics of the western United States: Am. Jour. Sci., v. 275-A, p. 397-436.

Swanson, D. A., 1964, The middle and late Cenozoic volcanic rocks of the Tieton River area, south-central Washington: Johns Hopkins Univ. Ph.D. thesis, 329 p. Plate 1, 1:50,688.

_____, 1965, Tieton dike swarm - Yakima Basalt relationships, Tieton River area, Washington (abs.): Geol. Soc. America Spec. Paper 82, p. 283.

_____, 1967, Yakima Basalt of the Tieton River area, south-central Washington: Geol. Soc. America Bull., v. 78, no. 9, p. 1077-1109. Figure 2, 1:190,080.

Swanson, D. A.; Wright, T. L.; Grolier, M. J.; Higgins, M. W.; Zietz, I., 1972, Feeder dikes for Yakima Basalt near Pasco, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 4, no. 3, p. 245.

_____, 1972, Yakima basalt near Pasco, Washington (abs.): Geol. Soc. America Abs. with Programs.

Swanson, D. A.; Wright, T. L., 1973, Extent, source and structure of the Roza Member of the Yakima Basalt in southeast Washington: Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 113-114.

Swanson, D. A.; Wright, T. L.; Clem, R., 1975, Intracanyon flows of Yakima Basalt along the Snake River, southeast Washington: Geol. Soc. America Abs. with Programs, v. 7, no. 5, p. 645.

Swanson, D. A.; Wright, T. L.; Helz, R. T., 1975, Linear vent systems and estimated rates of magma production and eruption for the Yakima Basalt on the Columbia Plateau: Am. Jour. Sci. v. 275, no. 8, p. 877-905.

Swanson, D. A.; Wright, T. L., 1976, Guide to field trip between Pasco and Pullman, Washington, emphasizing stratigraphy, vent areas, and intracanyon flows of Yakima Basalt: Geol. Soc. America, Cordilleran Section Meeting, Pullman, Washington, Field Guide 1, 33 p.

_____, 1976, Magnetostratigraphic units in the Yakima Basalt, southeast Washington: Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 413-414.

Swanson, D. A.; and others, 1977, Reconnaissance geologic map of the Columbia River Basalt Group, Pullman and Walla Walla quadrangles, southeast Washington and adjacent Idaho: U.S. Geol. Survey Open-File Report 77-100, map scale 1:250,000, 11 p.,2 plates.

Swanson, D. A.; Wright, T. L., 1977, The Columbia River Basalt, product of a major thermal event in the western Cordillera (abs.): Geol. Assoc. of Canada - Mineralogical Assoc. of Canada - Soc. Econ. Geol. - Canadian Geophys. Union, 1977 Annual Mtg., Vancouver, B. C., Program with Abstracts, v. 2, p. 50.

Swanson, D. A.; Wright, T. L.; Byerly, G. R., 1977, Complex tectonic setting of the Columbia Plateau (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1194.

"The Columbia River Basalt Group forms a moderate volume (about $2 \times 10^5 km^3$) tholeiitic flood basalt province in the Columbia Plateau and adjacent Blue Mountains. The basalt issued from linear fissure systems apparently confined to the eastern two thirds of the province. Most of the basalt was erupted between about 17 and 14 m.y.b.p., with sporadic eruptions continuing until about 6 m.y.b.p. This was a time of relative east-west extension of the province, as shown by the consistently north to north northwest trend of feeder dikes and the development of slowly subsiding basins, such as the Pasco basin, in which the basalt flows ponded. The total amount of extension is small, however, probably less than 10 km as estimated from the thickness and frequency of dikes. An important departure from simple east-west extension is indicated by growth of the northeast trending Blue Mountains uplift, along which deformation may have progressed toward the northeast during Columbia River time. On the western Columbia Plateau, folds trending from northeast to southeast and even due south began to form during the middle and late stages of volcanism. Stratigraphic studies indicate that calc-alkaline volcanism in the Cascade Range occurred before, during, and after Columbia River activities farther east. Mapping suggests that all active Cascade volcanoes during Columbia River time were situated south of the Olympic-Wallowa lineament, and 8.5 m.y.b.p. Columbia River dikes are truncated

by the lineament southeast of Pasco. These complex tectonic and magmatic relations cannot be fitted into a simple marginal basin, continental rift, or mantle plume model, and the known spreading history of the Juan de Fuca Ridge offers little help toward unraveling the structure because of these complexities."

Swanson, D. A.; Wright, T. L.; Hooper, P. R.; Bentley, R. D., in press, Revisions in stratigraphic nomenclature of the Columbia River Basalt Group: U.S. Geol. Survey Bull.

Symons, T. W., 1882, The upper Columbia River and the Great Plain of the Columbia: U.S. 47th Cong., 1st sess., Senate Ex. Doc. 186, 133 p., maps.

Tabor, W; Waitt, R. B., Jr.; Frizzell, V. A., Jr.; Swanson, D. A.; Byerly, G. R., 1977, Preliminary geologic map of the Wenatchee 1:100,000 quadrangle, Washington: U.S. Geol. Survey Open-File Report 77-531, 24 p., 1 plate, 4 figures.

Taubeneck, W. H., 1966, An evaluation of tectonic rotation in the Pacific Northwest: Jour. Geophys. Research, v. 71, p. 2113-2120.

_____, 1967, Reply to comments on a paper by William H. Taubeneck, "An evaluation of tectonic rotation in the Pacific Northwest," made by N. D. Watkins: Jour. Geophys. Research, v. 72, p. 1415-1421.

_____, 1969, Feeder dikes for Columbia River Basalt in northeastern Oregon, western Idaho, and southeastern Washington (abs.): Northwest Sci., v. 43, no. 1, p. 43.

_____, 1969, Dikes of Columbia River Basalt in northeastern Oregon, western Idaho, and southeastern Washington. In Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Cheney, Washington, Eastern Washington State College Press, p. 73-96.

_____, 1973, Field relationships near the trans-Idaho discontinuity, western Idaho and eastern Washington (abs.): Geol. Soc. of America Abs. with Programs, v. 5, no. 1, p. 115.

Taubeneck, W. H.; Armstrong, R. L., 1974, The Trans-Idaho discontinuity viewed as a transform fault (abs.): Geol. Soc. America Abs. with Programs, v. 6, no. 5, p. 478.

Taylor, T. L., 1976, The basalt stratigraphy and structure of the Saddle Mountains of south-central Washington: Washington State Univ. M.S. thesis.

Tengesdal, J. L. and others, 1976, Main canal, stations 1 + 13.5 to 216 + 00 Bacon Siphon and tunnel no. 2, Columbia Basin Project, Washington: Preconstruction geologic report, v. 1 and 2: U.S. Bur. Reclamation, Div. of Design and Constr., Geology Branch, Boise, Idaho, illus., geol. maps, drill cores.

Thayer, T. P.; Brown, C. E., 1965, Basalt extruded along dike swarm; U.S. Geol. Survey Prof. Paper 525-A.

_____, 1966, Columbia River Group, p. A23-A25. In Changes in stratigraphic nomenclature by the U.S. Geol. Survey, 1965: U.S. Geol. Survey Bull. 1244-A, 60 p.

Thompson, R. N., 1977, Columbia/Snake River-Yellowstone magmatism in the context of western U.S.A. Cenozoic geodynamics: Tectonophysics, v. 39, no. 4, p. 621-636.

Tillson, D. D., 1970, Analysis of crustal changes in the Columbia Plateau area from contemporary leveling and triangulation measurement: Battelle Northwest Laboratories, BNWL-CC-2174.

Treasher, R. C., 1924, Geologic record of eastern Washington to accompany a geologic map of eastern Washington: Washington State College B.S. thesis, 26 p.

_____, 1925, Geology of the Pullman quadrangle, Washington: Washington State College M.S. thesis, 74 p. Plate 1, 1:125,000.

Trimble, D. E., 1950, Joint controlled channeling in the Columbia River Basalts: Northwest Sci., v. 24, no. 2, p. 84-88.

_____, 1954, Geology of the Haas quadrangle, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-43, 1:62,500.

_____, 1957, Geology of the Portland quadrangle, Oregon-Washington: U.S. Geol. Survey Geol. Quad. Map GQ-104, 1:62,500.

_____, 1963, Geology of Portland, Oregon, and adjacent areas: U.S. Geol. Survey Bull. 1119, 119 p. Plate 1, 1:62,500.

Tschabold, E. L., 1964, Columbia Basin: Gems and Minerals, v. 324, p. 18-19.

Twiss, S. N., 1933, Stratigraphy of the Saddle Mountains, Washington: Washington State College M.S. thesis, 36 p. Plate 1, 1:62,500.

Ulmer, G. C.; Zaman, A., 1973, The thermal debit of the Miocene Plateau Basalts (abs.): Eos (Am. Geophys. Union, Trans.), v. 54, no. 4, p. 512.

U.S. Army Corps of Engineers, Walla Walla district, 1950, The Snake River from its mouth to the vicinity of Kahlotus: Unpublished map on 4 sheets, 1:126,720.

U.S. Bureau of Reclamation, Design Office, 1974, Analysis of the Grand Coulee Forebay Dam Foundation and Forebay Channel Walls. In Rock Mechanics: The American Northwest, p. 254-256.

U.S. Dept. of War, 1934, Columbia River and minor tributaries - letter from the Secretary of War, vol. 2: Cong. Doc., 73d Cong., 1st Sess., House Doc. 103, 1845 p.

U.S. Geological Survey, 1966, Spokane and vicinity, Washington, 1950-63: U.S. Geol. Survey, 1 sheet, 1:24,000.

Vallier, T. L.; Hooper, P. R., 1976, Geologic guide to Hells Canyon, Snake River: Geol. Soc. America, Cordilleran Section, Field Guide no. 5, 38 p.

Van Houten, F. B., 1961, Maps of Cenozoic depositional provinces, western United States: Am. Jour. Sci., v. 259, p. 612-621.

Vehrs, Robert, 1974, A summary of the engineering geology of the Grand Coulee Dam and related features. In Voight, Barry; and others, eds., Rock Mechanics: The American Northwest: Penn. State Univ. Press, University Park, Penn., p. 252-253.

Walcott, W. E.; Neff, G. E., 1950, Report on the flow structure of the basalt in the Coulee City - Long Lake - Soap Lake area, Columbia Basin project: U.S. Bur. Reclamation Report, 11 p., 21 illus., map, scale 1:36,000.

Waldron, H. H.; Gard, L. M., Jr., 1951, Preliminary report on the geology of part of the lower Snake River Canyon, Washington: U.S. Geol. Survey Open-File Report, 66 p. Plate 1, 1:24,000.

Waldron, H. H., 1954, Geology of the Hay quadrangle, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-48, 1:62,500.

Waldron, H. H.; Gard, L. M., Jr., 1955, Geology of the Penawawa quadrangle, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-56, 1:62,500.

Walker, G. W., 1969, Some comparisons of basalts of southeast Oregon with those of the Columbia River Group. In Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Washington State College Press, Cheney, Washington, p. 223-238.

Wallace, R. E., (chairman), 1950, Columbia River Basalts, a recorded informal discussion (symposium): Northwest Sci., v. 24, no. 2, p. 51-58.

Walters, K. L.; Grolier, M. J., 1960, Geology and ground water resources of the Columbia Basin Project area, Washington: Washington Div. Water Resources Water-Supply Bull. 8, v. 1, 542 p., Plate 3, 1:205,670.

Walters, K. L.; Glancy, P. A., 1969, Reconnaissance of geology and of ground water occurrence and development in Whitman County, Washington: Washington Dept. Water Resources, Water-Supply Bull. 26, 169 p.

Waring, G. A., 1913, Geology and water resources of a portion of south-central Washington: U.S. Geol. Survey Water-Supply Paper 316, 46 p.

Warren, W. C., 1940, Relation of plateau basalts of eastern Washington to certain andesitic rocks of the Cascade Mountains: (abs.): Geol. Soc. America Bull., v. 51, no. 12, part 2, p. 2034.

"The Yakima basalt of eastern Washington is a typical plateau which is associated toward the west in the Cascade Mountains with a different type of volcanic formation, the Keechelus andesitic series. The latter series has generally been regarded as the younger.

In the Mount Aix quadrangle the upper part of the Keechelus andesitic series, which has long been known to be unconformable on the lower part, has been split off as a separate unit. This unit, consisting of basic andesite flows and pyroclastics, has been named the Fifes Peak andesite. Marginal flows of the Yakima basalt overlap the Fifes Peak andesite and are clearly younger than the andesite.

The Yakima basalt is generally considered to be middle Miocene. Therefore, the Fifes Peak andesite is presumably not younger than middle Miocene. The lower part of the Keechelus andesitic series may be no younger than Oligocene. The Snoqualmie granodiorite, the intrusion of which has widely altered the lower Keechelus, but apparently has not altered the Fifes Peak andesite or Yakima basalt, is presumably of intermediate age.

Warren, W. C., 1941, Relation of the Yakima Basalt to the Keechulus andesitic series: Jour. Geology, v. 49, no. 8, p. 795-814, Figure 2, 1:500,000.

Washington Public Power Supply System, 1973, Preliminary safety analysis report: WPPSS Nuclear Project No. 1, Richland, Washington, v. 1 and 2, Docket -50397.

_____, 1977, Preliminary safety analysis report (Amendment 23): WPPSS Nuclear Project No. 1, Richland, Washington, 13 sub-appendices in 2 volumes, pagination varies.

Washington State Univ. Geol. Dept., approx. 1950, Geologic field trip, Wenatchee to Pullman, Washington: 5 p.

Waters, A. C., 1930, Geology of the southern half of the Chelan quadrangle, Washington: Yale Univ. Ph.D. thesis, 256 p., plate 1, 1:72,410.

_____, 1939, Resurrected erosion surface in central Washington: Geol. Soc. America Bull., v. 50, p. 635-660.

_____, 1950, Multiple dike feeders of the Columbia River Basalt (abs.): Geol. Soc. America Bull. v. 51, p. 4, p. 1533.

_____, 1958, Part of the Columbia River Gorge: U.S. Geol. Survey unpub. map, 1:125,000 (based in part on independent work by A. C. Waters).

_____, 1960, Two-fold division of the Columbia River Basalt (abs.): Geol. Soc. America Bull., v. 71, no. 12, p. 2082.

_____, 1961, Stratigraphic and lithologic variations in the Columbia River Basalt: Am. Jour. Sci., v. 259, no. 8, p. 583-611.

_____, 1961, Basalt magma types and accelerating tectonic movements: Miocene-Quaternary of the Pacific Northwest: Symposium on volcanism and plutonism in relation to types of crustal deformation, John Hopkins Univ., Baltimore, (abs.) Pacific Science Congress, 10th, Abstracts of Symposium Papers, p. 394-395, 1961.

_____, 1962, Basalt magma types and their tectonic associations: Pacific Northwest of the United States. In The Crust of the Pacific Basin: Am. Geophys. Union Mon. 6, p. 158-170.

_____, 1963, Washington State Univ. Columbia Basin field trip - an introduction: The XI Transactions of Sigma Gamma Epsilon, XI Chapter, Washington State Univ., v. 1, no. 1, p. 1-6.

_____, 1963, The Columbia River Basalt of Washington, Oregon, and Idaho: The XI Transactions of Sigma Gamma Epsilon, XI Chapter, Washington State Univ., v. 1, no. 1, p. 16.

_____, 1969, Geology of the southern half of the Chelan quadrangle, Washington (abs.): Diss. Abs. Int., Sec. B, Sci. and Eng., v. 30, no. 5, p. 2259B-2260B.

_____, 1973, Problems of basalt correlation (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 120.

_____, 1973, The Columbia River Gorge - Basalt stratigraphy, ancient lava dams, and landslide dams. In Beaulieu, J. D., Chairman, Geologic field trips in northern Oregon and southern Washington: Oregon Dept. of Geology and Mineral Ind. Bull. 77, p. 133-162.

_____, 1976, Columbia River Basalts - Interesting places to visit: Geol. Soc. Oregon Country Geol. News Letter, v. 42, no. 2, p. 6-12.

Watkins, N. D., 1964, A paleomagnetic survey of Miocene lavas in northern Oregon, southeastern Washington, and west-central Idaho (abs.): Am. Geophys. Union Trans., v. 45, no. 1, p. 37.

_____, 1964, Structural implications of paleomagnetism in Miocene lavas of northeastern Oregon, southeastern Washington, and west-central Idaho: Nature, v. 203, no. 4947, p. 830-832.

Watkins, N. D.; Baksi, A. K., 1968, The age of the Picture Gorge Basalt at the type section and at Imnaha, and the maximum duration of a Miocene geomagnetic epoch (abs.): Program, Geol. Soc. America (and associated societies) Ann. Mtg., Mexico City, 1968, p. 312-313.

_____, 1974, Magnetostratigraphy and oroclinal folding of the Columbia River, Steens and Owyhee Basalts in Oregon, Washington, and Idaho: Am. Jour. Sci., v. 274, p. 148-189.

Weis, P. L., 1960, Geology of the Greenacres quadrangle and adjacent area: U.S. Geol. Survey unpub. reconnaissance map, 1:380,160.

_____, 1968, Geologic map of the Greenacres quadrangle, Washington and Idaho: U.S. Geol. Survey Ged. Quad. Map GQ-734, 1 sheet accompanied by 4 pages of text, map 1:62,500.

Weissenborn, A. E.; Weis, P. L.; Fryklund, Jr., V. C., 1960, Reconnaissance geology of eastern Washington: Washington Div. Geology and Earth Resources library, 3 sheets (Spokane, Newport and Chewelah quadrangles), scale 1:125,000.

Weissenborn, A. E., 1969, Geologic map of Washington, lat. 46° to 49°, long. 118° to 124°: U.S. Geol. Survey Misc. Geol. Inv. Map I-583, scale 1:2,000,000.

_____, 1974, Geologic map of the Mount Spokane quadrangle, Washington and Idaho: U.S. Geol. Survey Open-File Report 74-211, map and text on one sheet, 1:31,680.

Weissenborn, A. E.; Weis, P. L., 1976, Geologic map of the Mount Spokane quadrangle, Spokane County, Washington, and Kootenai and Bonner Counties, Idaho: U.S. Geol. Survey Quad. Map GQ-1336, map and text on one sheet, scale 1:62,500.

Weissenborn, H. F., 1955, Study of the Columbia River Basalts at Spokane, Washington, with a comparison of the "Rimrock and Valley" flows: Smith College M.A. thesis, 64 p. Plate 2, 1:250,000.

Williams, I. A., 1916, The Columbia Gorge: Its geologic history interpreted from the Columbia River Highway: Min. Res. Oregon, Oregon Bur. Mines and Geology, v. 2, no. 3, 130 p.

Willis, Bailey, 1939, Discussion of "Resurrected erosion surface in central Washington": Geol. Soc. America Bull., v. 50, p. 658-659.

Winters, H. A.; Stradling, D. F., 1967, The Yakima folds - Some relationships between topography and structures (abs.): Assoc. Am. Geographers Annals, v. 57, no. 1, p. 194-195.

Wise, D. U., 1963, An outrageous hypothesis for the tectonic pattern of the North American Cordillera: Geol. Soc. America Bull., v. 74, no. 3, p. 357-362.

Wise, W. S., 1970, Cenozoic volcanism in the Cascade Mountains of southern Washington: Washington Div. Mines and Geol. Bull. 60, 45 p.; illus., tables, geol. map.

Wright, T. L.; Grolier, M. J.; Swanson, D. A., 1973, Chemical variation related to the stratigraphy of the Columbia River basalt: Geol. Soc. America Bull., v. 84, p. 371-386.

Wright, T. L.; Swanson, D. A.; Fruchter, J., 1976, Petrogenesis of Yakima Basalt in southeastern Washington: Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 422.

Yates, R. G.; Becraft, G. E.; Campbell, A. B.; Pearson, R. C., 1964, The tectonic framework of northeastern Washington, northern Idaho, and northwestern Montana: Am. Inst. Mining and Metallurgical Engineers and Canadian Inst. Mining and Metallurgy Joint Meeting, Vancouver, B. C.

_____, 1966, Geology-Northeastern Washington. In Mineral and Water Resources of Washington: U.S. Cong., 89th, 2d sess., Comm. on Interior and Insular Affairs, Comm. Print, p. 15-22.

_____, 1968, The Trans-Idaho discontinuity. In International Geol. Congress, 23d, Prague, 1968, Proc., Section 1, Upper mantle (geological processes): Academia Prague, p. 117-123.

Yeaton, W. J., 1923, Geology of the Zillah quadrangle, Washington: Univ. of Chicago M.S. thesis, 88 p., map, 1:125,000.

York, D.; Watkins, N. D.; Bakso, A. K., 1971, The Columbia volcanic episode: Evidence for major volcanism during a limited part of the Middle Miocene (abs.): EOS (Am. Geophys. Union, Trans.), v. 52, no. 4, p. 383.

ADDITIONAL REFERENCES - PLATEAU BASALT GEOLOGY

Bond, J. C., 1962, Geology of the Clearwater embayment in Idaho: Univ. of Washington, Ph.D. thesis.

Brown, R. E.; Brown, D. J., 1958, Surface of the basalt series in the Pasco Basin, Washington: (abs.) Bull. Geol. Soc. Am. v. 69, no. 12, pt. 2, p. 1677.

Coe, R. S.; Bogue, S.; Myers, C. W., 1978, Paleomagnetism of the Grande Ronde (Lower Yakima) Basalt exposed at Sentinel Gap: potential use for stratigraphic correlation: Rockwell-Hanford Operations Rept. RHO-BWI-ST-2, 24 p.

Culver, H. E.; Kirkham, V. R. D., 1927, General geology of eastern Washington and northern Idaho: Northwest Sci., v. 1, p. 25-30, map, 1:500,000.

Hubbard, P. S., 1968, Geology of the Saddle Butte quadrangle, Washington: Univ. of Hawaii, M.S. thesis.

Piper, C. V., 1905, The basalt mounds of the Columbia Lava: Science, new series 21, p. 824-825.

Portland General Electric Co., 1974, Pebble Springs Nuclear Plant Units 1 and 2, License Application, PSAR, section 2.5 - geology and seismology, section 2.6 - references.

Reidel, S. P., 1978, The stratigraphy and petrogenesis of the Grande Ronde Basalt in the lower Salmon and adjacent Snake River canyons: Washington State Univ. Ph.D. thesis.

Shannon and Wilson, 1973, Geologic studies of the Columbia River Basalt and age of deformation, the Dalles - Umatilla region, Washington and Oregon, The Boardman Nuclear Project: Report to Portland General Electric Co., Portland, Oregon.

Steen-McIntyre, Virginia, 1977, A manual for tephrochronology-collection, preparation, petrographic description and approximate dating of tephra (volcanic ash): Published by the author, Box 1167, Idaho Springs, Colorado, 80452, 167 p.

Thayer, T. P.; Wagner, N. S., 1969, Geology of the Blue Mountain region: Oregon Dept. of Geol. & Min. Ind., Bull. 64, p. 68-74.

POST-PLATEAU BASALT GEOLOGY (Annotated)

Sedimentary Units

Alwin, J. A., 1970, Clastic dikes of the Touchet Beds, southeastern Washington: Washington State University M.S. thesis, 87 p.

1. Thesis.
2. Clastic dikes of Touchet Beds, southeastern Washington.
3. Yakima, Benton, Franklin, Columbia, Garfield, Asotin, Whitman, Walla Walla Counties.
4. Touchet Beds - Pleistocene.
5. Each dike studied individually, its characteristics noted and recorded during field observation. Strike and dip recorded. Material subjected to sieve analysis and heavy minerals separated. Mineralology determined by X-ray and optical methods.
6. Sedimentary beds overlying Columbia River Basalt.
7. No geologic map. Built flume to simulate conditions of formation of original dikes with similar results. Photos of individual clastic dikes. Pole plot of 50 major dikes.
8. Touchet Beds are cyclic lacustrine sands and silts of Pleistocene age in southeast Washington. Many clastic dikes crosscut the beds from a few inches to 100 feet deep. Strike random; dip vertical. Width varies from less than 1 inch to several inches, mostly compounded to form vertically stratified dikes to 80 inches wide. Common features: claywall linings with chevrons, cross-stratification, graded beds, oriented grains. Primary structures indicate downward filling of dike crevices by sand and silt. Dikes represent fillings of perma-frost-related crevices.

Ames, K.; Fryxell, Roald, 1973, Two glacial tills at Grand Coulee Dam, Washington (abs.): Northwest Scientific Assoc. Abstracts of Papers, 46th annual meeting, p. 1.

1. Scientific periodical.
2. Glacial tills at Grand Coulee Dam, Washington.
3. Crown Point near Grand Coulee Dam, Washington.
4. Two glacial tills representing two glacial advances of Cordilleran Ice Sheet.
5. Field observation, sieving of till, X-ray diffraction of clay.
6. Sedimentary beds overlying Columbia River Basalt.
7. No geologic map or sections; field and lab data.

8. Superposed lodgment tills representing two different glacial advances of the Cordilleran Ice Sheet are exposed at Crown Point near Grand Coulee Dam. The lower still appears slightly more oxidized, contains more striated pebbles, fewer granitic clasts, more fragments 2-9 mm in diameter, and has a finer matrix than the upper till. X-ray diffraction peaks indicate montmorillonite is the dominant clay in the lower till, but is absent from the upper till; little illite and no vermiculite were found in the lower till, although both occur in the upper one. Striae on bedrock show both tills were deposited by easterly advancing ice.

Antevs, Ernst, 1929, Maps of the Pleistocene glaciations (excerpts): Geol. Soc. America Bull., v. 40, no. 4, p. 631-720. Washington, p. 648, 650, 653.

1. Geological journal.
2. See title.
3. Excerpts of Washington State.
4. Pleistocene ice extent, drift borders.
5. Compilation of existing maps on extent of Pleistocene glaciation of northern and southern hemisphere.
6. See title.
7. Maps including Washington State showing Pleistocene mountain glaciation and borders of ice-sheets in southern Canada and U.S. west of 112th Meridian, scale 1:60,000,000.
8. Excerpt on Washington State: In northern Washington, Spokane and Vashon (Wisconsin) drift sheets are recognized. The Spokane drift, according to Alden, should probably be correlated with the Iowan. The Spokane border has been mapped through Spokane west-northwestward to the Columbia River (Bretz, 1928, plate 5). Here it seems to disappear under the Wisconsin drift. At about latitude 47° 50' north, longitude 119½° west, its border inside the Wisconsin boundary has been relocated by Bretz.

   The Wisconsin drift border in the eastern part of Washington is compiled from data supplied by Stewart (1913, page 428), Pardee (1918, page 51), Anderson (1927), Bretz (1928), Salisbury (1901, page 722), and Russell (1900, page 169). Its course is not well known. In the Cascade Mountains there was a network of glaciers that was more or less confluent with the ice-sheet. The differentiation between these glaciers and the ice-sheet, especially on the east side of the mountains, is difficult to determine from the data now at hand. The course

of the drift border west of the Columbia River is unknown. On the west side of the Cascades the extreme limit of the last ice-sheet, the Puget Sound Glacier, is somewhat better known. On the lowland of Puget Sound and farther west the limit of the last continental glacier is satisfactorily established (Leighton, 1918; Bretz, 1920).

Barker, P. A., 1968, Glaciation of the Chelan Trough: Washington State University M.S. thesis, 52 p.

1. Thesis.
2. Glaciation of the Chelan Trough, Washington.
3. Chelan Trough, Washington.
4. Glacial features in trough - expecially terraces lining slopes at lower end of Lake Chelan. Basalt erratics also observed and measured. Morraines mapped, drumloidal topography, coulees, and small Pleistocene drainage ways noted.
5. All observable glacial features measured, sampled, and mapped.
6. Sedimentary and glacial beds and features overlying or adjacent to Columbia River Basalt.
7. Description and map of glacial features as well as photos of individual features. Profiles of major north-side and south-side terraces.
8. Lake Chelan occupiesclassic glacial trough, created by Cascade glaciers, on east side of North Cascades. It was further modified by southwest trending continental Okanogan Glacier. Pleistocene sequence repeated in valleys west and north of Chelan valley. Evidence for Okanogan Glacier is terraces (mostly kame) built alongside glacier, sloping uplake (west) and descending to lake level. At least 12 terraces on lower valley create giant staircase, more developed on north side of valley. The few basalt fragments and several basalt erratics were brought to area from continental glacier passing over terrain east of Columbia River.

Barksdale, J. D., 1941, Glaciation of the Methow Valley: Jour. Geology, v. 49, no. 7, p. 721-737, illus., incl. index maps; (abs.) Northwest Sci., v. 15, no. 4, p. 100.

Beck, G. F., 1940, Late Tertiary stratigraphy and paleontology of south-central Washington and adjacent Oregon (abs.): Geol. Soc. America Bull., v. 51, no. 12, pt. 2, p. 2018.

Bingham, J. W.; Grolier, M. J., 1965, Geologic map and sections of parts of Grant, Adams, and Franklin Counties, Washington: U. S. Geol. Survey Open-File Report, scale 1:60,000.

_____, 1966, The Yakima Basalt and Ellensburg Formation of south-central Washington: U.S. Geol. Survey Bull. 1224-G, 15 p. Figure 2, 1:7,000,000.

1. Geological bulletin.
2. Yakima Basalt and Ellensburg Formation, south-central Washington.
3. Ellensburg-Yakima area between T.12N-T.18N and R.17E-R.24E., Kittitas and Yakima Counties, Washington.
4. Columbia River Group and Ellensburg Formation.
5. --
6. Stratigraphic description of Columbia River Group and Ellensburg Formation.
7. Composite stratigraphic sequence in the northwestern Columbia Plateau; location of type sections of Yakima Basalt; descriptions of members.
8. The uppermost part of the Yakima Basalt - herein assigned to the Columbia River Group - has the following largely conformable units (from oldest to youngest): lower basalt flows; the Vantage Sandstone Member; the Frenchman Springs Member, which locally includes the Squaw Creek Diatomite Bed; the Roza Member; the Priest Rapids Member, which locally includes the Quincy Diatomite Bed; and the Saddle Mountains Member. Sedimentary deposits of the Ellensburg Formation interfinger with basalt flows of the youngest member of the Yakima Basalt.

   The maximum thickness of the Yakima Basalt is not known, but the formation is about 4,500 feet thick at a test well drilled in the Odessa area, and is probably much thicker toward the center of the Columbia Plateau. The part described herein has a composite thickness of about 1,200 feet above the Vantage Sandstone Member. The overlying and interfingering Ellensburg Formation is as thick as 2,000 feet in the type area, and the Beverly Member, which represents the lower part of the Ellensburg in the Sentinel Gap area, is as thick as 300 feet.

   The Yakima Basalt is late Miocene and early Pliocene in age, as determined from the flora and fauna in the underlying Mascall Formation in Oregon, the intrabedded sedimentary rocks and the interbedded and overlying Ellensburg Formation.

_____, 1978, Geology of parts of Grant, Adams, and Franklin Counties, east-central Washington: Washington Div. Geol. and Earth Resources Bull. 71, 91 p.

Birkeland, P. W.; Crandell, D. R.; Richmond, G. M., 1971, Status of correlation of Quaternary stratigraphic units in the western conterminous United States: Quaternary Research, v. 1, no. 2, p. 208-227.

1. Quaternary geological periodical.
2. Correlation of stratigraphic units in western U.S.
3. Rocky Mountains to Pacific Coast in western conterminous U.S.
4. Quaternary deposits include Snake River Plain, Idaho, western Washington, and Cascade Range, Washington.
5. Correlation (on charts) of representative sequences of deposits of Quaternary environments based on published and unpublished work; radiocarbon, K/Ar, and U-series dating; rock magnetism; fossil ages; and key volcanic horizons used in correlation.
6. Representative sequences of Quaternary deposits from a variety of environments.
7. Charts showing status of correlation between stratigraphic units of early to middle Quaternary age in western U.S.
8. Deposits of Quaternary age from the Rocky Mountains to the Pacific Coast in the western conterminous U.S. represent a great variety of environments. The deposits include those of continental and alpine glaciers, glacial meltwater streams, non-glacial streams, pluvial lakes, marine environments, eolian environments, and mass-wasting environments. On two charts we have attempted to correlate representative sequences of deposits of many of these environments, based on published sources and recent unpublished investigations. Evidence for correlation is based mainly on stratigraphic sequence, soil characteristics, the amount of subsequent erosion and interlayered volcanic ash beds identifiable as to source. Chronologic control is based on numerous radio-carbon dates. U-series dates on marine fossils, and K-Ar dates on volcanic rocks. The Bishop volcanic ash bed and one of the Pearlette-like volcanic ash beds appear to represent significant regional key horizons, respectively about 700,000 and 600,000 years old. Rock magnetism is shown to suggest the paleomagnetic polarity at the time of rock deposition. Assigned land-mammal ages of included fossils help to put limits on the age of some units.

Blinman, E.; Mehringer, P. J.; Sheppard, J. C., 1977, Pollen influx and the depositional chronologies of Ma ama and Glacier Peak tephra (abs.): Geol Soc. America Abs. with Programs, v. 9, no. 7, p. 901.

1. Geological society meeting abstract.
2. See title.
3. Pacific Northwest.
4. Pollen in tephra deposits.
5. Analysis of pollen content in lake sediment and tephra deposits.
6. See title.
7. --
8. Pollen content of lake sediments and tephra can be used to estimate the duration of short term depositional events. When pollen influx estimates are applied to volcanic ash they may also provide information on the season and ecological effects of ash falls.

   At Lost Trail Pass Bog, Montana, two distinct layers of Glacier Peak ash were separated by 7.5 mm of lake sediment containing 10-20 years of average pollen influx for the vegetation at that time. The later fall of 7.3 cm of Mazama ash contained nearly 3 years of pollen as compared with the average pollen influx of adjacent lake sediments. Subsampling of Mazama ash revealed that it first fell in autumn and nearly 4.9 cm were deposited before spring. The remaining 2.4 cm fell sporadically during the next two years.

   Sediments from a scabland lake of eastern Washington contain a different and more complex record of the Mazama ash fall. Here, two ash layers are separated by 24 cm of organic sediments. The low pollen and low detritus contents of the lower portion of each ash are indicative of two distinct airfalls. Nearly 6 m of secondary Mazama ash were deposited during the 1200 years following the second ash fall.

Blissenbach, Erich, 1954, Geology of alluvial fans in semi-arid regions: Geol. Soc. America Bull., v. 65, no. 2, p. 175-189.

   An alluvial fan is a body of detrital sediments built up at a mountain base by a mountain stream. Bold relief is essential, moderately arid to semiarid climate favorable for the development of fans. The depositing agents are sheet floods, stream floods, and streams. Compound alluvial fans result from lateral coalescence of single fans.

Development of alluvial fans is affected by changes in the course of a cycle, varying base level, climatic changes, tectonic movements, and slumping of fan deposits. Telescoped or superimposed structure may be developed.

Fan deposits are arkosic or graywacke. Sorting and roundness of particles range widely. The matrix is primary or secondary. In general, alluvial-fan deposits are stratified. Channel cut-and-fill is pronounced. Individual strata in fans are up to 20 feet thick. Particles in stream deposits are inbricated.

Talus-slope deposits at the apex of a fan, and floodplain deposits at its base, can be separated from those of an alluvial fan by particle sizes, angularity and orientation of fragments, sorting, and original dip of strata. Mudflow deposits in an alluvial fan indicate certain climatic conditions during its formation.

Many ancient fan deposits may have escaped recognition because of the common misconception that fan deposits are necessarily unstratified, composed of angular fragments, poorly sorted, and without distinctive sedimentary structures.

Bond, J. G., 1969, The eastern Columbia Plateau: A study in isostatic response and post extrusion adjustments: Int. Assoc. Volcanol. Chem. Earth's Interior, Oxford Univ., Dept. Geol. Mineral., 1969, in Symposium on volcanoes and their roots, Oxford 1969, v. Abs., p. 154-155.

Borchardt, G. A.; Harward, M. E.; Schmidt, R. A., 1971, Correlation of volcanic ash deposits by activation analysis of glass separates: Quaternary Research, v. 1, no. 2, p. 247-260.

1. Geological publication.
2. See title.
3. Cascade Mountains area, Pacific Northwest.
4. Volcanic ash: Glacier Peak, Mazama, Mount St. Helens, Newberry.
5. Neutron activation analysis and computer program analysis.
6. See title.
7. Location map of volcanic ash sampling sites; mean elemental compositions of glassy separates from several volcanic ash sources in Cascade Range; coefficients of variation for regional ash samples.

8. Volcanic ash deposits whose source is the Cascade Mountains area were correlated on the basis of 19 elemental abundances obtained by instrumental neutron activation analysis (INAA). After activation of glassy separates in a TRIGA reactor, gamma ray spectra were obtained and analyzed with computer programs. The elements Na, Sm, Sc, Fe, Ce, Hf, and Th were determined with relative standard deviations less than 5%; the precision for La, Co, Eu, Yb, Cs, Ba, and Lu was less than 17%; larger errors were obtained for Rb, Ta, Nd, Tb, and Cr. A statistical method was developed for correlation on the basis of relative elemental compositions unique to the ash deposits. Elemental abundances of Mazama glassy separates were independent of distance for the source. The site to site chemical variability of crystal rich Glacier Peak and St. Helens ash layers was greater than for Mazama and Newberry ashes. The Rb, Yb, Lu, Th, and Ta contents in Newberry glass were more than twice those in Mazama glass. The concentrations of trace elements in Glacier Peak and St. Helens ashes generally were less than one-hald those in Mazama glass. The presence of Mazama ash has been confirmed at sites in Oregon, Washington, Alberta, and in sediments of the Pacific Ocean.

Borchardt, G. A.; Norgren, J. A.; Harward, M. E., 1973, Correlation of ash layers in peat bogs of eastern Oregon: Geol. Soc. America Bull., v. 84, no. 9, p. 3101-3108.

Bretz, J H., 1919, The late Pleistocene submergence in the Columbia Valley of Oregon and Washington: Jour. Geology, v. 27, p. 489-506.

1. Geological periodical.
2. See title.
3. Columbia Valley, Washington and Oregon.
4. Pleistocene sediments and glacial features.
5. --
6. Data to substantiate Pleistocene submergence of Columbia Valley including descriptions of gravel terraces, lacustrine sediments, foreign boulders and debris.
7. Figure showing areal extent of submergence.
8. Article reviews previous references to a Champlain submergence in the lower drainage of

Columbia River, eliminates erroneous interpretations and correlates data belonging to the subject, presents more evidence in support of submergence, correlates this with the Pleistocene history of northwestern Washington, and raises unanswered questions.

_____, 1923, Glacial drainage on the Columbia Plateau: Geol. Soc. America Bull., v. 34, no. 3, p. 573-608.

1. Geological journal.
2. See title.
3. North Columbia Plateau.
4. Glacial depositional and erosional features.
5. Field investigations.
6. See title.
7. Maps of: glacial drainage features of east-central Washington; glacial ice and drainage near Spangle, Washington; part of Drumheller Channels Plexus; The Potholes.
8. Geological history of northern part of Columbia Plateau and discussion of erosive force of glacial streams over large tracts of land far from ice front. Discussion of topography and drainage physiography, and glaciation of region. Spokane Glaciation is discussed in terms of Spokane River, Palouse River, Crab Creek drainage and Moses Coulee. Wisconsin glaciation in region also discussed.

_____, 1924, The age of the Spokane glaciation: Am. Jour. Sci., 5th Ser., v. 8, p. 336-342, 1 fig.

1. Geological periodical.
2. See title.
3. Northern portion Columbia Basalt Plateau, Washington.
4. Columbia Basalt as cliffs along stream channels.
5. Solution to problem of the relative lapse of time since Spokane glaciation by determining the ratio of height of talus to height of cliff and working out a mathemetical model.
6. Same as above.
7. --
8. In order to determine the age of Spokane glaciation, author finds the relative lapse of time since each glaciation (Spokane and Wisconsin) by studying the ratio of height of talus (accumulated at bottom of stream channel basalt cliffs in eastern Washington) to height of cliffs. Conclusion is that the times of fill are directly proportional to the squares of the heights filled. Angles of repose and densities of fills do not vary with ratios

obtained. The result is that the lapse of time since Spokane glaciation is 2.25 times as great as that since Wisconsin glaciation. This makes the Spokane equivalent to the Iowan or early Wisconsin.

_____, 1929, Valley deposits immediately east of the Channeled Scabland of Washington, I-II: Jour. Geology, v. 37, p. 393-427, and 505-541, 6 fig.; (abs.) Revue de Geologie et des Sciences Connexes, v. 10, no. 8, p. 308, 1929.

1. Geological journal.
2. See title.
3. East of Channeled Scablands, southeast Washington.
4. Pleistocene valley flood deposits.
5. Field observations, measurements and correlations of Scabland flood deposits in support of Spokane flood.
6. Same as above.
7. Figure showing location of valley deposits east of Scabland.
8. Forty-one valleys whose drainage enters the eastern margin of scabland spillways are known to contain deposits made by glacial waters. Thirty-nine of these valleys never have carried drainage from glaciated areas, and the glacial waters in them must have been backed up from the scabland. These deposits possess such extraordinary features and relations that they, like the scabland topographic forms, are considered unique.

    1. Each separate area of backwater is recorded by a widespread mantle of silt containing abundant grains of unweathered basalt (the country rock) and pebbles of foreign rock.

    2. In each, this mantle extends up to a definite upper limit on the valley slopes and along the valley lengths.

    3. These upper limits in each case agree closely with the upper limit of scabland where the valley enters.

    4. The altitudes of the upper limits, constant throughout any one back-water area, vary with different pondings, forming a descending series from north to south along the scabland gradient.

5. Remarkable large mounded gravel deposits in the tributary valley debouchures possess foreset strata which dip out of the scabland and up the valleys. The composition, topography topographical relations, structure, and size of these deposits are inexplicable without great reverse currents.
6. In no case could these reverse currents continue through and escape from the valleys they entered. They are simply a record of the rapid backflow into these valleys.

It is concluded that these glacio-aqueous deposits cannot be explained by conditions associated with ordinary glacial ablation or by a sequence of several Pleistocene epochs. They require the volume and rapid rise of glacial rivers across the plateau, which the writer has previously read from the scabland itself.

_____, 1930, Valley deposits immediately west of the Channeled Scabland: Jour. Geology, v. 38, no. 5, p. 385-423, 14 fig.; (abs.) Revue de Geologie et des Sciences Connexes, v. 11, no. 11, p. 519-520, 1930.

1. Geological journal.
2. See title.
3. Western margin of scabland, both in Columbia Valley and Yakima Valley.
4. Columbia River Basalt, Swauk shale and sandstone, glacial and other sedimentary beds overlying basalt.
5. Field observations, measurements and correlation of glacial and fluvial features in support of the Spokane Flood theory.
6. Same as above.
7. Cross-section of Yakima Valley through Chandler Narrows; contour map of Yakima Valley.
8. If a "Spokane Flood" ever occurred, and if the valley system of eastern and central Washington was already in existence, these valleys must have become channels and abnormal deposits of great magnitude must have been formed. This paper calls attention to such deposits along the western margin of the scabland, both in Columbia Valley, a main discharge route, and in Yakima Valley, a capacious tributary valley entering from an area unaffected by the flood. Three extraordinary situations are given especial attention: the mouth of Moses Coulee, the Columbia Valley

deposits near Trinidad, and the truly astounding features in lower Yakima Valley. The conclusion is reached that nothing short of a catastrophic flood can explain these features. Skepticism can be justified only by the construction of workable alternatives.

Brown, D. J.; Brown, R. E., 1958, Subsurface eolian deposit at the Hanford Project, Washington (abs.): Geol. Soc. America Bull., v. 69, no. 12, pt. 2, p. 1676-1677.

1. Geological abstract.
2. Subsurface eolian deposit at the Hanford Project, Washington.
3. Hanford Reservation, Pasco Basin.
4. Eolian deposit overlying Ringold Formation.
5. Mineral composition and mechanical properties analyses, and grain size analysis.
6. Stratigraphic relationship, age, and origin of eolian deposit.
7. --
8. A subsurface eolian deposit of silt and clay occurs at the Hanford Project in the Pasco Basin of Washington. It is buried beneath a mantle of glacial outwash and materials correlated with the Touchet beds and was found and explored by extensive drilling during investigations for Hanford's waste-disposal program. The deposit is believed to be of eolian origin, similar to the main body of the Palouse formation of eastern Washington. It lies directly over the Ringold formation close to the Ringold type locality at White Bluffs and appears to have been derived from that formation. If this subsurface eolian deposit is equivalent to the Palouse loesses, additional evidence will be established to indicate that at least part of the Palouse formation was likewise derived from the Ringold formation. Supporting the eolian origin of the deposit at Hanford are characteristics similar to eolian deposits elsewhere. These include (1) a high quartz, mica, and chlorite content in contrast to the composition of adjacent, underlying and overlying deposits, (2) all particles of a size characteristic of wind-blown material, and (3) quartz and feldspar grains subangular and slightly frosted.

   Inasmuch as this deposit overlies the Ringold Formation and underlies the glacial sediments, it is post-Ringold and pro-latest glaciation in age. This stratigraphic position supports the general concept that at least part of the equivalent Palouse loess was deposited before the close of the latest glacial age.

Brown, D. J., 1959, Subsurface geology of the Hanford separation areas: Hanford Atomic Products Operation Report HW-61780, 21 p.

_____, 1960, An eolian deposit beneath 200-west area: Hanford Atomic Products Operation Report HW-67549, 11 p.

1. Unclassified AEC Report.
2. Eolian deposit beneath Hanford 200-west area.
3. 200-west area, Hanford, east of Yakima Ridge, 4 miles.
4. Eolian sediments overlying Ringold Formation and underlying Touchet sediments.
5. Earth samples were collected from wells drilled in region surrounding 200-west area, mechanical analyses, cation exchange studies, and mineral composition studies performed.
6. Cation exchange capacity, mineral and mechanical analyses of Touchet sediments, the eolian deposit, and the Ringold Formation were determined and origin of eolian deposits therefore determined.
7. Distribution and thickness of eolian deposit beneath 200-west, tables showing cation exchange capacity, mineral composition, and mechanical analyses of Ringold Formation, eolian deposits, and Touchet sediments; table showing average heavy mineral frequencies of the 50-100 M size fraction from Palouse, eolian deposit, Touchet, Ringold Formation and Ellensburg Formation 50:1 profiles.
8. Physical examination of materials from geologic strata underlying 200-west area show bed of eolian loess to 70 feet deposited on Ringold Formation erosional surface. Cation exchange capacity of loess 50 to 70% higher than other material lying above water table is factor governing volume of radioactive waste dischargeable to ground without creating radiological hazard. This uniform, fine-grained material would be expected to influence pattern of downward percolation of wastes discharged to ground.

_____, 1962, Geology underlying Hanford Reactor Areas: Hanford Atomic Products Operation, Rept. HW-73337, p. 212-218.

Brown, D. J.; Brown, R. E., 1962, Touchet clastic dikes in the Ringold Formation: Hanford Atomic Products Operation Report HW-SA-2851, 11 p.

1. Unclassified AEC report.
2. Touchet clastic dikes in the Ringold Formation.

3. Northwestern end of type Ringold Formation locality at the White Bluffs on the Columbia River.
4. Clastic dikes in Ringold Formation and the Touchet material of which they are composed.
5. Field observation.
6. Field measurements of size and location of dikes.
7. Photographs of dikes.
8. Undoubtedly many different processes were involved in the formation of the clastic dikes in the Columbia Basin region. It is possible that these different processes and combinations of them varied from time to time and from place to place creating a multiplicity of dike forms. At least one of these processes, however, must account for the presence of clastic dikes within the Ringold sediments as they cannot be explained by filling of landslide fissures or fissures caused by slumping of the basalt bedrock, as in the case of the Clarkston deposits. It is suggested that surface earthquake waves moving through the Ringold Formation and saturated Touchet sediments could provide the mechanism of forming the fissures in the Ringold and injecting the Touchet sediments downward.

Brown, D. J.; Brown, R. E., 1965, Problems associated with the extension of the stratigraphic units of south-central Washington: Part 1, The late basalt flows, Ellensburg and lower Ringold formations: Battelle Memorial Institute Pacific Northwest Laboratory Report BNSA-135, 11 p.

1. Unclassified AEC report.
2. See title.
3. South-central Washington.
4. Ellensburg and lower Ringold formations, late basalt flows.
5. Review of existing stratigraphic descriptions and nomenclature for the above rock units for purposes of regional correlation.
6. Same as above.
7. Two figures showing stratigraphic sequences and showing thickening section toward the Pasco Basin.
8. Paper attempts to consolidate and interpret geological studies at Hanford of last 18 years and relate it to classical stratigraphic units within and without the plant area. The Pasco Basin, lying at the structural and topographic

low point of eastern Washington and at the stratigraphic high point, is the meeting ground for many of the geologic units of eastern Washington. The Columbia River has traversed the Pasco Basin for many millions of years so that some record of all geologic events in its drainage basin in that time period are there recorded. Report summarizes recent work and attempts an evolutionary solution.

_____, 1965, Problems associated with the extension of the stratigraphic units of south central Washington; Part 2, The post basalt sediments: Battelle Memorial Institute Pacific Northwest Laboratory Report BNSA-135, 10 p.

1. Unclassified AEC report.
2. See title.
3. South-central Washington.
4. Ringold Formation, Palouse soil, Touchet beds, glacial outwash gravels.
5. Compilation of new field evidence to correlate the post-basalt sediments in south-central Washington.
6. Extensions and definitions of units at type localities followed by simplified correlations throughout region.
7. Historical geology of south-central Washington; review of previous formational descriptions, stratigraphy and nomenclature.
8. Paper describes the four principal stratigraphic units as found in Pasco Basin and presents possible chronological sequence of events to explain various relationships observed between each unit at that site. Several published descriptions of stratigraphic units discussed to show problems of correlation of these sediments.

Brown, D. J., 1965, Correlation of sediments overlying the Columbia River Basalt in southeastern Washington (abs.): Geol. Soc. America Spec. Paper 82, p. 321.

1. Geological abstract.
2. See title.
3. Southeastern Washington.
4. Fluvial, glaciogluvial, lacustrine and eolian deposits overlying Columbia River Basalt, e. g. Ellensburg and Ringold formations, Palouse soil.
5. --
6. --

7. --
8. New evidence makes possible the correlation of the fluvial, glaciofluvial, lacustrine, and eolian deposits which overlie the Columbia River Basalt in southeastern Washington. These correlations suggest that during the Pliocene, with gradual cessation of volcanic activity, the region existed as a broad and very shallow basin. Small lakes dotted much of the region, and streams and rivers flowed into the basin from the west, north, and east. At the close of the Tertiary, tectonism significantly altered the drainage pattern of the basin. Most of the fluvial sediments in the western portion of the basin (Ellensburg Formation) became isolated and in the central portion of the basin (Pasco Basin), a shallow inland lake or floodplain was created. Lacustrine and fluvial sediments continued to accumulate on top of the Ellensburg deposits in the Pasco Basin and gave rise to the Ringold Formation. Continued tectonism formed the Lewiston Basin to the east. Following an interglacial age a thick wedge of sands and gravels which later became cemented was deposited in the Pasco and Lewiston basins. Evidence suggests that at the beginning of an interglacial age, thick deposits of eolian sediments accumulated (Palouse soil). Many of the smaller lakes were filled in, and the longitude hills of eastern Washington were created. At the close of the last glacial age, a layer of glaciofluvial sediments was deposited over parts of southeastern Washington. In slack-water areas, finer-grained sediments accumulated (Touchet beds), and the remaining portion of the region was covered by the outwash gravels. Consideration should be given to reconciling the differences which exist in the names and descriptions of these sedimentary deposits.

Brown, R. E.; McConiga, N. W., 1960, Some contributions to the stratigraphy and indicated deformation of the Ringold Formation: Northwest Sci., v. 34, no. 2, p. 43-54.

1. Geological periodical.
2. See title.
3. Ringold Formation type locality, western Franklin County, Washington, 12 miles north of Richland.
4. Ringold Formation.
5. Five beds were traced and surveyed. Recorded data of earlier work were then correlated and

reconciled as necessary. Continuous red silt bed used.

6. Accurate detailed stratigraphic sequence of beds of type Ringold Formation and their attitude.
7. Longitudinal section through Ringold Formation in White Bluffs from Saddle Mountains to Yakima River-Columbia River junction. Well log information.
8. Ringold beds dip westward, at angles less than 1 degree, at type locality. Dip directions of Ringold beds in Pasco Basin generally parallel those of underlying basalt and are radially inward toward center of Pasco Basin toward axis of Pasco syncline. Suggests these variations from horizontal attitude are not depositional dips. Deformation by differential compaction cannot be ruled out; however, parallelism of dip direction of Ringold sediments and the basalts, the general agreement in order of magnitude of angle of dip, conformity of conglomerate with basalts in the Yakima River outcrop, and dips of the blue clays up to 20°NE, question whether roles played by deposition and compaction are more than locally significant. Newcomb shows that Ringold conglomerate was deposited by southeastward-flowing stream. Local westward to northwestward dips (upstream) in that conglomerate, substantiated by comparable dips in higher and lower beds, indicate post-depositional warping. Proof that type Ringold beds are not necessarily flat-lying favors the acceptance that tilted Ringold-type beds, mapped by others in surrounding area, are Ringold. Sedimentary sequence, traced across Pasco Basin, helps assure this. Gradual general decrease in dips upward in Ringold section favors continuous deformation throughout Pasco Basin during period of deposition. Interpretation requires neither sudden cessation of deformation that produced latter part of 2-stage impoundment of Newcomb, nor deformation localized to anticlinal ridges alone. Deformation, according to this interpretation, could still be continuing.

Brown, R. E., 1960, An introduction to the surface of the Ringold Formation beneath the Hanford Works area: Hanford Atomic Products Operation Report HW-66289, 10 p.

1. Confidential AEC report.
2. See title.

3. Hanford Works area.
4. Ringold Formation surface.
5. Interpretation of well logs.
6. Concept of extensively channeled, highly irregular erosion surface on Ringold Formation beneath Hanford Works.
7. Description of topography of the Ringold surface.
8. Distinction between Ringold Formation sediments and recent fluviatile gravels, on the basis of properties affecting waste behavior, was made and these data were geologically correlated to the lithologic evidence, resulting in evidence that the surface of the Ringold Formation is extensively and irregularly eroded. This surface was formed by the Columbia River prior to deposition of the recent fluviatile gravels. A network of river channels crosses the Hanford area and dissects what was an earlier extensive erosional or land surface sloping gently from the hills toward the Columbia River. Many of the channels now bottom beneath the current ground water table. Where this occurs ground water flow toward the Columbia River is at least potentially at quite rapid rates through the highly permeable fluviatile gravels.

Brown, R. E.; Brown, D. J., 1961, The Ringold Formation and its relationships to other formations: Hanford Atomic Products Operation Report HW-SA-2319, 17 p.

1. Unclassified AE report.
2. See title.
3. Southeast Washington.
4. Ringold Formation and relationship to Ellensburg Formation, Palouse soil, upper basalt flows, Touchet beds, glaciofluvial deposits.
5. --
6. Stratigraphic and descriptive.
7. Geologic cross-section-Hanford Works; geologic map of the Ringold Formation surface beneath Hanford Works.
8. The Ringold Formation in the Pasco Basin, Washington, is the key to resolving the Pleistocene history of eastern Washington. It also is important in waste-disposal operations of the General Electric Company at the Hanford Works. The formation is divisible into three generally recognizable lithologic members. These grade from the underlying interbasalt sediments of Miocene-Pliocene age into overlying late Pleistocene to Recent (?)

sediments. Lowermost beds of the Ringold sequence are generally conformable to folded older basalt flows and interbasalt sediments and appear to be alluvial fan deposits equivalent to upper Ellensburg beds. Higher beds are progressively less folded. Two erosion periods followed Ringold Formation deposition. Caliche caps remnants of the older unconformity and is overlain by eolian silts, probably equivalent to Palouse soil. The younger unconformity locally truncates the older. It formed during excavation of Washington's channelled scablands before deposition of the latest glaciofluviatile sediments. Downward extension of the Ringold section to the basalt series, its continuity with Miocene-Pliocene sediments, and the unconformities separating it from late Pleistocene to Recent (?) sediments suggest that it more probably is early rather than late Pleistocene in age.

_____, 1958, The surface of the basalt bedrock beneath the Hanford Works: Hanford Atomic Products Operation Report HW-57935.

_____, 1959, The surface of the basalt series in the Pasco Basin, Washington: Geol. Soc. Oregon Country News Letter, v. 25, no. 4, p. 23-27.

Brown, R. E., 1966, The relationships between the Ellensburg and Ringold Formations in the Pasco Basin: Northwest Sci., v. 40, no. 1, p. 37.

_____, 1970, Some effects of irrigation in the Pasco Basin, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 2, no. 5, p. 326-327.

1. Geological abstract.
2. See title.
3. Pasco Basin, Washington.
4. Ringold Formation and other post-basalt sediments.
5. --
6. Information about geological effects of irrigation such as landslide activity, changes in water table, flooding, washouts, as well as climatic changes.
7. --
8. Sixty inches of irrigation water, applied each irrigation season, simulates a gross climatic change in the semi-arid Pasco Basin. Roads locally have washed out, some land is flooded, many

landslides have formed, the groundwater table locally has risen more than 100 feet, and more than six miles from irrigation sites the water table is rising between one half and two feet per year. Low lying residential areas are threatened and problem areas are enlarging.

Landslides occur with increasing frequency. They form in the floodplain deposits of the Pliocene Ringold Formation where pore pressure, increased by perched water, is reduced along bluffs, coulees and canyons. Some old slides evidently were caused by the glacial Lake Missoula and related floods of 50,000 to 10,000 years ago. Some probably were caused by the well-demonstrated more humid climatic in Pleistocenetime, which deposited perhaps 20 inches of precipitation. Many landslides are being reactivated.

Sensitive instruments on and adjacent to the Hanford Reservation have not detected earthquakes at the time of recent slides. Nor have large quarry blasts in several sites resulted in slides. Some old slides may have been caused by earthquakes but the assumption that they were is without sound supporting evidence. Irrigation is beneficial. Long-term addition of large amounts of water to ground, however, causes effects which must be identified long in advance to avoid conflicts of interest.

_____, 1971, Environmental changes by irrigation in the Pasco Basin, Washington: American Soc. Mining Engineers Preprint No. 71-AG-310, 8 p.

1. Environmental publication.
2. See title.
3. Pasco Basin.
4. Post-basalt sediments.
5. --
6. Observations of changes in water table level, landslides, road washouts.
7. --
8. The Pasco Basin has developed in response to an overall increasingly arid climate over the last several millions of years. Temporary but significant climatic changes during that time have produced appreciable environmental changes. Artificial climatic changes induced by extensive

irrigation can be expected to and are producing comparable environmental changes. Foremost among these are many and large landslides resulting from greatly raised ground water tables and the formation of perched water bodies. Data do not yet indicate that an equilibrium has been reached, hence an at least local worsening of the situation can be expected.

Bryan, Kirk, 1929, Geology of reservoir and dam sites: U.S. Geol. Survey Water Supply Paper 597, p. 1-72.

Campbell, M. R., 1915, Guidebook of the western United States. Part A, The Northern Pacific route, with a side trip to Yellowstone Park: U.S. Geol. Survey Bull. 611, sheets 21-27, 1:500,000.

Campbell, N. P., 1975, A geologic road log over Chinook, White Pass, and Ellensburg to Yakima highways: Washington Div. Geology and Earth Resources Inf. Circ. 54, 82 p.

Chappell, W. M., 1936, Geology of the Wenatchee quadrangle, Washington: Univ. of Washington Ph.D. thesis, 249 p., plate 1, 1:62,500.

_____, 1937, Glaciation of Columbia Valley in the Wenatchee-Chelan District: Geol. Soc. America Proc. 1936, p. 344.

1. Geological abstract.
2. See title.
3. Wenatchee-Chelan district.
4. Gneiss and granodiorite boulders, flood-plain gravels, loess.
5. Glacial deposits and features observed and measured to determine presence or extent of glaciation in region.
6. Same as above.
7. --
8. Huge angular boulders of gneiss and granodiorite in the valley of the Columbia near Wenatchee, Washington, were attributed by I. C. Russell to ice action. Morainal topography between Wenatchee and the mouth of Moses Coulee is ascribed by Bretz to a glacier that came down the Wenatchee Valley or the Columbia, possibly both.

   The rounded forms of gneiss and granodiorite protruding through the flood-plain gravels of

the Columbia between Wenatchee and Chelan are characteristic of glacial sculpture; there are grooves and striae on several of these, two miles north of Wenatchee. The Okanogan lobe of the last, or Wisconsin, ice sheet ended 30 miles above Wenatchee, as shown by A. C. Waters. Glacial features below this limit demonstrate that an earlier tongue extended at least as far as the mouth of Moses Coulee, 45 miles south of the Wisconsin front. No evidence of glaciation has been found in lower Wenatchee Valley; therefore, in all probability, the ice came down the Columbia Valley. Definite correlation of this early glaciation with established stages is not yet possible, nor is it known whether it represents only one stage or several. Furthermore, no southern limit of the earler continental ice sheet can be set. The region is largely covered with loess, but some old drift is known.

Cochran, B. D., 1976, Holocene alluvial chronology in east-central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 362-363.

1. Geological abstract.
2. See title.
3. Johnson Canyon, Washington.
4. Holocene alluvium.
5. Radiometric dates, stratigraphic correlations, volcanic ash and soil time-stratigraphic markers, and cultural remains.
6. Holocene alluvial chronology.
7. --
8. Alluvial stratigraphy in Johnson Canyon, Washington, indicates a sequence of geologic events consisting of three flood-plain depositions and three erosional episodes. The chronology is based on radiometric dates, stratigraphic correlations, volcanic ash and soil time-stratigraphic markers, and cultural remains. The early flood plain began before 7,000 years before present and terminated before 5,500 years before present. The mid-postglacial flood plain, contained in channels, represents an intense but short-lived depositional phase which began about 5,500 years before present. Late flood plain deposition was within large channels cut into older alluvium. Cultural remains contained in these sediments suggest initial deposition began between 2,000 and 3,500 years ago and ended about 200 years before present. There has been extensive

erosion and deposition since. Field evidence suggests that this sequence is typical of many drainage basins in central and eastern Washington. Fluctuating postglacial climate appears to be a controlling factor for the alluvial history of streams in this region. Consideration of local controls, which have greatly modified regional events, is necessary to prevent inclusion of spurious events in a regional chronology.

Cook, E. F., 1956, Volcanic stratigraphy (abs.): International Geol. Congress 20th, Mexico, D. F., 1956, Resumenes a de los trabajos presentados, p. 7.

1. Geological abstract.
2. See title.
3. Columbia Basin.
4. Columbia River basalt flows and ignimbrites (pyroclastic sheets).
5. Mapping basalt flows and ignimbrites.
6. Stratigraphic relationships of basalt flows and ignimbrites.
7. --
8. Where either plateau basalt flows or ignimbrites are well exposed, volcanic stratigraphy may be the key to structural history.

Although their origin and appearance differ, the stratigraphic and structural usefulness of these two types of extrusive bodies derived from their possible regional extent and original horizontality.

A basalt flow in the Columbia plateau has been traced 120 miles north-south and 50 miles east-west. Another flow has been followed 90 miles. This regional extent, which is probably the result of low viscosity and multiple loci of extrusion, makes such flows invaluable markers for structural mapping. Despite the closely similar composition of the many flows in the plateau, a considerable number of valid correlation criteria have been discovered.

Ignimbrites, which are pyroclastic sheets of probable nuee ardente origin, also may have regional extent and are more easily distinguished one from another, than are the monotonous plateau basalts. In the Basin and Range provinces

individual ignimbrites have been recognized over distances greater than 50 miles; they probably once covered several thousand square miles. Since ignimbrites have depositional horizontality, modified only be differential compaction, study of their stratigraphic relations is essential to complete understanding of areas in which they occur.

Coombs, H. A., 1941, Hornblende and magnetite heavies in the Ellensburg of central Washington: *Jour. Sed.* Petrology, v. 11, p. 142-144.

1. Geological journal.
2. See title.
3. Central Washington.
4. Ellensburg Formation.
5. Mineralogical study of Ellensburg mineral assemblage.
6. Same as above.
7. Sketch map showing sample localities and distribution of Ellensburg Formation. Histogram of samples.
8. The mineral assemblage in the Ellensburg Formation is unusual in many respects. The heavies are restricted exclusively to hornblende and magnetite. The lights are essentially glass and plagioclase. All of the minerals are remarkably euhedral although evidence points to sources up to 50 miles or more from their present position. The uniform mineral content persists over an area of many hundreds, if not thousands, of square miles and may prove to be an aid in working out the stratigraphy of central Washington.

Crandell, D. R.; Mullineaux, D. R.; Miller, R. D.; Rubin, M., 1962, Pyroclastic deposits of Recent age at Mount Rainier, Washington: U.S. Geol. Survey Prof. Paper 450-D, p. D64-D68.

Crandell, D. R.; Meier, M. F.; Mullineaux, D. R; Sigafoos, R. S., 1965, Quaternary geology of the route between Mount Rainier National Park and Yakima, Washington. In Internat. Assoc. for Quaternary Res., 7th Congress, Guidebook for Field Conf. J, Pacific Northwest: Nebraska Acad. Sciences, Lincoln, Neb., p. 27-34.

1. Field trip guidebook.
2. See title.
3. See title.
4. See title.
5., 6., 7., 8., ---

Crandell, D. R., 1971, Postglacial lahars from Mount Rainier volcano, Washington: U.S. Geol. Survey Prof. Paper 677, 75 p.

1. U.S. Geological Survey Professional Paper.
2. See title.
3. See title.
4. See title.
5. Field observations, laboratory analyses such as grain-size distribution, C-14 dating, X-ray determination.
6. Extent, origin, dates, and descriptions of lahars from Mount Rainier.
7. Table listing post-glacial eruptions, lahars, avalanches, and block and ashflows at Mount Rainier; tables and graphs showing mineralogy and grain-size districts of lahars; maps showing extent of various mudflows and lahars; topographic map of Mount Rainier area, showing distribution of Osceola and Electron mudflows and Paradise lahars; profiles and cross-sections of valley floors of White River; Nisqually River, and Kautz Creek, Mount Rainier area; topographic map of Mount Rainier National Park, Washington.
8. More than 55 lahars (mudflows and debris flows from a volcano) originated at Mount Rainier during Holocene time. These ranged in length from a few miles to 70 miles and in volume from a few million cubic yards to more than half a cubic mile. Some lahars were created by landslides of altered volcanic rock; they contain significant amounts of clay, which consists of montmorillonite and kaolinite and lesser amounts of other clay minerals, which were formed by hydrothermal alteration of rock within the volcano. Some of these lahars have been deep enough, when flowing, to fill valleys to depths of hundreds of feet; the fluidity of the lahar permitted most of it to progress downvalley and to leave in passing only a thin deposit on valley sides and terraces. Smaller lahars of the same kind seem to have progressed downvalley in a single massive wave hundreds of feet high. Clay-rich lahars originated in massive slides of clayey rock that had a high moisture content. The slides may have been triggered either by strong earthquakes or by volcanic explosions, or possibly by swelling that accompanied the ascent of molten rock into the volcano. Other lahars were created by the eruption of hot

volcanic bombs, dense rock fragments, and ash onto ice and snow at the summit of the volcano. Rapid melting of snow created floods down the volcano's flanks which carried down rock debris and also picked up loose detritus on valley floors to form lahars. Still other lahars resulted from precipitation of cloudburst proportions and by glacier outburst floods. Some outburst floods may have been caused by excessive melting of ice around subglacial steam vents.

There have been repeated episodes of volcanism at Mount Rainier within about the last 10,000 years. The last major eruptive period, between about 2,000 and 2,500 years ago, witnessed the eruption of pumice and lava flows and the formation of many lahars. During this period, erosion alternated with aggradation of lahars and fluvial gravels on the valley floors of the White and Nisqually Rivers, and possibly on those of some other rivers as well. The last pumice eruption, which occurred in the mid-1800's, apparently was on a very small scale, and there is no known record of floods or lahars at that time.

Crandell, D. R.; Miller, R. D., 1974, Quaternary stratigraphy and extent of glaciation in the Mount Rainier region, Washington: U.S. Geol. Survey Prof. Paper 847, 59 p.

Culver, H. E., 1937, Ellensburg Formation (abs.): Geol. Soc. America Proc. 1936, p. 317.

1. Geological abstract.
2. See title.
3. Southeast Washington.
4. Ellensburg Formation.
5., 6., 7. ---
8. A re-study of the Ellensburg Formation, now underway, brings out evidence that the upper part of the formation in the type area is stratigraphically separable. Original descriptions by Smith apply satisfactorily only to the lower portion.

   The essential reduction of the term Ellensburg to interbasalt beds may mean a relatively limited area of disposition. Similar deposits at many places in the Columbia River basalts may be interpreted as remnants of a widespread formation

or as discontinuous deposits that may not have been contemporaneous. The latter concept is favored. Consideration is also given to the question of correlation of other continental beds in the area, such as the Latah of Spokane.

Culver, H. E., 1937, Extensions of the Ringold Formation: Northwest Sci., v. 11, no. 3, p. 57-60.

1. Scientific journal.
2. See title.
3. Southeast Washington
4. Ringold Formation.
5. --
6. Stratigraphic and descriptive.
7. --
8. The Ringold may be looked upon as extending much more widely than suggested by Merriam and Buwalda. It appears to have been a general filling of the Columbia Basin. Sedimentary materials appear to be from all sides with the recently uplifted rocks along the west margin furnishing the major portion. The usual continental agencies of erosion and deposition appear to have been operative. Ringold deposition preceded uplift of Frenchman Hills and Saddle Mountains, but the formation has subsequently been trenched by streams of late glacial time, probably those by Bretz to his Scabland Flood. Still later, and continuing today, the original Ringold deposits appear to have been furnishing most of the material making up the substance of the Palouse soil.

Culver, H. E.; Kirkham, V. R. D., 1927, General geology of eastern Washington and northern Idaho: Northwest Sci., v. 1, p. 25-30, map 1:500,000.

Czamanske, G. K.; Porter, S. C., 1965, Titanium dioxide in pyroclastic layers from volcanoes in the Cascade Range: Science, v. 150, p. 1022-1025.

1. Scientific journal.
2. See title.
3. Pacific Northwest.
4. Pyroclastic layers.
5. X-ray emission techniques.
6. Determination of TiO_2 in volcanic ash for purposes of correlations and identification of pyroclastic units from Cascade volcanoes.
7. Chemical data tables.
8. Rapid determinations of titanium dioxide have been made by X-ray emission techniques to evaluate

the potentiality of using the TiO_2 content of samples for checking field correlations and assisting in identification of pyroclastic units from Cascade volcanoes. Preliminary data suggest that the two most widespread units have characteristic ranges of TiO_2 content and that other, less extensive layers have ranges which, though characteristic, often overlap the ranges of the more widespread layers. Relative to fresh samples, weathered samples from B and C soil horizons are enriched in TiO_2.

Damon, P. E., 1977, K-Ar dating applied to Quaternary geochronologic problems (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 941-942.

Davis, Owen; Kolva, D. A.; Mehringer, P. J., Jr., 1977, Pollen analysis of Wildcat Lake, Whitman County, Washington: The last 1000 years: Northwest Sci., v. 51, no. 1, p. 13-30.

1. Scientific journal.
2. See title.
3. Southeast Washington.
4. Holocene lake sediments.
5. Field and laboratory study.
6. Interpretation of Holocene climate and vegetation.
7. Photos of pollen, core description.
8. Examined 4 meters of lake sediments to detect variations in microfaunal and organic content. These variations, spanning the last 1000 years, reflect changes in the aquatic and terrestrial environment. Most significant event found resulted from introduction of livestock accompanied with destruction of natural vegetation and erosion.

Diery, H. D., 1967, Stratigraphy and structure of Yakima Canyon between Roza Gap and Kittitas Valley, central Washington University of Washington Ph.D. thesis, 116 p. Plate 1, 1:24,000.

Diery, H. D.; McKee, Bates, 1968, Stratigraphy of the Yakima River Canyon (abs.): Northwest Sci., v. 42, no. 1, p. 32.

Dobie, J. L., 1926, The "clastic dike" at Pullman: Washington State College B.S. thesis, 11 p.

1. B.S. thesis.
2. See title.

3. Pullman, Washington.
4. Clastic dike in basalt.
5. Field observations and measurements of dike and physical, mineralogical and chemical laboratory examination of components of dike (chiefly sand and clay).
6. Same as above.
7. --
8. A clastic dike in a quarry at Pullman, Washington, was studied. It is 2 feet wide and extends from the top of the quarry to an undetermined distance below quarry floor. It is composed chiefly of light-colored sand mixed with clay. Basalt fragments and quartz pebbles are also scattered throughout the dike. Weathering along a joint plane, combined with stream deposition in the joint and slumping of the basalt, might result in formation of such a dike.

Dort, Wakefield, Jr., 1960, Glacial Lake Coeur d'Alene and berg-rafted boulders: Idaho Acad. Sci. Jour., v. 1, p. 81-92.

Easterbrook, D. J., 1976, Quaternary history of Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 370-371.

1. Geological abstract.
2. See title.
3. Washington State.
4. Quaternary.
5. --
6. Glacial and volcanic.
7. --
8. Fluctuations of continental glaciers in the Puget Lowland, eruption of volcanoes in the Cascade Range, and catastrophic glacial flooding across the Columbia Plateau characterize the Quaternary of Washington. Evidence of early and middle Pleistocene glaciations are restricted to a few exposures in the southern Puget Lowland. Elsewhere, deposits of this age have been removed by erosion or buried by younger sediments. The early to middle part of the Wisconsin Glaciation consists of at least two stages and two interstades. An ice advance older than 50,000 years B. P. was followed by a phase of ice retreat in the interval between 35,000 and 50,000 or older. A readvance of Cordilleran ice

occurred between about 30-35,000 years B. P. The Olympia Interstade was the last nonglacial interval preceding the last major glaciation of the lowland. Radiocarbon dates indicate an age between about 19,000 and 30,000 years B. P. The Fraser Glaciation, constituting the last major advance of Cordilleran ice into the lowland, is divided into two stades and one interstade which encompass the time between about 10,000 and 20,000 years B. P.

Throughout a significant portion of the Pleistocene, volcanoes in the Cascade Range erupted lava and pyroclastic material. Volcanic ash from these volcanoes serves as important stratigraphic markers. Glaciation in eastern Washington and adjacent parts of Idaho and Montana provided the setting for creation of ice-dammed lakes which served as sources for immense floods across the Columbia Plateau upon bursting of the ice dams. An impressive array of glacial landforms marks the site of occupancy of Vashon age ice on the Waterville Plateau.

———, 1977, Paleomagnetic chronology and correlation of Pleistocene deposits (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 961.

1. Geological society meeting abstract.
2. See title.
3. Pacific Northwest, Europe, Japan.
4. Peat and ash-bearing sediments of Puget Lowland.
5. Paleomagnetic measurements.
6. Establishment of correlations and chronologies.
7. --
8. Magnetic cleaning of samples, replicate analyses, collection of parallel profiles, and tests of magnetic stability in samples are necessary to insure valid paleomagnetic measurements of Pleistocene sediments used in establishing chronology and correlations. Recent data on short magnetic excursions provide a basis for intra-epoch correlations. In addition to magnetic reversals, fluctuations in declination and inclination are useful for regional correlations. Several magnetic excursions during the Brunhes Normal Epoch are found in continental sediments where high sedimentation rates permit preservation of detailed records. The youngest of these are the Laschamp Event in 9,000 to 20,000

(?) year-old lavas of France and the Gothenberg Event in 12,500 year-old sediments of southern Sweden. Sediments in the Puget Lowland spanning the same time interval are not reversed but show similar virtual magnetic pole positions.

The Black Event, originally found in deep sea cores, has now been recognized in Japan, Czechoslovakia, and Utah and its age placed at about 100-117,000 years B. P. Reversals occur at two localities in the Puget Lowland in peat-and-ash-bearing sediments of early Wisconsin age. More exact dating of the reversals awaits fission track dating of the ash.

The Brunhes/Matuyama boundary is a widely-used marker horizon whose age is generally regarded as about .7 m.y. Sediments in the midwestern United States associated with Pearlette ashes provide evidence for correlation of deposits of the Kansan Glaciation with glacial sediments in Europe.

Easterbrook, D. J.; Rahm, D. A., 1976, Quaternary geology of the Pacific Northwest. In Mahaney, W., ed., Quaternary stratigraphy of North America: Dowden, Hutchinson, and Ross, Inc., Stroudsburg, Pa., p. 440-462.

Farkas, S. E., 1972, Structural relationships of folds and faults in Yakima Basalt and Ellensburg Formation, central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 4, no. 6, p. 375-376.

1. Geological abstract.
2. See title.
3. Central Washington.
4. Yakima Basalt and Ellensburg Formation.
5. --
6. Structural relationships of folds and faults.
7. --
8. High angle reverse faults are found to be associated with Umtanum Ridge and Selah Butte in Yakima, Kittitas, and Benton Counties, Washington. Similar structural relationships of overthrust rocks are found on the north flank of Umtanum Ridge and the south flank of Selah Butte. Yakima Basalt in the major allochthonous plate overrode the core of the Umtanum Ridge anticline, near Priest Rapids Dam. Several sheared minor allochthonous plates were also overridden as the major allochthonous plate moved over the

core of the anticline along a high angle reverse fault. This fault rapidly flattens out to assume low angle and reversed dips on the crest and north flanks of the fold, respectively.

Rocks of the Ellensburg Formation exposed along new highway cuts near the crest of Selah Butte in Yakima County show a somewhat similar relationship. Here, however, minor normal faulting is clearly shown to have followed severe compression of the rocks. Sharply deformed Ellensburg Formation, sands, shales, and basalt are found on the south limb of the fold and override flat-lying units of a similar nature to the north. Here again a high angle reverse fault rapidly flattens out to assume overthrust characteristics as it overrides the crest of the fold.

Field, R. F., 1936, Glacial-till borders of Washington (abs.): Pan-American Geologist, v. 65, no. 3, p. 240.

1. Geological abstract.
2. See title.
3. Eastern Washington.
4. Glacial till.
5. --
6. Glacial till borders, relationship to Scablands.
7. --
8. It has been generally considered that there are three glacial drifts in eastern Washington and northern Idaho. Recent work there seems to indicate that there were only two glaciations of this region. The ice appears to have had the character of a piedmont glacier formed from a number of valley ice-tongues. The southern margin of glaciation is deeply lobate, and the interlobate ridges do not show evidence of being glaciated. The relationships of the glacial margin to the peculiar scablands seem to demonstrate that the picturesque catastrophic hypothesis of scabland erosion, advanced by Bretz, is altogether untenable. The so-called Old Till, Spokane drift-sheet, proves to be a product of the last glaciation. No correlation is attempted of the two drifts with the glacial drift-sheets of the Great Plains.

Flint, R. F., 1934, Glaciation in the Okanogan region (abs.): Geol. Soc. America Proc. 1933, p. 81.

1. Geological abstract.
2. See title.
3. Okanogan region, Washington.
4. Glacial stratified drift, silt terraces, and morraines.
5. --
6. Extent of piedmont glaciation in eastern Washington, description of two silt terraces in Columbia trench above Grand Coulee Dam.
7. --
8. The Okanogan region in northern Washington and southern British Columbia was overrun two or more times by an extensive piedmont glacier, formed in the Interior Plateau of British Columbia by the coalescence of numerous valley glaciers emerging from the Rocky Mountain system, to the east, and from the Coast Ranges, to the west. It has long been recognized that during the last glaciation, the Okanogan lobe of this piedmont glacier crossed the Columbia trench in northern Washington and pushed south across the basalt of the Columbia Plateau, damming the Columbia and forcing it to spill south through the Grand Coulee, a capacious canyon excavated during an earlier glaciation. Extensive deposits of laminated silt, forming two rather distinct terraces, have been described in the Columbia trench above the dam.

   It is suggested that the higher silt terrace records a lake controlled by a rock threshold of scabland type in the Grand Coulee, and that the lower silt terrace records a later and lower profile, partly lacustrine and partly fluvial, along which the water, having abandoned the high-level Grand Coulee route, escaped via the Columbia trench, its course being much obstructed both by residual ice and by great volumes of stratified drift (constituting the "Great Terrace" of Russell) washed in through the tributary Okanogan trench.

   The Okanogan trench contains bulky deposits of stratified drift built into the trench by tributary streams along the lateral margins of wasting residual ice. This material, consisting of both fluvial and lacustrine deposits, forms conspicuous constructional terraces and irregularly knolled and kettle-pitted masses along the valley sides.

_____, 1934, Geomorphic fractures of the Okanogan region (abs.): Geol. Soc. America Proc. 1933, p. 81.

1. Geological abstract.
2. See title.
3. Okanogan region, Washington.
4. Geomorphic features.
5. --
6. Geomorphologic data including uplift, downwarp, and stream changes.
7. --
8. The Okanogan region in northern Washington and southern British Columbia exhibits an undulating past-mature highland surface developed in resistant rocks, uplifted, and dissected by deep valleys. Before the uplift, the surface appears to have been deformed into a downwarp flanked upwards, with north-south axes. The long, south-flowing Okanogan River may be consequent on the downwarp, but the southeast-flowing Similkameen appears to be older, antecedent to the upwarp west of the Okanogan. Smaller streams are controlled by minor structures.

   The southern part of the warped surface has been covered by the basalt of the Columbia Plateau. Although initially localized by the basalt margin in a roundabout route, the Columbia River now follows a shorter route through a deep gorge that cuts off a large salient of basalt. This and other stream courses in various parts of the region are attributed to glacial derangement of drainage. The inferred warping in the Okanogan region is related to the movements that brought the Cascade region into prominence.

_____, 1935, Glacial features of the southern Okanogan region: Geol. Soc. America Bull., v. 46, no. 2, p. 169-194, 2 figs. incl. map, 6 pls.; discussion by O. D. von Engeln, p. 2016-2017.

1. Geological journal.
2. See title.
3. See title.
4. Glacial erosional and depositional features.
5. Field investigations.
6. Discussion of relationships between glacial features in lower Okanogan trench and east up the Columbia River from mouth of the Okanogan.

7. Index map of southern Okanogan region, block diagram of region east and north of mouth of Okanogan River.
8. The wasting of the Okanogan lobe of the last ice invasion gave rise to vast quantities of stratified drift, the distribution of which shows that the ice wasted off the highlands while it remained in the chief valleys.

   The Nespelem silt records a deep and extensive late-glacial lake in the Columbia canyon, ice-dammed near the Grand Coulee intake. The lake drained southward over a scabland threshold in the Grand Coulee. As the dam wasted, the lake extended itself down the Columbia, and eventually the water found outlet via the present drainage route, over residual ice. Below the mouth of the Okanogan, wasting ice and accumulating sediments gave rise to a lake, or lakes, in which the "Great Terrace" sediments were accumulated. The accumulation, together with the stream terrace graded with respect to it (i.e., the 1400-foot terrace of Pardee), was stream-dissected while buried ice still lingered in the canyon.

_____, 1936, Stratified drift and deglaciation of eastern Washington: Geol. Soc. America Bull., v. 47, no. 12, p. 1849-1884, 8 pls. incl. geol. map, 2 figs. incl. geol. map;(abs.), Revue de Geologie et des Sciences Connexes, v. 17, no. 11, p. 693, 1937.

1. Geological journal.
2. See title.
3. Eastern Washington.
4. Pleistocene glacial sediments and landforms.
5., 6., 7. --
8. Drift, stratified and antedating the main outwash, occurs in two large areas north and northwest of Spokane. Stratified drift is found on the plateau west of Spokane and the river. Main outwash deposits are in the valleys of the Columbia River and its tributaries, coarse near Spokane and finer down the valley to Coulee Dam; then along the river down to a loop moraine and up a tributary above Mold beyond which an overflow channel occurs at Coulee City. Other overflow channels are known south of Spangle and south of Marshall; and loop moraines across the valleys are known down the Spokane River below Alameda, also across Sanpoil River, and several other streams coming in from the north. Outwash is in

two episodes, one represented by extensive fills in the valleys of gravel, sand, and silt, and the other by many remnants of terraces older and above these great plains. Strand lines are noted in several parts of the region which do not agree in level. Warping is suggested but not proven. Loess and dune sands are found on the valley floors and rarely on the drift areas. The outwash is deeply and broadly stream dissected and the stream has encountered rocks frequently causing falls and rapids.

_____, 1937, Pleistocene drift border in eastern Washington: Geol. Soc. America Bull., v. 48, no. 2, p. 20, p. 203-232, 5 plates, including geologic map, 1 figure; (abs.) Geol. Soc. America Proc. 1935, p. 77, 1936; (abs.) Revue de Geologie et des Sciences Connexes, v. 17, nos. 7-8, p. 460, 1937.

1. Geological journal.
2. See title.
3. Northeastern Washington.
4. Pleistocene glacial material.
5., 6., 7. --
8. The glaciation of northeastern Washington and northwestern Idaho is attributed to a piedmont glacier, fed by many valley glaciers chiefly in British Columbia, and somewhat lobate at its southern margin opposite the Rathdrum, Little Spokane, Colville, Columbia, Sanpoil, and Okanogan valleys. The tops of the intervening ranges were not glaciated. All the lobes except the Sanpoil lobe emerged from the highland on to the Columbia Plateau.

Viewed broadly, the drift border is bi-convex, indicating that the piedmont ice was fed laterally from the Rockies and the Cascades, rather than by direct precipitation upon its own surface. Measurement of the drift border along ice-free mountain ranges shows that the upper surface of the ice was concave-up along north-south profiles, supporting the same conclusion. The "old till" of the Spokane district consists of fresh and weathered foreign stones in a matrix of reworked "Palouse soil" (the material underlying the district). Hitherto it has been considered old because of the weathered matrix. The weathering however, is pre-till, and this drift is

correlated with the last glaciation of this district. The ice on the Plateau advanced over an irregular surface on weak material, modifying the topography very little. The relation of the drift border to the scabland on the Plateau indicates a modification of the catastrophic view of scabland origin.

_____, 1938a, Summary of the late-Cenozoic geology of southeastern Washington: Am. Jour. Sci., Series 5, v. 35, p. 223-230.

1. Geological paper.
2. See title.
3. Southeast Washington.
4. Columbia River lava, Ellensburg Formation, Latah Formation, interbedded sediments, post-basalt sediments.
5. Compilation of existing published data on subject and author's unpublished observations.
6. Same as above.
7. --
8. Summary of existing data through 1938 on late Cenozoic geology of southeastern Washington as well as author's own observations. Includes descriptions of Columbia River lava, sediments interbedded with basalt (Ellensburg, Latah Formations), and post-basalt sediments (Ringold Formation, Palouse soil, glacial sediments, and post-scabland eolian deposits). Also lists structures and drainage patterns in the Columbia Basin.

Flint, R. F.; Irwin, W. H., 1939, Glacial geology of Grand Coulee Dam, Washington: Geol. Soc. America Bull., v. 50, no. 5, p. 661-680, 6 plates, 1 figure, index map.

1. Geological journal.
2. See title.
3. See title.
4. Glacial stream and lake deposits.
5. Field investigations.
6. Study of sections of glacial fill in Columbia canyon and of stratigraphy and morphology of related downstream features to record behavior of Okanogan glacier lobe during last glaciation.

7. Map of regional relations of Grand Coulee Dam; cross section of fill in Columbia River Canyon at dam site.
8. Sections of the fill in Columbia canyon near Grand Coulee Dam, together with the stratigraphy and morphology of related features downstream, record the expansion and later shrinkage of the Okanogan glacier lobe during the last glaciation. Three stratigraphic zones are recognized: 1) a basal sequence of lacustrine fines interbedded with fluvial sediments, recording oscillatory ponding of the Columbia River as the glacier dammed it downstream. At first the lake was shallow and drained west around the ice margin. Later it was more effectively dammed, deepened, and forced to discharge south through Grand Coulee; 2) a till zone, recording the arrival of ice, with fluctuations, at Grand Coulee Dam during the glacial climax; 3) later deposits stratigraphically (but not everywhere vertically) overlying the till zone, recording oscillatory deglaciation accompanied by transition from lacustrine to fluvial conditions.

   The San Poil glacier lobe entered the lake-filled Columbia canyon at Keller Ferry, 15 miles upstream from Grand Coulee Dam, and contributed sediment to the lake. The maximum of this lobe appears to have been approximately contemporaneous with the maximum of the neighboring Okanogan lobe.

   While residual ice was still present locally in Columbia canyon downstream, drainage abandoned Grand Coulee and resumed its former (and present) course. Thereafter, grading of the long profile of Columbia River proceeded both by erosion of the lake fill and by deposition in depressions partly of ice-block origin and was marked by at least one delay recorded by a particularly conspicuous stream terrace.

_____, 1963, Glacial geology of Grand Coulee Dam, Washington (abs.): The XI Transactions of Sigma Gamma Epsilon, XI Chapter, Washington State Univ., v. 1, no. 1, p. 26.

Flint, R. F., 1971, Glacial and Quaternary geology: John Wiley and Sons, Inc., New York, 892 p.

Foley, L. L., 1976, Slack water sediments in the Alpowa Creek drainage, Washington (prepared under contract no. NPS-CX-8880-6-0015): Washington State Univ. Dept. Anthropology, Pullman, Washington, U.S. Army Corps Engineers, Walla Walla, Washington, National Park Service, San Francisco, California, Interagency Archeological Services, final report.

Foxworthy, B. L., 1962, Geology and ground-water resources of the Ahtanum Valley, Yakima County, Washington: U.S. Geol. Survey Water-Supply Paper 1598, 97 p., 11 figs, map, scale 1:62,500.

Freeman, O. W., 1926, Scabland mounds of eastern Washington: Science, new ser., v. 64, p. 450-451.

1. Geological publication.
2. See title.
3. Columbia Plateau.
4. Loess-like mounds on Columbia River Basalt.
5. Field observations.
6. See title. Size, occurrence, origin of mounds.
7. --
8. Thousands of nearly circular mounds are found on top of bare basaltic rock of Columbia Plateau. They are different sizes, from a few feet across to over 100 feet, with an average of 30 to 40 feet, and 3 or 4 feet in height at the center. The material of which they are composed is loess-like and appears to be deposited by the wind, probably derived from the soft lake beds of the Ellensburg Formation and the finest outwash material of the glacial period. Almost always they occur above a depression in the basalt. The catastrophic flooding in the region plucked potholes from the basalt surface; the mounds are only found in places where the basalt's surface contains depressions. Their absence from the surface of crystalline rock is accounted for by the fact that such rock is denser and potholes were not worn into its surface. Sediment accumulated first in the depressions, followed by vegetation that grew in the sediment and retained wind-blown material until the entire depression was surrounded by a mound. The fine material of the mounds holds moisture and promotes vigorous plant growth. The mounds are of economic importance because they provide the best available grazing and cultivated plant environment - due to their limited size however it is not economically feasible to cultivate them on a large scale.

_____, 1933, Stagnation of the Okanogan lobe of the Cordilleran ice sheet and the resulting physiographic effects: Northwest Sci., v. 7, no. 3, p. 61-66.

1. Scientific periodical.
2. See title.
3. Okanogan Highlands.
4. Pleistocene glacial sediments and landforms.
5. Field observations.
6. Documentation of glacial drainage changes.
7. --
8. The Okanogan lobe of the Cordilleran ice sheet during the last glaciation covered all of Washington, north of Spokane and Columbia Rivers crossing the Columbia near Big Bend to a thickness of 2000 feet. The Okanogan lobe deposited a mile-wide termainal moraine on the Waterville Plateau. Toward the close of the Wisconsin epoch the ice sheet stagnated and slowly wasted away, proof provided by eskers in sub-glacial streams and kames deposited in holes in the ice. Almost all of the melt water from the ice sheet on the Waterville Plateau drained into Moses Coulee. The Okanogan glacier completely filled the Columbia River canyon for a distance of 20 to 30 miles and formed a glacial lake to the east of the ice dam. This lake overflowed the divide and created Grand Coulee. All of the Okanogan Highlands was covered by ice except for the highest peaks. An outstanding feature of the Okanogan Valley is the great level terraces, some hundreds of feet high. The rest of the article describes glacial-drainage changes in the Okanogan Highlands, associated with stagnation of the ice of the region.

_____, 1934, Glacial drainage channels in Ferry, Stevens, and Pend d'Oreille Counties, Washington: Northwest Sci., v. 8, no. 3, p. 12-15.

1. Scientific periodical.
2. See title
3. See title.
4. Pleistocene glacial sediments and landforms.
5. Field observations; review of earlier work.
6. Glacial drainage changes and overflow channels in study area.
7. Map showing principal glacial lakes and drainage channels of northeast Washington.

8. The principal glacial drainage channel in Ferry County is the Kettle-Curlew-San Poil trench, extending from beyond the Canadian boundary to the Columbia. In Stevens County one main channel extends down the Kettle and Columbia Rivers from Canada. This is joined at Kettle Falls with the large Columbia Valley from the northeast. The Colville Valley to Springdale and thence via Chamokane Valley to Long Lake comprises a second principal glacial outlet channel. Four minor channels connect the upper Columbia Valley with the Colville and one obvious channel from Tiger to Arden through Little Pend d'Oreille Lakes connected the Pend d'Oreille and Colville Valleys. Glacial lobes remained in the Columbia and Colville valleys for a long time. In Pend d'Oreille County a late glacial lake named Lake Clark occupied the Pend d'Oreille Valley, north to Ione. Between Ione and Metaline an abandoned side channel extends east of the Pend d'Oreille Valley on a loop that includes Sullivan Lake.

_____, 1940, Glacial drainage changes north of the Columbia Plateau (abs.): Geol. Soc. America Bull., v. 51, no. 12, part 2, p. 2021-2022.

1. Geological journal.
2. See title.
3. See title.
4. Stream channel changes, stream depositional and erosional features.
5. Field observations.
6. Documentation of glacial drainage changes.
7. Map showing location of glacial drainage channels.
8. The Okangan Highlands and other ranges of northeastern Washington were covered by glacial ice that moved southward from the intermontane plateau of Canada. The southward extension of the ice sheet has been mapped by Bretz and Flint, who have also given their interpretations for the origin of the scablands that were eroded by glacial meltwaters. North of the area they describe are dozens of glacial drainage channels and other features such as marginal lakes and associated spillways that were developed during the melting and wasting of the ice sheet. Since the glaciers were thickest in the major valleys, the drainage channels generally form a braided sort of pattern on both sides of such north-south-

trending trenches. The character of deposits made by the meltwater during the glacial period is briefly mentioned. A map showing the location of the glacial drainage channels of Washington accompanies the paper.

_____, 1944, Glaciation and some human relationships at Lake Chelan, Washington: Northwest Sci., v. 18, no. 3, p. 59-62.

1. Scientific periodical.
2. See title.
3. Lake Chelan.
4. Glacial sediments and landforms.
5. Field observations.
6. Glacial relationships and origin of Lake Chelan and glacial landforms.
7. --
8. Lake Chelan, a fiord-like body, extends 60 miles from Columbia Valley northwest into the northern Cascade Mountains of Washington. Official depth is 1,510 feet, 2d deepest lake in United States. Average width is 1 to 2 miles. Originated as result of a combination of glacial erosion throughout upper and middle parts of the lake and deposition at the outlet of the lake. Pre-glacial Chelan Valley had a length of 75 miles represented now by Lake Chelan and the Stehekin River. Bedrock consists mostly of granite of Mesozoic age or older. Columbia Plateau basalt flows do not occur in drainage basin of Lake Chelan. A thickness of over one mile is indicated for the Chelan Glacier. Important tributary valleys are Agnes Creek, Park Creek, Horseshoe Basin, and Bridge Creek. Chelan Glacier may have extended nearly to the junction of the Columbia Valley but did not remain there long. The largest side feeded to Chelan Glacier came from Railroad Creek to the north. The Okanogan-Columbia Valley lobe of the Cordilleran Ice Sheet blocked the Chelan Valley and created a lake between the two. Two former outlets and numerous terraces of the high level glacial lake exist between the foot of Lake Chlan and Twenty-Five Mile Creek. When the outlet of the Chelan River had become blocked with debris from receding ice, a new course was established between the deposits and the south wall of the valley.

Fryxell, Roald, 1960, Problems in glacial chronology of northern Washington (abs.): Geol. Soc. America Bull., v. 71, no. 12, part 2, p. 2060-2061.

1. Geological abstract.
2. See title.
3. Northern Washington.
4. Glacial sediments and landforms.
5. --
6. Relationships and ages of ice advances.
7. --
8. Studies of continental glaciation in northern Washington have utilized a variety of criteria for establishing the age of various episodes. Depending on the availability of field evidence, different workers have used stratigraphy, weathering, erosion, physiographic expression, rate of talus accumulation, relationship to units in the Palouse loess, bedrock topography, and radiocarbon analysis. Weathering, topographic expression and radiocarbon dating support correlation of the last major glacial advance as Wisconsin. However, substage correlations result in major inconsistencies: 1) the last advance in Puget Sound has been referred to Tazewell (13,700 BP), while its apparently equally weathered and supposedly synchronous counterpart across the Cascades, the Okanogan lobe, has been designated Mankato (10,000 BP?); 2) restricted valley glaciers a few hundred feet thick, sharing the catchment divide in southern British Columbia of the mile-thick Okanogan lobe, have also been dated as Mankato (post 11,300 BP); 3) the Spokane lobe has been suggested to be early or pre-Wisconsin although north of its terminus it merged with the Okanogan lobe; 4) east of Grand Coulee the stratigraphic evidence available in Puget Sound and Cascade areas is almost lacking, and nearly every ice margin so far suggested has been disputed; little agreement exists here or in northern Idaho as to whether recognizable moraines are terminal or recessional. Until the precise relationship of ice advances within northern Washington itself can be established, correlation at the substage level with Midwestern chronology cannot be satisfactory. Present attempts fail because of insufficient field work, lack of stratigraphic information, and scarcity of radiocarbon dates.

_____, 1963, Limits of continental glaciation, north-eastern Washington: The XI Transactions of Sigma Gamma Epsilon, XI Chapter, Washington State Univ., v. 1, no. 1, p. 25.

1. Map accompanying field trip guidebook.
2. See title.
3. Northeast Washington.
4., 5., 6. --
7. Map showing limits of continental glaciation in northeastern Washington.
8. --

Fryxell, Roald; Daugherty, R. D., 1963, Late glacial and post-glacial geological and archaeological chronology of the Columbia Plateau, Washington: interim report: Washington State Univ. Lab. Anthropology Rept. Invest. 23, 22 p.

1. Geoarchaeological report.
2. See title.
3. Columbia Plateau, Washington.
4. Late and post-glacial sediments.
5. Field and laboratory study of archaeological site stratigraphy; geological field mapping and regional correlation to determine relationships of cultural horizons to late and post-glacial sediments;development of chronology of geologic events for late and post-glacial time.
6. Development of integrated late and post-glacial geoarchaeological chronology for the Columbia Plateau, Washington.
7. Geographic distribution map and listing of sites for which detailed geologic, stratigraphic and pedologic information is available. Schematic geological and archaeological chronology for eastern Washington and related areas.
8. Discovery at Lyons Ferry, Washington, of oldest (to date) human remains dated with certainty in Pacific Northwest found in context of a complete sequence of geological and cultural stratigraphy to Anathermal climatic period.

   C-14 dating of organic material collected from scabland flood gravel at Wanapum Dam as 32,700 ± 900 ybp,provides 1st radiocarbon dating for glacial chronology in Washington and provides maximum limiting date for late Wisconsin scabland flooding. Date also synchronizes Okanogan lobe

maximum with Puget lobe and shows eastern Washington to be free of ice by 12,000 ybp. Alignment of prehistoric population centers along major drainage in eastern Washington makes them of prime archaeological importance. Alluvial history of the lower Snake River and middle Columbia River are discussed and a regional history of cave and rockshelter sites is given. Paleo-climatic implications are made and volcanic ash deposits are discussed.

Fryxell, Roald; Cook, E. F., 1964, A field guide to the loess deposits and channeled scablands of the Palouse area, eastern Washington: Washington State Univ. Lab. Anthropology, Report Invest. 27.

Fryxell, Roald, 1964, Regional patterns of sedimentation recorded by cave and rock-shelter stratigraphy in the Columbia Plateau, Washington (abs.): Geol. Soc. America Special Paper 76, p. 273.

1. Geological-archaeological abstract.
2. See title.
3. Columbia Plateau.
4. Cave rockfalls, eolian sediments, organic debris.
5. --
6. Data to substantiate a general stratigraphic sequence from Okanogan Highland to north Oregon and from west Idaho to Cascade foothills.
7. --
8. Stratigraphic records from archaeological excavations at more than 20 cave and rock shelters show that a general stratigraphic sequence, with modifications reflecting local conditions, is present from the Okanogan Highlands to north-central Oregon, and from western Idaho to the eastern foothills of the Cascade Range. Stratigraphy of these sites may be described in terms of three major types of sedimentation: 1) accumulation of rockfall from the cave ceiling; 2) deposition of eolian sediment; and 3) build-up of organic debris.

   Alternate dominance or shift in relative importance of these processes, in the above order, are interpreted as reflecting control by regional climatic conditions. Thus coarse rockfall at the base of this sequence records a cool, moist environment accompanied by vigorous frost activity until about 8000 years ago; next followed a time of

relative aridity, lessened frost activity, and increased eolian sedimentation; beginning about 4000 to 2000 years ago conditions gradually shifted toward those of the present, resulting in moderately renewed frost-rockfall activity, moderating eolian deposition and increasing accumulation of organic debris.

Two major pumicite marker horizons commonly are found within this sequence. Field evidence and radiocarbon date establish the more recent of the two as dating from the eruption of Mt. Mazama at Crater Lake, Oregon, about 6500 years ago and suggest that Glacier Peak in the northern Cascades may have been the source for the earlier pumicite. Analysis of combined geological and archaeological stratigraphy confims human occupation at several of these sites over a period of 8000 years or longer.

Fryxell, Roald; Neff, G. E.; Trimble, D. E., 1965, Scabland tracts, loess, soils, and human pre-history. In INQUA, Guidebook for Field Conference E, northern Rocky Mountains: Nebraska Acad. Sci., Lincoln, Nebr., p. 79-89.

_____, 1965, Ephrata to Pullman. In Schultz, C. B.; Smith, H. T. U., eds., Guidebook for Field Conf. E., Northern and Middle Rocky Mountains: Internatl. Assoc. Quaternary Research, 7th Congr., Lincoln, Nebraska, Nebraska Acad. Sci., p. 79-90.

1. Field trip guide.
2. See title.
3. See title.
4. Pleistocene flood gravels, Ringold Formation, Columbia River basalt; loess.
5., 6. --
7. Stratigraphy of loess deposits and asaociated buried soils in central Columbia Plateau; correlation of post-glacial climatic events with stratigraphy and cultural sequence at Marmes Rock shelter; precipitation map, vegetation map, and distribution map of great soil groups for Columbia Plateau, map of relationships of loess, soils, and vegetation in Palouse Hills.
8. --

Fryxell, Roald, 1965, Mazama and Glacier Peak volcanic ash layers: relative ages: Science, v. 147, no. 3663, p. 1288-1290; (abs.) Geomorphological Abstracts, no. 27, p. 300, 1965.

1. Geological publication.
2. See title.
3. Pacific Northwest.
4. Volcanic ash - Glacier Peak and Mt. Mazama.
5. Physiographic and stratigraphic correlation and C-14 dating.
6. Regional correlation of Mt. Mazama and Glacier Peak ashes.
7. --
8. Physiographic and stratigraphic evidence supports the regional correlation of two volcanic ash layers with extinct Mt. Mazama at Crater Lake, Oregon and Glacier Peak in the northern Cascade Range of Washington. A radiocarbon age of 12,000 $\pm$ 310 years confirms geological evidence that ash derived from the Glacier Peak eruption is substantially older than ash from the Mazama eruption of 6600 years ago.

_____, 1967, Ice-flow pattern reconstructed for the Okanogan lobe of the Cordilleran ice-sheet, north-central Washington (abs.): Northwest Sci., v. 41, no. 1, p. 50.

1. Geological publication.
2. See title.
3. North-central Washington.
4. Glacial features.
5. Field mapping and use of topographic maps and air photos.
6. Direction of ice-flow for Okanogan lobe of Cordilleran ice sheet.
7. --
8. Directions of ice flow for the Okanogan lobe of the Cordilleran ice sheet can be inferred from several types of field evidence: glacial striae, glacial plucking, bedrock fluting and large-scale bedrock grooves,drumlinoid smear features (some with bedrock cores), boulder trains, indicator lithologies, and loops of moraine draped asymmetrically around nunataks. Mapping of these features in the field, from topographic maps, and from vertical air photos shows close alignment with trends of bedrock topography in the Okanogan Valley except at high elevations, where striae and grooves cross drainage divides. South of the Okanogan Highlands, these features fan out on the surface of the Okanogan and Waterville plateaus to forma radial pattern which terminates moraine of the Okanogan Lobe. Within

this pattern, which is not seriously disrupted by the Columbia River, bearings of striae shift in regular eastward progression from south-southwesterly (at the base of the Cascade Range) to due east (six miles north of Grand Coulee Dam). Thus, until the ice had advanced far enough south to escape confinement by the Okanogan Valley, only the upper portions of the Okanogan Ice Lobe moved independently of bedrock control. The lobe then spread fan-like across the basalt plateau after completely overriding the Columbia River Canyon. Within the canyon, local control of ice flow is recorded by striae transverse to the general trend of ice movement. Stratigraphic and topographic relationships show that most of these features represent an ice advance of mid-Pinedale age.

_____, 1972, Relationship of the late Quaternary volcanic ash layers to geomorphic history of the Columbia Basin, Washington (abs.): Geol. Soc. America, Abs. with Programs, v. 4, no. 3, p. 159.

1. Geological abstract.
2. See title.
3. Columbia Basin, Washington.
4. Volcanic ash (Mt. Mazama and Glacier Peak and Mt. St. Helens) and glacial sediments.
5. Field observations and lab analyses of ash.
6. See title.
7. --
8. Interpretation of Quaternary history in the Columbia Basin requires establishment of relationships between distinctive and extensive volcanic ash layers, and their geomorphic setting and events. Coarse Glacier Peak ash occurs at many localities on till and recessional outwash of the Okanogan Ice Lobe, demonstrating its retreat nearly to the Canadian border by 13,000 years ago. During ice retreat, the Great Terrace of the Okanogan and Columbia Rivers was graded, well beyond the terminal moraine, to about 1250 feet elevation, suggesting that its base level was an extensive lake of approximately the same elevation. At Vantage and at other localities, lacustrine sediments as high as 1150 feet contain pairs or triplets of cummingtonite-bearing ash of unknown source. The lake sediments, the cummingtonite-bearing ash layers, and the Great Terrace all

pre-date the Glacier Peak eruption, for coarse Glacier Peak ash fell subaerially on a bench cut into lake sediments at an elevation of about 1000 feet near Chelan after base level had been lowered and the Terrace dissected. Slack water remained to an elevation of at least 600 feet at Marmes Rockshelter in southeastern Washington, where lacustrine sediments contain fine Glacier Peak ash (identified petrographically by R. E. Wilcox). Archaeological evidence and radiocarbon dates show that the lake was drained by 11,000 years ago. Subsequently, Mazama ash (6700 BP) was deposited on surfaces graded to present river levels or lower. Post-Mazama alluvium and other deposits (all younger than 5000 BP) contain ash layers correlated with eruptions Y, P(?), W and T of Mount St. Helens.

_____, 1973, Salvage of geochronological information in the Wells Reservoir area, Washington (1964-1972): A report to the National Park Service in completion of Contract No. 14-10-0434-1505, Washington State Univ., 35 p., physiographic diagram, 1:125,000.

Gibbs, George, 1854, Report upon the geology of the central portion of Washington Territory. In Report of the Secretary of War, communicating the several Pacific Railroad explorations, in three volumes, 1855: U.S. Cong., 1st sess., House Ex. Doc. 129, v. 18, pt. 1, 1st v., p. 494-512.

Gresens, R. L., 1975, Geologic mapping of the Wenatchee area: Washington Division Geol. and Earth Resources Open-File Report, no. OF-75-6, scale 1:1,000.

Griggs, A. B., 1965, Stratigraphic relationships between the Columbia River Basalt and the Latah Formation in Spokane area, Washington (abs.): Geol. Soc. America Spec. Paper 82, p. 328.

_____, 1966, Reconnaissance geologic map of the west half of the Spokane quadrangel, Washington and Idaho: U. S. Geol. Survey Misc. Geol. Inv. Map I-464, 1:125,000.

_____, 1973, Geologic map of the Spokane quadrangle, Washington, Idaho and Montana: U.S. Geol. Survey Misc. Geol. Inv. Map I-768, map and text on one sheet, 1:250,000.

Gustafson, C. E., 1976, An ice age lake in the Columbia Basin: new evidence (abs.): Geol. Soc. America, Abs. with Programs, v. 8, no. 3, p. 377.

1. Geological abstract.
2. See title.
3. Columbia Basin.
4. Lacustrine deposits, volcanic ash, flood and glacial sediments.
5. Field evidence.
6. Evidence to determine origin of late Quaternary slack-water deposits in eastern Washington.
7. --
8. Controversy concerning the origin of late Quaternary slack-water deposits in eastern Washington has been partially alleviated by recent field evidence which suggests that some deposits resulted directly from scabland flooding whereas others represent different, later events. The later sediments occur throughout the Columbia Basin and probably were deposited in one or more widespread lakes. Regional correlation of sediments from one stand of the lake(s) is possible through stratigraphic relationships and through the presence of volcanic ash layers having distinctive physical and chemical characteristics. The lacustrine deposits can be traced to elevations of bout 1300 feet throughout their range. Freshwater Mollusca, including articulated bivalves, abound in laminated sediments at the higher elevations. Their presence in large numbers near a former lake margin habitat suggests the lake was not ephemeral, but existed long enough for molluscan fauna along with the fish necessary as intermediate hosts for the larval stage of the fingernail clam (Pisidium) to develop. Additional faunal remains include rodents, rabbits, extinct bison and mammoth. Clastic dikes and ice-rafted erratics are common. The erractics especially have proved useful for tracing former shorelines where deposits are mixed and not well-laminated. Archaeological sites stratigraphically above slack water sediments are at least as old as 10,000 years B.P. Thus the lake must be older than the archaeological materials, and it certainly is younger than the last major episode of Scabland flooding for lacustrine deposits unconformably overlie sediments unquestionably related to catastrophic flooding.

Hammatt, H. H.; Foley, L. L.; Leonhardy, F. C., 1976, Late Quaternary stratigraphy in the lower Snake River canyon: toward a chronology of slack water sediments (abs.): Geol. Soc. America, Abs. with Programs, v. 8, no. e, p. 379.

1. Geological abstract.
2. See title.
3. Lower Snake River Canyon, southeastern Washington.
4. Slack-water sediments.
5. Field observations.
6. Evidence to support chronology of slack-water sediments.
7. --
8. The origins of slack-water sediments in southeastern Washington and their relationship to catastrophic flood sediments have long been controversial. One interpretation is that the fine textured sediments represent slack-water phases of the floods; the second interpretation, the "Ancient Lake Lewis" hypothesis, holds that there were impoundments of water postdating the last major flood. Late Quaternary deposits in the Lower Snake River Canyon include at least two slack water units of different age and origin and at least three gravel units which relate to scabland floods. The earlier slack water unit, characterized by fine bedding, generally silty texture and Mt. St. Helens tephra layers, unconformably overlies the uppermost known flood gravel. This unit was likely deposited in standing water over a long period of time. The later slack water unit, characterized by sandy texture, rhythmic bedding, and erratic pebbles and striated cobbles, unconformably overlies the earlier unit and probably represents a slack water phase of a later scabland flood. The earlier deposits may date at least 20,000 years B.P.; the later deposits may date to 14,000 years B.P. To acount for the stratigraphic sequence and the regional distribution of slack water sediments we must postulate differing episodes of slack water deposition and one scabland flood postdating the standing water (Ancient Lake Lewis) episode. At present no gravel unit can be correlated with the upper slack water sediments which represent this postulated flood.

Hansen, H. P., 1947, Postglacial forest succession, climate and chronology in the Pacific Northwest: Am. Philos. Soc. Trans., v. 37, pt. 1.

_____, 1947, Chronology of postglacial volcanic activity in Oregon and Washington (abs.): Geol. Soc. America Bull., v. 58, no. 12, part 2, p. 1252.

1. Geological abstract.
2. See title.
3. Pacific Northwest.
4. Volcanic ash(Glacier Peak, Mount Mazama, St. Helens, Newberry Crater, Devils Hill) and peat bog pollen.
5. Pollen profile studies.
6. Chronology of volcanic activity using pollen profiles.
7. --
8. The chronology of volcanic glass and pumice strata interbedded in many peat bogs in the Pacific Northwest has been determined indirectly by pollen profiles from the peat sections. The postglacial climatic trends interpreted from the pollen profiles and correlated with chronological data from several sources provide a basis for segregating the postglacial into a series of time intervals. The stratigraphic position of the volcanic ejecta in relation to the climatic stages serves to date both relatively and approximately some of the volcanic activity. The eruption of Mount Mazama, which formed the caldera holding Crater Lake, occurred about 10,000 years ago, or before the warm, dry period of 8000 to 4000 years ago. The position of Newberry pumice above Crater Lake pumice in Summer Lake basin of south-central Oregon reveals that Newberry Crater erupted after Mount Mazama, but before the late Wisconsin lakes had become entirely desiccated. It is dated between 9000 and 8000 years ago. The stratigraphic position of a layer of volcanic ash in Washington peat columns, attributed to Glacier Peak, suggests that the eruption took place about 6000 years ago. A pumice stratum in peat sections of the northern Willamette Valley is believed to have come from Mount St. Helens and is dated at about 5000 years. The most recent volcanic activity recorded in peat sections that were analyzed was that of Devil's Hill in the Three Sisters region, and it is dated at about 4000 years.

Harrison, J. E., 1976, Dated organic material below Mazama (?) tephra: Elk Valley, B. C.: Canadian Geol. Survey Paper no. 76-1C, p. 169-170.

1. Geological publication.
2. See title.
3. See title.
4. See title.
5. Carbon-14 dating techniques.
6. See title.
7. --
8. A horizontal organic layer, 1 cm thick, north of Elkford, B.C., was dated by C-14 techniques. It underlies white volcanic ash believed to be Mazama. Two dates were obtained: 11,900 ± 100 ybp and 12,260 ± 160 ybp.

Hershey, O. H., 1912, Some Tertiary and Quaternary geology of western Montana, northern Idaho, and eastern Washington (abs.): Geol. Soc. America Bull., v. 23, p. 75.

1. Geological abstract.
2. See title.
3. Eastern Washington.
4. Glacial sediments and landforms.
5. Field observations.
6. Descriptions, locations and mode of origin of glacial features in eastern Washington, Idaho and Montana.
7. --
8. Evidence of two stages of glaciation in Deer Creek Valley, Montana, are given and brief reference is made to the latest glaciation in the Coeur d' Alene Mountains of Idaho. A system of river terraces distributed for 30 miles along the valley of the South Fork of the Coeur d'Alene River is described in detail. The 1,150-foot terrace is probably early Miocene in age, but merely marks a vicissitude in the erosion of a valley 4,000 feet deep. In middle Miocene time the Columbia River lava obstructed the valley and produced a lake in which were deposited white and variegated silts and the delta gravels of the river, filling the old valley 500 feet deep, to the level of the 600-foot terrace. A new valley 400 feet deep, partly on a new course, was trenched in early Quaternary time down to the 200-foot terrace. A remarkable distribution of granitic and gneissic boulders on this terrace

is attributed to icebergs in a lake produced by the glacial damming of the valley at some point not determined; this is considered evidence of very early glaciation somewhere in northern Idaho. The 60-foot terrace is a gravel-capped rock bench, but the 30-foot terrace was built by the river and is tentatively correlated with the first glacial stage in Deer Creek Valley. Physiographic features of the Clearwater region and the lake plateau of eastern Washington are discussed, and Coeur d'Alene Lake and the Post and Spokane falls are explained as the result of the deposition of glacial overwash gravels in the broad Spokane Valley during the last glacial stage.

Heusser, C. J., 1960, Late-Pleistocene environments of North Pacific - North America: Am. Geog. Soc. Spec. Pub. No. 35, 308 p.

Hobbs, W. H., 1943, Discovery in eastern Washington of a new lobe of the Pleistocene continental glacier: Science, v. 98, no. 2541, p. 227-230, illus.; (abs.) Geol. Soc. America Bull., v. 54, no. 12, p. 1825, 1943.

1. Geological publication and abstract.
2. See title.
3. Northeastern Washington.
4. Glacial sediments, glacial ice, glacial features.
5. Field observations.
6. New field evidence for extension of the Cordilleran ice sheet in the form of a "Scablands" Glacial Lobe.
7. --
8. A hitherto unsuspected southwestward extension of the Cordilleran glacier of late Pleistocene time has been established by studies in 1943. This extension of nearly 4000 square miles is the area of so-called "Scablands" in eastern Washington. Hitherto the glacier front was thought to have been in the latitude of Spokane. The newly discovered extension is heart-shaped and is called the Scablands Glacial Lobe. On the east this lobe blocked an ancestor of the Spokane River, which was much swollen by glacial meltwater, to impound the waters over an area of some 3,000 square miles as Glacial Lake Spokane. This lake had an outlet along the eastern and southern border of the lobe, and successive spillways into the Columbia and Snake rivers were through Esquatzel Coulee and Devils and Palouse canyons.

Six major recessions of the lobe have been made out with the new outlets for Lake Spokane successively westward through other canyon spillways into the Columbia River.

The main outwash apron of the Scablands lobe was the eastern portion of the Columbia Basin. Outside and peripheral to it is the contemporaneous apron of loess, which studies of the Greenland glacier have shown should always be found within the periglacial area of a continental glacier.

Complete evacuation of the ice of the Scablands with the retirement of the glacier front behind the Spokane and Columbia Rivers brought about an expansion of Lake Spokane down the canyons of these rivers. This had been named Glacial Lake Leverett. It was blocked by ice below the site of Coulee Dam and it cut an outlet through the Grand Coulee. This outlet is a double cataract gorge like that of Niagara, but five times as high and many times as wide - the greatest feature of the kind anywhere known.

_____, 1947, The glacial history of the Scabland and Okanogan Lobes, Cordilleran Continental Glacier: J. W. Edwards, ed., Ann Arbor, Mich., 36 p.

Hodge, E. T., 1931, Exceptional morainlike deposits in Oregon: Geol. Soc. Bull., v. 42, p. 985-1010.

_____, 1932, Geological map of north-central Oregon: Oregon Univ. Pub., Geol. ser., v. 1, no. 5, 1:250,000.

_____, 1938, Geology of the lower Columbia River: Geol. Soc. America Bull., v. 49, p. 831-930.

_____, 1940, Glacial history of southeastern Washington (abs.): Geol. Soc. America Bull., v. 51, no. 12, part 2, p. 2024; (abs.) Geol. Soc. Oregon Country Geological News Letter, v. 6, no. 16, p. 135, 1940.

1. Geological abstract.
2. See title.
3. Southeastern Washington.
4. Glacial sediments and features.
5. Field observations.
6. Glacial history of southeastern Washington including drainage patterns and changes, formation

of glacial topographic features, distribution of glacial sediments.

7. --

8. The basin of southeastern Washington was drained by westward and northward flowing streams. The former were dammed by Pleistocene volcanics, and the latter by the Continental ice sheet. Ponded waters filled the valleys of the Columbia Mountain system but did not submerge the higher ridges; they spilled over cols in the Sanderson-Cheney divide, deepened them, and so directed the course of ice lobes from the advancing ice-front. The glaciated cols produced the coulees, such as Grand and Moses. The ice reached as far south as Ephrata and Ritzville and over the area plucked the highly fractured basalt to make great gravel deposits and left holes filled with ice which are now sheer-walled undrained basins. Loess and gravel were spread over the greater part of the area, burying ridges and forming a lake-bed surface with an initial south-sloping surface. The lake was drained by an overspill at Wallula Gateway. As the glaciers melted, streams flowed southward over this surface. Some were superposed over ridges, such as Horse Heaven, Rattlesnake, Frenchman, and Waterville-Adrina. These streams were often choked and dammed by ice-floes, and forced out of channel. Repeated damming of diversion channels produced complex anastomosing channels incised in basalt. Erratics rafted were stranded over area and along Columbia and Willamette valleys in Oregon. Similar events followed a second and third advance.

Holmgren, D. A., 1968, Yakima-Ellensburg unconformity, central Washington (abs.): Northwest Sci., v. 42, p. 34-35; Univ. of Washington M.S. thesis, 69 p., Plate 1, 1:142,560; Plate 2, 1:42,768; Plate 3, 1:96,000, 1967.

1. Thesis and abstract.
2. See title.
3. Central Washington.
4. Pliocene Ellensburg Formation and Miocene Yakima Basalt.
5. Field observations of stratigraphic relationships and restriction of Ellensburg Formation to Beverly member, Pomona Basalt member and upper sedimentary member.

6. Same as above.
7. Regional geologic map; detailed map of Selah Gap and Kelley Hollow; table showing previous treatment of area; opposing views of Yakima Basalt and Ellensburg relationships; cross-section of platy joints show location and orientation of phenocrysts in Roza and Frenchman Springs flows; stratigraphic sections Selah Gap; stratigraphic section of Selah Butte anticline; structure map; several petrographic formation photos.
8. The Pliocene Ellensburg Formation unconformably overlies the Miocene Yakima Basalt in the Yakima region; thus, these two formations are not mutually intertongued as interpreted by Smith (1903) and subsequent investigators.

   The angular relationship is clearly exposed on the south flank of the Yakima anticline east of Selah Gap, where the basal Ellensburg beds truncate three Yakima Basalt flows. Map patterns show that basalt Ellensburg oversteps the Frenchman Springs-Roza-Priest Rapids succession of the Yakima Basalt from Wenas Valley eastward to Connell, rests on pre-Vantage Sandstone flows west of Ellensburg, and completely truncates the Yakima Basalt to rest on John Day (?) strata, 30 miles west of Yakima.

   This significant unconformity calls for restriction of the Ellensburg Formation to exclude the Vantage Sandstone, Squaw Creek, Quincy Diatomite, and other intra-Yakima sedimentary units. Thus restricted, the Ellensburg of this type area consists of a basal sedimentary (Beverly) member, Pomona Basalt Member, and an upper sedimentary member. These relationships imply that the earliest Cascadian uplift in this region was post-Yakima.

Hopkins, K. D., 1966, Glaciation of Ingalls Creek Valley, east-central Cascade Range, Washington: Univ. of Washington M.S. thesis, 79 p.

1. Thesis.
2. See title.
3. See title.
4. Glacial erosional features and glacial deposits.
5. Field observations; statistical treatment of granite-weathering ratios and surface-boulder frequencies.
6. Description of glaciation of study area including glacial-erosional features, surficial geology,

discrimination and relative ages of drift, correlation and age, snowline relations.

7. Altitudes of cirque floors in Ingalls Creek drainage; reconstructed long profiles of Ingalls Creek and glacier limits of drift sheets in Ingalls-Peshastin Creeks drainage; till fabric from older drift and remnants of erosional terraces along Peshastin Creek, abandoned channels of Peshastin Creek of post-intermediate driftage; late-glacial and neoglacial features in the Ingalls Creek drainage and adjoining valleys; correlation of Ingalls-Peshastin Creeks; glacial sequences; several photos.
8. Comparison of quantitative weathering parameters on glacial drift permits delineation of 3 distinct drift bodies along a single valley in the east-central Cascade Range, Washington. Marked differences in granite-weathering ratios, surface-boulder frequencies, and thickness of weathering profiles, as well as the degree of modification by erosion and mass wasting, suggest that the drifts represent three separate major glacial episodes. Relative ages based on weathering parameters agree with those determined from such time-independent criteria as morainal position and relative heights of outwash terraces graded to moraines. Contrasts in weathering parameters and erosional modification are greatest between 2 older drifts suggesting that the earlier of the 2 nonglacial intervals was of the greater magnitude. The latest glacial episode is correlated with the Fraser Glaciation of the Puget Lowland in western Washington and with the classical Wisconsin Glaciation of central North America. The intermediate episode is correlated tentatively with Salmon Springs Glaciation of Puget Lowland; oldest is considered pre-Salmon Springs. Moraines and terrace remnants within the youngest drift, together with weathering data, permit subdivision of the latest glacial episode into three, maybe four, separate advances or recessional stands. Outwash of the first recessional stand is overlain by postglacial fan gravels containing a layer of volcanic ash (Mazama - 6,600 years old). Other occurrences of Mazama ash in alluvial fans are indicative of widespread alluviation during the Hypsithermal interval. Several inactive rock glaciers in high cirques of adjacent valleys probably formed during neoglaciation.

Hosterman, J. W.; Scheid, V. E.; Allen, V. T.; Sohn, I. G., 1960, Investigations of some clay deposits in Washington and Idaho: U.S. Geol. Survey Bull. 1091, 147 p. Figure 3, 1:380,160; Plate 3, 1:12,000.

1. Geological publication.
2. See title.
3. Eastern Washington, northern Idaho (Palouse Hills).
4. See title.
5. Mineral composition studies; X-ray and differential thermal determinations.
6. Determination of distribution, quantity and quality of deposits.
7. Geologic map of Latah City clay deposits, the Excelsior, Bovill, Deary, Olson, Stanford, Canfield-Rogers and Stockton deposits; section of Olson and Bovill deposits; many chemical data tables.
8. The clay deposits of eastern Spokane County occur along the eastern and northeastern margin of the Columbia Plateau, where the basalt flows lap onto the older igneous and metamorphic rocks. Five genetic types of clay are available for making clay products, and three of the five types are possible future sources of alumina. The five types are 1) white residual clay derived from pre- Tertiary igneous and metamorphic rocks, 2) bluish-gray residual clay derived from Columbia River Basalt (Tertiary), 3) residual and transported clay beds in the Latah Formation (Miocene), 4) brown clayey silt and silty clay of the Palouse Formation (Pleistocene), and 5) light-greenish-gray silty clay of the glacial lake deposits. Residual clays, derived from igneous and metamorphic rocks, and clays from the Latah Formation would be best for refractory products, filler uses, and as an ore of aluminum. Residual clay derived from basalt would be useful only an an ore of aluminum with a possible byproduct of titanium. The best use of clay from the Palouse Formation and lake deposits is in making building brick. Five clay minerals have been identified by X-ray diffraction in samples from these deposits. Kaolinite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) is found in all types of clay, except residual clay derived from basalt. Halloysite ($Al_2O_3 \cdot 2SiO_2 \cdot 4H_2O$) is found primarily in the residual clay derived from basalt, and traces are found in the residual clay derived from pre-Tertiary rocks. Montmorillonite and illite do not occur in residual clay derived from basalt, but do occur in varying amounts in all other types of clay. Nontronite (a high iron montmorillonite) is found only in the residual

clay derived from basalt.

The clays formed under similar physical, chemical, and bacterial conditions during Tertiary time. It is likely therefore, that the mineralogic composition of the unweathered parent rock controlled the type of clay mineral produced during katamorphic alteration. The augite in basalt altered to nontronite, and the ferromagnesian minerals in the pre-Tertiary rocks altered to montmorillonite. The pre-Tertiary rocks contained feldspars and muscovite that altered to kaolinite, and the basalt contained plagioclase (labradorite) that altered to halloysite.

The approximate content of SiO_2, Al_2O_3, FeO_3, MnO, CaO, K_2O, and TiO_2 was determined by a rapid and inexpensive X-ray fluorescence method. The chemical composition of 220 samples indicates that the residual clay derived from basalt has an average Al_2O_3 content of 22 percent with individual samples as high as 39 percent; the Latah Formation, 20 percent with a high of 37 percent; and the residual clay derived from pre-Tertiary rocks, 20 percent with a high of 29 percent. The Palouse Formation loess has an Al_2O_3 content of about 15 percent, and the lake deposits, about 16 percent.

_____, 1969, Clay deposits of Spokane County, Washington: U.S. Geol. Survey Bull. 1270, 96 p.

1. Geological publication.
2. See title.
3. See title.
4. See title.
5. X-ray diffraction, X-ray fluorescence; chemical and mineralogic composition; auger-drilling sampling of clay deposits; ceramic properties studies.
6. Information on distribution, quality and quantity of clay deposits in study area.
7. Chemical tables; stratigraphic sections; geologic map of pre-Palouse of Mica-Manito-Saxby area, Washington-Idaho.
8. The investigation of clay resources, made jointly with the U.S. Bureau of Mines 1942-1947, began as a part of a general investigation of possible sources of aluminum in the United States. It was

undertaken as a precaution against the depletion of aluminum reserves, owing to the greatly increasing demand for aluminum during World War II.

The clay deposits of eastern Washington and northern Idaho, known as the Palouse Hills, are at the eastern edge of the Columbia Plateau physiographic province. Three types of clay occur in the area: residual clay derived from the Columbia River basalt of Tertiary age; residual clay derived from the granodiorite and related intrusive rocks of the Idaho batholith of late Jurassic or Cretaceous age; and transported clay, an erosional product of the granodiorite and related intrusive rocks, deposited as part of the Latah Formation of Tertiary age. The two types of residual clay were formed during an interval of weathering called the "Excelsior weathering period" that occurred between flows of the Columbia River basalt, when the land surface had a low to moderate relief and the climate was warm and humid with good oxidation conditions.

The mineral composition of a few samples has been studied in detail. X-ray and differential thermal determinations on these clays show that kaolinite and halloysite (hydrated) are the principal clay minerals. The residual clay derived from basalt is composed of white halloysite commonly colored blue, gray, or black by ilmenite and occasionally stained brown by limonite or green from nontronite. The residual clay derived from granodiorite and related intrusive rocks contains both halloysite and kaolinite, and the transported clay is predominantly kaolinitic. The latter two types of clay are very similar in physical appearance; both are white and both contain abundant quartz grains and mica flakes - but the residual clay retains a relict granitic texture and is not bedded. It is estimated that about 300,000 tons (dry) of clay containing more than 20 percent available alumina occurs in eastern Washington and northern Idaho. About 90 percent of this tonnage is in four major deposits in Latah County, Idaho: Bovill clay deposits, Olson high-alumina clay deposit, Canfield-Rogers clay deposits, and Benson clay deposit.

Huff, L. C., date unknown, Spokane, Greenacres, Medical Lake, Clayton, Deerpark, and Mt. Spokane quadranges: U.S. Geol. Survey Ground-Water Branch, Tacoma, unpublished maps, scale 1:62,500.

Huntting, M. T.; and others, 1961, Geologic map of Washington: Washington Div. Mines Geol., scale 1:500,000, 2 sheets.

Izett, G. A.; Wilcox, R. E.; Powers, H. A.; Desborough, G. A., 1970, The Bishop ash, a Pleistocene marker bed in the western United States: Quaternary Research, v. 1, p. 121-132.

1. Geological publication.
2. See title.
3. Eight localities from California to Nebraska.
4. Pleistocene Bishop ash, Green Mountain Reservoir ash, Pearlette-like ash in alluvial and lacustrine deposits.
5. Field observations and sampling; radiometric dating; petrographic and chemical analyses; stratigraphic correlation.
6. Confirmation of extent, age and stratigraphic relationship of Bishop and other ashes in western United States.
7. Sample localities map; generalized stratigraphic section showing relations of ash beds; summary of petrographic characteristics of ash beds of this report, table of electron microprobe and an analysis of glass from report.
8. Biotite-bearing chalky-white rhyolitic ash, here called the Bishop ash bed, occurs in middle Pleistocene alluvial and lacustrine deposits at eight localities scattered from California to Nebraska and is correlated with the basal air-fall lapilli of the Bishop Tuff, an ash flow of eastern California, radiometrically dated about 0.7 million years. Correlation of the Bishop ash bed with the air-fall lapilli is made on the basis of similar petrography and on chemistry as determined by electron microprobe, atomic absorption, and emission spectrographic analyses. At five localities the Bishop ash bed lies stratigraphically below a Pearlette-like ash. As more occurrences of the Bishop ash bed are found, it sould become an increasingly important dated stratigraphic marker relating middle Pleistocene deposits and events across several geomorphic provinces.

   Another biotite-bearing chaulk-white ash, here called the ash of Green Mountain Reservoir, occurs at three other localities and is distinguishable from the Bishop ash bed by small differences in chemical composition of the glass.

The ash of Green Mountain Reservoir is younger than the Bishop ash bed, as shown by the fact that at one locality it lies stratigraphically above the aforementioned bed of Pearlette-like ash.

Jenkins, O. P.; Cooper, H. H., 1922, Geological investigation of the Grand Coulee: Washington Dept. Conservation and Development, Div. Geology, Pullman, geol. map, scale 1:62,500.

1. Geological report (informal).
2. See title.
3. Grand Coulee area, north-central Washington.
4. Granite bedrock, basalt and sedimentary units.
5. Field study and mapping.
6. Description of topography, general geology, structure.
7. Photographs of area, geologic map of Grand Coulee.
8. Describes the geologic and geological units exposed in the Grand Coulee, including the granitic bedrock, overlying basalt and unconsolidated sedimentary cover. Gives brief discussion of major structural features in immediate vicinity of Coulee. Includes one geologic map of the coulee, showing geology in general terms, along with two cross sections.

Jenkins, O. P., 1924, Unconformity between the Ringold and Ellensburg Formations, Washington: Univ. of California Publications in Geological Sciences, v. 15, no. 2, p. 45-47, 1 fig., 1 plate.

1. University of California geological publication.
2. See title.
3. White Bluffs, Washington.
4. Ringold and Ellensburg Formations.
5. Field observations.
6. Observations of angular unconformity between Ringold and Ellensburg Formations.
7. Geologic cross-section from Gable Mountain to White Bluffs, Washington, showing relation between Ellensburg and Ringold Formations.
8. Exposure of angular unconformity between Ringold and Ellensburg Formations in White Bluffs of south-central Washington (500 foot dissected cliff). Ellensburg Formation is Miocene, Ringold Formation is possibly late Pliocene or early

Pleistocene. Lower shales and sandstones dip at a marked angle in northeast direction into bluffs. Ringold Formation overlies them in horizontal layers. Dip of lower beds conforms with general direction of dip of basalt beds on west side of river, indicating that, in the folding of the basalt, these sedimentary beds, which appear to overlie the lava, were folded with it. The anticline formed in basalt runs in general east-west direction, plunging eastward and bending south-east, forming the mountain range south of Priest Rapids, which breaks into isolated hills such as Gable Butte, Gable Mountain, etc. These hills are surrounded by extensive alluvial deposit formed by Columbia River and are composed of basaltic beds which form the north flank of the anticline, the axis of which probably passes through the alluvial area a few miles south of Hanford. Character of lower beds in White Bluffs differs from Ringold, in that former show more lacustrine nature, consisting of shales (diatomaceous), with local arching. Hanford quadrangle shows irregularity in topography of bluffs in this locality and a high terrace along which number of depressed contour lines are indicated. This bench is on older tilted sedimentary beds (Ellensburg). Terrace formed by differential erosion combined with some landsliding.

_____, 1925, Clastic dikes of eastern Washington and their geologic significance: Am. Jour. Sci., 5th series, v. 10, p. 234-246.

1. Geological publication.
2. See title.
3. Eastern Washington.
4. Clastic dikes in Touchet beds.
5. Field observations.
6. Origin, age, composition of clastic dikes.
7. Pictures of dikes.
8. Study of clastic dikes in alluvial deposits near Walla Walla, Washington. Presence of unconformity between limonitic clay dikes and overlying glacial drift, occurring in surface exposures above extensively oxidized lead ore chimneys in Electric Point Mine, shows oxidation of lead ore chimneys is pre-glacial in age. Geological significance is that at Pullman, a former sedimentary deposit, now eroded away, is indicated by the preservation of entrapped portion. In Touchet sand pit evidence

is preserved of former seismic disturbances of great magnitude. All clastic dikes are ramifying in form, having many branching arms. Shorter dikes die out at depth. Within some, a few nearly horizontal layers of cross-bedded structure were observed. Some show no apparent regular structural arrangement of the materials. In most, a banded form of sorted materials was found parallel to length of dike, following twisted waviness of dikes themselves. Materials derived from above or from wall rocks. Dikes represent filled fissures. Gravity had most to do with material getting into fissures in the presence of water. Banded character indicates material was forced into fissures under pressure although they may have been compressed after formation. It appears then that fissures are first formed, and fragmental material dropped, washed, or pressed into them from above, below or from the side. This takes place at surface in open fissures, under water in fissures on sea bed, and far below surface of Earth in consolidated rocks. Filling from below comes about by pressure - probably hydrostatic.

_____, 1925, Clastic dikes of southeastern Washington (abs.): Geol. Soc. America Bull., v. 36, no. 1, p. 202.

1. Geological abstract.
2. See title.
3. Southeastern Washington.
4. Post-glacial clastic dikes in Touchet beds.
5. Field observations.
6. Description, age, and possible origin of clastic dikes.
7. --
8. Many curious sand and dust dikes occur in southeastern Washington, especially in a region west of Walla Walla. Those near Touchet occupy fissures in loess deposits and in stream terraces of cross-bedded sands and gravels. The dikes are structurally arranged in layers which lie parallel to the walls of the fissures. Some of the dikes are as thin as paper, while others are several feet thick, and all have a tendency to branch. Their materials are of water-worn basaltic sand and volcanic glass dust. The fissures might have been formed by earthquakes and their subsequent filling undoubtedly came from above. Their age is postglacial.

Jones, F. O.; Deacon, R. J., 1966, Geology and tectonic history of the Hanford area and its relation to the geology and tectonic history of the state of Washington and the active seismic zones of western Washington and western Montana: Douglas United Nuclear, Inc., consultant agreement CA-00056, Spokane, Washington, 21 p.

Judson, Sheldon; Ritter, D. F., 1964, Rates of regional denudation in the United States: Jour. Geophys. Research, v. 69, no. 16, p. 3395-3401.

1. Geological publication.
2. See title.
3. Includes Columbia Basin.
4. Surface sediments.
5. Mathematic models of stream loads and surface denudation.
6. Measurements of stream sediment loads to calculate regional rates of land denudation.
7. Tables showing suspended sediment loads by individual stream basins including Columbia; estimates of annual chemical denudation; and rates of regional denudation; comparison between regional denudation rates reported in this study and others; relation by regions between detrital load and dissolved load.
8. Data, in large part collected since World War II, allow a recalculation of the rates of regional erosion in the United States. These data indicate a rate of denudation for the United States as a whole of 2.4 in./1000 years, or about twice that of older estimates. The most rapid rate, 6.5 in./1000 years, is recorded from the Colorado drainage. The slowest rate, 1.5 in./1000 years is found in the Columbia basin. Other drainage areas and their rates are the Pacific slopes, California, 3.6 in./1000 years; the western Gulf of Mexico, 2.1 in./1000 years; the Mississippi River watershed, 2.0 in./1000 years; the South Atlantic and the eastern Gulf of Mexico, 1.6 in./1000 years; and the North Atlantic, 1.9 in./1000 years.

Kaatz, M. R., 1959, Patterned ground in central Washington: A preliminary report: Northwest Sci., v. 33, no. 4, p. 145-146, illus.

1. Geological publication.
2. See title.
3. Central Washington (Manatash Ridge and portions of

Kittitas Valley and Yakima County).
4. Patterned ground in surficial sediments.
5. Field observations.
6. Description and mode of origin of patterned ground.
7. --
8. Intensive frost action during a periglacial climate has been more significant in the development of patterned ground in central Washington than formerly recognized. Water (running) has had some significance in shaping the patterned ground, as has polygonal jointing in basalt, especially in the initiation of the pattern of stone nets in some situations. These are of secondary importance when compared with frost action.

Keyes, C. R., 1935, Glacial origin of the Grand Coulee: Pan American Geologist, v. 63, no. 3, p. 189-202, 5 plates incl. geol. map, 1 figure geol. map.

Kittleman, L. R., 1973, Mineralogy, correlation, and grain-like distributions of Mazama tephra and other postglacial pyroclastic layers, Pacific Northwest: Geol. Soc. America Bull., v. 84, no. 9, p. 2957-2980.

1. Geological publication.
2. See title.
3. Pacific Northwest.
4. Mazama tephra and other unidentified tephras.
5. See title.
6. See title.
7. Selected radiocarbon ages reported for Mazama tephra; refractive indices for natural glass and artificial glass for Mazama tephra; median grain-size distribution diagrams.
8. Mazama air-fall tephra is a pumiceous pyroclastic deposit dispersed over almost a million square kilometers by an eruption about 7,000 years ago of ancient Mount Mazama, the precursor of Crater Lake caldera, Oregon. The tephra layer is valuable as a stratigraphic marker and for what it reveals about the production and dispersal of tephra.

   The tephra is characterized by its minerals, which include plagioclase (73.1 $\pm$ 1.2 percent), hypersthene (9.4 $\pm$ 0.5 percent), magnetite (10.2 $\pm$ 1.1 percent), hornblende (3.9 $\pm$ 0.4 percent), and clinopyroxiene (2.8 $\pm$ 0.3 percent). Mean refractive index of glass is 1.508 $\pm$ 0.001. Mineral abundances and refractive index are homogeneous, and over the region sampled the variances of

these properties are no greater than in a single fragment of pumice. Within about 300 km of Crater Lake, the abundance of discrete mineral grains increases, but the proportion of heavy minerals does not change with increasing distance.

Tephra at 14 localities can be correlated with Mazama tephra mineralogically. The localities are at Blue Mountains, Columbia Gorge, and China Hat Butte in Oregon; Curelom Cirque in Utah; and at archaeologic sites at Fort Rock Cave, Paisley Cave, Connley Cave. Three Sheep Rockshelter, Everyone, Hobo Cave, Wildcat Canyon, and Big Eddy in Oregon; and Nightfire Island in California.

Other tephra layers in the region studied contain assemblages of minerals similar to the Mazama assemblage, perhaps because all have sources among volcanoes of the Cascade Range. This makes discrimination difficult, and no layers could be definitively correlated or identified with a specific source.

Mazama tephra has heterogeneous size-frequency distributions that fit Rosin's distribution. Heterogeneity is caused by intermingling of coarse pumiceous fragments and finer crystalline grains; however, if grain size is expressed as terminal velocity, then frequency distributions are log-normal and homogeneous; grains of disparate size or density occur together because they a have equivalent terminal velocities. Phi median diameter varies curvilinearly with distance from Crater Lake, but the relation is not readily interpreted in terms of mechanism of deposition. Median terminal velocity, however, varies as $V_t^* = K_3 D^{-r}$, where V_t^* is median terminal velocity and D is distance. The parameters K_3 and r may characterize individual eruptions and facilitate understanding of the production and dispersal of air-fall tephra.

Knox, J. B.; Short, N. M., 1964, Diagnostic model using ash fall data to determine eruption characteristics and atmospheric conditions during a major volcanic event: Bull. Volcanologique, v. 27, p. 5-24.

Landes, H., 1930, Geology of the Columbia River. In Columbia River and minor tributaries: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, U.S. Dept War, v. 2, 1934, p. 1197-1198.

Large, Thomas, 1922, Glacial border of Spokane: Pan American Geologist, v. 38, p. 359-366.

_____, 1922, The glaciation of the Cordilleran region: Science, v. 56, p. 335-336.

1. Scientific journal.
2. See title.
3. Spokane, Washington area.
4. Glacial deposits and features.
5. Field observations.
6. Observations concerning glaciation of Spokane region.
7. --
8. Evidence of glaciation on basalt plateau about Spokane four or five hundred feet above the train of the valley glacier in Spokane Valley. The prairies occupying the plateau bore evidence, in form of erratic boulders, gravel, sand and clay to depths of 15 feet, of ground ice on the level tops of the plateau. Hangman Creek valley holds deposits 5 to 6 hundred feet deep. The Spokane Valley was completely dammed, impounding waters of entire Columbia drainage basin. In gap between Mica Peak and Moran Peak, south of Spokane, at 2,460 feet, two outlets for this body of water were found. Hangman Creek was obstructed also. This glaciation was followed by a period when stream erosion cleared valleys of Spokane River and Hangman Creek and eroded Spokane Valley 200 feet below present floor. Some evidence of glacier almost reaching Spokane from north by way of valley of Little Spokane River; evidence of three periods of glaciation here. Long time period has elapsed since cutting of great trench through Palouse soil. As yet eolian deposits have not covered bare rocks of its floor, though for eight miles between North Pine Creek and Hangman Creek there is no stream sufficient to account for removal of deposits.

_____, 1922, Glacial border of Spokane, Washington: Pan American Geologist, v. 38, no. 5, p. 359-366.

1. Geological publication.
2. See title.
3. Spokane, Washington.
4. Glacial deposits and landforms.
5. Field observations.
6. Description and explanation of glacial features around Spokane.

7. --
8. Discusses location of tills and various moraines in and around Spokane and speculates on the number of glacial epochs northeastern Washington has witnessed. Mentions Palouse Formation and its possible origin (sediments from lakes forming by spreading basalt damming streams). Discusses formation of Lake Spokane by ice sheet damming Spokane Valley, and the Mica outlet.

_____, 1924, Drainage changes in northeastern Washington and northern Idaho since extravasation of Columbia basalts: Pan American Geologist, v. 41, no. 4, p. 259-270, 4 plates.

1. Geological publication.
2. See title.
3. Eastern foothills of Cascade Mountains to Purcell Trench.
4. Stream sediments and Columbia River basalts as they record changes in stream patterns.
5. Field observations.
6. Evidence to support stream drainage changes.
7. Map of ancient and modern eastern Washington lakes.
8. Article deals with recent changes in the course of Columbia River and tributaries between eastern Cascades and Purcell Trench. Mainly discusses prehistoric Lake Clark and its drainage and reasons to account for disappearance of the lake.

_____, 1943, Confusion over glacial Lake Spokane: Science, v. 98, no. 2556, p. 560-561.

1. Geological publication.
2. See title.
3. Spokane region.
4. Palouse Formation, glacial deposits.
5. Field observations.
6. Evidence for glacial lake.
7. --
8. Evidence for glacial lake in Spokane River Valley (Lake Spokane) formed by ice dam made by lobe of Cordilleran ice sheet approaching Spokane from the north to 20 miles south of city. Eastern margin was marked by moraine. This lake collected all water from eastern British Columbia, western Montana and northern Idaho. Represented major interruption of drainage and its outlets through two channels at Mica, Washington, 12 miles southeast of Spokane. Lake level assumed 2,500 feet

at lowest level giving depth of 500 feet at Spokane. Mentions Bretz's Lake Latah formed by blockage by glacier of the Mica channels and Latah (Hangman) Creek near Spangle. Also mentions Hobbs' larger Lake Spokane. States case for Palouse Formation being older than the last glaciation and flood.

Laval, W. N., 1948, An investigation of the Ellensburg Formation: Univ. of Washington M.S. thesis, 52 p.

1. M.S. thesis.
2. See title.
3. Ellensburg-Yakima region (Mount Stuart and Ellensburg quadrangles).
4. Ellensburg Formation.
5. Channel samples collected throughout study area, then size graded and screened and viewed through petrographic microscope.
6. Field and petrographic studies to classify beds mapped as Ellensburg Formation in the Mount Stuart and Ellensburg quadrangles.
7. Geologic map of Ellensburg area and structure cross-sections.
8. Classification of Ellensburg Formation in Mt. Stuart and Ellensburg quadrangles into five separate stratigraphic units. Three units at Ellensburg: 1) upper beds deposited by Wilson Creek as alluvial fan; 2) cobble conglomerate; 3) pebble conglomerate. Latter two units deposited by Yakima River. All three units stratigraphically younger than typical Ellensburg exposed to north and south. In Naches-Wenas occurrences are two units regarded as most typical Ellensburg: 1) beds above Wenas basalt and 2) beds below Wenas basalt. Other occurrences in two quadrangles have been found to correspond to these units. Other units exist which can't be classified at this time: 1) beds on south end of mesa north of Ellensburg, which may correspond to one of the units at Ellensburg, 2) and 3) two interbasalt units on Taneum Creek, neither of which seem to correspond to the beds below the Wenas basalt, 4) the beds in the Cowiche Mountain-Ahtanum Ridge area which are petrographically dissimilar to the typical Ellensburg.

_____, 1956, Stratigraphy and structural geology of portions of south-central Washington: Univ. of Washington Ph.D. thesis, 208 p.

Ledbetter, M. T., 1977, Duration of volcanic eruptions: Evidence from deep-sea tephra layers (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1067.

1. Geological abstract.
2. See title.
3. Eastern Pacific.
4. Worzel ash.
5. Model developed to predict distribution of tephra particle sizes as function of duration of eruption and settling time of particles.
6. See title.
7. --
8. An instantaneous volcanic eruption produces a range of particles sizes which, in turn, are carried downwind and deposited on the sea surface. The differential settling times of these particles in the water column produces a size fractionation that creates a graded bed (fining upward) on the seafloor. A volcanic eruption of a few days or weeks produces a similar range of particle sizes, however, the style of grading is quite different. A model has been developed which predicts the distribution of particle sizes within the graded tephra deposit as a function of the duration of the eruption and the settling time of the particles. If we assume that the range of particle sizes remains constant during the eruption, then there is a zone of coarse particles near the base of the ash layers which results from the faster settling velocity of the largest particles. The top of this coarse zone should include the last large particle ejected at the end of the eruption and also much smaller particles which were ejected earlier but were overtaken while settling. The smallest particle deposited at the top of the coarse zone was ejected in the initial phase of eruption would still be settling. Since both the coarsest and finest particles arrived together at the seafloor, then the difference in settling time is a measure of the duration of the eruption.

   The model has been tested on an ash layer in two Trident deepsea cores from the eastern Pacific. The ash layer is correlated with the Worzel Ash (layer D). The mean duration of the volcanic event that resulted in the 8 cm ash layer in both cores is 21 days $\pm$ 5 days. The apparently long duration is consistent with the greater ash thickness relative to the observed ash thickness from historical eruptions.

Lemke, R. W.; Mudge, M. R.; Wilcox, Ray E.; Powers, H. A., 1975, Geologic setting of the Glacier Peak and Mazama ash-bed markers in west-central Montana: U.S. Geol. Survey Bull. 1395-H, 31 p.

Leverett, F., 1917, Glacial formations in the western United States (abs.): Geol. Soc. America Bull., v. 28, p. 143-144.

1. Geological abstract.
2. See title.
3. Western U.S. - excerpts from Puget Sound region, Washington, northeast Washington and Yakima Valley, Washington.
4. Glacial deposits.
5. Field observations.
6. Comparison of western glacial features with eastern.
7. --
8. In northeastern Washington, the occurrence of a very old drift, probably Kansas, was established by the discovery of till and striated stones on a high divide southwest of Spokane in the vicinity of Cheney. Boulders had been observed in this region and the possibility of glaciation had been suggested by M. R. Cambell in the Northern Pacific Guide Book. In Yakima Valley, the distribution of erratic boulders has been referred to floating ice by earlier students. It seems an open question, however, whether this region, like that near Spokane, may have been glaciated in early Pleistocene time.

   Discussion by G. F. Wright: The glacial accumulations near Spokane, so far from the recognized glacial area, are certainly of great significance. A similar isolated accumulation of glacial material has just been reported 40 or 50 miles south of generally recognized limits of Kansan drift. All this indicates that the "attenuated border" is much more attenuated than we have been accustomed to suppose. It is, however, well known that this attenuated border occasionally has large areas where glacial material is absent.

Livingston, E., 1977, Torrential deposits in southern B.C. and northern Washington (abs.): Geol. Assoc. Canada; Mineralogical Assoc. Canada; Soc. Econ. Geologists; Canadian Geophys. Union 1977 Annual Meeting, Abs. with Programs, v. 2, p. 33.

1. Geological abstract.
2. See title.
3. South British Columbia and northern Washington.
4. Torrential deposits.
5. Field observations.
6. Descriptions of torrential deposits.
7. --
8. Torrential deposits have been recognized in the Okanogan Valley between Okanogan Falls, B.C. and Brewster, Washington. Similar deposits are found intermittently along the Similkameen River Valley upstream from Keremeos, B.C.

   Typical torrential landforms such as boulder bars, streamlined mounds of gravel, giant ripple marks and scooped-out closed depressions are present. The torrential deposits in the Okanogan Valley are associated with rapid drainage of a large glacial lake extending from south of Okanogan Falls to the Shuswap and Kamloops areas. The source of torrential flow in the Similkameen is not clear. Rough calculations based on valley gradient and water depth indicate a very high rate of flow in the Okanogan Valley.

   The presence of the torrential deposits poses many questions about the glacial lake in the Okanogan area, particularly the location of the dam or dams at the south end, and how it was formed, and when it was drained.

Long, W. A., 1951, Glacial geology of Tieton Valley, south-central Washington: Northwest Sci., v. 25, no. 3, p. 142-148.

1. Geological publication.
2. See title.
3. See title.
4. Ice-contact deposits, landforms.
5. Field observations.
6. See title.
7. Map of Tieton Valley, south-central Washington.
8. The Tieton Valley, a tributary to the Naches Valley, which joins with lower Yakima Valley in south-central Washington, contains deposits of two late Pleistocene glaciations. The older glacier advanced down Tieton Valley and terminated 3 miles beyond the town of Rimrock. Weathering in the older till has resulted in a zone of oxidation extending through an average depth of 20 feet.

Erosion has almost completely destroyed the original glacial features of the moraines. The younger glacier reached one-fourth mile beyond Rimrock. Weathering has progressed to a depth of about 5 feet in the younger till, and the glacial topography of the moraines is almost entirely preserved.

_____, 1951, Glacial geology of the Wenatchee-Entiat area, Washington: Northwest Sci., v. 25, no. 1, p. 3-16.

1. Geological publication.
2. See title.
3. See title.
4. Glacial deposits and topography.
5. Field observations.
6. See title.
7. --
8. Valley glacial deposits in central and southern Chelan County, north-central Washington, suggest two successive late Pleistocene glaciations. The older, more extensive glaciers occupied the Wenatchee Valley and tributaries, the Entiat Valley, and the Wenatchee Mountains. The older glacial deposits are oxidized through an average depth of 20 feet and are partially blanketed by later deposits of sand and silt. They form prominent lateral moraines against Boundary Butte Ridge; elsewhere, the deposits are limited to materials rather than to topography. The younger glaciers occupied the same valleys as did their predecessors but were unable to advance as far. Their deposits are fresh, unaltered, and retain much moraine topography.

_____, W. A., 1968, High gravels of Wenatchee River below Leavenworth, Washington (abs.): Northwest Sci., v. 42, no. 1, p. 37-38.

1. Geological abstract.
2. See title.
3. Leavenworth, Washington to Cashmere, Washington.
4. Preglacial River gravels.
5. Field observation and mapping of river gravels and relationship to lower terrace gravels.
6. Same as above.
7. --
8. High, unconsolidated preglacial river gravels at two levels were observed and mapped on the

Wenatchee River between Leavenworth and Cashmere. The upper-level gravels cap high hills and flat ridge spurs 500-700 feet above the river; the lower-level gravels occur on benches at 200-250 feet. These high gravels are unrelated in weathering characteristics, areal extent, and altitude above the river to the Pleistocene terrace gravels, which at much lower levels border the river and are closely related to repeated valley glacier advances.

Long, W. A.; Porter, S. C., 1968, Revision of the alpine glacial sequence in the Leavenworth area, Washington (abs.): Geol. Soc. America Spec. Paper 115, p. 338, table.

Long, W. A., 1969, A preliminary report on the glaciation of the middle Entiat Mountains, Washington (abs.): Northwest Sci., v. 43, no. 1, p. 39.

1. Geological abstract.
2. See title.
3. Middle Entiat Mountains, Washington.
4. Glacial features and deposits.
5. Field observations of features indicative of extent and age of glaciation of middle Entiat Mountains, Washington.
6. Same as above.
7. --
8. The broad, rolling 5,000 to 6,500-foot high upland of the middle Entiat Mountains was occupied by a small Pleistocene ice cap with at least four outlet glaciers. Marble Creek and Mad River glaciers deposited well-defined end moraines; Tommy Creek and Three Creek glaciers joined a 34-mile-long valley glacier built on an end moraine on the Entiat River.

   The principal products of glaciation on the Entiat upland are well rounded rock bosses and widely scattered patches of smoothed and striated bedrock, whose spatial distribution confirms that an ice cap lay on its surface.

   One episode of glaciation is recognized; it is considered Wisconsin and predates Glacier Peak volcano pumice-ash which is widespread on the upland and is on all moraines.

Lowry, W. D.; Baldwin, E. M., 1952, Late Cenozoic geology of the lower Columbia River Valley, Oregon and Washington:

Geol. Soc. America Bull., v. 63, part 1, p. 1-24.

1. Geological publication.
2. See title.
3. See title.
4. Columbia River lavas, Quaternary deposits, Troutdale Formation.
5. Field observations and mapping of geology in the lower Columbia River Valley, Oregon and Washington, to resolve the relationship between some Cenozoic formations.
6. Same as above.
7. Locality map of lower Columbia River Valley; cross sections through lower Columbia River Valley and Columbia River basalt; correlation chart of late Cenozoic formations of lower Columbia River Valley.
8. The late Cenozoic formations in the lower Columbia River drainage basin constitute one of the best records of the terrestrial history of western North America. The main events within the Cascade Mountains and westward to the Pacific Ocean, which culminated in the Cascadian Revolution, are:
    1. Columbia River basaltic lavas were erupted from fissures during the middle Miocene upon a low-lying terrain of older Cenozoic sedimentary and volcanic rocks. Marine sediments of the Astoria Formation were deposited just prior to extrusion in what is now the seaward part of the valley. The flows interfinger with beds which in general overlie the marine members of the Astoria Formation.

    2. Limonite beds and associated clastic sediments were deposited in depressions locally developed on the lava plain.

    3. Additional lavas were extruded in the bog areas and perhaps on other parts of the lava plain.

    4. While the Columbia River basaltic terrain lay near sea level, the uppermost basalt was extensively laterized to ferruginous bauxite. The Columbia River had established essentially its present course at or near the margin of the lava plain, but erosion prior to deformation was of little consequence.
    5. Northerly trending open folds were produced in the basalt with those near the axis of the

Cascade Range showing the greatest effect of the compression. Contemporaneously, anticlinal highs were modified by erosion and the lower part of the Troutdale Formation was deposited in downwarps along the Columbia River while calated pyroclastics and flows herald the start of widespread Cascade volcanism. Basin lavas and pyroclastics were erupted from numberous vents including the major cones. All these events probably took place in the first half of the Pliocene.

6. Additional sediments were deposited as sea level rose in later Pliocene time. Most of the present valley areas were covered with fluviatile sediments and the rivers established their present courses on or from such fills. Most of the Cascade volcanic activity had apparently taken place before the Portland Hills silt member of the Troutdale was deposited in the late (?) Pliocene time.

7. Differential uplift began in late (?) Pliocene time and has continued to the present. The cutting of the Columbia River Gorge is the result of uplift which near the axis of the Cascade Range has been more than 2,500 feet. Uplift in the Coast Range has been somewhat less.

8. Downcutting by the Columbia River during the (?) early Wisconsin as a result of a eustatic lowering of sea level, amounted to approximately 600 feet. Deposition of the Portland gravels with their glacial erratics and contemporaneous sediments occurred with the ensuing rise in sea level.

9, Subsequent uplift in the Portland area has amounted to about 400 feet.

Lupher, R. L., 1940, Origin of clastic dikes in the Lewiston Basin, Washington and Idaho (abs.): Geol. Soc. America Bull., v. 51, no. 12, part 2, p. 2027.

1. Geological journal.
2. See title.
3. See title.
4. Clastic dikes in Pleistocene sediments and Columbia River basalt.

5. Field observations.
6. See title.
7. --
8. Numerous clastic dikes penetrating Pleistocene sediments have long been known in southeastern Washington. They occur also in the Lewiston region in gravels, sands, and silts related to glacial stages, and even in the basalt lavas beneath. The dikes are composed of clay, silt, sand, gravel, and basalt rubble. Dikes and enclosing deposit are rarely alike in grain size. Many dikes are of a multiple character, showing repeated opening and filling of small fissures. The dikes are almost invariably bounded by thin laminated clay layers representing the accumulation from muddy water. Many lines of evidence show that most fissures were filled from above. More than one process of filling is indicated, but most commonly running water dropped sediment into a water-filled fissure. The sediment accumulated upon the "foot-wall" of the fissure and, reaching the top of the upbuilding dike, it commonly assumed the angle of repose oblique to the fissure walls and produced stratification which reflected the fluctuations of current and materials in the running water above. Some dikes were filled with infalling material without the aid of running water.

   Strong evidence shows that the fissures are not the result of earthquakes. On the contrary, a very gentle opening process is required. Some fissures, particularly those that reach into the bedrocks, are related to slumping, but there is some evidence that settling resulting from the melting of buried ice may have been the most common origin.

_____, 1940, Pleistocene history of the Lewiston basin of Washington and Idaho (abs.): Geol. Soc. America Bull., v. 51, no. 12, part 2, p. 2027-2028.

1. Geological journal.
2. See title.
3. See title.
4. Columbia River basalt, Ringold Formation, Pleistocene stream sediments.
5. Field observations.
6. See title.
7. --

8. The Lewiston-Clarkston region reveals a sequence of Pleistocene events which has some bearing on the development of scablands and related features in central and southeastern Washington.

Camas Prairie is not far outside the definitely known area of Pleistocene Cordilleran glaciation, and a temporary influx of water across its northern rim might have been caused by an ice dam in the outlet of the neighboring Little Bitterroot Valley. Camas Prairie is also within the area flooded by an arm of glacial Lake Missoula, and the topographic relations of this basin are such that a rapid draining of the lake might have caused, for a brief time, a huge current to flow across it. Certain gravel deposits inside gulches along narrows in Clark Fork Valley nearby may be explained as bars formed by large rapid outflowing currents.

_____, 1944, Clastic dikes of the Columbia Basin region, Washington and Idaho: Geol. Soc. America Bull., v. 55, p. 1431-1462.

1. Geological publication.
2. See title.
3. See title.
4. Clastic dikes in lake and stream deposits.
5. Field observations.
6. Evidence for mode of origin, age, and composition of clastic dikes.
7. Sketches of clastic dike sections to illustrate structures and materials.
8. Pleistocene lake and stream deposits of southeast Washington and the adjacent portion of Idaho are cut by innumerable clastic dikes of an unusual kind. Dikes are most abundant in the Touchet beds and scabland deposits, a few are present in the earlier Clarkston deposits, and rarely, they enter the Columbia River basalt. The processes of formation were long-continued and concurrent with proglacial deposition. An analysis of the sedimentary environment indicates that ice played an important role in deposition of dike-bearing deposits.

Many dikes occur in compound units of several or many individuals lying parallel in the same major fissure; they were formed by repeated filling of growing fissures. Fissures were filled from

streams, lake currents, and waves, some collapsed from fissure walls or poured in from unconsolidated surficial deposits, a small amount was carried by underground currents, and films of clay and silt were spread upon fissure walls in several ways. Wind-borne sediments are indicated but not proven. Two or more processes generally operated together or alternately to fill each fissure; dike material, ranging from clay to fine gravel, may be sorted or unsorted, stratified or unstratified, and the stratification may be horizontal, inclined, or vertical. Any or all possible combinations or the variables may be present even in individual dikes.

Five processes of fissure development are recognized: (1) uneven settling and cracking through melting of buried ice, (2) gravity sliding and faulting on inclined zones of subsurface melting, (3) formation of cavities where ice blocks and layers melted, (4) erosion by underground streams, and (5) faulting and fissuring by landslides in the Columbia River basalts.

Lupher, R. L.; Warren, W. C., 1945, Clarkston stage of the northwest Pleistocene: Jour. Geology, v. 53, no. 5, p. 337-338.

1. Geological.
2. See title.
3. Lewiston Basin region on lower Snake River.
4. Stream gravels (Pleistocene).
5. Field observations, descriptions of gravels, mapping.
6. Description of the "Clarkston stage" in its type area.
7. Map of Lewiston Basin region.
8. An episode of proglacial aggradation, here named the "Clarkston stage," is recorded in the Lewiston Basin region on the lower Snake River. Stream gravels accumulated to a depth of more than 400 feet in the Snake River canyon and in the lower portions of most tributary canyons. One or two tributary streams were ponded by the fill of the main canyon. The deposits are characterized by considerable cementation, weathering of basalt and granitic stones, and iron oxide stain. Two-story canyons were formed by cessation of erosion beneath the fill, prolonged lowering of slopes above, and later excavation of the fill. The Clarkston stage followed earlier Pleistocene deposition, deformation, and dissection but antedated the Wisconsin stage.

Mackin, J. H., 1941, Mounded fans in the Columbia Plateau area, Washington (abs.): Northwest Sci., v. 15, no. 4, p. 80.

1. Geological abstract.
2. See title.
3. See title.
4. Mounded fans.
5. Field observations.
6. Same as No. 5. above.
7. ---
8. Alluvial fans along the sides of coulees in the Columbia Plateau exhibit two types of surface form, one type being the smooth radial slopes of the conventional fan, and the other being characterized by small hillocks or mounds on the fan surface. In general, large low-gradient fans tend to be smooth surfaced, and small high-gradient fans tend to be mounded, but there are intergradations, and both types of surface form may occur on different radial segments of the same fan. The mounds may attain a height of six feet, are generally elongate with the steeper end down the slope, and are made up largely of angular blocks of basalt.

   The following hypothesis for the origin of the mounds is offered: Small channels in the uplands become partly filled by slope wash and by mass movements of loessic **upland soils** during the long intervals between times when they carry running water. When runoff occurs, especially when thawing surface soils rest on frozen sub-soil, mud flows may originate both in the stream channels and on soil mantled slopes.

   The pasty mass, carrying with it angular blocks of basalt, moves out onto the fan and terminates as a steep-ended tongue of mud on the fan surface. The mud flow phase may or may not be followed by a phase of running water. Rain falling directly on the fan subsequently washes away the fine mud, leaving a mound of angular basalt blocks.

   Such mud flows, terminating on fans, are of very infrequent occurrences, but the mounds of basalt, once formed, are long lived. They may be destroyed only by burial or by the active cutting of a relatively large stream of water. For this reason they are common only on small fans which apex in valleys with restricted drainage area, and are rarely seen on the fans of larger upland streams.

_____, 1947, Diatomite deposits in eastern Washington (abs.): Northwest Sci., v. 21, no. 1, p. 33.

_____, 1961, A stratigraphic section in the Yakima Basalt and the Ellensburg Formation in south-central Washington: Washington Div. Mines and Geology Report Invest. 19, 45 p.

1. Geological publication.
2. See title.
3. See title.
4. See title.
5. Field observations; review of existing literature.
6. See title.
7. Columnar sections of lower part of Ellensburg Formation in Sentinal Gap - Priest Rapids area; stratigraphic sequences in lower part of Ellensburg Formation.
8. Purpose of paper is to formalize the nomenclature associated with stratigraphic units in the Columbia Plateau. The Ellensburg Formation consists of fluvial and lacustrine sediments from several different sources, and intercalated basalt flows. The stratigraphic contemporaneous complexity is increased by contemporaneous folding. Several sections are described and correlations made. Term Beverly member is redefined. Basalt flows in Ellensburg are described. The Selah member of the Ellensburg formation is designated and described. Problems of correlation are discussed. Changing patterns of sedimentation and erosion are discussed. States that Selah and Beverly members are correlative. Emphasizes effects of folding and spreading of detritus from the west on localization of drainage lines and erosional and depositional activities on rivers in south-central Washington during late Cenozoic subsidence of Columbia Plateau also considered.

Malde, H. E., 1965, Snake River Plain. In H.E. Wright, Jr.; D. G. Frey, Eds., The Quaternary of the United States: Princeton Univ. Press, Princeton, N. J., p. 255-263.

Markham, D. K., 1971, Quaternary loess deposits of Douglas County, central Washington: Univ. of Washington M.S. thesis, 23 p.

1. Geological student report.
2. See title.
3. See title.

4. See title.
5. Field methods; sampling of loess deposits and laboratory work with samples.
6. Same as No. 5. above
7. Geologic map of the Waterville Plateau region; idealized loess profile; isolines of average grain-size diameter.
8. Theory proposed that catabatic winds off the Okanogan ice lobe are responsible for loess deposits on the Waterville Plateau. The average grain size diminishes with distance from the Withrow moraine which marks the maximum extent of Pinedale glacial advance on the plateau. As ice front receded north of Columbia River, the Badger Mountains and the Columbia River Gorge inhibited the prevailing southwest winds from carrying alluvium onto the plateau; little additional loess has been deposited in the region. Pumice from Glacial Peak eruption is integrated with loess reflecting continuous animal and wind reworking. A buried B clay peak and associated caliche layer may be pre-Bull Lake remnants. Three hypotheses can be considered to explain the absence of loess unitl Pinedale time, as dated by the pumice incursion. Either 1) the loess was deposited but was flushed away by the Missoula floods, 2) the rate of deposition was very slow when the Okanogan lobe failed to cross the Columbia River, and sizeable amounts of loess were deposited only in the Pinedale, or 3) the caliche formed under different climatic conditions than the Palouse and thus is much younger than pre-Bull Lake.

McKnight, E. T., 1923, The White Bluffs Formation of the Columbia: Univ. of Washington B.S. thesis, 22 p.

1. Bachelor's thesis.
2. See title.
3. White Bluffs, Washington region.
4. White Bluffs (Ringold) Formation.
5. Field observations.
6. Stratigraphic and structure, extent, description, fossils, landsliding in, and age of the Ringold.
7. ---
8. A close examination of the White Bluffs, 2 miles north and 4 miles south of town of White Bluffs. White Bluffs have an elevation of 300-500 feet and extend along Columbia River 35-40 miles from 12 miles above Pasco to Wahluke. Ringold exposed widely to east and north of Saddle Mountains. The surface

extending several miles eastward from Hanford, is a plane 950 feet above sea level, a surface of aggradation. Ringold only occurs on east side of Columbia River. Sediments are soft, very fine grained sandy shale, somewhat coarser sands, shales, travertine, volcanic ash and coarse gravels. Lower part of section is shale, while upper part more sandy. Underlying shale is massive in detail though stratified in thick beds, light gray, fractured in all directions. Sandy shales at top well-stratified horizontally, block-jointed and creamy yellow. Wherever stratified and undisturbed, Ringold beds are horizontal. The high bluff is topped by travertine and provides the sharp rim of the bluff, protecting underlying sediments from erosion. Gravel beds are common along summit of bluff and were deposited by Columbia River. Gypsum occurs in lower shales. Mentions some landslides, the largest across the river from Hanford. Obtained numerous fish, shark, turtle, bird, mammal and fresh-water molluscan remains. Determined age to be approximately Pleistocene and fluviatile or lacustrine in origin.

McMacken, J. G., 1925, Lake Lewis due to flood waters of Spokane ice (abs.): Northwest Sci. Abstracts of Papers, p. 40.

Mehringer, P. J., Jr.; Blinman, E.; Petersen, K. L., 1977, Pollen influx and volcanic ash: Science, v. 198, no. 4314, p. 257-261.

1. Geological publication.
2. See title.
3. Pacific Northwest.
4. Volcanic ash.
5. Pollen influx (estimate of amount of pollen grains incorporated into sediments within a particular time and with a particular surface area.)
6. Pollen content of Mazama and Glacier Peak ashes to reveal depositional chronologies.
7. Figure showing pollen percentages and total pollen content of 8 Mazama ash samples.
8. Summary. Pollen influx can be used to estimate the duration of short-term depositional events. When applied to volcanic ashes, it may also provide information on the season and ecological effects of ashfall. In our initial application of the method to volcanic ashes from Lost Trail Pass, Bitterroot Mountains, Montana, we have illustrated that (i) two falls of Glacier Peak ash, which occurred about 11,250

C-14 years ago, were separated by 10 to 25 years; and (ii) volcanic ash from a major eruption of Mount Mazama (about 6700 C-14 years ago) first fell in the autumn and 4.6 centimeters of ash was deposited before the following spring. We also believe there is a reasonable probability that (i) about 1 centimeter of ash fell during the following year and about 1.7 centimeters fell the year after; (ii) in all, the sporadic primary Mazama ashfall lasted for nearly 3 years; (iii) Mazama ash resulted in low lake productivity, as measured by the occurrence of Botryococcus and Pediastrum; (iv) Mazama ash, perhaps through a mulching effect, may have produced increased vigor and pollen production in some sagebrush steppe genera; and (v) as measured by the records of fossil pollen and acid-resistant algae, effects on the acquatic and terrestrial ecosystems were short-lived. With refinement of the methods and broader geographic application, pollen influx studies may prove valuable for separating the regional and chronological details of tephra attributed to Mazama, Glacier Peak, and other Cascade Range volcanoes.

Meinig, D. W., 1950, Environment and settlement in the Palouse, 1868-1910; unpub. Master's thesis, Dept. of Geog., Univ. of Washington.

Meinzer, O. E., 1918, The glacial history of Columbia River in the Big Bend region (abs.): Washington Acad. Sci. Jour. v. 8, no. 12, 411-412.

1. Geological abstract.
2. See title.
3. See title.
4. Cataracts and other glacial features in Yakima Basalt.
5. Automobile reconnaissance.
6. See title.
7. ---
8. In Glacial epoch, a lobe of ice sheet was pushed down the valley of Okanogan River, and across Columbia River, diverting waters of Columbia over upland of central Washington, cutting precipitous gorges several hundred feet deep, developing 3 cataracts, formed a large lake in Quincy Valley, and carried boulders many miles and gouging out holes 200 feet deep.

Region underlain by Yakima basalt. Where the diverted water reached the monoclinal fold in basalt that causes the descent into Quincy Valley, they apparently formed a cataract which retreated about 17 miles, cutting through the basalt a gorge several hundred feet deep. As an agent of erosion, the Pleistocene Columbia had 2 great advantages over the Niagara: 1) It fluctuated much more and in heavy floods carried 3 times as much water as the maximum modern Niagara: 2) It was much better provided with tools for erosion than the Niagara, shown by large quantity and size of bounders in glacial outwash below mouth of gorge. At the mouth of the gorge the ancient river discharged in the early part of its history, into a lake which occupied Quincy Valley, as is indicated by the topography, by fossiliferous stratified deposits, by erratic glacial boulders of granite and quartzite which must have been carried to present positions by icebergs, and by 2 ancient water falls along the present gorge of Columbia River obviously caused by the overflow of the lake.

Merriman, J. C.; Buwalda, J. P., 1917, Age of strata referred to the Ellensburg Formation in the White Bluffs of the Columbia River: Calif. Univ. Dept. Geol. Sci. Bull., v. 10, no. 15, p. 255-256, plate 13.

1. Geological publication.
2. See title.
3. North Yakima, Washington and White Bluffs near Hanford and Ringold.
4. See title.
5. Collection of vertebrate remains from the formation, field observations of stratification section and physiography and structure.
6. Paleontological evidence to determine age of Ringold Formation and relation to Ellensburg Formation.
7. Estimated section of Ringold Formation in White Bluffs below Hanford.
8. Determination of age of Ellensburg Formation through vertebrate remains. The genus Hipparion (horse type) was found in the type area (Pleistocene) and from the White Bluffs area (Ringold). The genus Equus was represented (Pleistocene). Evolution stages of the horses belong to different periods of which White Bluffs stage (Ringold) is later. Ellensburg Formation is Miocene to early Pliocene; White Bluffs area (Ringold) is distinct and later stage in history of sedimentation of eastern Washington. The collection

of fossils included Megalonyx, Equus or Phliohippus, Camelid, Cervid, Leporid, Testudo and fish vertebrae. Includes description of Ringold Formation and proposes that name for it. Beds not sharply stratified, strata not indurated and exposures assume roundness and subdued topography. Strata lie parallel to Columbia River water surface and deformation is due to land sliding. Bluffs follow Columbia River 30 miles from 10 miles north of Pasco then northwestward and have elevation of 500 feet. Ringold Formation deposited in a basin bordered by Yakima Range on west, Saddle Mountains on north, and lava plateaus on east and south, by Columbia River in a flood plain environment. It covers an area up to 600 square miles. It is suggested that the Ringold unconformably overlies the Ellensburg Formation.

Merriman, J. C., 1934, Nature and extent of Tertiary Formations immediately following the Columbia lava flows of the Northwest (abs.): Science, new series, v. 80, no. 2085, p. 550-551.

1. Geological abstract.
2. See title.
3. Eastern Washington and Oregon.
4. Ellensburg Formation.
5. Field observations.
6. See title.
7. ---
8. In description of the series of formations in the John Day valley of eastern Oregon, published in 1901, the writer described under the name of the Mascall Formation a series of deposits in a depression formed by the down-folded Columbia lavas. It was noted that the dip of the lower Mascall is approximately the same as that of the lavas upon which it rests. Reference was made to the fact that the Ellensburg beds of central Washington are probably in part of the same age as the Mascall, and that a similar formation occurs in the Crooked River region to the south. There has been question as to the original extent of the Mascall and discussion of its possible extension over a considerable part of the Columbia lava region east of the Cascades in Oregon and Washington. The purpose of the present note is to call attention to the fact that as studies have been extended by geologists and paleontologists in eastern Oregon and Washington the number

of localities representing beds of the Mascall type has gradually increased. It is now important to have a study of the whole area with mapping of the beds of the Mascall stage and careful paleontological determination of the horizons. There is reason to believe that beds of the type of the Mascall may have existed over a considerable part of the Columbia lava region in the latter part of Miocene time. The present occurrences of Mascall may be due to post-Mascall depressions through which certain areas have been subject to relatively less intensive erosion, leaving relics of this formation to be covered in part by later accumulations.

Merrill, D. E., 1966, Glacial geology of the Chiwaukum Creek drainage basin and vicinity: Univ. of Washington M.S. thesis, 36 p.

1. M.S. thesis.
2. See title.
3. Central Cascades, Chiwaukum Creek drainage basin, northwest of Leavenworth.
4. Ice contract deposits and landforms and ice-scoured bedrock.
5. Field observations.
6. See title.
7. Hatchery Creek moraine system; correlation of glacial deposits of region; glacial geologic map; generalized bedrock map; glacier profiles.
8. Deposits of three distinct glacial advances are present in Chiwaukum Creek drainage basin, and a possible older advance is present in the surrounding area. The deposits can be differentiated on the basis of granite-weathering ratio 5, surface-boulder frequence, depth of oxidation, and the sharpness of their morphology.

   The oldest deposits, which are patches of ground moraine in the Wenatchee River valley, suggest that ice from the Wenatchee drainage once entered Tumwater Canyon. Ice from the Chiwaukum drainage probably coalesced with the Wenatchee glacier near the mouth of the Canyon. An end moraine, possibly associated with this advance, lies along the south fork of Hatchery Creek.

The next youngest ice advance left a series of well-preserved, sharp-crested morainal ridges in Hatchery Creek and an arcuate end moraine at the mouth of Chiwaukum Canyon. The only ice to reach Tumwater Canyon during this advance was the outlet glaciers draining an upland ice cap west of the Canyon.

Younger glacial deposits are present in the valley heads and probably are due to Neoglacial and pre-Hypsithermal advances. An inactive rock glacier in Chiwaukum Canyon probably is Neoglacial in age.

The glacial sequence of the Chiwaukum drainage is broadly comparable to those of the Ingalls - Peshastin Creek area and the Leavenworth area, where three major glacial episodes are recognized. The drainage pattern of the Chiwaukum Creek drainage basin is controlled primarily by foliation and a prominent joint set at nearly right angles to the foliation.

Michelson, J. C., 1954, Buried soil zones in the Palouse loess, eastern Washington (abs.): Geol. Soc. America Bull., v. 65, no. 12, pt. 2, p. 1345.

Mills, H. H., 1977, Textural characteristics of drift from some representative Cordilleran glaciers: Geol. Soc. America Bull., v. 88, no. 8, p. 1135-1143, illus.

1. Geological publication.
2. See title.
3. Cascade Range, northern Washington - Southern British Columbia.
4. Glacial drift.
5. Particle-size analysis.
6. See title.
7. Ranges of cumulative particle-size distributions of drift form various glaciers, ranges of graphic statistics for various grain-size samples.
8. Particle-size analyses of more than 300 samples of drift from Nisqually, Paradise, and South Cascade glaciers in the Cascade Range of Washington, from Athabasca Glacier in Alberta, Canada, and from other alpine glaciers show that textural differences exist

both between glaciers and between glacier subenvironments. Differences between glaciers probably reflect bedrock terrane and are shown by the percentage of silt + clay in the < -1.00 ø fraction, which increases in the following order: Nisqually and Paradise (volcanic bedrock), south Cascade (metamorphic and plutonic bedrock), and Athabasca (sedimentary bedrock). Differences between subenvironments are shown best by analyses of samples which include clasts as large as -6.67 ø; average frequency curves of these samples show that basal tills lack dominant modes in the coarse fraction and may have dominant modes in the fine fraction at about 4.00 ø, whereas sediments of other subenvironments possess dominant modes in the coarse fraction at or above about -5.00 ø. Mean size and sorting increase, and percentage of silt + clay decreases in the following order: basal till, recessional-moraine till, end-moraine till, ablation drift, and stratified drift. Skewness, but not kurtosis, also varies with subenvironment.

A comparison of alpine drift with continental ice-sheet drift from Ontario shows that, in general, alpine drift is coarser, but that alpine basal till is comparable to ice-sheet basal till. When comparing nonglacial diamictons to alpine drift, it may be possible to distinguish the former from the sediments of one glacier subenvironment but not from those of another.

Moodie, C. D.; Okazaki, R.; Smith, H. W.; Kittrick, J. A., 1966, A note on the clay mineralogy of four samples from the Ringold Formation: Northwest Sci., v. 40, no. 2, p. 43-45, table.

1. Geological publication.
2. See title.
3. Central Washington.
4. Ringold Formation.
5. X-ray diffraction of 4 samples of clay.
6. Same as No. 5. above.
7. Table showing clay minerals in size separates.
8. Four samples of horizons within the Ringold Formation to assay the clay mineral assemblage. Sample locations are described. Samples freed of organic matter and iron and size separated, then examined by X-ray diffraction. Minerals with 18A spacings recorded as

montmorillonite and 10A spacing as illite. Results are summarized in a table. The dominant presence of montmorillonite in the Ringold accounts for its use by the Bureau of Relcamation for lining canals.

Moody, U. L., 1976, Late Quaternary stratigraphy of the Lind Coulee and surrounding area: Northwest Scientific Assoc., Programs, Abs. p. 18.

_____, 1977, Correlation of flood deposits containing St. Helens Set S ashes and the stratigraphic position of St. Helens Set J and Glacier Peak ashes, central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1098.

1. Geological Society Meeting - Abstract.
2. See title.
3. Central Washington.
4. Volcanic ash.
5. Field realtionships and petrographic and chemical analyses.
6. See title.
7. ---
8. Volcanic ashes found in water laid deposits were studied from 12 sites in central Washington from Crescent Bar to Wallula Gap. The purpose of the study was to correlate flood associated sediments and establish a chronology for St. Helens set J and Glacier Peak ashes. Field relationships along with petrographic and chemical analyses were used for the correlations. Triple banded ash layers were found in fine clastic sediments and associated flood deposits in six sites north of the Saddle Mountains. Similar sediments to the south contain an ash couplet which corresponds to the upper and lower ashes of the triplet. These ashes appear to correlate with the upper and middle St. Helens set S. The presence of these ashes in gravels of the last major scabland flood indicates that the age of this flood was about 13,000 B. P. (Mullineaux and others, this symposium). One site on the Lind Coulee Wasteway contains 11 ash layers in floodplain deposits. The lower ashes correlate with a St. Helens J ash and the upper ashes correlate with Glacier Peak. Stratigraphically above this section there are floodplain sediments with another St. Helens

J ash dated at 8700 B. P. The Glacier Peak ashes were bracketed by two St. Helens set J ashes.

_____, 1978, The microstratigraphy and related geology of the Lind Coulee early man site and surrounding area, central Washington: Washington State Univ. Ph.D. thesis, (in press).

Mullineaux, D. R.; Gard, L. M.; Crandell, D. R., 1959, Continental sediments of Miocene age in Puget Sound Lowland, Washington: American Assoc. Petroleum Geologists Bull., v. 43, no. 3, pt. 1, p. 684-695.

Mullineaux, D. R., 1964, Extensive recent pumice lapilli and ash layers from Mt. St. Helens volcano, southern Washington (abs.): Geol. Soc. America Special Paper 76, p. 285.

1. Geological abstract.
2. See title.
3. See title.
4. See title.
5. Field observations and measurements.
6. See title.
7. ---
8. Three distinct layers of pumice from Mount St. Helens, separated by duff and lithic sand, extend generally northeastward from the volcano. Two of these layers, called layers Y and W by Crandell, Mullineaux, Miller, and Rubin in the Mount Rainier area, are about 3200 and 300 years old, respectively; these are the "older" and "younger" Mount St. Helens pumices of Carithers. The third layer, here called layer T, probably is the 1802 lapilli deposit described by Lawrence. Other pumices on Mount St. Helens apparently have relatively small areal extent.

   Layer T is 8 feet thick, locally, on Mount St. Helens; 25 miles northeast it is about 5 inches thick and contains lapilli 20 mm across. Layer W is 20 feet thick on the volcano; 25 miles northeast it is 12 inches thick, locally, and contains lapilli 8 mm across. Layer Y predates the modern volcano but is thick just north-northeast of it; 50 miles north-northeast it is 1.5 feet thick locally and contains lapilli 8 mm across.

   Each pumice can be distinguished by color or content and character of Fe-Mg phenocrysts. Most lumps of Y pumice have thin light-brown oxidation rinds, whereas the other pumices are white. In Y pumice light and

dark hornblende phenocrysts are abundant, and pyroxene is rare. Both W and T pumices contain abundant orthopyroxene and dark hornblende; however, orthopyroxene from W pumice has a higher refractive index than does orthopyroxene from T pumice, and T pumice contains clinopyroxene, but W pumice does not.

Mullineaux, D. R.; Hyde, J. H.; Rubin, Meyer, 1972, Preliminary assessment of upper Pleistocene and Holocene pumiceous tephra from Mount St. Helens, southern Washington (abs.): Geol. Soc. America Abs. with Programs, v. 4, no. 3, p. 204-205.

1. Geological Society Abstracts with Programs.
2. See title.
3. Pacific Northwest.
4. See title.
5. Chemical analyses, including prominent Fe-Mg minerals.
6. Division of St. Helens ash into 7 sets, each having characteristic suite of Fe-Mg minerals.
7. ---
8. Within the last 35,000 years, vents at the site of Mount St. Helens have erupted more than 40 voluminous pumice deposits. Most of these deposits can be grouped into 7 sets, each having a characteristic suite of Fe-Mg phenocrysts; cummingtonite in 3 sets appears to distinguish them from tephra derived from other Cascade volcanoes.

Set	Approximate age	Prominent Fe-Mg Minerals	Distribution
T---	150-200 years	hy, hb, augite	NE
W---	450	hypersthene(hy), hornblende(hb)	NE to S
P---	3,000-2,000	hy, hb	NE to E
Y---	4,000-3,000	cummingtonite(cm), hb	NE to SE
J---	<12,000,>8,000	hy, hb	NE to SE
S---	<18,000,>12,000	cm, hb	NE to E
Unnamed---	>35,000 -18,000	cm, hb, biotite	E to S

Each set except T includes several pumice beds. The unnamed set probably can be subdivided further. Pumice in set J is similar in composition to the "Glacier Peak" tephra about 12,000 years old. The most voluminous layers in set Y form a NE-trending lobe, a NNE-trending

lobe known at Mount Rainier and in Canada that is several hundred years younger, and a still younger ESE-trending lobe. Between sets P and T are many less-extensive layers of olivine-bearing scoria. Some of the pumiceous tephras could be valuable stratigraphic markers in the northwestern United States and adjacent parts of Canada.

Mullineaux, D. R., 1974, Pumice and other pyroclastic deposits in Mount Rainier National Park, Washington: U.S. Geol. Survey Bull. 1326, 83 p.

Mullineaux, D. R.; Hyde, J. H.; Rubin, Meyer, 1975, Widespread late glacial and postglacial tephra deposits from Mount St. Helens volcano, Washington: Jour. Res. U.S. Geol. Survey, v. 3, no. 3, p. 329-335.

1. Geological publication.
2. See title.
3. Pacific Northwest.
4. See title.
5. Descriptions of tephra sets S, J, Y, and W; discussion of use of tephra layers for dating a correlation; study of content of ferromagnesian minerals in Mt. St. Helens pumice; data on stratigraphy, description and age of 4 tephra sets.
6. Same as No. 5 above.
7. Table listing age and Fe-Mg phenocrysts content of tephra sets; diagrammatic section showing stratigraphic positions of some key C^{14} samples to determine tephra set ages; Columnar section of sets; minimum distribution inferred from known occurrences of layers Yb, Yn and Ye; columnar section of set Y, J, and W; minimum distribution of layers Wn and We.
8. Pumice layers composing four different groups of tephra beds (termed "sets"), whose stratigraphy, age, and trend away from Mount St. Helens are fairly well known, are potentially valuable stratigraphic markers in the northwestern United States and adjacent parts of Canada. All four tephra sets are less than about 18,000 years old. The oldest set described (set S) is between about 18,000 and 12,000 years old; the most extensive pumice layers of the set, however, probably are no more than about 13,000 years old. Relatively voluminous layers in the next younger tephra unit (set J) probably range from slightly less than 12,000 to slightly more than 8,000 years old; in the overlying set Y, the most extensive layers range from about 4,000 to 3,400 years old. The largest tephra layers in the youngest tephra set described, set W, are apparently all about 450 years old. All the extensive tephra deposits were carried

chiefly east of Mount St. Helens, and the bulk of them form an arc which extends from northeast of the volcano clockwise around to the southeast.

Mullineaux, D. R.; Wilcox, R. E.; Ebaugh, W. F.; Fryxell, R.; Rubin, M, 1977, Age of the last major scabland flood of eastern Washington, as inferred from associated ash beds of Mount St. Helens Set S (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1105.

1. Geological Society Meeting Abstracts.
2. See title.
3. See title.
4. Mount St. Helens tephra in fine-grained sediments.
5. C-14 dating; Fe-Mg mineral suites, chemical composition, refractive indices.
6. See title.
7. ---
8. Four groups of upper Pleistocene pumice layers from Mount St. Helens, called sets C (oldest), M, K, and S (youngest), are mineralogically similar to certain cummingtonite-bearing ash beds of the channeled scabland. The scabland ash beds occur as closely spaced "couplets" and "triplets" in fine-grained sediments associated with gravels of the last major scabland flood. Fe-Mg mineral suites and refractive indices and chemical compositions indicate that set S pumice layers are the near-source equivalents of "couplet" and "triplet" ash beds exposed near Vantage and Wanapum Dam along the western margin of the scabland. These data confirm earlier tentative correlations of set S with scabland ash beds by us and several other investigators.

   Near Mount St. Helens, set S is dated by radiocarbon as about 13,000 years old. Thus, the last major scabland flood is also about 13,000 years old, in contrast to most previous estimates of about 20,000 years or older. The younger age, however, is consistent with an age estimate of possibly 14,000 years for a scabland flood by H. H. Hammatt, L. L. Foley, and F. C. Leonhardy in 1976. It is also consistent with an age of less than 13,500 (?) years estimated for the last flood by R. B. Waitt, Jr., in 1977 from relations of flood and glacial deposits marginal to the scabland. In addition, an age of about 13,000 years for the last major scabland flood is supported by a radiocarbon date of 13,080 $\pm$ 350 years (W-3404) we obtained for peat that directly overlies the Portland

delta of J. H. Bretz, which is a downvalley deposit of that flood.

Newcomb, R. C., 1938, Cause of the asymmetrical profile of the typical Palouse Hill, Northwest Sci., v. 12, no. 4.

_____, 1958, Ringold formation of Pleistocene age in type locality, the White Bluffs, Washington: American Jour. Sci., v. 256, no. 5, p. 328-340; Washington Div. Mines and Geol. Reprint no. 1, p. 328-340, Figure 1, 1:1,013,760.

1. Geological publication.
2. See title.
3. See title.
4. See title.
5. Field observations and measurements; well-log analyses; general composition, origin, and stratigraphy of sediments.
6. Same as No. 5 above.
7. Map showing outcrop of Ringold formation in type area, several geologic sections.
8. The type section of the Ringold formation in the White Bluffs of the Columbia River consists of a stratigraphic thickness of about 620 feet of horizontally bedded continental sediments lying between river level and the tops of the bluffs, from about 340 to 960 feet in altitude. The beds are of middle to late Pleistocene age.

   The uppermost 505 feet of the type section, between 455 and 960 feet in altitude, is composed largely of lacustrine sand and silt. The lower part, extending upward from river level at 340 feet to the base of the lacustrine deposits, at 455 feet, is composed of a weakly indurated conglomerate number that was deposited by river currents. The conglomerate number extends also below river level, down to an altitude of about 290 feet. It is underlain by 100 to 290 feet of lacustrine silt, clay, and sand, and some gravel beds. This lower lacustrine composite, a part of the Ringold, is commonly called the "blue clays" section and lies, in turn, upon the basalt bedrock, whose surface is somewhat irregular but is near sea level in the central part of a broad syncline.

   The succession of lithologic types is believed to indicate two stages in the relative uplift of the drainage rim, the Horse Heaven Ridge, in a total amount of about 1,000 feet. The Horse Heaven Ridge is believed to have

been a part of the impounding rim. Its main uplift must have been more or less contemporaneous with the deposition of the lower part of the Ringold formation and must have preceded the deposition of the upper part in middle to late Pleistocene.

Newcomb, R. C., 1961, Age of the Palouse Formation in the Walla Walla and Umatilla River basins, Oregon and Washington: Northwest Sci., v. 35, no. 4, p. 122-127, illus.

1. Geological publication.
2. See title.
3. See title.
4. See title.
5. Field observations of sediments and their stratigraphic relationships and determination of ages.
6. Same as No. 5. above.
7. ---
8. The typical Palouse Formation of the Walla Walla Valley is considered by the author to be middle to late Pleistocene.

   The greatest deposition of the Palouse Formation closely followed, or accompanied, the deposition of the Ringold Formation and preceded the Wisconsin Glacial Stage. This dating agrees in general with the age findings of Culver (1937, p. 60), is slightly younger than the age assigned by Scheid (1940, p. 57), and narrows a broader time interval given by Bryan (1926, pp. 37 and 45).

   If younger eolian deposits that have been termed Palouse soil, especially those in the western parts of the Walla Walla and Umatilla River basins, are to be included in the Palouse Formation, the age would be middle Pleistocene to Recent.

   The evidence in these basins suggests that the whole Palouse soil problem would be clarified by restriction of the term "Palouse" to the pre-Wisconsin loess.

_____, 1962, Hydraulic injection of clastic dikes in the Touchet beds, Washington, Oregon, and Idaho (abs.): Geol. Soc. Oregon Country Geol. News Letter, v. 28, no. 10, p. 70.

1. Geological abstract.
2. See title.
3. See title.

4. See title.
5. Field observations.
6. See title.
7. ---
8. Dikes composed of silt, sand and gravel cut generally vertical, with great variety of size and spacing; in the Touchet beds, which are the lake-floor sediments of proglacial Lake Lewis. The Touchet beds occur in places widely distributed below 1,150 feet altitude in the Columbia River basin above Hood River. The dikes are the main part of those described by Lupher, whose basic observations are augmented by 6 groups of evidence bearing on the origin. 1) In plan, the dikes occur as large polygonal networks with distance across the cells ranging generally from 50 to 400 feet. 2) Dikes occur most profusely at places within the altitude zone 400-800 feet and are weak above 1,000 feet. 3) Dikes are most numerous where Touchet beds overlie highly permeable material. 4) The vertical section of a typical dike includes an irregular and an involved "root" part at the bottom, a central "trunk" part, and an uppermost 10 or 20 feet of branches that disperse and taper out. 5) Dikes cut all but uppermost 10 or 20 feet of the thickest sections of the Touchet beds. 6) Silt, laminae on the walls, are filter cake attesting to outward filtration of sedimentary-carrying fluids from each successive dike lamina. Clastic dikes resulted from upward injections of ground water, each caused by bank-storage effluent when pressure difference caused by lowering of Lake Lewis. Lowering occurred after a deterioration of impounding dam and might have been repeated. First lowering produced hydraulic lift and injection of water into equidimensional system of fractures. Later injections used mostly the established transverse dike planes and produced many laminae of dikes.

_____, 1971, Relation of the Ellensburg Formation to extensions of the Dalles Formation in the area of Arlington and Shutler Flat, north-central Oregon: Ore Bin, v. 33, no. 7, p. 133-142.

1. Geological publication - Oregon State Survey.
2. See title.
3. See title.
4. See title.

5,6. Field observations and mapping of region, including extension of Ellensburg Members to Shutler flat, basalt below the Selah Member, Dalles Formation as extended to this area; determinations of age of units.
7. Type stratigraphic columns in south-central Washington and north-central Oregon.
8. The top flows of the Yakima Basalt taper out southward into the Ellensburg Formation near Arlington much as they do westward in the Yakima Valley.

The extension of the Selah member, and possibly of the Rattlesnake Ridge member, for many miles beyond the end of its capping basalt flows, requires that large areas be mapped as Ellensburg Formation, a new experience for mappers in Oregon.

The relation of the lower part of the sedimentary facies of the "Dalles Formation extended" to the Rattlesnake Ridge member is not yet clear and the possibility that the two are in part contemporaneous has not been ruled out.

The Ellensburg Formation and the "Dalles Formation extended" comprise the materials that have been referred to in reconnaissance studies as "Arlington Lake Beds" and "Shutler Formation," terms that are no longer needed.

The discrepancies still exist between early Pleistocene age in the type area of the Dalles Formation and middle Pliocene age for the supposed correlative strata ("Dalles Formation extended") in the Arlington area.

Norgren, J. A.; Borchardt, G. A.; Harward, M. E., 1970, Mount St. Helens Y ash in northeastern Oregon and southcentral Washington (abs.): Northwest Sci., v. 44, no. 1, p. 66.

1. Scientific periodical.
2. See title.
3. See title.
4. See title.
5. Stratigraphy, mineralogy, and particle-size data, C-14 dating.
6. Information that ascribes ash deposit to an easterly extension of the "4" ash layer from Mount St. Helens.
7. ---
8. Stratigraphy, mineralogy, and particle-size data are

presented for a volcanic ash deposit which occurs in forest soils and bogs along a transect between Mount St. Helens and Enterprise, Wallowa Co., Oregon. The above information, plus a radiocarbon date of approximately 3,000 years B. P. leads to the conclusion that this deposit is a significant easterly extension of the "Y" ash layer previously described northeast of Mount St. Helens.

Okazaki, R.; Smith, H. W.; Gelkeson, R. A.; Franklin, J.; 1972, Correlation of West Blacktail ash with pyroclastic layer T from the 1800 A. D. eruption of Mount St. Helens: Northwest Sci., v. 46, no. 2, p. 77-89.

1. Geological publication.
2. See title.
3. Pacific Northwest.
4. See title.
5. Stratigraphic study of ash at sample localities and mineralogic analysis.
6. See title.
7. Soil monoliths with Mount St. Helens layer T and (D) with west Blacktail ash.
8. We recently described a thin, intermittent, but pedologically distinctive volcanic ash layer, the West Blacktail ash, that occurs in northern Idaho as well as in adjacent Washington and Montana (Smith and others, 1968). Later, while considering pyroclastic layers as general contributors to soils in the Pacific Northwest, we observed the mineralogical similarity between this ash and young ejecta from Mount St. Helens, called the lapilli deposit of 1800 A. D. by Lawrence (1954), but renamed layer T by Mullineaux (1964). In this paper we report (1) the occurrence of layer T in the Cascade Range in Washington, beyond the fallout area recognized during the field conference of INQUA in the Pacific Northwest (Schultz and Smith, 1965); (2) our current information on the distribution of West Blacktail ash; (3) some bases for correlating layer T and West Blacktail ash; and (4) relationships between these pyroclastic layers and soil horizonation.

   Fallout from the 1800 A.D. eruption of Mount St. Helens, in southwestern Washington, was traced 185 km toward the northeast. This pyroclastic layer T correlates in terms of age, particle size distribution, and mineralogy with the West Blacktail ash,

which occurs in northeastern Washington, northern Idaho, and northwestern Montana. There is a 160-km gap between the known areas of occurrence of these two layers. Recognition of the A2 horizons in Spodosols is enhanced by the presence of thin layers of these pyroclastic materials.

Olson, T. M., 1975, The geology and ground water resources of part of the Hangman and Marshall Creek drainage basins, Spokane County, Washington: Eastern Washington State College M.S. thesis, 70 p.

Page, B. M., 1939, Multiple alpine glaciation in the Leavenworth area, Washington: Jour. Geology, v. 47, p. 685-815.

Pardee, J. T., 1918, Geology and mineral deposits of the Colville Indian Reservation, Washington: U.S. Geol. Survey Bull. 677, 186 p.

_____, 1922, Glaciation in the Cordilleran region (Spokane area, Washington): Science, new ser., v. 56, p. 686-687.

1. Scientific journal.
2. See title.
3. See title.
4. Glacial depositional and erosional features.
5. Field observations.
6. Observations of occurrence of glacial drift in previously unknown areas west and southwest of Spokane.
7. ---
8. That during May and June, 1922, he found glacial drift including till with striated stones similar to that mentioned by Leverett at many other places on the Columbia Plateau west and southwest of Spokane. The writer expects to study the region further and to publish the results later on, but the information now at hand is sufficient to warrant the statement that during one or more comparatively early stages of the Pleistocene ice from the north advanced over the Columbia Plateau in a southwesterly direction far beyond what heretofore has been regarded as the southern limit of glaciation. The evidence at hand tends to show that the ice extended at least over large parts of Spokane, Lincoln and Adams counties, and less complete information suggests the possibility that the glaciation extended much farther.

Concerning the glacial drift, which by the way is not the only evidence the region affords that land ice was formerly present, the alternative ideas that it was brought to place by floating ice or running water have been considered and rejected. Large patches of the drift may be seen southwest of Cheney, west of Lantz, and in the neighborhoods of Winona, Lacrosse and Kahlotus, these occurrences being selected for mention at random and not because they are more typical than scores of others scattered throughout the region.

The writer wishes to point out that he does not herein attempt to correlate or otherwise define the relations between the glaciation described and the glaciation already known to have covered the plateau west of the Grand Coulee or an ice stream which, as shown by recent observations, traversed the coulee itself.

Pardee, J. T.; Bryan, K., 1925, Origin of fossiliferous Latah clays and associated basalts near Spokane (abs.): Pan-American Geologists, v. 43, no. 5, p. 369-370.

1. Geological publication abstract.
2. See title.
3. See title.
4. Latah clays and associated basalts.
5. Observations.
6. Historical geological account of the Spokane region from the pre-basalt flows to the present.
7. ---
8. Historical geology of the Spokane region from the rugged pre-basalt terrain, through the lava flows, glaciation to the present. Describes formation of Spokane falls and stream action that is returning the area to the pre-basalt surface. Casual mention of leaf-bearing shales.

_____, 1926, Geology of the Latah Formation in relation to the lavas of the Columbia Plateau near Spokane, Washington: U.S. Geol. Survey Prof. Paper 140-A p. 1-17.

1. Geological publication.
2. See title.
3. See title.
4. Latah Formation and Columbia River basalt.
5. Field observations.

6. See title; paleontological record of Latah Formation; stratigraphic descriptions of Latah Formation and pre-Latah surface.
7. Geologic cross section from Sunset Prairie to Manito Prairie, Washington and from Manito Prairie to ridge north of Little Spokane River.
8. The name Latah Formation is proposed for a series of beds consisting mostly of clay and shale and of fresh-water origin that are found near Spokane, Washington, and that contain an abundant middle or lower Miocene flora. The formation is found in Latah Creek valley for 10 miles south of Spokane, on tributaries of Little Spokane Valley for 8 miles northwest and 5 miles east of the city. It occurs also in at least one place in the broad, open valleys of the mountains near Coeur d'Alene, Idaho. These beds rest upon a rough surface of granitic and schistose rocks of unknown age, attain a maximum thickness of 1,500 feet, and are overlain by "rim rock" basalt flows, probably Miocene; "valley" flows, probably later Tertiary; and gravel of Pleistocene age. Sills and dikes, which represent some of the conduits through which the "rim rock" basalt rose to the surface, cut and to a small extent deform the Latah beds, which otherwise retain their original horizontal attitude.

   During Latah time the lava floods of the Columbia Plateau, advancing from the west, were held back from the Spokane area by a ridge, the highest parts of which now form the hills near Cheney, Marshall, and Medical Lake. The drainage outlet of this area was thus gradually obstructed by the lava, and the sediments here described were accumulated. Eventually the lava piled up until the "rim rock" flows were enabled to cross the protecting ridge and to overspread the area of Latah sediments.

   The "rim rock" flows consist of olivine basalt that shows very conspicuous columnar jointing. They are considered to be of Miocene age but are doubtless younger than the Yakima basalt. West of the submerged ridge they are apparently indistinguishable from the great series of flows that make up the Columbia Plateau.

After a time interval measured by the cutting of valleys through a "rim rock" basalt and to a known depth of 800 feet into the Latah Formation another series of basalt flows, referred to as "valley" flows, were extruded. These flows occupy parts of the erosional valleys and rest unconformably upon the Latah, exhibiting at the contact "pillow structure" and other characteristic features. They are distinguished from the "rim rock" flows largely by their topographic position, by a more varied jointing, and by the absence of olivine.

Pavish, Marie, 1973, Stratigraphy and chronology of Holocene alluvium between the Cascade crest and the Columbia River in central Washington: Univ. of Washington M.S. thesis, 38 p.

1. Master's thesis.
2. See title.
3. See title.
4. See title.
5. Field observations of Holocene alluvial deposits and tephra layers; lab analysis of alluvial sediments and buried soils.
6. Same as No. 5. above.
7. Particle-size distribution for Hansel Creek alluvial-fan sediments; stratigraphic sections; selected soil properties at Bock Spring Gully and Rye Grass Coulee.
8. Holocene alluvial deposits exposed in gully walls and cuts in alluvial fans have been examined in central Washington between the Cascade crest and the Columbia River. Mazama and St. Helens Y tephra provide chronologic control in some exposures. A sequence of depositional units, erosional surfaces, and buried soils were analyzed and evaluated in terms of existing climatic and hydrologic conditions. Inferences as to past climatic and hydrologic conditions were made on basis of evidence reflecting particular environmental conditions. Alternate hypotheses of cause of change in stream regimen are considered, including effects of human activity and various climatic and vegetational effects. Alluvial-fan sediments derived from areas undisturbed by man record a sequence of degradational and aggradational events similar to those inferred for the gullies. Consequently, man's activities may be ruled out as major stimulus to changes in stream regimen in this area. A dynamic relationship exists between hydrologic and climatic variables and the gradational history of a

stream reflects a response to changes in one or more variables.

Petrone, Anthony, 1970, The Moses Lake sand dunes: Washington State Univ. M.S. thesis, 89 p.

1. M.S. thesis.
2. See title.
3. See title.
4. See title.
5. Field observations, detailed descriptions of dunes; measurement of dunes and movement; effects of water table; comparison with other dunes; sieve analysis.
6. Same as No. 5. above.
7. Table of results of sieve analysis, graphs of frequency percentage curves and cumulative frequency curves of grain sizes in various dunes.
8. The Moses Lake sand dunes are located in the semi-arid Quincy Basin, central Washington. Most are concentrated south of Moses Lake. Barchans,transverse and parabolic dunes are found within the area. Modified and regular barchans are dominant types at leading edge of dune fields. West of these barchans, double barchans andtransverse dunes are most common. Further westward parabolic dunes are prevalent. Sieve analysis of dune sand near the Columbia River showed an average grain size of 2.02 Ø. Sand from a leading dune is 2.22 Ø. Sorting values show change in down-wind direction, with sands showing a decreasing sorting down-wind. A mineralogical change is realized with more heavy minerals in sands at the leading tongue. These observations provide evidence for two source area: the Columbia River sands and the sandy soil covering the Quincy Basin. Direction of dune movement is N64^{o} E. Actual distance travelled by each dune depends on its size and location within the dune field. With construction of O'Sullivan Dam and rising water table, movement of dunes has been reduced in some areas and totally halted in others.

Piper, C. V., 1905, The basalt mounds of the Columbia Lava: Science, new series, v. 21, p. 824-825.

1. Geological publication.
2. See title.
3. Columbia Plateau, Washington.
4. Basalt mounds.
5. Field observations.

6. Origin, composition, size and positions of basalt mounds.
7. ---
8. Examples of these mounds occur near Spangle, Medical Lake, Winona and generally on north walls on crests of all canyons hewn out by streams in the basalt. They average 4 feet in height and 10-20 feet in diameter. They occur only where there has been running water. Where they occur at crests of canyons, there is a single series; where they occur in beds of broad shallow streams there are acres of them, evenly scattered and close together. The soil in them is the same as surrounding basalt derived soil. They are the result of decaying basalt caps from which flowing water has previously worn the softer surrounding rock. The mounds on south walls are buried by fine soil, blown in by prevailing southwesterly winds, and therefore less discernible. The occurrence of mounds only on crests of canyons is due to greater effect of erosion on slopes.

Porter, S. C., 1965, Quaternary geology of the route between Yakima and Seattle via Ellensburg, In Int. Assoc. for Quat. Res., 7th Congress, Guidebook for Field Conf. J, Pacific Northwest: Nebraska Acad. Sciences, Lincoln, p. 34-50.

1. Field trip guidebook.
2. See title.
3. See title.
4. Quaternary sediments and landforms.
5. ---
6. ---
7. Axis of principal anticlinal ridges crossed by Yakima River; early Wisconsin glacial features in the vicinity of Lookout Mountain; late Wisconsin moraines and outwash trains near Cle Elum; end moraines and outwash trains beyond Keechelus and Kachess Lake; late Wisconsin glacial features near Snoqualmie Pass.
8. ---

Porter, S. C.; Denton, G. H., 1967, Chronology of neoglaciation in the North American Cordillera: Am. Jour. Sci., v. 265, p. 177-210.

1. Geological publication.
2. See title.
3. See title.
4. Ice-contact deposits, glacial landforms.

5. Geological, botanical and historical evidence and C-14 dates to reconstruct history of glacier fuluctuations in western North America.
6. Same as No. 5. above.
7. Generalized curve of glacier fluctuations during neoglaciation; many radiocarbon dates.
8. Geological, botanical, and historical evidence, together with critical radiocarbon dates, permit reconstruction of a reasonably comprehensive picture of glacier fluctuations in western North America during the last three millennia. These fluctuations largely postdate the Hypsithermal interval as defined by Deevey and Flint (1957), and fall within the cool geologic-climate unit widely referred to as Neoglaciation. Following recession and disappearance of many residual Wisconsin-age alpine glaciers during the warmest part of the Hypsithermal, resurgence of glacier activity led to a possible widespread early Neoglacial advance close to 4600 years ago and to a major advance that culminated 2600 to 2800 years ago throughout the Cordilleran region. A long period of milder climate followed, during which most glaciers probably diminished in size; dated moraines deposited during this interval are restricted to Alaskan coastal glaciers, and their regional significance is not yet known. Glaciers throughout western North America again experienced marked Neoglacial positions. Recession has been general and rapid since the early 20th century, although local minor readvance and related glacier growth in recent years reflect a response to somewhat cooler and wetter conditions in the 1940's and 1950's. Glaciers in other parts of the world show broadly similar histories, indicating probable world-wide synchrony of glacier fluctuations in response to climatic change.

Porter, S. C., 1969, Pleistocene geology of the east-central Cascade Range, Washington: Pacific Coast Friends of the Pleistocene 3rd Field Conference Guidebook, 54 p., September 27-28.

_____, 1975, Weathering rinds as a relative-age criterion: Application to subdivision of glacial deposits in the Cascade Range: Geology, v. 3, p. 101-104.

1. Geological publication.
2. See title.
3. See title.
4. Teanaway basalt.

5. Measurement of basalt weathering rinds.
6. Weathering rinds used to construct relative time-distance curves for Cascade glaciers.
7. Geologic map of upper Yakima River drainage basin showing boundaries of principal drift sheets and distribution of Teanaway basalt; relative time-distance curves for glaciers in upper Yakima River drainage basin based on weathering rind data.
8. The thickness of weathering rinds on surface and near-surface clasts of Teanaway Basalt from alpine drift sheets in the southeastern North Cascade Range varies systematically with age of deposit. The rinds, which can be measured to the nearest 0.1 mm, result from oxidation of mafic minerals and mineraloids. Rind thicknesses for outermost moraines of three principal Pleistocene drift sheets are 1.96 $\pm$ 0.24 mm, 1.10 $\pm$ 0.11 mm, and 0.71 $\pm$ 0.12 mm. Sample variance may result from differences in composition and texture of clasts, microclimatic differences at sample sites, and incorporation of previously weathered stones. Weathering rinds can be used to construct relative time-distance curves for Cascade glaciers, but becasue rate of rind formation appears to be nonlinear, the true age of drift sheets cannot be obtained unless the weathering rate is calibrated by radio-metric dating.

_____, 1976, Quaternary glaciation in the Washington Cascades (abs.). In Geomorphology of the Canadian Cordillera and its Bearing on Mineral Deposits: Geol. Assoc. Canada, Cordilleran Section Meeting, Vancouver, B. C., 1976, p. 29-30.

_____, 1976, Stratigraphy and distribution of tephra from Glacier Peak (of 12,000 years ago) in the northern Cascade Range, Washington: U.S. Geol. Survey Open-File Report 76-186, map and text on one sheet, February 1976.

1. Geological map and text on one sheet.
2. See title.
3. North-central Washington.
4. Glacier Peak tephra.
5. See title.
6. See title.
7. Map showing distribution, thickness and maximum size of tephra.

8. Glacier Peak is a dormant volcano that is situated immediately west of the crest of the Cascade Range about 100 km (62 miles) northeast of Seattle, Washington. Although the summit of Glacier Peak stands 3209 m (10,451 ft.) above sea level, well above the general height of the surrounding mountains, it is perched on a high bedrock ridge and the volcanic rocks of the peak are only a few thousand feet thick. The volcano is made up of lava flows with a predominantly pyroxene-dacite composition, all of which probably were extruded within the last 700,000 years (Tabor and Crowder, 1969, p. 24-28).

The most recent series of eruptions approximately 12,000 years ago (Fryxell, 1965, p. 1288), produced immense quantities of pumice that were blown far downwind from the volcano. Although the pumice, here referred to as tephra, is found west of the Cascade crest only in the immediate vicinity of Glacier Peak, it has been found east of the volcano at distances up to 1000 km (625 miles).

Carithers (1946), studied the tephra in the vicinity of Glacier Peak and found two layers in many places. Present studies indicate that the tephra deposits consist of at least seven distinct layers that can be distinguished in the field on the basis of particle size, thickness, and stratigraphic position. The tephra generally rests directly on late-glacial drift that lacks any discernible weathering profile. The seven informally designated layers are listed in Table 1.

One tephra unit, identified as layer G by major-element analysis, reaches southern Alberta (Westgate and others, 1970). Another layer (layer B), probably is the same as that found overlying late-glacial sediments of the Yellowstone basin (Richmond, 1965, p. 49).

Preliminary studies indicate that eruptions that produced layers B and C were of approximately equal volume, whereas the layer M eruption was of lesser volume. Isopleth maps depicting maximum particle size are presented for layers B and G. An isopach map has not been prepared for layer M because in most outcrops the layer showed evidence of substantial reworking.

The reader is referred to the list of additional readings for discussions of hazards which are associated with volcanic eruptions and which might result from future large-scale eruptions of Glacier Peak. The effects might include damage to or destruction of vegetation by deposition of tephra downwind from the volcano, passage of hot ash flows or lahars (volcanic mudflows), or both, down valleys heading at Glacier Peak, and contamination of streams and lakes by widespread erosion of pumice for many years after an eruption.

_____, 1976, Pleistocene glaciation in the southern part of the North Cascade Range, Washington: Geol. Soc. America Bull., v. 87, no. 1, p. 61-75.

1. Geological publication.
2. See title.
3. See title.
4. Ice contact deposits, landforms.
5. Drift sheets distinguished on basis of stratigraphic relationships, differences in morphology, weathering characteristics, and soil profile development.
6. Same as No. 5. above.
7. Glacial geologic map of upper Yakima drainage basin and south fork of Snoqualmie River; Quaternary glacial-stratigraphic, rock stratigraphic, and soil stratigraphic units of upper Yakima River drainage basin; principal terraces along Yakima River; long profiles of same terraces; size-frequency distribution and mean values of weathering rinds developed on basalt clasts in principal drift sheets; long profiles of Pleistocene glaciers between North Bend and Ellensburg; sub-surface stratigraphic section between Cle Elum Lake and Indian John Hill; profile data for post-Kittitas and post-Lakedale soils; time-distance curve of glacier fluctuations along transect across southern North Cascade Range during past 25,000 years.
8. Three major Pleistocene drift sheets preserved along a transect across the southern North Cascade Range are distinguished on the basis of stratigraphic relationships and differences in morphology, weathering characteristics, and soil-profile development. The two youngest drifts have been further subdivided into members representing second-order fluctuations of glacier termini. Deposits of former southeast-flowing valley glaciers in the upper Yakima River drainage

basin can be traced across a low divide at Snoqualmie Pass to the west-draining valley of the South Fork of the Snoqualmie River where alpine drift is interstratified with deposits of the Puget Lobe of the Cordilleran Ice Sheet. Preliminary paleomagnetic measurements indicate that the deeply weathered and extensively eroded oldest drift (Thorp) antedates the Brunhes-Mayuyama reversal (700,000 year). Relative-age criteria suggest that the time elapsed between deposition of Thorp drift and the intermediate drift (Kittitas) was substantially longer than that between the intermediate drift and the youngest drift (Lakedale). Soil developed on Kittitas Drift shows pronounced clay enrichment in the B horizon, in marked contrast to the weakly developed post-Lakedale soil, suggesting that the Kittitas ice advances antedate the last interglaciation of the global marine record and therefore are more than 120,000 years old. On the basis of reconstructed ice gradients, the next-to-youngest member (Domerie) of the Lakedale Drift is believed to correlate broadly with Vashon Drift that was deposited during the last major expansion of the Puget Lobe between 15,000 and 13,500 years ago. Two more-extensive, pre-Domerie advances of Lakedale glaciers (Bullfrog and Ronald) preceded the maximum stand of the Puget Lobe, as indicated by stratigraphic relationships and reconstructed glacier profiles. A late Lakedale readvance led to deposition of the Hyak Member prior to 11,050 years ago in valley heads draining high-altitude source areas.

_____, 1977, Present and past glaciation threshold in the Cascade Range, Washington, U.S.A.; Topographic and climatic controls, and paleoclimatic implication: Jour. Glaciology, v. 18, no. 78, p. 101-116.

1. Glaciology journal.
2. See title.
3. See title.
4. Glacial ice.
5. Field investigations concerning configuration of glaciation thresholds.
6. Same as No. 5. above.
7. ---
8. Isoglacihypses depicting the configuration of the glaciation threshold ("glaciation limit") in Washington, broadly parallel the crest of the Cascade Range and curve around the west and south flanks of the Olympic

Mountians. In both uplands the glaciation threshold rises inland (eastward) with a mean gradient of 10-12 m/km. However, the gradient in the Cascades is more variable (7-25 m/km) due to five east-trending troughs in the glaciation threshold surface that coincide with topographic depressions along the range crest and that apparently result from greater eastward penetration of moist maritime air.

Mean accumulation-season precipitation correlates strongly (r2 = 0.86) with altitude of the glaciation threshold with altitude of the July freezing isotherm, determined from the calculated July lapse rate within the mountains, is much weaker (r2 = 0.40). Multiple regression analysis relating independent climatic variables that affect the height of the glaciation threshold indicates that 90.4% of variance is explained by accumulation-season precipitation and estimated mean annual temperature at the glaciation threshold.

The glaciation threshold during the greatest ice advance of the last (Fraser) glaciation in the southern North Cascade Range (c. 18,000-22,000 years B.P.) was 900 $\pm$ 100 m below that of the present. Depression of the glaciation threshold by this amount most likely resulted from a change in accumulation-season precipitation of no more than 30% from present values and a decrease in mean ablation-season temperature of 5.5 $\pm$ 1.5 degrees.

_____, 1977, Relationship of Glacier Peak tephra eruptions to late-glacial events in the North Cascade Range, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1132.

1. Geological Society Meeting Abstracts.
2. See title.
3. See title.
4. Tephra.
5. Field relationship of tephra layers and C-14 dating.
6. Field observations to show relationship of tephra eruptions from Glacier Peak to late-glacial events in Northern Cascades.
7. ---
8. Nine layers of pumiceous tephra from Glacier Peak volcano mantle much of the eastern North Cascade Range. Three major layers, designated G (oldest), M, and B, are separated by thinner layers of pumiceous ash. Layer M forms a south-trending lobe

having an axis that lies close to the crest of the range, whereas layer G trends east and layer B southeast. Layer G rests directly on moraines and outwash deposited about 14,000 years ago by Cascade Valley glaciers; in some drainage basins the unit has been traced to within 1 or 2 km of valley heads. However, airfall tephra has not been found throughout most of the lower Methow Valley and part of the lower Okanogan valley, both of which lie within the inferred fallout zone of layer G. This relationship implies that glacier ice still covered those areas at the time of the first major Glacier Peak eruption.

Although layer M is found near the heads of east-draining valleys south of Glacier Peak, it apparently is lacking on the surface of late-glacial moraines of the Rat Creek advance near Stevens Pass, a locality that lies well within the fallout area of this unit. Radiocarbon dates indicate that layer M was deposited before about 11,250 years ago but after about 12,750 years ago. A minimum limiting date of 11,050 $\pm$ 200 years has been obtained for a moraine at Snoqualmie Pass that is correlated with moraines of the Rat Creek advance farther north. Therefore, the late-glacial advance of Cascade valley glaciers apparently was broadly in phase with the Sumas readvance of the Cordilleran Ice Sheet in the Fraser Lowland of British Columbia which Armstrong (1975) considers to have culminated between about 11,400 and 11,800 years ago.

Powers, H. A.; Wilcox, R. E., 1964, Volcanic ash from Mt. Mazama (Crater Lake) and from Glacier Peak: Science, v. 144, no. 3624, p. 1334-1336, illus., table.

1. Geological publication.
2. See title.
3. Pacific Northwest.
4. Mazama and Glacier Peak.
5. Detailed petrographic and chemical study from late and post-glacial deposits of region and parallel study of lump pumice from Cascade volcanoes.
6. Same as No. 5. above.
7. Table of refractive indices of constituents in Mazama and Glacier Peak pumices; table of chemical compositions of glass from typical pumice and ash.

8. New petrographic and chemical data indicate that the great Mount Mazama eruption at Crater Lake, Oregon, about 600 years ago was the source of most ash which has been called "Glacier Peak" and some ash called "Galata". Glacier Peak volcano in Washington was itself the source of an older ash deposit, perhaps very late glacial or early post-glacial in age.

Rahm, D. A., 1969, Post-Miocene erosion of basalt in southeastern Washington (abs.): Northwest Science, v. 43, no. 1, p. 42, (abs.). In Columbia River Basalt symposium 2d, 1969, p. 328, East Washington State Coll. Press, Cheney.

1. Geological Abstract.
2. See title.
3. Southeastern Washington.
4. Columbia River basalt.
5. Field observations.
6. See title.
7. ---
8. Field evidence from the Lewiston Monocline suggests stripping of basalt flows in a manner reminiscent of the Great Denudation of the Colorado Plateau. The rimrock flow above the Lewiston Basin can be traced into the stratigraphically lowest of a series of flatirons above which a section at least 940 feet thick projects into the air. The crest of the Blur Mountain Anticline to the south has been stripped of all but a few residual buttes and resistant dikes that persist as cockscomb ridges. The steptoes of Southeastern Washington appear therefore to be exhumed features.

Randle, K.; Goles, G. G.; Kittleman, L. R., 1971, Geochemical and petrological characterization of ash samples from Cascade Range volcanoes: Quat. Research, v. 1, p. 261-282.

Richardson, Donald, 1968, Glacier outburst floods in the Pacific Northwest: U.S. Geol. Survey Prof. Paper 600-D, p. 79-86.

1. U.S. Geol. Survey Professional Paper.
2. See title.
3. See title.
4. Floods and flood deposits.

5. Field observations.
6. See title.
7. ---
8. Glacier outburst floods, not uncommon in the Pacific Northwest in late summer or fall, are sometimes triggered by heavy rain but may occur even during a rainless period. Associated mudflows often compound the destruction downstream. Outburst floods are particularly hazardous at Mount Rainier, Washington, where debris flows are reported to occur at a rate of one in 3-10 years. Several floods witnessed at Mount Rainier were much larger than expected from direct storm runoff or release of water temporarily impounded by landslides. The principal source of those floods is believed to have been the large volumes of water that are stored at times within and beneath glaciers. At present there is no known way of predicting glacier outburst floods. Conceivably, their imminence might be indicated by measurements of englacial water pressure, and their potential size would be indicated by determinations of the volume of water stored in glaciers.

Richmond, G. M.; Fryxell, Roald; Neff, G. E.; Weis, P. L., 1965, The Cordilleran ice sheet of the Northern Rocky Mountains, and related Quaternary history of the Columbia Plateau. In Wright, H. E.; Frey, D. G., eds., The Quaternary of the United States: Princeton Univ. Press, Princeton, New Jersey, p. 231-242.

1. Book.
2. See title.
3. See title.
4. Quaternary ice-contact deposits and landforms.
5. Compilation of other work and author's own observations.
6. See title.
7. Map of Cordilleran Ice Sheet and related features in Northern Rocky Mountains and on Columbia Plateau; correlation table of deposits and events of the Cordilleran region and Columbia Plateau.
8. Nonglacial Quaternary deposits discussed in this report are on the Colorado Piedmont along the eastern flank of the mountains and in broad basins between high mountain ranges. Alluvium on pediments and in fill terraces, higher than 450 feet (135 m) above present stream level, is the most widespread material. Windblown sand and loess are locally downwind

from broad flood plains and areas of easily deflated bedrock.

The surficial material was deposited as the result of five processes, which in chronologic order are: (1) downward stream cutting, (2) sideward stream cutting, (3) alluviation, (4) wind erosion and deposition, and (5) soil formation. These processes make up a geomorphic cycle that is repeated because of the repetition of climatic cycles. Most of the alluvium in the basins is inferred to be nonglacial, but deposited during glaciations and interglaciations; only the terrace deposits along streams from glaciated areas are inferred to be partly outwash from glaciers.

The Colorado Piedmont contains 9 formations of alluvium; 4 were deposited when base level was stable long enough to permit pedimentation, and 5 were deposited as terrace fills when streams cut downward more than sideward. The pediment deposits are coarse-grained alluvium of pre-Wisconsin age, and are characterized by strongly developed soils. The terrace deposits are medium-grained alluvium of Wisconsin to Recent age, characterized by more weakly developed soils.

The intermontane basins also contain a sequence of early, gravel-covered pediments and late fill terraces. Erosion predominated over deposition in the valley floors of all except one basin.

Rigg, G. B.; Gould, H. R., 1957, Age of Glacier Peak eruption and chronology of post-glacial peat deposits in Washington and surrounding areas: Am. Jour. Sci., v. 255, no. 5, p. 341-363, illus.

Ringe, Don, no date, Geomorphology of the Palouse Hills, southeastern Washington: unpub. Master's thesis, Dept. of Geol., Washington State Univ.

_____, 1970, Sub-loess basalt topography in the Palouse Hills, southeastern Washington: Geol. Soc. America Bull., v. 81, p. 3049-3060.

Ringe, L. D., 1976, Glacial geology of the Waterville Plateau, north-central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 403.

1. Geological Abstract.
2. See title.
3. See title.
4. Glacial landforms and deposits.
5. Field observations.
6. See title.
7. ---
8. The Okanogan Lobe of the ice sheet which covered the Waterville Plateau, the northwestern corner of the Columbia Plateau, left an exceptional array of erosional and depositional features. These landforms remain well exposed because the semi-arid climate has curtailed erosion and limited vegetative cover. The end moraine, commonly known as the Withrow Moraine, has about 60 m of relief in some places. West of Moses Coulee the former terminus of the glacier is approximated by Dutch Henry Draw, a proglacial stream channel. Topographic lineations and glacial striae indicate that the main thread of flow crossed the Columbia River a few miles east of Bridgeport and then fanned over the plateau.

   North of the end moraine the Waterville Plateau is mostly covered by ground moraine. Drumlins are found in a few places, but the principle features are the stagnant ice landforms - kames, kettles, eskers, crevasse fillings - and the large basalt erratics locally called haystack rocks. While eskers are scattered over much of the area north of the end moraine, there is a considerable concentration in and around T27N-R27E. Most of the isolated hills, such as Barnes Butte, Ragged Butte, and Lone Butte are large kames. Multiple kame terraces occur along the Columbia River, especially on the east side of the channel between Wells Dam and Chelan. This area of the plateau also has the greatest concentration of haystack rocks. The terraces also indicate that the glacier extended some distance down the Columbia River channel south of Chelan.

Runner, J. J., 1921, Origin and history of Lake Chelan (abs.): Geol. Soc. America Bull., v. 32, p. 87-88.

Russell, I. C., 1897, A reconnaissance in southeastern Washington: U.S. Geol. Survey Water Supply Paper 4, 96 p.

_____, 1898, The great terraces of the Columbia and other topographic features in the neighborhood of Lake Chelan, Washington: American Geologist, v. 22, p. 362-369.

_____, 1900, A preliminary paper on the geology of the Cascade Mountains in northern Washington: U.S. Geol. Survey 20th Ann. Report. pt. 2, p. 83-210.

_____, 1901, Geology and water resources of Nez Perce County, Idaho: U.S. Geol. Survey Water-Supply Paper 53, p. 28.

Salisbury, R. D., 1901, Glacial work in the western mountains in 1901: Jour. Geology, v. 9, p. 718-731.

Saunders, E. J., 1915, Relation between the Tertiary sedimentaries and lavas in Kittitas County, Washington (abs.): Geol. Soc. America Bull., v. 26, p. 137.

1. Geological abstract.
2. See title.
3. See title.
4. See title.

5,6,7. ---

8. "Doctor Branner asked as to the occurrence of coal in relation to the formations described. Doctor Merriam asked if the base of the Keechelus were older than the Ellensburg basalt. Mr. Weaver suggested that the Keechelus may there represent part of the series, due to overlapping. In reply to question by Professor Lawson as to size of dikes, the author stated that they ranged from about 3 to 40 feet thick, and the space occupied by them may represent 10,000 to 20,000 feet. The mechanism by which this amount of space was made available was not clear. The dikes lie across the axes of the folds."

Schmauch, S.; Conyac, M., 1978, Mineral resources of the Snake River drainage, Washington and Oregon: U.S. Bureau of Mines Bull. ___, (in press).

Schmincke, H. U., 1964, Petrology, paleocurrents, Stratigraphy of the Ellensburg Formation, and interbedded Yakima Basalt flows, south-central Washington: The Johns Hopkins Univ., Ph.D. thesis, 426 p.

_____, 1964, Petrology, current directions, and history of the Upper Late Yakima Basalt flows and interbedded sediments, south-central Washington (abs.): Fourth Ann. Grad. Student Symposium in the Geol. Sci., Univ. California, Los Angeles, California, 1964, p. 14-15.

_____, 1967, Graded lahars in the type sections of the Ellensburg Foramiton, south-central Washington: Jour. Sed. Petrology, v. 37, no. 2, p. 438-448, illus., tables.

1. Geological publication.
2. See title.
3. See title.
4. See title.
5. Field observations and measurements; morphology and grain-size distribution studies; petrographic analyses; description of source, transport, and deposition of lahars.
6. Same as No. 5. above.
7. Map showing regional distribution of Ellensburg sediments; stratigraphic column of Ellensburg at type section; cross section through lahars; abundance of heavy minerals in different fractions.
8. The volcaniclastic Miocene-Pliocene Ellensburg Formation west of Yakima contains up to about 15 lahars. These are massive, sheet-like deposits with an average thickness of 2-5 m (6-15 feet). The lahars are characteristically graded, having a thin fine-grained (medium sand) basal layer which abruptly grades into a massive, coarse, poorly sorted central portion that may contain blocks up to 3 m (9 feet) in diameter. This part grades into a bedded or cross-bedded top zone (fine to medium-grained sand, partly pebbly) that may be transitional to horizontally bedded tuffs. Clay and siltsized fractions form less than 10 percent of all three zones. Heavy minerals, cheifly hornblende, hypersthene and magnetite are abundant in the 125-200 μ fraction and may constitute as much as 20 percent of the weight of this fraction. Most lahars are predominantly composed of fragments of a pink to light violet hypersthene-hornblende dacite. The lahars probably originated on the flanks of explosive volcanoes in an ancient Cascade chain at least 60 km (40 miles) to the west. They seem to have moved partly as inertia type flows which would explain the inverse grading: pebbles and blocks moved upward during transport, leaving a layer of medium sand at the base.

Shedd, Solon, 1923, Topography and geology of the Okanogan Highlands and Columbia Plateau of Washington (abs.): Geol. Soc. America Bull., v. 34, no. 1, p. 75.

1. Geological journal.
2. See title.
3. See title.
4. Surface features and geology of eastern Washington.
5. Field study.
6. See title.
7. ---
8. A general discussion of the surface features and geology of the eastern part of Washington. The Okanogan Highlands constitute a large area of metamorphic rocks, part of which was probably originally sedimentary and part igneous. The Columbia Plateau, as used in this paper, refers to that part of the great lava field, in the northwestern part of the United States, which lies within the State of Washington. The surface features of parts of this area are very interesting and are a result, partly at least, of the action of the wind.

_____, 1925, Geologic map of Pasco and Prosser quadrangles, Washington: Washington Dept. Conservation and Development, Div. of Geol., Bull., 32, Plate 1.

_____, 1926, Abstract of report on geology and resources of the Pasco and Prosser quadrangles: Washington Div. Geology Report Invest. 1, pl. 1, 1:125,000.

Sheppard, R., 1960, Petrology of the Simcoe Mountains area, Washington: John Hopkins Univ. Ph.D. thesis, 153 p.

Shumway, R. D., Geology of the Lime Hill area, Asotin County, Washington: Washington State Univ. M.S. thesis, 54 p., Figure 11, 1:15,600.

Smiley, C. J., 1963, The Ellensburg flora of Washington: Univ. of California Pub. in Geol. Sci., v. 35, no. 3, p. 159-276.

Smith, D. G. W.; Westgate, J. A.; Tomlinson, M. C., 1969, Characterization of pyroclastic units - a stratigraphic application of the microprobe, In Proceedings of the 4th National Conference on Electron Microprobe Analysis, Paper 34.

Smith, D. G. W.; Westgate, J. A., 1969, Electron probe technique for characterizing pyroclastic deposits: Earth and Planetary Sciences Letters, p. 313-319.

Smith, G. O., 1901, Geology and water resources of a portion of Yakima County, Washington: U.S. Geol. Survey Water Supply Paper 55, 68 p.

_____, 1903, Geologic folio of the Ellensburg quadrangle, Washington: U.S. Geol. Survey Geol. Folio 86, 7 p. 3 maps, scale 1:125,000.

_____, 1903, Contributions to the geology and physiography of central Washington: U.S. Geol. Survey Prof. Paper 19, p. 9-39.

Smith, H. W.; Okozaki, R.; Aavstad, J., 1968, Recent volcanic ash in soils of northeastern Washington and northern Idaho: Northwest Sci., v. 42, no. 4, p. 150-160.

Smith, H. W.; Okazaki, Rose; Knowles, C. L., 1975, Electron Microprobe analysis as a test of the correlation of West Blacktail ash from Mount St. Helens pyroclastic layer T: Northwest Sci., v. 49, no. 4, p. 209-215.

1. Geological publication.
2. See title.
3. Pacific Northwest.
4. See title.
5. Laboratory study.
6. See title.
7. Electron microprobe data for Ca, K, and Fe in a phase diagram.
8. Scanning electron micrographs illustrate the morphology of vesicular glass shards from the West Blacktail ash. These contrast sharply with shards having tubular voids. Electron microprobe analysis of the glass for content of Ca, K, and Fe shows no difference between this ash and Mount St. Helens pyroclastic layer T. The correlation of the two tephra layers is supported.

Smith, H. W.; Okazaki, Rose; Foley, L.; Knowles, C. R., 1977, Discrete tephra layers in the Holocene/Pleistocene loess of southeastern Washington (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1180.

1. Geological Society Meeting Abstracts.
2. See title.
3. See title.
4. See title.
5. Analyses of phenocryst suites, and morphology, refractive index and Ca: K: Fe proportions of glass shards.
6. All of above to characterize tephra samples taken from loess in study area.
7. ---
8. Phenocryst suite and such properties of glass shards as morphology, refractive index, and Ca: K: Fe proportions characterize the tephra samples collected from cut banks of loess. Each exposure used contains from one to six tephra layers. We correlate some samples with tephra already known in the Pacific Northwest: (1) from Mount St. Helens, tephra W-east, 450 yr. BP, and one or more parts of the "Unnamed" set, 37,600-18,000 yr. BP, and (2) from Mount Mazama (Crater Lake), 6600 yr. BP. We segregate samples older than the "Unnamed" set, but of unknown origin, into three groups. Only one phenocrystic sample represents the youngest of these groups. Hypersthene, augite, and magnetite are common (5-20%), and green hornblende is common to abundant (20-50%). Glass shards have a dominant index of 1.509-1.514, and a Ca:K ratio of 1.7. Seven samples in the middle group are phenocrystic, but variable. Hypersthene is common to abundant, green and brown hornblendes are abundant to sparce (1-5%), and magnetite is abundant to sparse. Some samples have sparce augite, ilmenite, and enstatite. Glass shards have a dominant refractive index of 1.502-1.512, and a variable but intermediate Ca:K ratio of 1.3-0.6. Three samples assigned to the oldest group are deficient in phenocrysts; hornblende, hypersthene, augite, and magnetite are sparse to rare (1%). Glass shards have a dominant refractive index of 1.500-1.508, and a distinctively low Ca:K ratio of 0.3.

Smith, H. W.; Okazaki, R.; Knowles, C. R., 1977, Electron microprobe analysis of glass shards from tephra assigned to Set W, Mount St. Helens, Washington: Quaternary Research, v. 7, no. 2, p. 207-217, illus.

1. Geological publication.
2. See title.
3. Pacific Northwest.
4. See title.
5. See title.
6. Extension of fallout area for Set W; stratigraphic and petrographic observations and chemical analysis.
7. Phase diagrams, chemical analysis tables.
8. We have extended the fallout areas for each of two members of tephra-set W, erupted from Mount St. Helens about 1500 AD by several hundred kilometers beyond the limits mapped in 1975. We traced one member (We) east into Idaho, and the other (Wn) northeast into British Columbia. After using stratigraphic and petrographic observations to assign more than 100 tephra samples to set W., we found 26 of these selected for chemical analysis, to be closely similar in content of Ca, Fe, and K in glass shards. But improved homogeneity was evident when the 26 sampling localities for tephra W were segregated geographically, east vs. northeast of the volcano. When Ca: Fe: K proportions were plotted on a ternary diagram, there was no overlap of the plotting areas for these two groups of tephra W samples. Without such data, tephra layers We and Wn are currently separable only from stratigraphic and geographic information. Partial glass analysis is also an aid, along with stratigraphic position and petrographic characteristics, in distinguishing tephra W from associated tephra layers. These include tephra layers T and Yn from Mount St. Helens, as well as older tephra layers from Mount Mazama and Glacier Peak.

_____, 1977, Electron microprobe data for tephra attributed to Glacier Peak, Washington: Quaternary Research v. 7, no. 2, p. 197-206.

1. Geological publication.
2. See title.
3. Pacific Northwest.
4. Glacier Peak Volcanic ash.
5. Electron Microprobe analysis.
6. See title.
7. ---
8. Reference samples of three prominent pumice units of Glacier Peak tephra collected east of the volcano within a distance of 100 km are similar petrographically to units described by earlier workers. Glass shards isolated from these samples were analyzed by electron microprobe to determine the content of Ca, Fe, and K.

Resulting data, plus those published for two other references samples, provide a basis for attributing certain outlying tephra layers from 14 locations in eastern Washington, Idaho, Wyoming, and Montana to eruptions of Glacier Peak. Ten of the samples have properties of both Glacier Peak tephra and Mount St. Helens set J tephra, but proportions of Ca: Fe: K in glass shards indicate that 9 of the 10 outlying samples came from Glacier Peak, whereas one is assigned to Mount St. Helens set J. The remaining six outlying samples, all from southeastern Washington, contain cummingtonite phenocrysts and are chemically similar to some parts of Mount St. Helens tephra sets that are older than 12,000 BP.

Sorem, R. K., 1963, Central Washington field trip led by A. C. Waters: The XI Transactions of Sigma Gamma Epsilon, XI Chapter, Washington State Univ., v. 1, no. 1, p. 7-8.

Staatz, M. H.; Morris, R. H., 1976, Resume of the regional geology of the Grand Coulee area, Washington: U.S. Geol. Survey Open-File Report 76-782, 34 p. 4 figures.

Steen, V. C.; Fryxell, R., 1965, Mazama and Glacier Peak pumice glass: Uniformity of refractive index after weathering: Science, v. 150, p. 878-880.

1. Scientific journal.
2. See title.
3. Pacific Northwest.
4. Volcanic ash - Mt. Mazama and Glacier Peak.
5. Laboratory methods to determine effects of weathering on refractive indicies of volcanic glass.
6. Same as No. 5 above.
7. Refractive index ranges of values chart.
8. Weathering has had little differential effect on modal values of the index of refraction of pumice glasses from the eruptions of Mount Mazama and Glacier Peak thousands of years ago. Confidence is thus increased that the ranges of values for the index of refraction are reliable characteristics by which the two glasses may be distinguished from one another.

Steen, V. C., 1965, Effects of weathering environment on the refractive index of pumice glass from Glacier Peak, Washington, and Mount Mazama (Crater Lake), Oregon: Washington State Univ. M.S. thesis, 147 p.

1. M.S. thesis.
2. See title.
3. Glacier Peak, Washington, Mt. Mazama, Oregon.
4. Pleistocene and Recent units.
5. Laboratory investigations and field observations.
6. Sources of volcanic ejecta, weathering of volcanic glass and soil formation, relationship of weathering to refractive index of glass, laboratory methods.
7. ---
8. Petrographic examination of pumice glass shows Mt. Mazama and Glacier Peak glasses have different values of modal refractive index (modal refractive index of physically cleaned Glacier Peak samples = 1.501 (+) - 1.504: for Mazama = 1.510 - 1.512). No gross correlation was found between refractive index of clean shards of Glacier Peak and Mazama glass and weathering environment although significant variation in modal n (range of refractive index) occurs between major soil horizons at one sample site. Concluded that refractive index of Glacier Peak and Mt. Mazama pumice glass collected from the B and C soil horizons is little affected by topography, climate and vegetation at the collecting site, and that coarse (1 mm (+)) pumice from the two eruptions can be distinguished solely by refractive index of the pumice glass. Found that the A2 soil horizon was unreliable for use.

Steen-McIntyre, V., 1975, Hydration and superhydration of tephra glass-A potential tool for estimating age of Holocene and Pleistocene ash beds. In Quaternary Studies: Suggate, R. P., and Cresswell, M. M., eds., The Royal Society of New Zealand, Wellington, p. 271-278.

Sternberg, C. H., 1881, The Quaternary of Washington Territory: Kansan City Review of Science, 601-602.

Stevenson, R. E., 1942, Petrology of the Ringold in the Palouse area: Washington State College M.S. thesis, 43 p.

1. M.S. thesis.
2. See title.
3. East-central Washington.
4. Ringold formation.
5. Field and laboratory work consisted of systematic collection and examination of Ringold samples from the Palouse region; mineral analysis.

6. See title.
7. Several stratigraphic sections; map showing mineral contours of andesine in Palouse area.
8. There is an eroded sedimentary mantle overlying the Columbia basalts in east-central Washington. This mantle appears largely unstratified; however stratification has been found at several localities, although not occurring in the same manner as Treasher found them. These shaly and laminated deposits are not widespread and in most instances are characterized by a higher percentage of clay than the other localities. The "caliche" layers are local accumulations of calcium carbonate. Lithologically, the Ringold in the Palouse area is a clay-silt (average grain size approximately 0.014 mm.) consisting of unweathered, slightly rounded crystalline fragments of hornblende, hypersthene and some plagioclase, rounded grains of quartz and orthoclase, and mica flakes imbedded in a matrix of brown clay minerals. A comparison of the Ringold with Middle Western and Chinese loess shows that it has a higher percentage of clay and smaller percentage of silt. A much weathered boulder and several weathered pebbles were found imbedded in unstratified Ringold at one locality. Such indefinite results were obtained in the examination of the mineral contour maps with one exception, the andesine map, that one could only guess from what direction the material had come. It seems probable that in the case of the others, it seems that the material was brought from all directions.

Stewart, C. A., 1922, The geological history of eastern Washington: Washington State College B.S. thesis, 94 p.

Strand, J. R.; Hough, Jean, 1952, Age of the Ringold Formation: Northwest Sci., v. 26, p. 152-154.

1. Geological publication.
2. See title.
3. White Bluffs north of Pasco, Washington.
4. See title.
5. Fossil collection and identification to set age of Ringold at middle or late Pleistocene.
6. Same as No. 5 above.
7. ---
8. Condensed account of fossil collections and identifications that confirm a Pleistocene age for these deposits.

Formation is 490' high. Lower 90 feet are iron-stained pebble and conglomerate with few sand lenses and is resistant to erosion; above this is clay, sand, sandstone, siltstone, with thin beds of ash, diatomite, gravel; uppermost part is thick caliche zone in a sandy siltstone, fossils described: caribou found at top of conglomerate; camel in thin gravel bed higher in formation; others in siltstone beds, found a ground sloth, peccary and mastadon also, fossil identifications and descriptions included, as well as locations.

Suppe, John; Powell, Christine; Berry, Robert, 1975, Regional topography, seismicity, Quaternary volcanism, and the present-day tectonics of the western United States: Am. Jour. Sci., v. 275-A, p. 397-436.

Swanson, D. A., 1964, 1964, Graded subaerial and subaqueous pyroclastic flows, Bethel Ridge, south-central Washington (abs.): Fourth Annual Graduate Student Symposium in the Geological Sciences, Univ. California, Los Angeles, Program, p. 15-16.

Swanson, D. A.; and others, 1977, Reconnaissance geologic map of the Columbia River Basalt Group, Pullman and Walla Walla quadrangles, southeast Washington and adjacent Idaho: U.S. Geol. Survey Open-File Report 77-100, map scale 1:250,000, 11 p., 2 plates.

Tabor, W.; Waitt, R. B., Jr.; Frizzell, V. A., Jr.; Swanson, D. A.; Byerly, G. R., 1977, Preliminary geologic map of the Wenatchee 1:100,000 quadrangle, Washington: U.S. Geol. Survey Open-File Report 77-53, 24 p., 1 plate, 4 figures.

Theisen, A. A.; Harward, M. E.; Schmitt, R. A., 1968, Neutron activation for distinguishing Cascade Range pyroclastics; Science, v. 161, p. 1009-1011.

1. Scientific journal.
2. See title.
3. Pacific Northwest.
4. Volcanic ash.
5. Neutron activation.
6. See title.
7. Chemical composition tables.
8. Neutron activation of glassy separates of volcanic ash resulted in 21 nuclides measurable with instrumental techniques. The relative activities of most of the nuclides distinguish samples from Mount Mazama, Newberry Crater, and Glacier Peak. The usefulness of

the technique was assessed by comparing the values for known sources with those from fine ash of uncertain origin. The data strongly suggest Mount Mazama as the source.

Thomson, J. P., 1935, Palouse topography and its relation to stream history: Northwest Sci., v. 9, no. 8, p. 16-17.

_____, 1936, Some relationships between the soil canyons of certain southeastern Washington valleys and summer-fallow cultivation: Northwest Sci., v. 10, no. 1, p. 8-11.

Treasher, R. C., 1924, Geologic record of eastern Washington to accompany a geologic map of eastern Washington: Washington State College B.S. thesis, 26 p.

_____, 1925, Geology of the Pullman quadrangle, Washington: Washington State College M.S. thesis, 74 p. Plate 1, 1:125,000.

Trimble, D. E., 1954, Geology of the Haas quadrangle, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-43, 1:62,500.

_____, 1957, Geology of the Portland quadrangle, Oregon-Washington: U.S. Geol. Survey Geol. Quad. Map GQ-104, 1:62,500.

_____, 1963, Geology of Portland, Oregon and adjacent areas: U.S. Geol. Survey Bull. 1119, 119 p. Plate 1, 1:62,500.

Tucker, Glennda, 1977, Morphologic parameters of Mount Mazama and Glacier Peak tephras: a scanning electron microscope study: Univ. of Washington M.S. thesis, 108 p.

1. M.S. thesis.
2. See title.
3. Pacific Northwest.
4. Mt. Mazama and Glacier Peak tephras.
5. Scanning electron microscope investigation.
6. Attempt to characterize and distinguish between two tephras.
7. ---
8. Samples of tephra from Mount Mazama (Crater Lake, Oregon) and Glacier Peak, Washington were studied using a scanning electron microscope (SEM) to measure and compare the following morphological parameters: vesicle maximum diameter; vesicle minimum diameter;

vesicle length; wall thickness, and vesicle density. Sample means ($\bar{X}$) from 27 different localities exhibit considerable variations for both tephra suites. At one standard deviation, the vesicle parameter values for the two source volcanoes overlap. Consequently, tephra morphology, by itself, does not appear to constitute a reliable criterion for distinguishing between the two tephras. No obvious relationship was found between distance of transport and any of the five morphological parameters investigated. However, the SEM does provide a rapid and reliable method for characterizing vesicle morphology of tephra units.

Tullis, E. L., 1944, Contributions to the geology of Latah County, Idaho: Geol. Soc. America Bull., v. 55, p. 131-164.

Twiss, S. N., 1933, Stratigraphy of the Saddle Mountains, Washington: Washington State College M.S. thesis, 36 p. Plate 1, 1:62,500.

U.S. Dept. of War, 1934, Columbia River and minor tributaries - letter from the Secretary of War, v. 2: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, 1845 p.

1. U.S. Congressional Document.
2. See title.
3. See title.
4. ---
5. Field reconnaissance.
6. Extensive study of Columbia River and tributaries on the general geology (pre-Cambrian-Recent), climate, topography, soils, stream flow, population, transportation, industry, power, irrigation of the area, and papers on proposed dam sites investigating the geology at the sites.
7. Various maps, tables.
8. ---

U.S. Geological Survey, 1966, Spokane and vicinity, Washington, 1950-63: U.S. Geol. Survey, 1 sheet, 1:24,000.

Vallier, T. L.; Hooper, P. R., 1976, Geologic guide to Hells Canyon, Snake River: Geol. Soc. America, Cordilleran Section, Field Guide no. 5, 38 p.

Van Houten, F. B., 1961, Maps of Cenozoic depositional provinces, western United States: Am. Jour. Sci., v. 259, p. 612-621.

Ver Steeg, Karl, 1926, Drainage changes in northeastern Washington, Univ. of Chicago M.S. thesis, 116 p.

1. M.S. thesis.
2. See title.
3. See title.
4. Geomorphological stream changes.
5. Reconnaissance field observations.
6. See title.
7. Maps showing several drainage and drainage changes; geologic map of Colville Indian Reservation showing Omak trench; map of the channeled scablands and relation to associated features; map of limit of Wisconsin moraine.
8. Broadly generalized description of the geography and geology of region and a discussion on glaciation and its effects on the area in terms of drainage changes.

Waitt, R. B., Jr., 1977, Guidebook to Quaternary geology of the Columbia, Wenatchee, Peshastin, and Upper Yakima Valleys, west-central Washington: U.S. Geol. Survey Open-File Report 77-753, prepared for Geol. Soc. America 1977 Annual Mtg. (Seattle) Field Trip No. 13, Nov. 77, 25 p.

_____, (1977) in press, Late-Cenozoic deposits and tectonism in Kittitas Valley, Washington: U.S. Geol. Survey, Jour. Research.

Waldron, H. H.; Gard, L. M., Jr., 1951, Preliminary report on the geology of part of the lower Snake River Canyon, Washington: U.S. Geol. Survey Open-File Report, 66 p. Plate 1, 1:24,000.

Waldron, H. H., 1954, Geology of the Hay quadrangle, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-48, 1:62,500.

Waldron, H. H.; Gard, L. M., Jr., 1955, Geology of the Penawawa quadrangle, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-56, 1:62,500.

Walker, F. C.; Irwin, W. H., 1954, Engineering problems in Columbia Basin Washington varved clays: Am. Soc. Civil Engrs. Proc., v. 80, Separate no. 1515, 18 p.

1. Civil Engineering journal.
2. See title.
3. See title.
4. See title.

5. Discussion of engineering problems - see title.
6. Same as No. 5 above.
7. ---
8. In many places clay deposits are found which have definite laminated structure. The individual layers or varves represent seasonal deposition in lakes resulting from annual inflows. Consequently, each separate layer contains a wide range of grain sizes, but exhibits a gradation from coarsest grains near the base of the layer to finest near the top. The Nespelem deposits are predominantly of this type and were developed during the end of the last Glacial Era when the Columbia River was dammed by ice and its flow diverted through high level channels such as the Grand Coulee. The Nespelem deposits are therefore confined to the pond created by the glacial dam. The thinness of the layers and their total depth indicate that sedimentation in this pond continued for many hundreds of years and produced a material that has had a profound effect on engineering problems in this area.

   Undisturbed deposits show some of the characteristics of sedimentary rocks but, once disturbed, they reassume all the worst engineering characteristics of freshly deposited alluvial and lacustrine clays. As a consequence, test results both in the field and the laboratory are very deceptive. The varved nature of the undisturbed materials, the occurrence of old landslides, and the usually saturated condition of both disturbed and undisturbed materials make the testing and interpretation of results extremely difficult.

   Once the ice dam was removed, the river entrenched itself into these valley deposits, leaving oversteepened slopes along the sides of the valley with treacherous combinations of undisturbed deposits, landslide debris, and reworked sediments. Landslides continue to be of frequent occurrence. Overburden excavation for Grand Coulee Dam and the new high water levels of the reservoir activated many slides. These entailed many difficult construction problems and right-of-way problems along the reservoir rim.

   The solution of the engineering problems of structures found in varved clays has run the entire gamut of accepted practice and has required the introduction of considerable ingenuity in the solution of specific

cases. These range from freezing the material in place, through minimizing disturbance of the deposits, to avoidance, loading or unloading, and various types of drainage, including taking advantage of subsurface bedrock configuration and gravel zones.

Experiences with the Nespelem varved clays have served to emphasize the deficiencies in classical design and testing procedures. In particular they have demonstrated the need for thorough and critical appraisal of the nature of such soils using to the utmost the arts of Geology and Soil Mechanics in evolving solutions to engineering problems. These expereinces have also served to develop a procedure for the analysis of other types of foundations now generally followed by the Bureau of Reclamation.

Walker, E. H., 1967, Varved lake beds in northern Idaho and northeastern Washington: U.S. Geol. Survey Prof. Paper 575-B, p. 83-87.

1. Geological publication.
2. See title.
3. See title.
4. See title.
5. Field observations; measurements and descriptions of beds.
6. Descriptions of beds and repetition of clay-sand-silt-clay sequence in representative section; discussion of weather and climate inferred by beds, rate of accumulation and ground water in beds.
7. Section of glacial-lake deposits in Priest River Valley; map of extent of late glacial lake in Pend Oreille and Priest River valleys.
8. Thick deposits of fine-grained sediment underlie the floors of the Purcell Trench, the Pend Oreille Valley and adjacent lowlands, and the Priest River Valley in northern Idaho and northeastern Washington. The deposits formed in a late glacial lake while ice blocked the north-flowing stretch of the Pend Oreille River. Sheets of clay, distinctly varved in places, are interbedded with sheets of sand and silt. The sheets of sand and silt are interpreted as drainage varves that were deposited when the lake burst out past the ice dam at about 12- to 65-year intervals. The sheets of sand in the lowlands underlain by lake deposits provide small,

but in most places adequate, water supplies for domestic and stock needs.

Walters, K. L.; Grolier, M. J., 1960, Geology and ground water resources of the Columbia Basin Project area, Washington: Washington Div. Water Resources Water-supply Bull. 8, v. 1, 542 p., plate 3, 1:205,670.

Walters, L. L.; Glancy, P. A., 1969, Reconnaissance of geology and ground water occurrence and development in Whitman County, Washington: Washington Dept. Water Resources, Water-Supply Bull. 26, 169 p.

Waring, G. A., 1913, Geology and water resources of a portion of south-central Washington: U.S. Geol. Survey Water Supply Paper 316, 46 p.

Warren, C. R., 1939, The Hood River conglomerate in southern central Washington: Yale Univ. Ph.D. thesis, 285 p.

1. Ph.D. thesis.
2. See title.
3. See title.
4. See title.
5. Field observations.
6. Description, age, origin of Hood River conglomerate; course of Columbia River through time; petrographic study on Columbia River basalts.
7. Plate showing distribution of the Hood River Conglomerate.
8. The Hood River conglomerate is a fluvial conglomerate resting stratigraphically and probably conformably on the Columbia River basalt in southern central Washington. It is interbedded with sandstone from which late Miocene or early Pliocene fossils have been collected, and is traced in the field into the Ellensburg and Dalles formations, both of which are late Miocene and early Pliocene.

   The conglomerate occurs in a zone extending from the Columbia River near Priest Rapids southwest past Sunnyside and Goldendale, Washington, to the type locality at Hood River, Oregon, adjacent to the Columbia River. The pebbles in the conglomerate resemble lighologically those in the gravel carried by the Columbia River today, and differ markedly from rock types indigenous to the region or to the drainage basin or any of the other streams of the region. This fact, in

conjunction with the probable conformity on the basalt, is believed to indicate that the conglomerate marks the course followed by the Columbia River at the end of the period of accumulation of the Columbia River Basalt.

Washington Public Power Supply System, 1973, Preliminary safety analysis report: WPPSS Nuclear Project No. 1, Richland, Washington, v. 1 and 2 Docket-50397.

_____, 1977, Preliminary safety analysis report (Amendment 23): WPPSS Nuclear Project No. 1, Richland, Washington, 13 sub-appendices in 2 volumes, pagination varies.

(Includes regional physiographic map, regional geologic map, regional tectonic elements map, regional setting geologic map and structural map, geological problems in site region, stratigraphic chart, stratigraphic section at plant sites, geologic map site vicinity, structural geology of site areas, geologic cross sections of sites and structural geology of sites.)

Washington State University Geology Dept., approx. 1950, Geologic Field trip, Wenatchee to Pullman, Washington: 5 p.

Waters, A. C.; Flagler, C. W., 1929, Origin of the small mounds on the Columbia River Plateau: Am. Jour. Sci.,5th ser., v. 18, no. 105, p. 209-224, 8 figs.

1. Geological publication.
2. See title.
3. Southwestern portion Columbia River Plateau, Oregon.
4. See title.
5. Field observations.
6. See title.
7. ---
8. Mounds are polygenetic in general, but areas of mound topography on Columbia River Plateau have had common origin, being the erosional remnants of a once continuous layer of volcanic ash. Large unmodified areas of this ash have survived erosion at many localities. Mound topography was developed only where ash was deposited directly upon basaltic surface, the basic condition being that subsoil be less movable than upper soil. Mounds developed on slope sufficient to permit run-off. Mounds elongated in direction of slope, the amount a function of steepness of slope. Local irregularities

in slope reflected in production of irregularly shaped mounds. If ash of uniform thickness, mound areas pass with decrease of slope into area completely mantled by ash. With increase in slope, may pass into area where ash has been completely stripped. Height of mounds equal to, or less than, thickness of adjacent undissected parts of ash blanket. Mound topography not seen where ash blanket more than 7 feet thick. Areas between mounds form definitely integrated and minutely adjusted drainage system, the symmetry of this system influenced by columnar jointing of ash. Mounds do not indicate climatic change. They were carved from material that was deposited rapidly at time of a period of explosive volcanic activity.

Waters, A. C., 1930, Geology of the southern half of the Chelan quadrangle, Washington: Yale Univ. Ph.D. thesis, 256 p., plate 1, 1:72,410.

_____, 1932, Glacial features along Columbia River near Lake Chelan (abs.): Pan-American Geologist, v. 57, no. 5, p. 372; (abs.): Geol. Soc. America Bull., v. 44, no. 1.

1. Geological abstract.
2. See title.
3. See title.
4. See title.
5. Field observations.
6. See title.
7. ---
8. At the time of the last glaciation in north-central Washington, a broad expanse of ice known as the Okanogan lobe occupied the area immediately east of the northern part of the Cascade Range. This lobe crossed Columbia River and rode out upon the northwestern part of the broad, flat Columbia plateau. In the spurs of the Cascades west of the river it encroached upon a region of serrate topography and buried peaks and ridges that rise 4,000 feet above the adjacent streams. The deposits left by the ice in the two regions are striking and distinctive. On the Plateau there is a huge moraine dotted with hundreds of erratic basalt boulders many of which measure 60 feet on a side. Stratified till is very rare. In the region of rough topography, on the other hand, moraines and other deposits of till are only locally found, but numberless terraces composed of stratified glacial drift are conspicuous elements of the scenery. Most of the terrace material shows

deltaic structures, and appears to have been deposited during the period of deglaciation in temporary lakes which were dammed by the ice. Suites of these terraces block each tributary valley of the Columbia upstream from the lowermost limit of the ice in Columbia canyon. Their form and association with other topographic features indicate that they were built in lakes dammed in the tributary valleys by an ice tongue that still occupied the main Columbia trough. These lakes were drained by streams flowing along the margin of the ice-tongue. Locally the marginal streams crossed rock spurs between adjacent tributaries and excavated precipitous walled spill-ways which were subsequently abandoned upon withdrawal of the ice. The majority of the spill-way notches are less than 50 feet in depth, but in the case of a few a prodigious amount of rock excavation was accomplished. The most remarkable is Alta coulee, a narrow cliff-walled slot cut 500 feet into fresh granodiorite by a marginal glacial stream.

_____, 1933, Resurrected erosion surface in central Washington (abs.): The XI Transactions of Sigma Gamma Epsilon, XI Chapter, Washington State Univ., v. 1, no. 1, p. 23.

_____, 1933, Terraces and coulees along the Columbia River near Lake Chelan, Washington (abs.): The XI Transactions of Sigma Gamma Epsilon, XI Chapter, Washington State Univ., v. 1, no. 1, p. 24; (abs.) Geol. Soc. America Bull., v. 44, no. 1, p. 150, 1933; (abs.) Revue de Geologic et des Sciences Connexes, v. 16, no. 5, p. 212, 1936.

1. Geological abstract.
2. See title.
3. See title.
4. Glacial features.
5. Field observations.
6. See title.
7. ---
8. A long series of glacial features is described both such as occur on a plateau surface and such as occur in more rugged mountains. Great erratic moraines, terraces,

marginal channels, and ice carvings occur. The author shows that system can be had from this wealth of features by postulating a broad lobe of ice, spreading in the ice age over much of North Central Washington, across the Columbia Canyon, diverting the river, and covering serrate topography 4,000 feet above the major streams. Marginal lakes received the deposits which subsequently became the terraces. After the ice withdrew the river took its former course and bore great floods which left visible surface down the Columbia Canyon.

_____, 1937, Erosion surfaces in the Wenatchee-Chelan district, Washington (abs.): Geol. Soc. America Proc., 1936, p. 319-320.

1. Publication abstract.
2. See title.
3. See title.
4. Columbia River basalt; supposed "Methow Plain"; "Entiat Surface".
5. Field observations.
6. Erosional history of the area.
7. ---
8. Mapping of the geology of the Wenatchee-Chelan-Okanogan district in recent years has made necessary certain modifications of the published interpretations regarding the erosional history of the district. The principal changes proposed are:

   (1) The existence of a "Methow Plain" or "Cascade Peneplain" is questioned. Supposed remnants of it appear to be either outliers of the Columbia River basalt or structural platforms on gneiss.

   (2) The "Entiat surface" is well developed only on resistant granodiorite and gneiss and is exceedingly fragmentary or absent in areas underlain by greenstone, phyllite, graywacke, and schist, except at a few localities near the border of the lava field. It is nowhere recognizable in areas underlain by the Columbia River basalt. The residuals of the "Entiat surface" described in the literature are interpreted by the writer as being largely resurrected fragments of a widespread late mature erosion surface buried beneath the Miocene Columbia River lavas and associated sediments, and then partially exhumed

in post-Miocene time. Certain fragmentary remnants of this surface on massive crystalline rocks may be original in the sense that they were never covered by the lavas, but they have probably lost much of their former height by solifluction and frost weathering and so do not give an accurate record of the former base level of stream erosion.

(3) Supposed peneplain remnants, bevelling anticlines of basalt in the Yakima district, are believed to be of very local extent, and are, in part, desert pediments.

Waters, A. C.; Krauskopf, Konrad, 1941, Protoclastic border of the Colville Batholith (Washington): Geol. Soc. America Bull., v. 52, p. 1355-1417.

Waters, A. C., 1955, Geomorphology of south-central Washington, illustrated by the Yakima East quadrangle: Geol. Soc. America Bull., v. 66, no. 6, p. 663-684.

_____, 1958, Part of the Columbia River gorge: U.S. Geol. Survey unpub. map, 1:125,000 (based in part on independent work by A. C. Waters).

_____, 1963, Washington State Univ. Columbia Basin field trip - an introduction: The XI Transactions of Sigma Gamma Epsilon, XI Chapter, Washington State Univ., v. 1, no. 1, p. 1-6.

_____, 1969, Geology of the southern half of the Chelan quadrangle, Washington (abs.): Diss. Abs. Int., Sec. B, Sci. and Eng., v. 30, no. 5, 2259B-2260B.

Weiss, P. L., 1960, Geology of the Greenacres quadrangle and adjacent area: U.S. Geol. Survey unpub. reconnaissance map, 1:380,160.

Weiss, P. L.; Richmond, G. M., 1965, Maximum extent of late Pleistocene Cordilleran glaciation in northeastern Washington and northern Idaho, In Geological Survey Research 1965: U.S. Geol. Survey Prof. Paper 525-C, p. C128-132, illus.

1. Geological publication.
2. See title.
3. See title.

4. Ice-contact deposits, landforms, and ice-modified bedrock.
5. Field observation of above.
6. See title.
7. Map of Late-Pleistocene ice margins in vicinity of Spokane, Washington.
8. Late Pleistocene glaciers in northeastern Washington and northern Idaho were considerably less extensive than has been previously supposed. Ice which was part of a single large sheet farther north formed a number of lobes that were for the most part valley glaciers near their southern margins. Ice-contact deposits, landforms, and ice-modified bedrock were used as criteria for determining the outermost position of the ice margins. Deposits south of those margins that were once considered to be till are now thought to have formed as a result of the catastrophic floods from glacial Lake Missoula.

Weiss, P. L., 1968, Geologic map of the Greenacres quadrangle, Washington: U.S. Geol. Survey Quad. Map GQ-734, 1 sheet accompanied by 4 pages of text, map 1:62,500.

Weissenborn, A. E.; Weis, P. L.; Fryklund, Jr., V. C., 1960, Reconnaissance geology of eastern Washington: Washington Div. Geology and Earth Resources library, 3 sheets (Spokane Newport and Chewelah quadrangles), scale 1:125,000.

Weissenborn, A. E., 1969, Geologic map of Washington, Lat. 46° to 49°, long. 118° to 124°: U.S. Geol. Survey Misc. Geol. Div. Map I-583, scale 1:2,000,000.

_____, 1974, Geologic map of the Mount Spokane quadrangle, Washington and Idaho: U.S. Geol. Survey Open-File Report 74-211, map and text on one sheet, 1:31,680.

Weissenborn, A. E.; Weiss, P. L., 1976, Geologic map of the Mount Spokane quadrangle, Spokane County, Washington, and Kootenai and Bonner Counties, Idaho: U.S. Geol. Survey Quad Map GQ-1336, map and text on one sheet, scale 1:62,500.

Westgate, J. A.; Dreimanis, A., 1967, Volcanic ash layers of Recent age at Banff National Park, Alberta, Canada: Canadian Jour. Earth Sciences, v. 4, p. 155-161.

Westgate, J. A.; Gold, C. M., eds., 1974, World Bibliography and index of Quaternary Tephrochronology: University of Alberta, Edmonton, Alberta, Canada, 528 p.

Whetten, J. T.; Kelley, J. C.; Hanson, L. G., 1969, Columbia River sediment sources (abs.): Geol. Soc. America Spec. Paper 121, p. 576-577.

1. Geological abstract.
2. See title.
3. Columbia River.
4. Sediments.
5. Mean grain-size measurements, heavy mineral, clay mineral and bulk mineral composition, major and trace element composition.
6. See title above.
7. ---
8. Sediment carried on the bed of the Columbia River increases in mean grain size with distance downstream to the mouth. Other measured variables (heavy mineral, clay mineral, and bulk mineral composition; and major and trace element composition) also show consistent changes along the river. In general, discrimination is marked between sediments of Grand Coulee, Ice Harbor, and the three downstream reservoirs (McNary, The Dalles, Bonneville), whereas differences among the downstream reservoirs are small and inconsistent.

   Most of the textural, mineral, and chemical changes in Columbia River sediments are correlated with changes in source materials. Sediments of the upper Columbia are derived largely from the reworking of generally non-volcanic glacial and eolian surficial deposits and eroded basalt. The sediments contributed by tributaries to the lower Columbia contain large quantities of volcanic materials derived from the erosion of Cascade volcanoes and Tertiary sedimentary rocks of volcanic origin. Some lower Columbia tributaries contribute quartz-free sediment.

   The relatively large quantity of coarse sediment contributed by lower Columbia River tributaries dilutes the sediment contributed by the upper Columbia. Bedload sediment at the mouth therefore appears to be largely of volcanic origin.

Wilcox, R. E.; Powers, H. A., 1963, Petrographic characteristics of Recent pumice from volcanoes in the Cascade Range: Geol. Soc. America Abs., 1963, Spec. Paper 76, p. 232.

1. Geological Society Meeting abstracts.
2. See title.
3. Pacific Northwest.
4. Volcanic ash.
5. Petrographic study including spindle stage and focal-masking techniques.
6. See title.
7. ---
8. Siliceous pyroclastic rocks of Recent age from particular volcanoes in the Cascades show many similarities, but detailed petrographic study, facilitated by the spindle stage and "focal masking" techniques, reveals small but consistent differences. Thus the glass from the Mazama eruption of Crater Lake has refractive index characteristically ranging from 1.500 to 1.511, and, among the phenocrystic minerals, the abundant zoned hornblende has principal refractive index ranging from 1.658 to 1.669. Both ortho- and clinopyroxene are present. The glass from Glacier Peak Volcano, on the other hand, has from 1.495 to 1.500 (rarely as low as 1.486), and the abundant zoned hornblende has an index from 1.644 to 1.655. Phenocrystic orthopyroxene is present, but clinopyroxene is absent. The glass from Newberry Crater has an index from 1.493 to 1.496, and the rare hornblende has an index from 1.668 to 1.674. Ortho- and clinopyroxene are rare. Glass from the pumice of the Bridge River area of British Columbia has an index from 1.496 to 1.501, and the abundant strongly zoned hornblende has an index from 1.640 to 1.658. Phenocrystic ortho- and clinopyroxene are present, and biotite is common.

   Similarly, one or more unique characteristics has shown up on the material of each of the other Recent vents so far studied, and these are reflected in several cases by recognizable differences in the chemistry of the glasses. Such specific petrographic data on material known to have been erupted from a particular major Recent vent provides a basis for identification of the corresponding ash deposit among the several prominent layers of volcanic ash in the Recent sediments of the Pacific Northwest, and for more confident use of this layer as a stratigraphic marker.

Wilcox, R. E., 1965, Volcanic-ash chronology. In The Quaternary of the United States, H. E. Wright, Jr.; D. G. Frey, eds. p. 807-816.

1. Geological book - chapter form.
2. See title.
3. Western United States.
4. Volcanic ash.
5. Discussion of volcanic ash chronologic techniques.
6. Same as No. 5 above.
7. Location map of Quaternary volcanoes in Western U.S.
8. Several extensive ash-fall layers provide useful time-stratigraphic markers in the Quaternary deposits of western United States. The Mazama ash, erupted from Crater Lake, Oregon, about 6,000 years ago, mantled much of northwestern United States and adjacent parts of Canada. To it belongs most of the ash previously called "Glacier Peak" in Washington and "Galata" in Montana. The ash fall that actually had its source at Glacier Peak Volcano is about 12,000 years old, and it covered a broad zone to the east and southeast. Pearlette ash fall (or ash falls) of late Kansan age spread over the Great Plains, and very similar ash has been found in middle Quaternary deposits in the Rocky Mountains and as far west as Nevada. Valles caldera in New Mexico and the Yellowstone Park region have been suggested as sources for the Pearlette ash fall, but further study appears necessary to establish which, if either, is the source and whether the Pearletts as now used is only one ash fall.

   Many more Quaternary ash layers await investigation and application as time-stratigraphic markers. Some, such as the ash fall associated with the Bishop Tuff eruption in California, dated by potassium-argon methods, are probably extensive but are still to be traced outward from their sources. Satisfactory identification of individual ash beds requires detailed field investigation of the stratigraphic relations and thorough laboratory determinations of petrographic characteristics of the ash, supplemented in some cases by chemical analyses.

_____, 1969, Airfall deposits of two closely spaced eruptions in late glacial time from Glacier Peak volcano, Washington (abs.): Geol. Soc. America Abs. with Programs 1969, part 5, p. 88-89.

1. Geological abstract.
2. See title.
3. East of Glacier Peak, northern Cascades.
4. Glacier Peak tephra.
5. Petrographic analysis; stratigraphic analysis.
6. See title.
7. ---
8. Two units are recognized in the thick airfall pumice lapilli a few miles east of their source, Glacier Peak Volcano, in the northern Cascades: A lower coarse gray lapilli and an upper coarse buff-stained lapilli, separated at some localities by a thin parting of crystal-rich ash. Petrographic characteristics of the two lapilli units are similar: Vesicular glass of refractive index near 1.500 enclosing abundant phenocrysts and microlites of plagioclase, orthophroxene, hornblende, and magnetite. Traced east and southeast into Idaho and western Montana, the deposits maintain their twofold character, although as progressively thinner layers of finer-grained material. A C-14 age of 12,750 $\pm$ 350 years (W-1644) was obtained from snails out of associated silt at a locality in western Montana. Locally the two clean ash layers are separated by ordinary detrital sediment as much as several feet thick, and it seems obvious that the two layers represent separate eruptions but closely spaced in time. Commonly these ash layers, either paired or alone, are found in deposits of proglacial lakes or glacially fed streams, consistent with conditions presumed to have prevailed during the last withdrawal of glacial ice. An idea of the position of the ice margins at that time is obtained from the northerly limits of known occurrences of Glacier Peak ash.

Williams, Howell; Goles, G. G., 1968, Volume of the Mazama ash-fall and the origin of Crater Lake Caldera, in Dole, H. M., ed., Andesite Conference Guidebook: Oregon Dept. Geology and Mineral Industries Bull. 62, p. 37-41.

1. Geological publication.
2. See title.
3. Pacific Northwest and Crater Lake, Oregon.

4. See title.
5. Mathematical models, using measurements of thickness of ash deposits at various distances from vent, to determine volumes of ash-falls.
6. Same as No. 5 above.
7. Distribution map of Mazama ash; Mazama air-fall ash contour along N. vector.
8. Paper corrects miscalculation by Williams (1942) of volume of ash blown from Mt. Mazama during initial phase of climatic eruption and volume of Mazama that collapsed. The volume of Mazama ash that fell between 60-1000 miles from Crater Lake was 5.7 cubic miles (23 km^3) and was greater than the volume of ash that fell closer to vent. Beyond 1000 miles is a few hundredths of a cubic mile. Content of crystals and lithic fragments in ash diminishes rapidly away from source while pumiceous particles and glass shards increase until only vitric dust is found near limits of fallout. Volume of material blown from Mazama before top collapsed is 13.3-17.3 cubic miles.

   It is now believed that Mazama summit was less than 12,000 feet and that less than 17 cubic miles of the top fell - more like 15 cubic miles. The discrepancy between the volume of material ejected from the volcano and the volume of the mountain top that collapsed is suggested to be provided by subterranean withdrawal of magma and may have triggered the explosive eruptions that led to engulfment.

Willis, Bailey, 1887, Changes in river courses in Washington Territory due to glaciation: U.S. Geol. Survey Bull., v. 6, no. 40, p. 473-480.

Wise, W. S., 1970, Cenozoic volcanism in the Cascade Mountains of southern Washington: Washington Div. Mines and Geol. Bull. 60, 45 p., illus., tables, geol. map.

Yates, R. G., 1966, Geology-Northeastern Washington. In Mineral and Water Resources of Washington: U.S. Cong., 2d sess., Comm. on Interior and Insular Affairs, Comm. p. 15-22.

Yeaton, W. J., 1923, Geology of the Zillah quadrangle, Washington: Univ. of Chicago M.S. thesis, 88 p., map, 1:125,000.

ADDITIONAL REFERENCES - Sedimentary Units

Antevs, Ernst, 1954, Telecorrelation of varves, radiocarbon chronology, and geology: Jour. Geol., v. 62, p. 516-521.

Antevs, Ernst, 1955, Varve and radiocarbon chronologies appraised by pollen data: Jour. Geol., v. 63, p. 495-499.

Bingham, J. W.; Longquist, C. J.; Baltz, E. H., 1970, Geologic investigation of faulting in the Hanford region, Washington: U.S. Geol. Survey, Open-file Report, 103 p.

Brown, R. E., 1962, Geologic features and ground water flow at Hanford: Hanford Atomic Products Operation Report HW-73337, p. 211-212; Hanford Atomic Products Operation Report HW-77609, p. 4.43-4.44, by Brown, R. E.; Brown, D. J., 1963.

Davis, W. M., 1920, Features of glacial origin in Montana and Idaho: Annals Assoc. Am. Geog. 10, p. 75-147.

Dawson, W. L., 1898, Glacial phenomena in Okanogan County, Washington: Am. Geologist, v. 22, p. 203-217.

Fryxell, Roald, 1971, The contribution of interdisciplinary research to geologic investigation of prehistory, eastern Washington: Univ. of Idaho, Ph.D. thesis, Moscow.

Hubbard, P. S., 1968, Geology of the Saddle Butte quadrangle, Washington: Univ. of Hawaii, M.S. thesis.

Large, Thomas, 1922, The glaciation of the Cordilleran region: Science, new series, 56, p. 335-336.

Leverett, Frank, 1922, Old glaciation in the Cordilleran region: Science, new series, 56, p. 388.

McConiga, M. W., 1955, Deofrmation of the Ringold Formation: Hanford Atomic Products Operation Report HW-36373.

Monahan, C. J., 1957, Geologic features of McNary Dam, Oregon-Washington: Geol. Soc. Am. Engineering Case Histories, No. 1, p. 33-38.

Newcomb, R. C., 1971, Geologic map of the proposed Patterson Ridge pumped storage reservoir, south-central Washington: U.S. Geol. Survey, Misc. Invest. Map I-653.

Newman, K. R., 1969, Palynology of interflow sediments from the Standard Oil Company of California Rattlesnake Hills No. 1 well, Benton County, Washington: Proceedings-Second Columbia River Basalt Symposium, Eastern Washington State College, Cheney, p. 201-208.

Nimick, D. A., 1977, Glacial geology of Lake Wenatchee and vicinity, Washington: Univ. of Washington, M.S. thesis.

Portland General Electric Co., 1974, Pebble Springs Nuclear Plant Units 1 and 2, License Application, PSAR, section 2.5-Geology and Seismology, section 2.6-References.

Raisz, Erwin, 1945, The Olympic-Wallowa lineament: Am. Jour. Sci., v. 243-A, p. 479-485.

Rieger, Samuel, 1950, Origin of the Palouse formation: Washington State College, Geol. Dept. class paper, 12 p.

Rieger, Samuel, 1952, Development of the A_2 horizon in soils of the Palouse area: State College of Washington, Ph.D. thesis, 107 p.

Shannon and Wilson, 1973, Geologic studies of the Columbia River Basalt and age of deformation, The Dalles-Umatilla region, Washington and Oregon, the Boardman Nuclear Project: Report to Portland General Electric Co., Portland.

Shedd, Solon, 1910, The clays of the State of Washington, their geology, mineralogy and technology: State College of Washington, Ph.D. thesis, Pullman.

Steen-McIntyre, Virginnia, 1977, A manual for tephrochronology-collection, preparation, petrographic description and approximate dating of tephra (volcanic ash): published by the author, Box 1167, Idaho Springs, Colorado, 80452, 167 p.

Stewart, C. A., 1913, The extent of the Cordilleran ice sheet: Jour. Geol., 21, p. 427-430.

U.S. Bureau of Reclamation, Columbia Basin Project, 1976, Preconstruction geologic report, Main Canal, Bacon Siphon and Tunnel No. 2, v. 1 & II: U.S.B.R., Boise, Idaho.

Thayer, T. P.; Wagner, N. S., 1969, Geology of the Blue Mountain region: Oregon Dept. of Geol. and Min. Ind., Bull. 64, p. 68-74.

Upham, Warren, 1904, Outer glacial drift in the Dakotas, Montana, Idaho, and Washington: Am. Geologist, 34, p. 151-160.

Hammett, H. H., 1977, Late Quaternary geology of the lower Granite Reservoir area, lower Snake River, Washington: Geol. Soc. Am. Map MC-18, one sheet, mapped to 1,200 foot contour, 1:25,000.

Parrott, Gwynn, 1932, Study of the fresh water sediments north of Leavenworth: Washington State College B.S. thesis, 21 p.

Allison, I. S., 1933, New version of the Spokane Flood: Geol. Soc. America Bull., v. 44, no. 4, p. 675-722.

1. Geological periodical.
2. See title.
3. Eastern Washington.
4. Physiographic features.
5. Field observations.
6. Different interpretation of the Spokane Flood than Bretz'.
7. Sketch maps; table describing glacial erratics in Umatilla quadrangle.
8. Abstract -In conclusion, it may be noted that the writer agrees with Bretz that there was a Spokane Flood, and that the erratics, the scabland, the diversion channels, and certain perched gravel deposits and sidehill rubble heaps are authentic records of it. The writer's interpretation differs from that of Bretz, however, in many particulars, among them: (1) That the distribution of all glacial erratics is definitely assigned to the flood; (2) that erosion by the flood below Wallula Gateway was local and limited in volume; (3) that most of the gravels near Umatilla, Hood River, White Salmon, Lyle, Carson, and Portland are older than the flood; (4) that the flood attained a uniform level from the Wallula Gateway to the Columbia River gorge through the Cascade Mountains; (5) that this uniformity and the pebbly silts on the uplands and in tributary valleys record a general ponding of the flood; and especially, (6) that ice, rather than mere volume, was the critical factor in the flood. Accordingly, our conceptions of the flood, and particularly its cause, its mechanics, its geologic effects, its volume, and its duration differ widely. Perhaps this revision will make the idea of such a flood more generally acceptable.

_____, 1933, Revision of the Spokane Flood (abstract): Geol. Soc. America Bull., v. 44, no. 1, p. 68.

1. Geological periodical.
2. See title.
3. Yakima Valley — scablands.
4. Columbia River Basalt and flood deposits.
5. Field observations.
6. See title.
7. ---
8. Abstract -Steep-walled buttes beside deep, narrow channels in the scabland of Chandler narrows in Yakima Valley are considered

inconsistent with a "gigantic bore" type of flood. Instead, the scabland is better explained as the product of water repeatedly diverted around a growing icejam. Such diversions present an epitome of the flood on the Columbia plateau.

New data indicate that the flood rose to a consistently high level from the Wallula Gateway to the Columbia River gorge through the Cascade Mountains, that it left slack-water deposits both in tributary valleys and on the uplands, and hence that it was virtually ponded. The writer, therefore, proposes a new version of the flood: that the ponding was produced by a blockade of ice in the Columbia River gorge, that the rise of the river to abnormally high levels began at the gorge and not on the plateau of eastern Washington, that the blockade gradually grew headward until it extended into eastern Washington, that as the waters were dammed to progressively higher levels they were diverted around the ice and into a succession of routes across secondary drainage divides at increasing altitudes, producing scablands and perched gravel bars along the diversion routes, distributing berg-rafted erratics far and wide, and depositing pebbly silts in slack-water areas. This interpretation does not require a short-lived, catastrophic flood, but explains the scablands, the gravel bars, diversion channels, and divide crossings as the effects of a moderate flow of water, now here and now there, over an extended period of time.

Allison, I. S., 1941, Flint's fill hypothesis of origin of scabland: Jour. Geol., v. 49, no. 1, p. 54-73.

1. Geological journal.
2. See title.
3. Eastern Washington scablands.
4. Scabland features.
5. Field observations.
6. Difference of opinion concerning origin of scabland features as opposed to R. F. Flint's fill hypothesis.
7. Photographs.
8. Abstract -Flint's fill hypothesis is explanation of the scabland features of eastern Washington, which bases the deposition-excavation sequence upon the rise and decline of glacial Lake Lewis, has the advantage of reducing the events and conditions to terms of streams of moderate size but, nevertheless, has serious shortcomings which make it unacceptable.

These considerations lead us to conclude that Flint's fill hypothesis (1) imposes a task on the eroding streams which requires decidedly abnormal, if not impossible, behavior of

the several strands of current; (2) involves a misinterpretation of the ages of certain gravel deposits relative to that of the Touchet beds; (3) fails to consider adequately the rounded and sloping forms of some of the gravel deposits; and (4), as it is not applicable to Wallula Gap and other scabland areas, is not a general solution of the scabland problem. On the other hand, none of these objections is prejudicial to the idea that these scabland features were developed under conditions of glacial drainage clogged by ice jams.

Baker, V. R., 1971, Paleohydrology of catastrophic Pleistocene flooding in eastern Washington (abstract): Geol. Soc. Am. Abs. with Programs, v. 3, no. 7, p. 497.

1. Geological Society meeting abstracts.
2. See title.
3. See title.
4. Flood deposits and scour features.
5. Field observations and measurements and mathematical models.
6. See title.
7. ---
8. Abstract -The early Pinedale (22,000 years B.P.) breakout of glacial Lake Missoula probably involved the largest discharges of fresh water that can be documented in the geologic record. This flood left considerable high-water mark evidence in the form of (1) eroded channel margins, (2) highest flood gravel, (3) minor divide crossings, and (4) ice-rafted erratics. Reconstructed water surface gradients and channel geometry provide input data for the slope-area and contracted-opening hydraulic calculation procedures. Maximum discharges through scabland channels ranged from 752×10^6 cubic feet per second in the Rathdrum Prairie to 17.5×10^6 cubic feet per second in Rocky Coulee. The flood's duration was probably only a week or two.

   Bed forms produced by the early Pinedale flood are preserved at over 60 locations. Chords for these "giant current ripples" vary from 60 to 425 feet. Mean ripple heights vary from 1.5 to 22 feet. Ripple dimensions correlate to depth, depth-slope product, mean flow velocity, and stream power. Correlation coefficients generally exceed 0.7. Correlation coefficients greater than 0.9 occur for the regressions of ripple chord versus depth-slope and ripple chord versus stream power. These empirical relationships only allow the prediction of hydraulic parameters for the narrow range of flow conditions which characterized the flood reaches containing the giant current ripples.

Baker, V. R., 1973, Paleohydrology and sedimentology of Lake Missoula flooding in eastern Washington: Geol. Soc. America Spec. Paper 144, 79 p.

Baker, V. R., 1974, Erosional forms and processes for the catastrophic Pleistocene Missoula floods in eastern Washington: In Morisawa, Marie, ed., Fluvial geomorphology: Binghamton, N. Y., State Univ. Publ. in Geomorphology, p. 123-148.

Baker, V. R.; Patton, P. C., 1976, Missoula flooding in the Cheney-Palouse scabland tract: Terrestrial analogue to the channeled terrain of Mars? (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 351-352.

1. Geological Society meeting abstracts.
2. See title.
3. See title.
4. Flood deposits, loess, and calcic horizons; scour features in basalt.
5. Field observation.
6. See title.
7. ---
8. Abstract -At least two episodes of catastrophic Pleistocene flooding are recorded in the Cheney-Palouse scabland tract. An older flood gravel is everywhere capped by brown loess (Palouse Formation) on which is developed a 30-60 cm petrocalcic horizon. The gravel contains boulders of deep red loess stained by manganese dioxide (pre-Bull Lake loess). At Marengo this gravel is covered by 3 loess units, each separated by calcic horizons, which are overlain by flood gravel of the last catastrophic flood (approximately 18,000-20,000 years B.P.; early Pinedale Stade).

   Flood erosion and deposition by the early Pinedale event were largely determined by the locations of residual loess "islands" within the main flood channel. Irregular scabland was produced by scour in constricted reaches between the islands, and deposition, often as pendant bars and giant current ripples, was favored in channel expansions. Sizes of macroturbulently transported boulders decrease rapidly (1) downstream from resistant basalt ledges, (2) laterally toward the margins of a channel, and (3) in the lee of loess islands, which have depositional "tails" of cobble- to granule-sized material. Relatively smooth, scoured basalt with occasional large basalt blocks (4x3x2.5 m) is common immediately below depositional reaches.

Mariner 9 imagery of the Chryse Planitia region of Mars shows streamlined forms of striking similarity to the loess islands and pendant bars of the Cheney-Palouse scabland tract. Because the Chryse region is the Viking A prime landing site for summer, 1976, the analogy may actually be tested. If correct, however, localized zones of deposited boulders and scabland scour would pose a hazard to the delicate Viking lander.

Booth, C., 1971, An investigation of sedimentary stratigraphy near Lamona, Washington, and its relation to the Bretz hypothesis for the development of the channeled scabland topography of the Columbia Plateau (abs.): Assoc. Pacific Coast Geographers Yearbook, v. 33, p. 176.

Bretz, J H., 1923, The channeled scablands of the Columbia Plateau: Jour. Geol., v. 31, p. 617-649.

_____, 1925, The Spokane Flood beyond the channeled scablands: Jour. Geol., v. 33, no. 2, p. 97-115; no. 3, p. 236-259, 17 figures (abs.): Pan-American Geol., v. 43, no. 2, p. 146, 1925.

1. Geological journal.
2. See title.
3. Columbia Plateau.
4. Channel scablands—physiographic features.
5. Field observations.
6. Field evidence for flood dimensions at Wallula Gap and beyond.
7. ---
8. Abstract -

Channeled scablands of the Columbia Plateau, in Washington, are extensive, elongate, denuded tracts of basalt, deeply scored by huge, high gradient, glacier-born rivers. As physiographic features, the scablands are unique, as were the conditions which produced them.

Field evidences indicate that the Columbia River valley, below the confluence of Snake River, carried a flood which at Wallula gateway was two miles wide and reached 750 feet above present river-level, and at Portland was nearly 20 miles wide and 350 feet above present river-level.

_____, 1927, Channeled scabland and the Spokane Flood (abstract with discussion): Wash. Acad. Sci. Jour., v. 17, no. 8, p. 200-211.

1. Scientific society proceedings.
2. See title.
3. Eastern Washington.
4. Erosional and depositional landforms.

5. Field observations.
6. Interpretation of landforms as result of catastrophic Spokane Flood.
7. ---
8. Abstract -Bretz hypothesizes the origin of the scabland tracts and then summarizes the more significant features and relationships: (1) Canyons of the scabland including rock basins in canyons, plexus groupings of canyons and cataracts; (2) areas surrounded by channeled scabland tracts including aligned scarps of loess facing scablands and small isolated loessial hills on the scabland; (3) trenched divides; (4) deposits of the scabland and in Snake and Columbia valleys including gravel bar forms, deltaic bars, and Quincy basin; (5) Anastomosis of entire scabland tract on Plateau; (6) Wallula Gateway high-level scabland; (7) Columbia Valley below Wallula Gateway including Portland delta and bars in mouths of tributaries.

Discussions by W. C. Alden, James Gelluly, E. T. McKnight, G. R. Mansfield, D. E. Meinzer, and J. T. Pardee. Bretz' replies to discussion.

_____, 1927, The Spokane Flood; a reply (origin of physiographic features, Washington): Jour. Geology, v. 35, no. 5, p. 461-468.

1. Geological journal.
2. See title.
3. Eastern Washington.
4. Ringold Formation and flood erosional and depositional features.
5. Field observations.
6. See title.
7. ---
8. Abstract -Reply to McKnight's discussion of the Spokane Flood including several criticisms and new field evidence.

_____, 1927, What caused the Spokane Flood? (abs.): Geol. Soc. America Bull., v. 38, no. 1, p. 107; Pan-American Geologist, v. 47, no. 1, p. 64, 1927.

1. Geological journal.
2. See title.
3. Columbia Plateau.
4. Channeled Scablands, flood gravel deposits.
5. Field observations.
6. Theoretical hypothesis for basalt flows under glacial ice being cause of Spokane Flood.
7. ---
8. Abstract -New data will be presented on the distribution and character of channeled scabland and associated gravel deposits on the Columbia Plateau. They indicate that the Spokane flood was an even greater affair than previously thought. Studies

in Washington and British Columbia north of the scabland strongly suggest that basaltic flows which were extruded beneath the Cordilleran ice sheet produced the great flood. The field has not yet been sufficiently studied to justify a definite affirmative. The paper is a report of progress in following up a promising clue.

_____, 1928, Alternative hypotheses for channeled scabland, Part I and II: Jour. Geol., v. 36, no. 3, p. 193-223, 6 figs.; no. 4, p. 312-341, 4 figs.

1. Geological journal.
2. See title.
3. Columbia Plateau.
4. Scabland features.
5. Field observations.
6. See title.
7. ---
8. Abstract -This paper begins with a summary statement of the features of scabland and of the writer's explanation of their origin. In the body of the paper, various criticisms and suggestions are considered on the light of significant field data. Revision of some of the writer's ideas is indicated. The second half of the paper deals with the question of simultaneous development of all channels of the scabland pattern and with proposed tests of the writer's hypothesis.

_____, 1928, Bars of channeled scabland (abs.): Geol. Soc. America Bull., v. 39, p. 643-701.

1. Geological journal.
2. See title.
3. Columbia Plateau.
4. Gravel deposits of abandoned channels.
5. Field observations.
6. Origin of bars—evidence to substantiate.
7. ---
8. Abstract -
The noteworthy denudation of limited tracts on the Columbia plateau in Washington, confined to an extraordinary anastomosing pattern, is the product of glacial streams of high gradient. Descriptions already published indicate that these streams operated under very unusual conditions. This paper is an attempt to portray the gravel deposits of the abandoned channels with sufficient definiteness to show that they can be explained only as stream-bars. If this explanation be accepted the magnitude, composition, and topographic setting of these deposits lead unavoidably to the conclusion that the streams far transcended in volume any other known glacial dischargeways.

_____, 1928, The channeled scabland of eastern Washington: Geog. Rev., v. 18, no. 3, p. 446-477, 27 figs., map.

1. Geographical journal.
2. See title.
3. Columbia Plateau.
4. Scabland features.
5. Field observations.
6. See title.
7. ---
8. ---

_____, 1930, Lake Missoula and the Spokane Flood (abs.): Geol. Soc. America Bull., v. 41, no. 1, p. 92-93.

1. Geological journal abstract.
2. See title.
3. Eastern Wash.
4. Flood deposits and scour features.
5. Field observations.
6. See title.
7. ---
8. Abstract -It is suggested that bursting of an ice-barrier, which confined a large glacial lake among the mountains of western Montana, suddenly released very great volumes of water which escaped across the plateau of eastern Washington and eroded the channeled scablands. There is very little field evidence which can be interpreted as a record of such escaping waters between the lake basin and the scabland channels.

_____, 1930, Relation of Yakima Valley to the channeled scabland (abs.): Geol. Soc. America Bull., v. 41, no. 1, p. 93.

1. Geological journal.
2. See title.
3. Yakima Valley-Columbia Plateau
4. Scabland features, flood deposits.
5. Field observations.
6. Relations between Yakima Valley and scabland flooding.
7. ---
8. Abstract -Yakima River enters Columbia River near the southern and lower limit of the plateau scabland. Yakima Valley is a group of structural depressions connected structurally or by short canyons across separating upfolds. The convergence of two anticlinal folds produces a noteworthy narrowing of the valley just above its junction with the Columbia. Glacial silts and berg-transported erratics

occur throughout this valley up to 1,100 feet A. T. The maximum depth of the water recorded was 600 feet. Evidence will be presented to show that the water was backed up the Yakima from the scabland, that in the narrows near the mouth it possessed tremendous current up the valley floor gradient and that much of the erratic material came from the Rocky Mountains in northern Montana and Idaho.

_____, 1932, History of Grand Coulee: Pan-American Geologist, v. 58, no. 2, p. 158-159.

1. Geological journal.
2. See title.
3. See title.
4. Scabland flood scour features.
5. Field investigations.
6. See title.
7. ---
8. Abstract -Dry Falls is part of much larger cataract with five member falls with collective width of 3 1/8 miles. Castle Lake, 1 mile south of Coulee City, is a member. An ancient Upper Grand Coulee cataract, contemporaneous with other members, 4 miles north of Coulee City, retreated through Waterville Plateau until it destroyed itself, creating Upper Coulee. It possessed a dozen smaller lateral falls through the 30 miles of recession; they are now abandoned and hang on the margins of the Upper Coulee as Northrup and Barker Canyons, Martin Falls, and Hubbard Creek. Upper Coulee floor is a series of shallow basins lying in an elongate plunge pool eroded 20 feet below present floor. Width of gorge cut by receding waterfall determined by width of fall itself. Upper coulee is 2 miles wide at southern and northern extremes. In vicinity of Steamboat Rock, it widens to 5 miles, an expression of greatest discharge during the Spokane Flood. The flood was preceded and followed by normal glacial Columbia River. During flood, Steamboat Falls (now gone) was 5 miles wide and 900 feet tall and eroded a plunge pool 200 feet deep. Lower Grand Coulee lies in a "coulee monocline" of tilted basalt. Preglacial Lower Coulee was 1 mile east of Lake Lenore, but 200-400 feet higher. It was occupied by glacial Columbia River while Upper Coulee was being developed by cataract recession. With Spokane Flood, preglacial route was overflooded so that torrents attacked monoclinal basalt. With its greater weakness, the deepest place in the flood channel was developed. When the flood subsided, the normal glacial Columbia River abandoned its former Lower Coulee course and located where Lake Lenore now lies. Dry Falls took origin near head of Park Lake and are a product of glacial Columbia River after flood subsided.

_____, 1932, Channeled scabland: 16th Internat. geol. cong. guidebook 22.

_____, 1932, The Grand Coulee: American Geog. Soc. Spec. Publ. 15, 89 p.

Bretz, J H.; Smith, H. T. U.; Neff, G. E., 1956, Channeled scabland of Washington: New data and interpretations: Geol. Soc. America Bull., v. 67, no. 8, p. 957-1059. Plate 1, 1:506,880.

1. Geological journal.
2. See title.
3. Columbia Plateau.
4. Scabland erosional and depositional features.
5. Field observation, topographic map interpretation.
6. See title.
7. Map of channeled scabland of eastern Washington; map of Trail Lake anticline and vicinity; map of main portion of Quincy Basin; map of Moses Lake and vicinity; topographic map and profiles across Drumheller Channels; map of bars in upper Crab Creek valley; profiles of scabland on Palouse-Snake divide; map of glacial Lake Missoula and channeled scabland.
8. Abstract -The existence of four different interpretations of that extraordinary assemblage of erosional and depositional land forms of eastern Washington, the "Channeled Scabland", indicates that rigorously definitive diagnostic characters had not been found. This study, dealing with new data, largely from extensive excavations and detailed topographic maps made by the U.S. Bureau of Reclamation in developing the great Columbia Basin Irrigation Project, returns to the earliest of the four interpretations: that channeled scabland is almost wholly the consequence of catastrophic flooding of glacial water across this part of the Columbia Plateau which remade preglacial valleys into an anastomosing complex of great river channels with huge cataracts, deep rock basins, and bars attaining magnitudes unknown elsewhere on earth.

   The new evidence is held to establish firmly the following points:
   (1) Some structural basins of the region did not have exterior drainage prior to arrival of glacial water.
   (2) The gravel hills called bars by Bretz (1928a) have the shapes, surface markings, structures, and topographic situations possible only for subfluvial constructional deposits. In magnitudes and bouldery composition, they are sui generis.
   (3) Several episodes of catastrophic discharge have occurred across this part of the Columbia Plateau.
   (4) The Columbia Valley skirting the plateau has had comparable floods in which the scabland complex did not share.
   (5) Successive floods have been differentiated only by topographic relations of their records, not by differential weathering and erosion.

(6) Bretz did not overestimate the magnitude of the erosion by glacial waters.
(7) The existing scabland features contradict the three later interpretations.

Bretz, J H., 1959, Washington's channeled scablands: Washington Div. Mines and Geology Bull. 45, 57 p. Plate 1, 1:570,240; Plate 3, 1:342,144.

1. State geological survey publication.
2. See title.
3. See title (eastern Wash.).
4. Scabland features: flood erosional and depositional features.
5. Field observations.
6. Documentation of flood hypothesis.
7. Physiographic diagram of scablands; block diagram and map of great cataract group in Hartline Basin; topographic map of Potholes Cataract; Quincy Basin distributary channels; sketch map of region at mouth of Palouse River; cross section through Shoulder Bar (mouth Palouse River); map of glacial Lake Missoula and channeled scabland; plates of channeled scabland, Dry Falls system, Grand Coulee and upper Crab Creek valley
8. Abstract -A summary of results of Bretz' many years of study on channeled scabland. Includes 8 general features of channeled scabland, Grand Coulee, Quincy Basin and its outlets, Lower Crab Creek, and Othello Channels, Moses Coulee, Upper Crab Creek, Cheney-Palouse Scabland tract, and Pasco Basin.

_____, 1969, The Lake Missoula floods and the channeled scabland: Jour. Geol., v. 77, no. 5, p. 505-543.

1. Geological journal.
2. See title.
3. Columbia Plateau.
4. Scabland erosional and depositional features.
5. Field investigations and measurements.
6. Review of evidence for scabland flood behavior.
7. Map of glaciated and flooded areas on Columbia Plateau; outline map of Lake Missoula; map of giant current ripples north of Plains, Montana; table of tentative correlations of events in Grand Coulee System; map of the Narrows, Oregon and environs; structural features involved in history of Grand Coulee floods.
8. Abstract -This paper reviews the outstanding evidence for (1) repeated catastrophic outbursts of Montana's glacially dammed Lake Missoula, (2) consequent overwhelming in many places of the preglacial divide along the northern margin of the Columbia Plateau in Washington, (3) remaking of the plateau's preglacial drainage pattern into an anastomosing complex of floodwater channels (Channeled Scabland) locally eroded hundreds of feet into underlying basalt, (4) convergence of these flood-born rivers into the Columbia Valley at least as far as Portland, Oregon,

and (5) deposition of a huge delta at Portland. Evidence that the major scabland rivers and the flooded Columbia were hundreds of feet deep exists in (1) gravel and boulder bars more than 100 feet high in mid-channels, (2) subfluvial cataract cliffs, alcoves, and plunge pools hundreds of feet in vertical dimension, (3) back-flooded silts high on slopes of preglacial valleys tributary to the scabland complex, and (4) the delta at Portland. Climatic oscillations of the Cordilleran ice sheet produced a succession of Lake Missoulas. Following studies by the writer, later investigators have correlated the Montana glacial record with recurrent scabland floods by soil profiles and a glacial and loessial stratigraphy, and have approximately dated some events by volcanic ash layers, peat deposits, and an archaeological site. Several unsolved problems are outlined in this paper.

Brown, D. J., 1965, The flood that changed the face of Hanford: Hanford Project news 1:14.

Brown, R. E., 1973, The glacial Lake Missoula floods in the Pasco Basin (abs.): Northwest Scientific Association Abstracts of Papers presented at the 46th annual meeting, p. 6.

1. Scientific meeting abstracts.
2. See title.
3. See title.
4. Flood sediments, tephra, scour features.
5. Field observations.
6. Sedimentary record of scabland flooding.
7. ---
8. Abstract -The Pasco Basin contains a complete but unappreciated sedimentary record of the glacial Lake Missoula and related floods.

   The oldest floods pre-date 45,000 years. Minor floods preceded a gigantic flood of probably 18-20,000 years ago. Scouring was followed by a flood crest to about 1200 feet altitude and deposition of distinctive sediments. The Glacier Peak ash lies within deposits of a later flood that peaked at about 900 feet altitude.

   Terrace remnants and alluvial plains, correlated to the flood deposits, identify periodic basin fill levels. Erosion and shifting of the Columbia River in the last 12,000 years is identifiable.

_____, 1975, Groundwater and the deposits of the glacial Lake Missoula floods in the Pasco Basin: EOS (Am. Geophys. Union, Trans.), v. 56, no. 8, p. 532.

1. Geophysical journal.
2. See title.

3. Pasco Basin.
4. Pasco gravels, Ringold Formation, Columbia River Basalts, Touchet Beds.
5. Explanation of irrigation techniques in terms of geological history of basin.
6. Discussion of geological knowledge required to develop irrigation in Pasco Basin.
7. ---
8. Abstract -Irrigation development of the Pasco Basin requires geological knowledge to degrees not earlier needed. Low to moderate permeability of the basalt and Ringold Formation respectively leaves only the Pasco Gravels (coarse flood deposits) as high yield aquifers. Knowledge of the sites and extent of erosion and deposition, and altitudes of deposits are vital in planning but are ignored by most. Best irrigation wells lie in the Basin center where basalt and the Ringold Formation were down-folded and the Ringold Formation was scoured then buried by the graded Pasco Gravels. Outward, yields decrease and coulees provide the major supplies. Locally coulees are filled with Touchet Beds (fine-graded flood deposits) but buried alluvial fans provide water. Drainage problems in west Pasco formed where subsurface scour channels lie athwart groundwater flow paths and groundwater levels are rising owing to extensive use of Columbia River water. An industrial disposal site was sited at an optimum location with regard to irrigation, groundwater flow paths and protection of domestic wells. A sewage lagoon, constructed without due regard for the nature of the deposits, leaked and contaminated numerous domestic wells.

Culver, H. E.; Kirkham, V. R. D., 1927, General geology of eastern Washington and northern Idaho: Northwest Sci., v. 1, p. 25-30, map, 1:500,000.

Easterbrook, D. J.; Baker, V. R.; Waitt, R. B., 1977, Glaciation and catastrophic flooding of the Columbia Plateau, Washington (Field Trip No. 13). In Geological excursions in the Pacific Northwest: Geological Society of America 1977 Annual Meeting, Seattle, Washington, p. 390-414.

Flint, R. F., 1938 , Origin of the Cheney-Palouse scabland tract, Washington: Geol. Soc. America Bull., v. 49, no. 3, p. 461-563; (abs.) GSA Proceedings 1936, p. 72, June 1937.

1. Geological journal.
2. See title.
3. Columbia Plateau.
4. Scabland erosional and depositional features.

5. Field observations and measurements.
6. See title - opposite view of Bretz.
7. ---
8. Abstract -Flint's thesis on scabland channels is that it can be explained by normal erosion rather than cataclysmic flood. Gives the order of events by Flint. Discusses scabland sediment in terms of grain size, sorting, etc. Riparia Lake on Snake is discussed, as are Touchet beds. Summary and conclusions follow:

   The order of events inferred from the features of the Cheney-Palouse tract and the Pasco basin may be summarized as follows:

   1. Advance of glacier ice lobes across the Spokane-Columbia canyon at the northern margin of the plateau, to the divide between drainage north to the canyon and drainage south on the plateau. If the Okanogan Lobe or the Columbia Lobe (Flint, 1936; 1937) reached the plateau before the Little Spokane Lobe, a lake may have been formed in the canyon, and an overflow spill established down the Cheney-Palouse tract, before the encroachment of actual glacier ice south of the divide.
   2. Occupation of preglacial valleys and erosion of basalt in them, by the meltwater flow.
   3. Rise of Lake Lewis in the Pasco basin, causing aggradation in the tributary valleys to form a thick fill, growing vertically upward and also headward.
   4. Cutting of Palouse scarps by lateral planation and development of lateral distributaries from the principal routes as the streams rose on their own fills. Sedimentation in Lake Lewis, progressively overlapping stream deposits in the mouths of tributaries.
   5. Draining of Lake Lewis, accompanied by progressive dissection of the fill into cut terraces, together with the cutting of more Palouse scarps and terraces and the erosion of more basalt, chiefly by stream channels superposed from the fill. Offlap deposits built into receding Lake Lewis, most of this secondary sediment later eroded and carried off down the Columbia.
   6. Backwasting of the glacier ice margin beyond the divide in the Spokane district, shutting off the supply of meltwater and causing the Cheney-Palouse tract to run dry except for the through drainage of the modern Palouse River-lower Snake River system.
   7. During the whole sequence of events, showers of volcanic ash fell at many different times, and the ash was incorporated in the growing fill, and in the deposits of Lake Lewis and the Riparia Lake.

A hypothesis of filling followed by dissection demands no more than one glaciation for the general development of such a scabland tract, but certain features brought out in this discussion seem to indicate that more than one glaciation, with meltwater flow, did, in fact, control the evolution of the Cheney-Palouse tract. The key to the latest fill in the tract is Lake Lewis. If this water body had not come into existence, temporarily providing an abnormally high base level, the glacial record in the scabland tract probably would have consisted of a thinner fill in the form of a valley train, slightly dissected by postglacial streams, instead of a thick fill greatly dissected by meltwater streams. Again, if Lake Lewis had maintained its high level until after the withdrawal of the glacier ice from the area south of Spokane, the fill would still be essentially nondissected, except in Snake River canyon, and would form broad valley floors contrasting little with the adjacent surface of the "Palouse soil."

Freeman, O. W., 1926, Scabland mounds of eastern Washington: Science, new ser., v. 64, p. 450-451.

1. Geological publication.
2. See title.
3. Columbia Plateau.
4. Loess-like mounds on Columbia River Basalt.
5. Field observations.
6. See title - size, occurrence, origin.
7. ---

_____, 1933, Origin and economic value of the scabland mounds of eastern Washington: Northwest Sci., v. 6, no. 2, p. 37-40, 5 figs.

1. Scientific journal.
2. See title.
3. See title.
4. Scabland mounds (volcanic ash on basalt depressions).
5. Field observations.
6. See title.
7. ---
8. Abstract -Tens of thousands of mounds occur in scablands. Mounds are stationary and oval elongated downslope, without regard to wind direction. Diameter from few to a hundred feet. Elevation from few inches to 4 feet. Occur in depressions above basalt material, is composed of volcanic ash. Scabland flooding pitted surface of basalt bedrock by the plucking action of running water. Depressions contained clay, sand, gravel, and basalt chips after water disappeared. Sediments in depressions provided place for first vegetation to grow after flooding. After flood a layer of ash

covered eastern Washington. Vegetation in depressions pushed through ash and protected it from erosion. Wind also helped accumulate ash around plants and into depressions. Areas between pits couldn't retain ash so that it was swept away.

Comments on effect of mounds on agriculture and economics of eastern Washington

Fryxell, Roald, 1962, A radiocarbon limiting date for scabland flooding: Northwest Sci., v. 36, no. 4, p. 113-119.

1. Scientific journal.
2. See title.
3. Wanapum Dam, eastern Washington.
4. Datable material in scabland flood gravels.
5. C^{14} dating.
6. See title.
7. ---
8. Abstract -Radiocarbon dating of organic material collected from scabland flood gravel at Wanapum Dam as 32,700±900 years BP represents the first available C-14 date for glacial chronology in eastern Washington. This figure represents the age of interstadial organic material picked up and redeposited by catastrophic discharge into the Columbia River over Frenchman Springs cataract before the furthest advance of the Okanogan lobe, and thus provides a maximum limiting date for late Wisconsin scabland flooding.

Fryxell, Roald; Cook, E. F., 1964, A field guide to the loess deposits and channeled scablands of the Palouse area, eastern Washington: Washington State Univ. Lab. Anthropology, Rept. Inv. 27, 32 p.

1. Geologic field trip guide.
2. See title.
3. See title.
4. See title.
5. Description of observations made on field trip.
6. See title.
7. Stratigraphy and physiographic distribution of eolian deposits in eastern Washington; map of aligned topography in southwest Palouse; block diagrams showing: evolution of ideal scabland tract; schematic geoarchaeological chronology for eastern Washington.
8. Abstract -Field trip guide to eastern Washington taking in topics such as: origin of Palouse loess, southern extent of Pleistocene glaciation, chronology of Pleistocene events, and the origin of the channeled scablands.

Fryxell, Roald; Neff, G. E., 1965, The origin of Grand Coulee. In INQUA, Guidebook for Field Conference E, northern Rocky Mountains: Nebraska Acad. Sci., Lincoln, Nebr., P. 77-79.

1. Field trip guidebook (geological).
2. See title.
3. See title.
4. Scabland erosional and depositional features.
5. Field observations.
6. Evidence for Pleistocene ice sheet dam across Columbia River as origin of Grand Coulee.
7. Stratigraphy on east wall Columbia River showing lacustrine, outwash and glacial deposits of 2 stades of Pinedale glaciation; inferred velocities of Lake Missoula Flood.
8. Abstract -Discusses formation of the Grand Coulee through glacier and flood action at two stops of the field trip.

Fryxell, Roald; Neff, G. E.; Trimble, D. E., 1965, Scabland tracts, loess, soils, and human prehistory. In INQUA, Guidebook for Field Conference E, northern Rocky Mountains: Nebraska Acad. Sci., Lincoln, Nebr., p. 79-89.

1. Field trip guidebook.
2. See title.
3. Columbia Plateau.
4. See title.
5. Field observation.
6. See title.
7. Stratigraphy of loess deposits and buried soils in central Columbia Basin; correlation of post-glacial climatic events with stratigraphy and cultural sequence at Marmes Rock Shelter; precipitation, vegetation, soils map for Columbia Plateau; cross-section showing loess, soils and vegetation relationships in Palouse Hills.
8. Abstract -Discusses stratigraphic relationships, distribution, and formation of various scablands, loesses, and soils between Ephrata and Pullman. Mentions Marmes Rock Shelter, human occupation, dating, and climatic conditions recorded.

Hanson, L. G., 1970, The origin and development of Moses Coulee and other scabland features on the Waterville Plateau, Washington: Univ. Washington Ph.D. thesis, 137 p.

1. Thesis.

2. See title.
3. See title.
4. See title.
5. Field observations.
6. See title.
7. Map showing principal relief features and scabland channels of Waterville Plateau; general geology and structure sections of Waterville Plateau; stratigraphy of Yakima Basalt, Moses Coulee; surficial geology, Moses Coulee mouth area; structure contour map, Vantage Horizon, Moses Coulee area; cross-profile Moses Coulee; others.
8. Abstract -Moses Coulee is incised along the line of a major pre-existing drainage of the Waterville Plateau. This drainage occupied primarily downwarped northeast-trending folds which began to form during the time of extrusion of the post-Vantage Yakima Basalt. The drainage was maintained across the later rise of the Badger Mountain anticline which was initiated in latest Yakima or post-Yakima Basalt time. Moses Coulee was cut by one or more catastrophic floods exceeding discharge of 40 million cubic feet per second. This flood was routed to present coulee site as sheet of water several miles wide and less than 100 feet deep. Water spilled across broad low-relief tract of NE corner of Waterville Plateau. This tract was carved into complex of shallow scabland channels in short time. Late Wisconsin Okanogan lobe of Withrow advance extended no more than few miles onto plateau at time of flood and effected diversion of flood waters to coulee. A portion of this flood was channeled from Waterville Plateau to Grand Coulee area to begin cutting of that coulee. Floor of coulee was back-filled with several hundreds of feet of coarse gravel in broad trains, which surfaced locally by wave forms. Many huge gravel bars hundreds of feet high formed downstream of bedrock obstructions to flood flow. A massive delta-alluvial fan was built into Columbia Valley at mouth of coulee. Foster and Horse Lake Coulees pre-date cutting of Moses Coulee but relate to diversion of meltwater from Columbia River by Okanogan lobe. Withrow advance overrode northern scablands but modified them little. Withrow terminal moraine was built during two stadial events. At same time outwash train developed on flood gravels of coulee. Glacier then retreated leaving ice-stagnation features and 13 moraines. Coulee was obscured by landsliding and events of alluvial fan and minor floodplain building during late and post-glacial time. Badger Mountain anticline uplifted during this time also.

Hodge, E. T., 1934, Origin of Washington scablands (abs.): Pan-American Geologist, v. 62, no. 2, p. 155; (abs.) Internat. Geological Congress, 16th, U.S., 1933 Report, v. 2, p. 1105, 1936; Northwest Sci., v. 8, p. 4-11, 1934.

1. Geological journal.
2. See title.
3. Eastern Washington scablands.
4. Ice-scoured landforms and glacial sediments.
5. Field observations.
6. See title.
7. ---
8. Abstract -The phenomenal and unique geomorphic scabland forms, unlike the rest of the arid West, resulted from glacial advances, partly into a closed basin and onto a basalt and lake-bed surface. The first advance produced two great united lakes, which spilled across the Cascade mountains and then produced the integrated Columbia River from many ancestral streams. Ice-lobes dammed the Columbia River and eroded Moses and Grand Coulee and Rock Basin lakes. Stagnant ice produced water-falls, pot-holes, and kames. Ice-jams produced scablandy and anastomosing channels. Melting ice produced loessal deposits, gravel plains, gravel terraces, and upstream bars. Recessional ice permitted the entrenchment and superposition of the Columbia canyon. A second advance dammed the Columbia canyon and produced great falls, recessed from its canyon where diverted water spilled into it. All three advances enhanced the scabland features and dispersed erratics by floating icebergs that reached the Willamette valley. The third advance repeated the same effects, and the retreat of the ice left many stagnant ice features in the valleys entering the scabland area. The scablands and contiguous territory give no evidence of a catastrophic flood but resulted from glacial influences on a peculiar surface effective throughout the Pleistocene.

Hoffman, A. D.; Search, M. A.; Hoffman, M. G., 1931, The geology of Moses Coulee: Washington Div. Mines Geol. 23 p.

1. Field investigative report.
2. See title.
3. Moses Coulee.
4. Clastics (Latah Formation?), Wenas basalt, recent sands, gravels, glacial tills.
5. Field investigation.
6. General geology of area.
7. ---
8. Abstract - Describes the structure, Miocene history and basalt series in the area from the Columbia River on southwest, northeastward to Jameson Lake and from 2 to 10 miles in width. Length of the coulee was traversed with plane table and alidade and outline located by triangulation. Lowest formation exposed is a 35' section of clastics in Douglas Canyon, $\frac{1}{2}$ mile north of the coulee, believed to be Latah. Resting conformably over this is a 1900' section of basalts, unconformably overlying them are

gravels, sands, silts, and glacial tills. Identified the basalts as Wenas. Included also is a short petrographic of the basalts.

Hoffman, M. G., 1932, Several phases of geology of the Moses Coulee area (Washington): Northwest Sci., v. 6, no. 4, p. 120-123, 129.

_____, 1933, Structural features in the Columbia River lavas of central Washington: Jour. Geol., v. 41, no. 2, p. 184-195, 5 figs.

Howell, Paul, 1968, The great glacial floods of the Columbia River: Geol. Soc. Oregon Country Geol. Newsletter, v. 34, no. 5, p. 133-137.

1. Geological newsletter.
2. See title.
3. Eastern Washington scablands.
4. Scabland scour features and flood deposits.
5. Popular account of scabland flooding.
6. Popular account of scabland flooding.
7. Map of glacial Lake Missoula and channeled scablands; map of Willamette flood impoundment.
8. Abstract -Popular account of scabland flooding. Breach in ice dam at north end of Bitterroot Range started flood. It progressed down Cour d'Alene Valley, turned west across Spokane and ran into Okanogan Lobe of Cordilleran Ice Sheet. It thereupon glanced off ice dam and went down Grand Coulee. The rest backed up and overflowed rim of plateau all the way back to Spokane. The water sloshed southwestward across Columbia Plateau ripping away Palouse soil and bedrock as it went. Part of water went to Snake River, part to Columbia, and part towards Pasco. When the water hit the rivers, it temporarily went upstream, but eventually it all converged on Wallula Gap, the only low passageway through the Horse Heaven Hills, $1\frac{1}{2}$ miles wide and 800 feet deep. Here the water velocity was 120 mph. Four hours later the water reached the mouth of the Columbia Gorge. Seven floods occurred in like fashion.

Jenkins, O. P., 1921 and 1922, Geological investigations of the Grand Coulee: Washington Div. Geology, illus, 1 plate, 21 p.

1. Field investigative report.
2. See title.
3. Grand Coulee, Columbia Plateau.
4. Granite basement, Plateau basalts, terrace sands and gravels.
5. Field investigation.
6. Damsite study and general geology information.
7. ---
8. Abstract -Discusses feasibility of damming north and south ends of Grand Coulee and geological factors relative to placement of dams.

Jones, F. O., 1947, Grand Coulee from "Hell to Breakfast"; a story of the Columbia River from molten lavas and ice to the Grand Coulee Dam: Binfords and Mort, Portland, Oregon, 64 p.

Kaatz, M., 1963, Scabland mounds of Washington—depositional or erosional? (abs.): Northwest Sci., v. 37, no. 4, p. 158-159.

1. Scientific journal.
2. See title.
3. Channeled scablands.
4. Silt mounds.
5. Areal reconnaissance and aerial photo interpretation.
6. See title.
7. ---
8. Abstract -Silt mounds, 10-40 feet across and 2-4 feet high, are widely distributed in the Channeled Scablands. Reconnaissance study of the region together with examination of aerial photographs indicates that, contrary to the findings of Olmsted, the mounds are not an early stage in the restoration of a loess mantle.

Mound occurrence is not restricted to submound depressions. Mounds are generally elongated downslope rather than downwind; they are not encroaching on the intermound surfaces; and climatic records do not indicate conditions favorable to mound growth today.

On the other hand, the frequent occurrence of periglacial phenomena such as stone nets and stripes, solifluction scars, and talus deposits reflects a past climate more severe than today's. The mounds originated under such a climate when, as in Alaska today, the erosion of frost crack or ice-wedge polygons resulted in the dissection of a former more or less continuous loess mantle. Today's silt mounds are the erosional remnants of that mantle.

Keyes, Charles, 1935, Glacial origin of the Grand Coulee: Pan-American Geologist, v. LXIII, p. 189-202; (abs.) Revue de Geologie et des Sciences Connexes, v. 17, no. 1, p. 28-29, 1937.

1. Geological journal.
2. See title.
3. See title.
4. See title.
5. Field observations.
6. See title.
7. ---
8. Abstract -The Grand Coulee, of northern Washington State, is, as is well known, one of the scenic spots of Earth. As canyons, go, it is also unique. Its one-time water-falls appear to have surpassed in magnitude and drop all others of which we know. The genesis of this noble gorge, or canyon, is usually ascribed to the work of a swollen Columbia

River, when thwarted in its normal course through damming by a great glacier. But the Grand Coulee does not seem to be the former effect of fluviatile activities of our Columbia since when it was chiefly formed the Columbia River valley was buried deeply beneath glacier-mass. When present-day Columbia River rose again from its icy grave, the Grand Coulee was already an accomplished fact, much as we see it today. Development of Grand Coulee is really not nearly so simple as it has been commonly pictured, and the origin of its grand canyon is not the simple corrasive work of our mighty Columbia.

For the mechanism of Grand Coulee formation we have to look to far way Iowa, where, recently, deep gorges, newly gashed in the illimitable prairie along the axes of one-time ice-lobes of fast vanishing ice-sheet mark the line of post-Glacial streams, and give clue to what must have happened at the Grand Coulee, when the Columbia River was not around. Grand Coulee is particularly interesting in this connection as revealing one stage of the development of which the distant eastern relative gives no inkling. It is therefore doubly instructive.

The modus operandi of the development of a perfectly new drainage-line upon an elevated plain never before trenched by stream, during an ice-sheet retreat, is lately revealed and described in considerable detail in the instance of the Des Moine River in Iowa, and the James and Sheyenne rivers in the Dakotas, which streams were developed, de noro, on the axes of waning ice-lobes and excavated deep gorges for their bed in the tills-plains round about, while the ice-sheet till formed the upper parts of the local canyon-walls.

A great opportunity now awaits at Grand Coulee for determining Glacial successions, and till-body relationships. The field is still a virgin one. In a few weeks' time more may be learned concerning the behavior, work, and interactions of Cordilleran glaciers than was accomplished in the Alps in a whole century. A new Eludes sur les Glaciers written in Washington and British Columbia will as far surpass the first great exposition under that title as Agassiz's did all previous literature. A monumental Opus beckons.

Livingston, V. E., Jr., 1964, Origin of Dry Falls: Washington Div. Mines and Geology Report, 4 p.

1. Popular account report.
2. Origin of Dry Falls and Grand Coulee.
3. Dry Falls, Grand Coulee.
4. Basalt.
5. Field observation.
6. See title.

7. ---
8. Abstract -Popular account of Miocene and Pliocene history of Columbia basin, and formation of Grand Coulee and Dry Falls by melt water from ice-lobe blocking Columbia River at Coulee Dam.

McKnight, E. T., 1927, The Spokane Flood; a discussion: Jour. Geol., v. 35, no. 5, p. 453-460.

1. Geological journal.
2. See title.
3. Eastern Washington.
4. White Bluffs-Ringold Formation.
5. Reconnaissance field observations.
6. See title.
7. ---
8. Abstract -Records of glacial history left on surface of Ringold Formation in area south of Saddle Mountains is discussed in terms of a non-catastrophic development. Concludes that lateral planation by Columbia has been dominant factor in physiographic development of White Bluffs region based on: (1) relation of present area of Ringold to its former extent; (2) hanging character of normal valley at north end of White Bluffs; (3) landslide topography of present White Bluffs; and (4) widespread gravel deposits on west side of river, most of planation post-glacial in age.

McMacken, J. G., 1931, Grand Coulee of Washington: Pan-American Geologist, v. 55, no. 2, p. 81-92, 5 plates.

1. Geological journal.
2. See title.
3. See title.
4. Glacial erosional and depositional features.
5. Geologic history of Grand Coulee region.
6. Geologic history of Grand Coulee region.
7. ---
8. Geologic history of Grand Coulee region from pre-lava floods through lava floods; regional deformation of basalt, glaciation, and post-glacial modifications of landscape.

_____, 1937, Vicissitudes of Spokane River in late geologic times: Pan-American Geologist, v. 68, no. 2, p. 111-132, 8 plates.

Milton, D. J.; Baker, V. R., 1974, Erosion by catastrophic floods on Mars and Earth: Icarus (N. Y.), v. 23, no. 1, p. 27-41.

Mullineaux, D. R.; Wilcox, R. E.; Fryxell, Roald; Ebaugh, W. F.; Meyer, Rubin, 1977, Age of the last major scabland flood of eastern Washington, as inferred from associated ash beds of Mount St. Helens Set S: Geol. Soc. America Abs. with Prog., v. 9, no. 7, p. 1105.

1. Geological Society meeting abstracts.
2. See title.
3. See title.
4. See title.
5. Lab investigations of Fe-Mg mineral suites, refractive indices and chemical compositions, radiocarbon dating.
6. See title.
7. ---
8. Abstract -Four groups of upper Pleistocene pumice layers from Mount St. Helens, called sets C (oldest), M, K, and S (youngest), are mineralogically similar to certain cummingtonite-bearing ash beds of the channeled scabland. The scabland ash beds occur as closely spaced "couplets" and "triplets" in fine-grained sediments associated with gravels of the last major scabland flood. Fe-Mg mineral suites and refractive indices and chemical compositions indicate that set S pumice layers are the near-source equivalents of "couplet" and "triplet" ash beds exposed near Vantage and Wanapum Dam along the western margin of the scabland. These data confirm earlier tentative correlations of set S with scabland ash beds by us and several other investigators.

   Near Mount St. Helens, set S is dated by radiocarbon as about 13,000 years old. Thus, the last major scabland flood is also about 13,000 years old, in contrast to most previous estimates of about 20,000 years or older. The younger age, however, is consistent with an age estimate of possibly 14,000 years for a scabland flood by H. H. Hammatt, L. L. Foley, and F. C. Leonhardy in 1976. It is also consistent with an age of less than 13,500(?) years estimated for the last flood by R. B. Waitt, Jr., in 1977 from relations of flood and glacial deposits marginal to the scabland. In addition, an age of about 13,000 years for the last major scabland flood is supported by a radiocarbon date of 13,080±350 years (W-3404) we obtained for peat that directly overlies the Portland delta of J H. Bretz, which is a down-valley deposit of that flood.

Neff, George, 1974, Roadlog: Ephrata - Coulee Dam: In Rock Mechanics The American Northwest: Penn State Univ. Press, p. 269-270.

Olmsted, R. K., 1963, Silt mounds of Missoula flood surfaces: Geol. Soc. America Bull., v. 74, no. 1, p. 47-53.

1. Geological journal.
2. See title.
3. Columbia Plateau.
4. See title.
5. Field observations and measurements.
6. Clarification of contradictions in theories of origin for mounds and assemblage of additional data.
7. ---
8. Abstract -The small natural mounds of the Missoula Flood channels are a result of the transportation of wind-borne dust across the region. Dry air is cooled and becomes moist as it is forced up the slope of the plateau. The dust becomes heavy by absorption of water from the air and settles in a thin mantle. Over most of the denuded area the removal of dust by drier winds keeps pace with deposition, and the surfaces remain barren. Dust has accumulated in shallow depressions in the surface. Vegetation, ground water, or a combination of these retard dust loss in these places. Over a period of a few thousand years mounds have grown above the sites of these depressions. The mounds retain ellipsoidal shapes, their major axes aligned with the prevailing wind because of differential rates of dust removal by the wind. The mounds constitute an early stage in the restoration of the loess mantle.

Olson, E., 1969, Introduction to J Harlen Bretz's paper on "The Lake Missoula Floods and the Channeled Scabland": Jour. Geol., v. 77, p. 503-504.

1. Geological journal.
2. See title.
3. Columbia Plateau.
4. Scabland depositional and erosional features.
5. Introduction.
6. ---
7. ---
8. Abstract -Discusses, in general terms, the catastrophic hypothesis Bretz used to explain the scablands and the reluctance of the rest of the geologic community to accept his ideas.

Ouellette, C. M., 1961, Dry Falls: Skeleton from the Columbia's past: Pacific Discovery, v. 14, no. 1, p. 24-25, illus.

_____, 1964, Grand Coulee-Monument to an ancient river: National Parks Magazine, v. 38, no. 204, p. 12-15.

_____, 1972, Caves of the Grand Coulee: Pacific Discovery, v. 25, no. 2, p. 28-32.

Pardee, J. T., 1910, The glacial Lake Missoula: Jour. Geology, v. 18, p. 376-386.

_____, 1942, Unusual currents in glacial Lake Missoula, Montana: Geol. Soc. America Bull., v. 53, p. 1569-1600, 8 pls.,9 figs.

1. Geological journal.
2. See title.
3. See title.
4. Flood features such as giant ripple marks.
5. Field investigation.
6. Topography and geology of Lake Missoula; description of and evidence for unusual currents.
7. Map of glacial Lake Missoula; geologic maps of southern part of Plains Basin, Eddy Narrows, Thompson Falls Valley, Quinn and Perma Narrows, and Paradise Narrows; topography and geology of Markle Pass, North Camas Prairie Basin and Rainbow Lake Pass.
8. Abstract -The area submerged by Glacial Lake Missoula includes several intermontane basins and constricted interconnecting valleys or "narrows" that drain to a single outlet, the Clark Fork River. A sudden failure of the ice dam that blocked this valley, near the Idaho-Montana State line, caused unusually large and rapid currents through the narrows and wind gaps in the partly submerged rim of Camas Prairie basin. Evidences of such currents include commensurate, but otherwise ordinary, effects of streams confined to rocky channels and the unique giant ripple marks. At its high stage the lake is roughly estimated to have held more than 500 cubic miles of water of which nearly three-fourths was stored above a constricted part of the Clark Fork Valley called the Eddy Narrows. Calculations based on available incomplete data indicate a flow through the Eddy Narrows that reached a maximum of 9.46 cubic miles per hour. Whether the lake was completely drained at that time has not been determined, but a later set of beaches testified that the basin held a lake soon after the rapid outflow. Apparently the final draining was gradual.

Quinn, Robert, 1972, The origin and chronology of the scabland channels of the Columbia Plateau of eastern Washington: Unpublished paper by the author, 17 p.

Richmond, G. M.; Fryxell, Roald; Weiss, P. L.; Neff, G. E.; Trimble, D. E., 1965, Glacial Lake Missoula, its catastrophic flood across the Columbia Plateau and the loesses and soils of the Columbia Plateau, Pt. F. In Guidebook for Field Conference E, Northern and Middle Rocky Mountains, Internat. Assoc. Quaternary Research, 7th Cong., USA, 1965: Lincoln, Nebr., Nebraska Acad. Sci., p. 68-89, illus.

1. Field trip guidebook.
2. See title.
3. Dixon to Clark Fork to Coeur d'Alene to Grand Coulee Dam to Ephrata to Pullman.
4. See title.
5. ---
6. ---
7. Maps: Giant current ripples in Mont.; successive paths of flood from glacial Lake Missoula near Spokane; surface elevations of high-velocity flood water from Lake Missoula to Portland, Ore.; inferred velocities of Lake Missoula flood; stratigraphy of loess deposits and associated buried soils in central Columbia Plateau; correlation of post-glacial climatic events with stratigraphy and cultural sequence at Marmes Rock Shelter; several stratigraphic sections; precipitation, vegetation, and distribution of great soil groups for Columbia Plateau.
8. Abstract ---

Satterfield, A., 1971, "After 42 years, the professor finally was victorious". In Seattle Times Magazine, 11 July 1971, p. 12-13.

_____, 1975, J Harlen Bretz and the flood catastrophe in Channeled Scabland: Pacific Search, v. 10, no. 2, p. 51-52.

1. Popular geographical journal.
2. See title.
3. Eastern Washington.
4. Scabland flood features.
5. ---
6. ---
7. ---
8. Popular account of J Harlan Bretz' long battle to find acceptance of his catastrophic flood theory.

Staatz, M. H.; Morris, R. H., 1976, Resume of the regional geology of the Grand Coulee area, Washington: U.S. Geol. Survey Open-file Report 76-782, 34 p., 4 figs.

Thomsen, D. E., 1974, The day the dam burst: similarities between giant erosion features in Washington (scabland) and on Mars, considered evidence of catastrophic flooding: Sci. News (Wash., D.C.), v. 106, no. 16, p. 250-257.

U.S. Geological Survey, 1973, The channeled scablands of eastern Washington—The geologic story of the Spokane Flood: U.S. Govt. Printing Office, Stock no. 2401-02436, 24 p.

1. Geological publication—popular account.
2. See title.

3. Columbia Plateau.
4. Scabland depositional and erosional features.
5. Field observations.
6. See title.
7. Photographs; sketches; map of advance of glacial ice and corking of Clark Fork River and channeled scablands; satellite photograph of channeled scablands.
8. Abstract -Popular account of scabland flooding, summarizing the sequence of geologic events that culminated in the Spokane Flood.

Waitt, R. B., Jr., 1972, Revision of Missoula flood history in Columbia Valley between Grand Coulee Dam and Wenatchee, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 4, no. 3, p. 255-256.

1. Geological meeting abstracts.
2. See title.
3. See title.
4. Flood eratics and other flood and glacial deposits.
5. Field observations; mathmatical models concerning amount of flood water impounded at Grand Coulee by Lake Missoula flood.
6. See title.
7. ---
8. Abstract -In lower Methow Valley erratics of Columbia provenance rest on Late Wisconsin till of Cascade provenance; in Antione Creek stratified gravel with upvalley-dipping forset beds underlies an anomalous flat valley floor at altitude 2000 feet; in East Wenatchee a broad calichified Early- or Pre-Wisconsin terrace separates an unweathered 100-foot erratic from its only potential upslope source. These and other anomalous Columbia Valley deposits,as giant-boulder fields, giant expansion and eddy bars, and Columbia-provenance erratics up tributaries, are evidence of an iceberg-laden Late Wisconsin flood surge 1200 feet deep through Columbia Valley.

   Catastrophic discharge of a late-glacial lake ice-dammed at Grand Coulee (spillway altitude 1550 feet) is inadequate to explain higher effects of flood downvalley; the Missoula Flood crest (2665 feet at Spokane) is adequate. Although erratics rafted downvalley indicate residual preflood Columbia ice, distribution of the deglacial Great Terrace requires confinement of valley ice below 1500 feet.

   At a surge head of altitude 2500 feet, the combined cross-sectional areas of Grand Coulee and ice-choked Columbia gorge at Coulee Dam approximately equal the cross-sectional area of the channel above Coulee Dam. Therefore, if mean velocity through all conduits was equal, only after ponding to 2500 feet altitude could discharge out of Columbia and Grand Coulee conduits have equalled flood inflow.

The Missoula Flood, thus hydraulically ponded at Coulee Dam, produced a 1200-foot surge that abruptly terminated the Late Wisconsin glacial history of Columbia Valley.

_____, 1977, Missoula Flood sans Okanogan lobe: Geol. Soc. America Abs. with Programs, v. 9, p. 770.

1. Geological Society meeting abstracts with programs.
2. See title.
3. Columbia Valley.
4. Flood deposits and scour features.
5. Field observations.
6. Proof of catastrophic flooding of area (Wenatchee-Rock Island segment of Columbia valley) previously believed to be protected by Okanogan Lobe of Cordilleran Ice Sheet.
7. ---
8. Abstract -The Wenatchee-Rock Island segment of Columbia Valley, historically presumed to have been isolated by the Okanogan Lobe from the downvalley surge of the Missoula Flood, contains unweathered bedload gravel to altitude 440 m, or 255 m above the river. The gravel contains boulders as large as 5 m, displays downvalley-dipping foreset beds in sets at least 15 m thick, and is embellished by giant current ripples whose lee slopes face downvalley and whose mean chord spacing is 100 to 250 m. Unweathered ice-rafted erratics occur to altitude 525 m, or 340 m above the river--higher than the surface of "Lake Columbia" (of depth 200 m and surface altitude 500 m), which therefore was not the floodwater source of these Columbia Valley deposits. The flood-surface profile in Columbia Valley projects nicely upvalley to Bretz' 820 m flood-surface altitude near Coulee Dam, and downvalley to Neff's 445 m flood-surface altitude in Quincy Basin. The Columbia Valley flood, evidently identical to the last Missoula flooding of the Channeled Scablands, occurred after the Okanogan Lobe of Cordilleran ice had largely retreated from Columbia Valley (13,500 B.P.,?), but before the eruption of the Glacier Peak about 12,000 B.P.

   Deposits from the Columbia Valley flood underlie and are mixed with Missoula Flood deposits that issued westward from Quincy Basin: floodwater surged into Quincy Basin first via the Columbia conduit, later via the Scablands. Reversal of flood currents in Quincy Basin from eastward inflow to westward outflow may reflect a late-flood increase in Scabland discharge owing to completion of the Grand Coulee by cateract retreat.

_____, 1977, Guidebook to Quaternary geology of the Columbia, Wenatchee, Peshastin, and upper Yakima Valleys, west-central Washington: U.S. Geol. Survey Open-file Report 77-753, prepared for GSA 1977 Annual Mtg. (Seattle), Field Trip No. 13, Nov. 77, 25 p.

Weis, P. L., 1976, Erosional and depositional features of the Spokane Flood (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 419.

1. Geological society meeting abstracts.
2. See title.
3. Channeled scablands.
4. See title.
5. Field and aerial reconnaissance.
6. See title.
7. ---
8. Abstract -The catastrophic emptying of glacial Lake Missoula had a profound and nearly instantaneous effect on the environment that lay within reach of the flood. The water produced a wide range of unusual erosional and depositional features within the lake basin in western Montana and in the channels that lay downstream to the west, in the path of the suddenly released flood. Although many features of the Spokane flood are well documented, few geologists have had the opportunity to visit them. Fewer still have had the opportunity to see these features from the air, where their magnitude and significance can be best appreciated.

   Giant ripple marks and high eddy gravels in the glacial lake basin in western Montana give evidence of the current velocities. Giant ripple marks, streamlined gravel bars, lag gravel, and bedrock scour are the result of currents in Spokane Valley. Denuded and deeply eroded basalts are evidence of the flood on the lava plateau of eastern and central Washington. On the plateau, some channels contain island-like remnants of Palouse loess, and an abrupt loess scarp forms the channel margin. Satellite photos provide an overall view, that might well have settled the controversy of the channel origins if these photos had been available 50 years ago.

Whitmer, J. H., 1974, The channeled scabland of Washington—Part 1 and 2: Geol. Soc. of the Oregon Country Geol. Newsletter, v. 40, no. 3 and 4, p. 18-19, 28-29.

1. Newsletter.
2. See title.
3. See title.
4. Flood scour features and deposits.
5. Description of and explanation for channeled scablands region of eastern Washington.
6. Description of and explanation for channeled scablands region of eastern Washington.
7. Geological map of channeled scablands.
8. Abstract -Description of, and geologic history of, eastern Washington and in particular the channeled scablands. A list of 11 major points of interest are given.

ADDITIONAL REFERENCES - Catastrophic Flood Scabland Features

Baker, V. R., 1971, Paleohydrology and sedimentology of Lake Missoula flooding in eastern Washington: Univ. of Colorado, Ph.D. thesis.

Shelton, J. S., 1966, Geology Illustrated: W. H. Freeman & Co., © 1966, p. 338-351.

Webster, G. D.; Baker, V. R.; Gustafson, Carl, 1976, Channeled Scablands of southeastern Washington, a road log via Spokane - Coulee City - Vantage - Washtucna - Lewiston - Pullman: Geol. Soc. Am. Cordilleran Section Mtg., Pullman, Wash., Field Guide No. 2, April 1976.

Barr, Scott, 1972, A conservation and environmental proposal for the Columbia, Snake, Palouse region. In Soil Conservation Society of America, The earth around us: Soil Conservation Society of America, Annual Meeting, Proceedings, no. 27, p. 223-225.

Bechtel Corp., 1971, Final soil investigation report for the Fast Flux Test Facility, Richland, Washington (prepared for Wedco Corp., Richland, Washington): Bechtel Corp., San Francisco, Calif., 195 p.

Borchardt, Glenn A., 1970, Neutron activation analysis for correlating volcanic ash soils: Ph.D. thesis, Oregon State University, Corvallis, Oregon. 219 p. (Diss. Abstr., v. 30, no. 11, Pub. No. 70-7917).

1. Agricultural soils publication.
2. See title.
3. Pacific Northwest.
4. See title.
5. Neutron activation analysis.
6. Correlation of volcanic ash soils.
7. ---
8. Abstract - The objectives of this study were: 1) To determine the trace element differences between sample sites and between deposits of Mazama, Newberry, Glacier Peak, and St. Helens volcanic ash in the Pacific Northwest, 2) To correlate volcanic ash in peat bogs with volcanic ash from upland sites, 3) To verify Mazama ash as parent material of soils occurring along a 450 km transect in Oregon, and 4) To determine the trace element composition of clays derived from volcanic ash.

Bryan, Kirk, 1927, The "Palouse soil" problem, with an account of elephant remains in wind-borne soil on the Columbia Plateau, Washington: U.S. Geol. Survey Bull. 790, p. 21-45, 4 plates.

1. U.S. Geological Survey Bulletin.
2. See title.
3. See title.
4. See title.
5. Historical review of Palouse soil, field observations, description of elephant remains.
6. New data to clarify issues in Palouse soil problem.

7. ---
8. Abstract - 1) The soil that is useful in agriculture (Palouse, Ritzville, Helmer series, etc., as defined by the Bureau of Soils) consists of a top skin, or veneer, that is largely wind borne throughout the plateau and rests on material of various sorts. 2) Where the unconsolidated material, or so-called "Palouse soil," is thick, the inner core of the hills composing the intricate topography is largely unknown. At various places this inner core consists of (1) laminated silt, (2) almost structureless reddish compact silt with limy concretions that may be a loess, (3) yellow clay and clay silt that seem with little doubt to be loess, (4) ancient glacial till (older than the intermediate till of this region), and (5) very doubtfully, a residual soil derived from basalt. 3) In the western part of the plateau there is in numerous valleys a well-defined terrace in part underlain by gravel. The valleys and the terrace antedate the great coulees formed by glacial waters. 4) The soil on these terraces is a definite wind-deposited material, as shown by the arrangement of the bones of an extinct elephant. 5) The soil on the terraces is younger than the unknown inner core of the adjacent "Palouse soil" hills but is of Pleistocene age. 6) In the eastern part of the plateau thin and discontinuous layers of gray to green-gray material, residual from basalt, underlie yellow clay composed of minerals foreign to the basalt and having all the characteristics of loess. 7) In one place at least, the top layer of soil or veneer contains volcanic ash. 8) The present rate of deposition of dust in the vicinity of Spokane is an accelerated rate induced by the cultivation of immense areas of loessial soil to the west and south. 9) Deposition of loess since the Wisconsin and intermediate bodies of till were laid down has been moderate in amount, and the great period of deposition of wind-borne soil antedates these later advances of glacial ice.

_____, 1927, The "Palouse soil" problem of the Columbia Plateau, Washington: Washington Acad. Sci. Jour., V. 17, no. 5, p. 120-121.

Caldwell, H. H., 1961, The Palouse in diverse disciplines: Northwest Sci., v. 35, no. 4, p. 115-121.

1. Scientific paper.
2. See title.
3. Southeast Washington.
4. Palouse soil
5 and 6. Collection and composite of views regarding definition and geographic boundaries of "Palouse".
7. Map showing core area and proposed extensions to geographic boundaries of "Palouse."
8. Summary - Attempt to define what "Palouse" means as regional phenomena and to indicate on a map the area conceived as representing the Palouse. Depending upon the discipline, the "Palouse" is considered to be a unique regional landform shaped by wind, snow, and stream action, and to reflect a particular climate, soil, prairie vegetation, and land use, or a bunchgrass ecologic community with associated climate and soil that developed on eolian materials, or a regional agricultural land-use type that reflects the topography, climate, vegetation, soils, and eolian materials. There is nearly universal agreement of the position of the eastern border but the most disagreement involves the southern border. Historical account of term "Palouse" is given. Due to the common agreement on "core" area boundaries, it is proposed that unadorned term "Palouse" be applied to denote a natural region and other names represent limited-factor areas, elements, dimensions, or extensions of the core area.

Calkins, F. C., 1903, Soils of the wheat lands of Washington (abs.): Science, new series, v. 17, no. 434, p. 668.

1. Scientific periodical.
2. See title.
3. Eastern Washington.
4. Soil.
5 and 6. Study of physical and chemical properties of soil and lack of transition between soil and underlying rock.
7. ---
8. Abstract - The soil covering the higher portions of the Columbia plains has generally been considered to be residuary, and derived from the underlying Miocene basalt. Recent observations, however, have led the author to believe that this soil is an eolian deposit.

The argument for the eolian hypothesis is based on the physical and chemical properties of the soil and the complete lack of transition between it and the underlying rock. The wind-blown material is supposed to come from the soft volcanic sediments that overlie the basalt in the southern portion of the Columbia plains.

Call, W. A., 1974, Soil survey of Cowlitz area, Washington: U.S. Dept. Agric., Soil Conserv. Serv., 112 p., soils maps 1:20,000.

Carmichael, V. W., 1956, The relationship of the "soils" of the Palouse to the Columbia River basalt: Compass of Sigma Gamma Epsilon, v. 34, no. 1, p. 6-28, illus.

1. Scientific journal.
2. See title.
3. Southeast Washington.
4. See title.
5. Study of configuration of basalt surface beneath soil and chemical analyses of soil.
6. See title.
7. ---
8. Abstract - The major problem of this thesis was to determine the relationship of the "Palouse soil" to the Columbia River basalt. A minor problem considered was the possibility of finding a method for predicting depths from soil surfaces to basalt by an examination of the "soil."

   In an effort to obtain solutions to the above problems the basalt surface of an area approximating 50 square miles in Whitman County, Washington, and adjoining Latah County, Idaho, was mapped and a number of samples of "Palouse soil" and basalt were chemically analyzed.

   The surface of the basalt shows considerable decomposition between elevations of 2550 and 2650 feet above sea level in many places within the area of study. Considerable dissection of the basalt has taken place and sinuous valleys have been eroded into its surface. In some places there is a complete lack of accordance of the surface topography of the "soil" with the basalt surface. In other words, valleys in the basalt are in some places overlain by Palouse hills.

Chemical analyses of "soils" and basalt show that the Palouse soil is not genetically related to the basalt, but that there is a mixture of residual basaltic soil and "Palouse soil" in a relatively thin zone at the contact between the two materials. Decomposition of the "soil" advances in degree toward the bottom of the "soil" layer. The decomposition of the basalt increases in an upward direction. Alumina content of "Palouse soil" is higher than that of other loessal deposits throughout the United States.

The results of this study and a review of the literature suggest that: (1) There has been one or more long periods of erosion between extrusions of groups of basalt flows. (2) Although much of the Columbia River basalt was extruded from the Grande Ronde region of northeastern Oregon, the marginal plateau basalt in the region between Moscow and St. Joe, Idaho, probably came from a different source. (3) Although the major portion of the Columbia River basalt dips centripetally toward the Pasco, Washington, region the marginal plateau basalt has been only locally deformed in Post-Miocene time. (4) A thickness of basalt approaching 800 feet may have been removed by erosion in some areas along the eastern margin of the Columbia plateau before the deposition of the "Palouse soil" parent material. (5) The parent material of the "Palouse soil" was probably loess, a portion of which may have been pumicite from the Cascade region.

Chapin, R. W., 1968, General soils map, State of Washington: U.S. Soil Conservation Service, 1:1,500,000.

Chichester, F. W., 1967, Clay mineralogy and related chemical properties of soils formed on Mazama pumice: Oregon State Univ. Ph.D. thesis, 152 p.; Diss. Abstr., v. 27, p. 3749B.

Cline, J. F.; Uresk, D. W.; Richard, W. H., 1975, Soil water in a sagebrush—bunchgrass and cheatgrass communities in southeastern Washington (prepared under Contract No. AT(45-1)-1830): Battelle Pacific Northwest Labs. Report No. CONF-750326-2, Richland, Washington, 15 p.

Culver, H. E., 1937, New version of the Palouse problem (abs): Geol. Soc. America Proc. 1936, p. 338-339.

1. Geological Society meeting proceedings.
2. See title.
3. Palouse region, Southeast Washington.
4. Palouse soil and topography.
5. Reconnaissance field observations.
6. See title.
7. ---
8. Abstract - Shapes of the Palouse hills, with their prominent steeper northerly slopes, the dendritic drainage pattern characteristic of the region, the wide range of lithologic character shown by the unconsolidated material lying above the Columbia basalt, and the prevailing southwesterly winds, together with a number of other items, have been scrambled, during the past half century, into a mass of apparently conflicting data from which a varied set of hypotheses of origin and development have been derived. Reconnaissance studies over practically all parts of the Columbia Plain in Washington, together with some detailed work, have suggested a concept under which many, if not all, the data now available can be harmonized.

   The eastern scabland channels cross Columbia Plain near the west margin of the recognized "Palouse country," thus suggesting a boundary where in reality none exists. Extension of the Ringold formation rather generally over southeastern Washington, suggested in previous papers by the writer, may explain the presence of the two types of deposits in the hills of the Palouse region, and at the same time may account for the present topographic character of the area. In parts of eastern Washington, erosion of the Ringold after its deformation may well have provided much of the material now composing the uppermost portion of the "Palouse formation," thus repeating the relationship believed to obtain locally between the Ringold and the Ellensburg formations. It seems doubtful that the term "Palouse" should be retained as a formation name.

Cunningham, R. L., 1964, Genesis of the soils along a traverse in Asotin County, Washington: Washington State University Ph.D. thesis, 158 p.

1. Ph.D. thesis.
2. See title.
3. See title.
4. See title.
5. Laboratory analyses; morphological studies; and studies of pH particle size distribution, morphology of sand and clay, and electron microscopy of fine particles.
6. Explanation of occurrence of different soils on Anatone plateau, along a traverse where soil characteristics changed due to differing soil forming factors.
7. Soils map on aerial photograph mosaic; soil monoliths; mineral distribution in soil horizons; X-ray diffraction traces for soil samples; electron micrographs of soil samples.
8. Abstract - An explanation of the occurrence of the different soils on the Anatone plateau is the purpose of this study. A traverse was selected along which soil characteristics changed because of differing soil forming factors. Soils were sampled at eight sites along the 7-mile traverse in order that laboratory analyses might be used in conjunction with morphological studies to infer the genesis of the soils. The soils at sites 1 through 8 are characterized in terms of their morphology, pH, particle size distribution, mineralogy of the very fine sand and clay, and the appearance of the fine particles in electron micrographs.

Davis, Owen K.; Kolva, David A.; Mehringer, Peter J., Jr., 1977, Pollen analysis of Wildcat Lake, Whitman County, Washington -- The last 1,000 years: Northwest Science, vol. 51, no. 1, p. 13-30.

Dobie, J. L., 1924, The origin of the Palouse soils: Washington State College A.I.M.E. Paper, Department of Geology, State College of Washington, 22 p.

1. Professional paper.
2. See title.
3. Eastern Washington - Palouse region.
4. Palouse soil.
5. Field observations.

6. See title.
7. Map of Pullman quadrangle.
8. Abstract - determination of origin of Palouse soil by comparison of conditions there with other areas. Discussion of geology in Pullman quadrangle. Results: (1) discovery of faulting and other disturbances pre-dating present soil deposition; (2) discovery of clastic dikes representing former formation on top of basalt, now destroyed; (3) realization that present soil will be eroded away, leaving barren scabland of mesa type.

Donaldson, N. C.; Giese, L. D., 1968, Soil survey of Spokane County, Washington: U.S. Soil Conservation Service in cooperation with the Washington Agricultural Experiment Station, 143 p., plus 148 map sheets.

Easterbrook, D. J.; Baker, V. R.; Waitt, R., 1977, Glaciation and catastrophic flooding of the Columbia Plateau, Washington (Field Trip No. 13): In Geological Excursions in the Pacific Northwest: Geological Society of America 1977 Annual Meeting, Seattle, Washington, p. 390-414.

1. Guidebook for field trip.
2. See title.
3. See title.
4. Deposits of Okanogan lobe of Vashon glacier and channeled scabland features.
5. Field study.
6. Interpretation of glacial and catastrophic flood geology.
7. Maps and photos of glacial and flood features.
8. Examines location, nature, and significance of Winthrow moraine, outwash terrace, giant flood bars, Moses coulee, Dry Falls cataract, Grand Coulee, Quincy Basin, Ephrata bar, and giant current ripples in Lind Coulee.

Franklin, J. F.; Dyrness, C. T., 1969, Vegetation of Oregon and Washington: U.S. Dept. Agriculture Forest Service Research Paper PNW-80, 216 p.

Fryxell, R., 1965, Mazama and Glacier Peak volcanic ash layers relative ages: Science, v. 147, p. 1288-1290.

1. Scientific journal.
2. See title.
3. Pacific Northwest.
4. See title.

5 and 6. Radiocarbon dating; physiographic and stratigraphic evidence to correlate volcanic ash layers.

7. Location map showing inferred extent of minimum areas affected by fallout of ash from eruptions of Glacier Peak and Mt. Mazama.
8. Abstract - Physiographic and stratigraphic evidence supports the regional correlation of two volcanic ash layers with extinct Mount Mazama at Crater Lake, Oregon, and Glacier Peak in the northern Cascade Range of Washington. A radiocarbon age of 12,000 + 310 years confirms geological evidence that ash derived from the Glacier Peak eruption is substantially older than ash from the Mazama eruption of 6600 years ago.

_____; Neff, G. E.; Trimble, D. E., 1965, Scabland tracts, loess, soils, and human prehistory. In INQUA, Guidebook for Field Conference E, northern Rocky Mountains: Nebraska Acad. Sci., Lincoln, Nebr., p. 79-89.

(Annotated under Scablands section).

Garber, Lowell W., 1965, Relationship of soils to earthflows in the Palouse: Jour. Soil and Water Conserv., v. 20, no. 1, p. 21-23, illus.

1. Soils periodical.
2. See title.
3. See title (eastern Washington and northern Idaho).
4. See title.
5. Field investigations.
6. Description of soils in Palouse region; discussion of physical forces contributing to earthflows and some preventions.
7. Cross-section of typical Palouse hill showing excavation of footslope by plowing, and percentage range in slopes.
8. Abstract - One striking form of soil erosion in the Palouse region of the Pacific Northwest is the earthflows that occur during the spring of the year. Several hundred tons of soil may move downslope in large earthflows. In this article, a soil scientist describes the properties of soils on which earthflows are likely to occur and relates these properties to physical forces operative in the soils. Also treated are management techniques that can be used to prevent earthflows.

Gilkeson, R. A., 1958, Washington soils and related physiography -- Columbia Basin Irrigation Project: Washington State Agricultural Experiment Station Circular, 9 p.

_____, 1965, Ritzville series; benchmark soils of Washington: Washington Agricultural Experiment Station Bull. 665, 18 p.

Hajek, B. F., 1966, Soil survey, Hanford project in Benton County, Washington: Battelle Memorial Institute, Pacific Northwest Laboratory Report BNWL-243, 18 p.

1. Industrial lab report.
2. See title.
3. See title.
4. See title.
5. Soil classification, field verification, no lab work.
6. Soil mapping and descriptive report of Hanford Project soils.
7. Soil map of Hanford Project, Benton County, Washington.
8. Abstract - Soil map and descriptive report of Hanford Project soils classification scheme based on morphologic and genetic characteristics. Soil descriptions include: Ritzville silt loam, Rupert sand, Hezel sand, Koehler sand, Burbank loamy sand, Kiona silt loam, Warden silt loam, Ephrata sandy and stony loams, Scootney stony silt loam, Pasco silt loam, Esquatzel silt loam, Riverwash, Dune sand, and Lickskillet silt loam.

Harrison, E. T.; Donaldson, N. C.; McCreary, F. R.; Ness, A. C., 1964, Soil survey of Walla Walla County, Washington: U.S. Dept. Agri., Soil Conserv. Serv., 138 p., incl. soils maps 1:31,680.

Holmes, J. G., 1902, Soil survey of the Walla Walla area, Washington: U.S. Dept. Agri., p. 711-728, incl. soil map 1:63,360.

Johnson, L. C.; Papendick, R. I., 1968, A brief history of soil erosion research in the United States and in the Palouse, and a look at the future: Northwest Sci., v. 42, no. 2, p. 53-61.

1. Scientific periodical.
2. See title.
3. Palouse region.

4. Soils.
5 and 6. See title.
7. ---
8. Abstract - Summary of effects of different tillage and cropping practices on soil surface conditions and effects on runoff and soil erosion in Palouse region.

Kaiser, V. G., 1967, Soil erosion and wheat yields in Whitman County, Washington: Northwest Sci., v. 41, no. 2, p. 86-91.

1. Scientific periodical.
2. See title.
3. See title.
4. Soils (Palouse).
5 and 6. Documentation of soil erosion and crop yields.
7. Cross-section of typical Palouse hill.
8. Abstract - Documents wheat production and soil loss record from 1939-1965. Includes description of Palouse soil and typical Palouse hill. During 27 years of study, erosion moved an average of 0.7 tons of soil off steep cultivated slopes for each bushel of wheat produced. Areas of typical hill where erosion is most critical are also lowest wheat-producing areas. Cummulative effects of erosion reduces wheat-producing capacity of soil -- eroded soils produce 32 percent of the yield that noneroded soils produce.

Klock, G. O., 1969, Forest and range soils research in Oregon and Washington, a bibliography with abstracts from 1964 through 1968: Pacific Northwest Forest and Range Experiment Station Report No. FSRP-PNW-90, 31 p.

Kocher, A. E.; Strahorn, A. T., 1919, Soil survey of Benton County, Washington: U.S. Dept. Agri., 72 p.

_____, 1922, Soil survey of the Wenatchee area, Washington: U.S. Dept. Agri., 91 p. incl. soil map 1:62,500.

Krynine, P. D., 1937, Age of till on "Palouse soil" — Washington: Am. Jour. Sci., 5th ser., v. 33, no. 195, p. 205-216, 2 figs.

1. Scientific journal.
2. See title.
3. Columbia plateau.

4. See title.
5. Petrographic analysis.
6. See title.
7. ---
8. Abstract - The so-called "ancient" till of Washington, said to be of Pre-Wisconsin age, is shown by petrographic analysis to be really a late-glacial deposit whose weathered and "ancient" appearance is due to the fact that it contains much reworked and incorporated "Palouse soil," an old and decayed pre-late-glacial loess. Methods of differentiation between "Palouse soil" and till contaminated with even very large amounts of "Palouse soil" are offered. Finally, the apparent and real effects of the admixture of volcanic ash in "Palouse soil," and recent superficial loess are described.

Lenfesty, C. D.; and others, 1967, Soil survey of Adams County, Washington: U.S. Dept. of Agriculture, Soil Cons. Service, in coop. with the Wash. Agri. Exp. Sta., 110 p., plus 160 map sheets.

Lotspeich, F. B., 1952, A study of the Palouse catena: Washington State College M.S. thesis, 70 p.

1. M.S. thesis.
2. See title.
3. Southeastern Washington.
4. Palouse, Athena, and Thatuna soils of Palouse catena.
5. Morphological, physical, chemical, and minerological studies.
6. Using information gained to draw inferences concerning soil-forming processes involved in development of soils and degree of homogeneity of their parent materials.
7. ---
8. Abstract - Study of Palouse, Athena, and Thatuna series of Palouse catena including physical, chemical, and mineralogical properties.

_____; Smith, H. W., 1953, Soils of the Palouse loess, Pt. 1, The Palouse Catena: Soil Sci., v. 76, p. 467-480.

1. Soils journal.
2. See title.
3. Southeastern Washington.
4. Palouse soil.

5. Profile descriptions and sample collections, particle-size distribution study, petrographic analyses, standard lab soil tests.
6. Discussion of three Palouse soils.
7. Cross-section of Palouse hill showing extent, depth, and sequence of horizons; figure of distribution of sand, silt and clay in profiles of three soils.
8. Abstract - Physical, chemical, and mineralogical properties of three members of the Palouse catena, Palouse, Athena, and Thatuna soils, were investigated. The conclusions reached are applicable to an area restricted both geographically and topographically.

   Variation in microclimate, due to exposure and localized accumulation of snow, has been dominant in determining soil differences. The zonal prairie soil, Palouse silt loam, is found only on the relatively gentle south-facing slopes. A profile with chernozem morphology, Athena silt loam, is on the dry ridges. On the locally wet lee slopes a claypan soil, Thatuna silt loam has developed.

   Soil-forming materials are similar throughout the catena, except that the lee north slopes have accumulated a blanket of loess plus volcanic dust, younger than the underlying Palouse loess. Although the microclimate and associated changes in vegetation have determined the general course of soil formation in members of the catena, this layering of the soil-forming material has determined the position of the A-B break in the Thatuna profile, through its influence on the rate of water movement.

Mangum, A. W.; Van Duyne, C.; Westover, H. L., 1913, Soil survey of the Quincy area, Washington: U.S. Dept. Agri., 64 p., incl. soil map 1:62,500.

McCreery, R. A., 1954, Mineralogy of Palouse and related series: Washington State College Ph.D. thesis, 120 p.

1. Ph.D. thesis.
2. See title.
3. Palouse region, southeast Washington.
4. Palouse soil and loess.
5. Mineralogical methods.

6. Mineralogy of Palouse soil to determine its relation to soil morphology.
7. ---
8. Abstract - Based upon the mineralogy of the heavy fraction of the very fine sand, the loess from which the soils in the area have developed is identical with the Ringold Formation modified by the addition of pumicite. The Ringold Formation is thus a probable source of the loess in this area, but it cannot be considered as the source of the main body of loess. Volcanic derived minerals occur to considerable depth in the areas sampled. Vertical variation in the material deposited is evident from the mineral histograms presented.

   Illite is the predominant clay mineral found. Mica intermediates make up a significant portion of the clay from profiles of the drier area. Montmorillinite seems to be closely associated with exchangeable magnesium. Little kaolin is present in soils of the Palouse loess.

McHenry, J. R., 1957, Properties of soils of the Hanford Project: Hanford Works unclassified report HW-53218.

Michelson, J. C., 1954, Buried soil zones in the Palouse loess, eastern Washington (abs.): Geol. Soc. America Bull., v. 65, no. 12, pt. 2, p. 1345.

1. Geological journal.
2. See title.
3. See title.
4. See title.
5. Field observations of buried soil zones.
6. See title.
7. ---
8. Abstract - The Palouse loess is dominantly a silt with lesser amounts of fine sand and clay-size particles. In most instances it shows little or no bedding or lamination although locally it has the characteristic bedding and sorting of silts, sands, and gravels deposited in standing and/or moving waters.

   The Palouse loess is characterized by a near absence of fauna which makes it most difficult to assign a definite age to the deposit. Physical relationships

indicate a Pleistocene age and probably late Pleistocene. Within the main body of the Palouse loess are two quite well-defined buried soil horizons. The upper buried soil horizon occurs 4 to 10 feet below the surface and conforms to the present topography, with a high percentage of pumicite above. Lower in the loess section is another well-defined buried soil profile that has wide distribution throughout the loess area of eastern Washington. The development of these soils and their subsequent burial make it possible to delimit and correlate members within the main body of the loess and may aid in finally assigning relative ages to the several units.

Ness, A. O., 1960, Soil survey of Mason County, Washington: U.S. Dept. Agri., Soil Conserv. Serv., 76 p., incl. soils maps 1:31,680.

Newcomb, R. C., 1938, Cause of the asymmetrical profiles of the typical Palouse hill: Northwest Sci., v. 12, no. 4, p. 96.

1. Scientific journal.
2. See title.
3. Palouse region, southeastern Washington.
4. Palouse loess and topography.
5. Field investigations.
6. See title.
7. ---
8. Abstract - Dune action, coupled with unlike vegetation cover and resistance to seasonal erosion is dominant factor in typical, asymmetrical profile, not snowdrift erosion as proposed by W. A. Rockie.

_____, 1961, Age of the Palouse Formation in the Walla Walla and Umatilla River Basins, Oregon and Washington: Northwest Sci., v. 35, p. 122-127.

1. Geological article.
2. See title.
3. Walla Walla and Umatilla River Basins, Oregon and Washington.
4. Palouse Formation.
5. ---

6. Data on the age of the Palouse Formation, description of Palouse soils; stratigraphic relationships to other sedimentary units.
7. Index map of Walla Walla and Umatilla River basins.
8. Conclusions - Typical Palouse Formation of Walla Walla valley is middle to late Pleistocene.

   Greatest deposition closely followed or accompanied deposition of Ringold formation and preceded Wisconsin Glacial Stage.

   If younger eolian deposits (termed Palouse soil) are to be included in Palouse Formation, age would be middle Pleistocene to Recent. Whereas Palouse soil problem would be clarified by restriction of term "Palouse" to the pre-Wisconsin loess.

Peterson, P. P., 1922, Rate and mode of soil deposition in the Palouse area of Washington and Idaho: Science, new ser., v. 55, p. 102-103.

1. Scientific journal.
2. See title.
3. Southeast Washington and adjacent Idaho.
4. Palouse soil.
5. Field investigation of accumulation rate.
6. Field investigation of accumulation rate.
7. ---
8. Abstract - Discusses origin of loess in general, and the Palouse Hills, in particular. Believes they formed by eolian action: wind picking up silt from an arid region (to the west) and depositing it in a more humid region where moisture and vegetation keep the silt from being moved further. Presents data from series of field experiments showing that an average of 7,500 pounds of dust is deposited around Moscow, Idaho per year. Extrapolates this to show that 4 inches of material deposited per century (with no erosion), and that it took 25,000 years to deposit the 75 feet of soil covering the lava beds in this area. States that this accumulation rate is 4 times that calculated by Free.

Rasmussen, J. J.; and others, 1971, Soil survey of Benton County area, Washington: U.S. Dept. of Agri. Soil Conservation Service in cooperation with Washington Agricultural Experiment Station, 72 p. plus 114 sheets.

_____; Bayer, J. T.; Gale, P. S.; Raver, M. L., 1976, Soil survey of Yakima Indian Reservation irrigated area, Washington, part of Yakima County: U.S. Dept. Agri., Soil Conserv. Serv., 51 p. (incl. soils maps 1:20,000), Washington D. C.

Rieger, Samuel; Smith, H. W., 1955, Soils of the Palouse Loess, Part II, Development of the A_2 horizon: Soil Sci., v. 79, p. 301-319.

1. Soil science periodical.
2. See title.
3. Southeast Washington and adjacent Oregon and Idaho.
4. See title.
5. Field sampling; physical, chemical and mineralogical determinations.
6. Investigation to determine factors responsible for position of A_2 soil horizon in Palouse loess.
7. ---
8. Abstract - Several soils of eastern Washington and northwestern Idaho were studied to determine the factors responsible for the development of A_2 horizons at unusually great depths in their profiles.[2] Geographically associated soils without A_2 horizons were also studied.

   Bulk density, reaction, and textural variations among horizons in the profiles with A_2 horizons are comparable to those in planosols of the Middle West. Organic matter, under both forest and grass cover, usually decreases steadily with depth.

   Counts of heavy and light mineral grains from the very fine sand fraction of selected horizons indicate that the soils have developed from two mineralogically distinct parent materials; one, when present, always overlies the other. The upper parts of most of the profiles contain an admixture of volcanic ash. In many profiles, the A_2 occurs immediately above the boundary between the portion of the profile modified by volcanic ash and the portion containing no ash.

   The planosolic nature of the profiles with A_2 horizons is believed to be the result of the same process of whole fine clay translocation that operated in the formation of planosols of the Middle West. The location

of the A_2 horizon, however, is believed to have been determined by an abrupt change in compaction and permeability occurring at the lower boundary of volcanic ash admixture in the parent material. The absence of this boundary within reach of percolating waters in several geographically associated soils is believed to have been responsible for the failure of A_2 horizons to develop in those profiles.

It is expected that continued movement of fine clay would cause the A_2 horizon to migrate downward into the zone of parent material not affected by volcanic ash deposition. Several profiles illustrate soil development at this stage.

Richmond, G. M.; Fryxell, Roald; Weiss, P. L.; Neff, G. E.; Trimble, D. E., 1965, Glacial Lake Missoula, its catastrophic flood. . ., and the loesses and soils of the Columbia Plateau, Pt. F. In Guidebook for Field Conference E, Northern and Middle Rocky Mountains - Internat. Assoc. Quaternary Research, 7th Cong., USA, 1965: Nebraska Acad. Sci., Lincoln, Nebr., p. 68-89, illus.

(Annotated under Scablands section).

Smith, H. W.; Moodie, C. D., 1947, Collection and preservation of soil profiles: Soil Sci., v. 64, p. 61-69.

Smith, H. W,;McCreery, R. A.; Moodie, C. D., 1952, Collection and Preservation of soil profiles: Part II: Soil Sci., v. 73, no. 3, p. 243.

Smith, H. W.; Okazaki, Rose; Aarstad, John, 1968, Recent volcanic ash in soils of northeastern Washington and northern Idaho: Northwest Sci., v. 42, no. 4, p. 150-160.

1. Scientific journal.
2. See title.
3. See title.
4. See title.
5. Lab soil studies, field studies.
6. Properties, genesis and distribution of A_2 soil horizon.
7. ---

8. Abstract - Considers the properties, genesis, and geographic distribution of an A_2 soil horizon in the West Blacktail clearcut area (27-T62N-R3WBM, Idaho) in the Kaniksu National Forest.

Smith, L. H., 1945, Soil survey of Kittitas County, Washington: U.S. Dept. Agri., 69 p., incl. soils maps.

_____, 1958, Soil survey of Yakima County, Washington: U.S. Dept. Agri., 143 p., accompanied by set of 10 soil survey map sheets, 1:31,680, by the Washington Agri. Exp. Station.

Starr, W. A., 1953, Soil distribution in the Columbia Basin (Washington): Pacific Northwest Fertilizer Conf., 4th Ann., Pullman, Washington, 1953, Proc., p. 117-125.

Strahorn, A. T.; Carpenter, E. J.; Weir, W. W.; Ewing, Scott; Krusekopf, H. H., 1929, Soil survey (reconnaissance) of the Columbia Basin area, Washington: U.S. Dept. Agri., 55 p., incl. soil map.

Tidball, R. E., 1965, A study of soil development on dated pumice deposits from Mount Mazama, Oregon: Univ. California, Berkeley, Ph.D. thesis, 235 p.

Treasher, R. C., 1925, Origin of the loess of the Palouse region, Washington: Science, new ser., v. 61, p. 469.

1. Scientific journal.
2. See title.
3. See title.
4. See title.
5. Field observations.
6. See title.
7. ---
8. Abstract - Throughout east-central Washington, especially that region known as the Palouse wheat country, is a large area underlain by basalt, which is a part of the Columbia lava plateau. Above this basalt is a covering of very fine sand, which has a thickness as great as 250 feet and more.

   This fine sand has the characteristics of loess. When exposed in highway and railroad cuts, it stands with a vertical face, and in drying it shows vertical cleavage. It is composed of fine quartz sand, whose grains average 0.05 mm in diameter. The sand grains are sub-angular. The formation is iron stained and contains small concretions and tubelets of iron oxide. This loessial

formation has two phases: one phase is massive, the other laminated, that is, stratified in thin, well-defined layers. These two phases are identical in composition, but differ in structure.

From a study of the field conditions, the writer has reached the following conclusions in regard to the origin and occurrence of the Palouse loess: (1) That the loess was derived from the retreat of the continental ice sheet of pre-Spokane age, possibly Iowan or Illinoian. (2) That the loess was deposited in shallow, sluggish, ephemeral sheets of glacial water to a depth of about 250 feet on the surface of the flat-lying basalt before the period of Pleistocene deformation. (3) That a mature type of topography was developed on the surface of the loess. (4) That a period of deformation followed, during which the region was elevated. (5) That, following the uplift of the region, rejuvenation of the major streams came into evidence, developing deep canyons which were cut, first through the loess and then through the hard, underlying basalt. (6) That later, recent action of the wind shifted the water-laid loess, modifying its laminated structure to the massive type, and causing surface features to be developed characteristic of aeolian deposition. (7) That mud flows have subsequently developed on plowed hillsides during the rainy seasons of the year, modifying much of the surface covering so that the underlying laminated material has been largely lost to view.

Owing to the modification of the original loessial deposit by the surface action of wind and water, the underlying laminated phase is exposed only in widely separated localities, where deep road cuts have recently been made. This laminated phase is considered by the writer to be the original loessial deposit.

The writer proposes the name Palouse Formation to these sedimentary beds. The fertile soil of the Palouse region is largely a residual modification of the Palouse formation and has locally been redeposited by wind and surface wash.

Treasher, R. C., 1926, Stratigraphic aspects of loess of Palouse region: Pan-American Geologist, v. 46, no. 4, p. 305-314, 2 plates.

Udine, G., 1956, HAPO soil information: Hanford Atomic Products Operation unclassified report HW-50239.

Van Duyne, C.; Mortlock, H. C.; Hack, A. F.; Alvord, E. C., 1921, Soil survey of Spokane County, Washington: U.S. Dept. Agri., Bur. Soils, Field Operation 1917. 108 p

Vlasoff, P. I.; Wheeting, L. C., 1937, Characteristics of certain soil profiles of southeastern Washington: Soil Sci., v. 44, p. 71-72.

Waitt, R. B., Jr., 1977, Guidebook to Quaternary geology of the Columbia, Wenatchee, Peshastin, and upper Yakima Valleys, west-central Washington: U.S. Geol. Survey Open-File Report 77-753, prepared for GSA 1977 Annual Mtg. (Seattle), Field Trip No. 13, Nov. 77, 25 p.

1. Guidebook for field trip.
2. See title.
3. See title.
4. Surficial Quaternary deposits in eastern Cascade Valleys.
5. Field study.
6. Interpretation of Quaternary glacial history.
7. Maps of glacial features near Cle Elum and Ellensburg; table of stratigraphy.
8. Eastern Cascades south of Chelan Valley record alternating periods of episodic alpine glaciation and weathering and soil formation. Best exposures found in upper Yakima Valley, Wenatchee Valley near Leavenworth and in Peshastin and Entiat Valleys. Yakima Valley shows three periods of alpine glaciation interspersed with long periods of soil formation. Wenatchee Valley also records three glaciations from morainal material. But nature of its terraces beyond drift limit is very different from those in Yakima Valley. Indicates different processes influenced late Quaternary development in the two valleys. Postulates is due to nearness of Wenatchee Valley to Columbia River versus Yakima Valley, and much lower altitude of Wenatchee Valley than Yakima Valley. Catastrophic late Wisconsin events influenced and obliterated most of the pro-glacial record in the Wenatchee Valley.

Wooldridge, D. D., 1964, Effects of parent material and vegetation on properties related to soil erosion in central Washington: Soil Sci. Soc. Proceedings 1964, v. 28, no. 3, 1964.

1. Soils Society Proceedings.
2. See title.
3. See title.
4. See title.
5. Studies of soil's physical properties.
6. See title.
7. ---
8. Abstract - In a preliminary study of physical properties of wild land soils, three soil parent materials were sampled by horizons under forest and adjacent grass cover. Soil properties analyzed were mean water-stable aggregate, bulk density, organic matter pH, total porosity, and percent clay, silt, and sand. Several of the measured soil properties were related significantly to parent material and horizon depth. Effects of vegetative cover were not reflected in overall averages of soil property values. However, these values, broken down by parent materials and horizons, indicated that forest and grass covers were associated with soil property differences, although the relation of these differences to changes in parent materials and horizons is not consistent. Over 40% of the variation in soil erosion hazard (as measured by mean size of water-stable aggregates) is accounted for by multiple variation in soil organic matter content, pH, total porosity, and bulk density.

ADDITIONAL REFERENCES - SOILS

MacMacken, J. G., 1925, Eolative soils of Washington wheat lands: Pan-Am. Geologist, v. 43, p. 174-177.

Peterson, F. F., 1961, Solodized Solonetz soils occuring on the uplands of the Palouse Loess: Washington State Univ. Ph.D. thesis, Dept. of Agronomy, 280 p.

Rieger, Samuel, 1950, Origin of the Palouse formation: Washington State College, Geol. Dept. class paper, 12 p.

Rieger, Samuel, 1952, Development of the A_2 horizon in soils of the Palouse area: State College of Washington, Ph.D. thesis, 107 p.

Van Duyne, Cornelius; and others, 1920, Soil survey of Spokane County, Washington: U.S. Dept. Agr., Bur. Soils Field Operations for 1917, p. 35 et. seq.

Physiographic Features

Baldwin, E. W., 1950, Summary of the structure and geomorphology of the Columbia River Basalt: Northwest Sci., v. 24, no. 2, p. 59-64.

1. Scientific periodical.
2. See title.
3. Columbia Basin.
4. Geomorphologic features of basalt region.
5. Field observation.
6. See title.
7. ---
8. Abstract - Basalt forms dominant topographic features of region. Streams flow through deep canyons at margins of broad basins before emerging onto basin floor. Others flow through water gaps. Some have been superimposed onto the basalt by vast accumulations of glacial sediments in valleys as is the case for Columbia River in certain areas. Some streams are antecedant to rise of a Ridge, as parts of Columbia River were antecedant to rise of Cascades. Many rapids and ungraded portions of streams may be due to recent uplift or faulting. Question is posed about recent and ongoing deformation in region.

   Paper deals with other topics concerning Columbia River Basalt - only geomorphological section is annotated.

Chappell, W. M., 1936, The effect of Miocene lavas on the course of Columbia River in central Washington: Jour. Geology, v. 44, p. 379-386.

Denman, C. E., 1923, Topography and water supply of a Columbia River terrace: Washington State College B. S. thesis, 31 p.

1. B. S. thesis.
2. See title.
3. North of Spokane 100 miles.
4. River terrace.
5. Topographic field mapping.
6. Mapping topographic features and determination of water supply in area.
7. Topographic map of G. L. Denman place, Columbia River terrace.
8. Abstract - Topographic mapping of terrace to determine water supply of area.

Easterbrook, D. J.; Rahm, D. A., 1970, Landforms of Washington - The geologic environment: Western Washington State College, Department of Geology, Bellingham, Washington, 156 p.

Easterbrook, D. J.; Baker, V. R.; Waitt, R., 1977, Glaciation and catastrophic flooding of the Columbia Plateau, Washington (Field Trip No. 13). In Geological excursions in the Pacific Northwest: Geological Society of America 1977 Annual Meeting, Seattle, Washington, p. 390-414.

Fenneman, N. M., 1931, Physiography of western United States: McGraw-Hill Book Co., New York, 534 p.

1. Book.
2. See title.
3. See title.
4. ---
5. ---
6. ---
7. ---
8. Abstract - Contains section on the Columbia Plateau including: province as whole; Snake River Plain; Payette section; Blue Mountians; Walla Walla; Eastern margin; Coulee district; Yakima district; Harney section; north central Oregon.

Flint, R. F., 1934, Geomorphic features of the Okanogan region (abstract): Geol. Soc. America Proc. 1933, p. 81.

1. Geological abstract.
2. See title.
3. Okanogan region, Washington.
4. Geomorphic features.
5. ---
6. Geomorphologic data including uplift, downwarp and stream changes.
7. ---

Freeman, O. W., 1940, Physiographic divisions of the Columbia Plateau: Assoc. Pacific Coast Geog. Yearbook, v. 6, p. 12-20, illus. incl. index map.

1. Geographer's journal.
2. See title.
3. Columbia Plateau.

4. Columbia River Basalt Group, Palouse Formation, Ellensburg Formation, Ringold Formation, etc.
5. Field observations.
6. See title.
7. ---
8. Abstract - On the basis of differences in physiographic relief it has been found desirable to divide the Columbia Plateau into 12 main divisions: 1. Waterville Plateau; 2. Palouse Hills; 3. Channeled Scablands; 4. Central Plains; 5. Yakima marginal folds; 6. Bue-Wallowa-Seven Devils Mountains, and connecting Snake River High Plateau; 7. Tri-State Slopes; 8. Deschutes-Columbia Plateau; 9. Payette Section; 10. Snake River Plain; 11. Owyhee Section; 12. Harney Basin.

   These divisions are described in terms of geologic history and geomorphological form.

Fryxell, R., 1972, Relationship of late Quaternary volcanic ash layers to geomorphic history of the Columbia Basin, Washington (abs.): Abs. with Programs, Geol. Soc. Am. Cordilleran Sec.

Judson, S.; Ritter, D. F., 1964, Rates of regional denudation in the United States: Jour. Geophys. Research, v. 69, no. 16, p. 3395-3401.

1. Geological publication.
2. See title.
3. Includes Columbia basin.
4. Surface sediments.
5. Mathematic models of stream loads and surface denudation.
6. Measurements of stream sediment loads to calculate regional rates of land denudation.
7. Tables showing suspended sediment loads by individual stream basins including Columbia; estimates of annual chemical denudations; rates of regional denudation; comparison between regional denudation rates reported in this study and others; relation by regions between detrital load and dissolved load.
8. Abstract - Data, in large part collected since World War II, allow a recalculation of the rates of regional erosion in the United States as a whole of 2.4 in/1000 years, or about twice that of older estimates. The most rapid rate, 6.5 in./1000 years, is recorded from

the Colorado drainage. The slowest rate, 1.5 in./1000 years, is found in the Columbia basin. Other drainage areas and their rates are the Pacific slopes, California, 3.6 in./1000 years; the western Gulf of Mexico, 2.1 in./1000 years; the Mississippi River watershed, 2.0 in./1000 years; the South Atlantic and the eastern Gulf of Mexico, 1.6 in./1000 years, and the North Atlantic, 1.9 in./1000 years.

King, P. B., 1958, Evolution of modern surface features of western North America. In Hubbs, C. L., ed., Zoogeography: Am. Assoc. Advancement Science Pub. 51.

Kirkham, V. R. D.; Johnson, M. M.; Holm, D., 1931, Origin of Palouse hills topography: Science, new ser., v. 73, p. 207-209.

1. Scientific journal.
2. See title.
3. Whitman county.
4. Palouse Formation and topography.
5. Discussion and field observations.
6. Descriptions of measurements of amphitheaters at heads of small tributary streams in study area.
7. ---
8. Abstract - 90% of minor valleys (intermittent tributary streams) that drain into regular Stream Channels are of the cirque-like amphitheater type at their head. The predominant process of dissection of the loess-covered Columbia Plateau is by the formation and enlargement of amphitheaters. All of the valleys and depressions, regardless of age, present the characteristic curves of maturity with the upper part convex and the lower part concave.

Kraszewski, Stefan, 1952, Morphology and development of Palouse and related series: Washington State College Ph. D. thesis, 105 p.

1. Ph. D. thesis.
2. See title.
3. Walla Walla and Columbia Counties, Washington.
4. Palouse Formation.
5. Soil profiling and sampling; lab investigations including bulk density, mechanical analysis, chemical composition and other standard soil tests.
6. Soil investigations.

7. Descriptions of soil profiles; four diagrams showing how clay, water, organic carbon, and total nitrogen vary with depth of soil profiles; figure showing climatic conditions that prevail near sampling sites.
8. Abstract - An evaluation of most active soil-forming processes involved in development of soils. Determination of degree of development of Ritzville, Walla Walla, Athena and Palouse soils. Correlation of degree of development with morphological characteristics. Characterization of morphological features of these representative soils.

Lewis, P. F., 1960, Linear topography in the southwestern Palouse, Washington-Oregon: Assoc. Am. Geographers Annals, v. 50, no. 2, p. 98-111, incl. sketch maps, diagrams, and illus.

1. Geographical journal.
2. See title.
3. See title.
4. Topographic landforms and Palouse loess.
5. Field and lab work, interpretation of aerial photographs.
6. Explanation of linear topography and extent.
7. Map of aligned topography in southwest Palouse and vicinity; drainage maps for southwest Palouse and of Palouse loess from southwest to northeast; wind velocity and direction diagrams.
8. Abstract - Area of aligned topography is 2000 square miles (half of Palouse) and boundaries are indistinct. Lineation is dominant feature of landscape with a constant northeast direction. Ridges are quite uniform in dimensions. The alignment and essential form of linear topography has resulted from deposition of loessial material by the wind, more rapidly in some places than others. This is the "wind shadow" hypothesis. If wind is carrying loessial material in suspension, deposition will occur where wind velocity is reduced. The obstacles to wind were provided by obstacles in the eroded pre-loess basalt surface. Evidence for this theory: small streams are aligned with linear topography; the ridges, similar in shape, taper to the northeast, but end abruptly to southeast; silt-bearing winds blew from south-southwest with great consistency.

Lowther, F. L., 1959, Palouse Falls and Canyon: Ford times, p. 25-26.

Mackin, J. H.; Cary, A. S., 1965, Origin of Cascade landscapes: Washington, Div. Mines and Geology, Inf. Circ. No. 41, 35 p.

Meining, D. W., 1968, The great Columbia plain; a historical geography, 1805-1910: Univ. of Washington Press, Seattle, Washington, 576 p.

Meyer, B. E., 1971, Grit and grass; a historical geography of Adams County, Washington: Northwest Sci., v. 45, no. 1, p. 48-71.

1. Scientific periodical.
2. See title.
3. See title.
4. Topography, soils.
5. Historical account.
6. See title.
7. Topographic diagram, Adams County; land use capability classes in Adams County; historical agricultural tables.
8. Abstract - Geologic history of county and description of topography; description of climate, soils, ecological changes; historical account of natives and settlers, land acquisitions, ranching problems, early roads and settlements.

Molenaar, Dee, 1976, Pictorial landform map of the State of Washington and adjacent parts of Oregon, Idaho, and British Columbia: (Published by the author) Burley, Washington, 1 sheet, multicolor. Scale approximately 1:750,000.

Neal, V. T., 1972, Physical aspects of the Columbia River and its estuary. In The Columbia River estuary and adjacent ocean water bioenvironmental studies, p. 19-40.

Newcomb, R. C., 1938, Cause of the asymmetrical profiles of the typical Palouse hill: Northwest Sci., v. 12, no. 4, p. 96.

Othberg, K. L.; Pringle, R. F.; Jennings, J. W.; Howes, S. W., 1976, Geomorphology and soils mapping, Wahkiakum County, Washington: Geol. Soc. America, Abs. with Programs, v. 8, no. 3, p. 402.

1. Geological abstract.
2. See title.
3. See title.
4. Soils.

5,6. Geomorphological study of region to establish factors influencing soil formation, and soils mapping.
7. ---
8. Abstract - Interdisciplinary study of soil-forming factors in Wahkiakum County provided the conceptual base for mapping forest soils. The effects of time, topography and parent materials on soil formation were evaluated by studying the geomorphology of the county.

Distinctive landform characteristics were found to be controlled by particular assemblages of bedrock. Many landform characteristics vary with respect to mass wasting (creep, earth and soil flow, earth slide, slumping), which, in turn, varies with bedrock lithologies. Landform units are controlled by the presence of siltstones, sandstones, three basalt formations, interbedded sediments and basalts, and Quaternary fluvial deposits.

Soil associations closely correspond to landform units, except for modifications due to variation in precipitation and elevation.

An analysis of land use capability based on this soils mapping project benefits from an integration of geology and soils data.

Ozier, Ron, 1971, Pre-Miocene geomorphology and the Tertiary-pre-Tertiary unconformity, Grand Canyon of the Snake River, Oregon and Washington (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 4, p. 273-274.

Rahm, D. A., 1961, Terracettes - an index of erosional environment of slopes (abs.): Northwest Sci., v. 35, no. 4, p. 164.

1. Geological abstract - scientific periodical.
2. See title.
3. Columbia Plateau.
4. Soil and mantle rock on face of slopes.
5. Measurements and cross-sections through slope faces.
6. See title.
7. ---
8. Abstract - Terracettes, also known as "sheeptracks," "cat steps," etc., are a common feature on slopes of the Columbia Plateau. Contrary to lingering tradition, they are not the result of impact by the hooves of animals. Cross sections of terracettes, exposed near Pullman, Washington, show that they are slump blocks

produced by small-scale gravity faulting of unconsolidated surficial materials.

Terracettes form where the surface materials of a slope are placed under tension and pull apart. This comes about where the covermass can slump toward a "free face" or steep basal segment of the slope. Active lateral erosion against the base of a slope or simply downcutting by a stream at its base can serve to undermine the soil and mantle rock and bring about the tensile condition. Terracettes form best on steep slopes, straight or convex in profile, which are undergoing active basal erosion. They are relatively poorly developed on concave slopes where basal erosion is characteristically at a minimum. Thus the terracettes can be used to "read" the erosional environment of a slope.

Ringe, L. D., 1968, Geomorphology of the Palouse Hills, southeastern Washington: Washington State Univ. Ph. D. thesis, 73 p.

1. Ph. D. thesis.
2. See title.
3. See title.
4. Palouse Loess, Columbia River Basalt.
5. Field observations, measurements and distribution of loess deposits, resistivity measurements, drainage basin analyses, study of basalt outcrops.
6. Study of basalt surface under Palouse loess to determine topography and its effect on topography of loess.
7. Resistivity profile, Roundtop well, Howard Brown well, Whitman Company; topographic landform variations, Whitman Company; principal drainage map in southern Palouse, upper portion Penawa Creek drainage; topography of basalt surface in study area.
8. Abstract - Studies have recently been made on basalt surface beneath loess of Palouse Hills region of southeastern Washington to determine topography of this surface and effect on unique topography of the Palouse. Detailed and random resistivity measurements indicate the loess was deposited on gently undulating basalt surface which presently dips to southwest at less than one degree but becomes steeper to west. Loessial soils on basalt locally attain thickness over 250 feet in southwestern Palouse but thin to less than 100 feet to northeast. Palouse hills of high relief have a thick loess mantle and more steeply dipping basalt, while hills

of low relief characterize regions of thin loess and an almost flat basalt surface. Some of the large, intermittent stream valleys have thicker loess deposits on western or southwestern side, indicating wind-shadow effect during accumulation. Resistivity measurements in underfit valleys indicate channels in basalt up to 60 feet deep and filled with silt and clay. Drainage basin analyses reveal that average slope differs sharply between areas of different topography. Outcrops studied give no indication of thickness of basalt that may have been eroded away prior to deposition of the loess.

Ringe, Don, 1970, Sub-loess basalt topography in the Palouse Hills, southeastern Washington: Geol. Soc. America Bull., v. 81, no. 10, p. 3049-3060.

1. Geological periodical.
2. See title.
3. See title.
4. See title.
5. Study of outcrops, well-data and resistivity measurement reports.
6. See title.
7. Topography of basalt surface over study area, including well locations and resistivity stations; Garfield area, blown-up topographic map and cross section and topography profile; same for Pullman, St. John, Wilcox areas.
8. Abstract - The Palouse Loess of southeastern Washington was deposited on a gently undulating surface of Columbia River Basalt. Resistivity measurements indicate that the loess attains thicknesses in excess of 250 feet in the southwestern Palouse, but thins to less than 100 feet in the northeast. The low, rolling hills of the northeastern Palouse are formed in the areas of thin loess deposited on an almost horizontal basalt surface. The high, steep hills that typify the western and southwestern Palouse are associated with 200 feet or more of loess deposited on a more steeply inclined basalt surface.

Rockie, W. A., 1934, Snowdrifts and the Palouse topography: Geogr. Rev., v. 24, no. 3, p. 380-385; (abs.) Revue de Geologie et des Seiences Connexes, v. 15, no. 5, p. 254-255.

1. Geologic abstract.
2. See title.
3. Palouse region.
4. Palouse Formation.

5. Field observation.
6. Cause of Palouse topography, especially the effect of snow drifting.
7. ---
8. Abstract - Prevailing southwest winds cause the snow to form deep drifts on the northeast leeward slopes where they are protected from the low sun. The snow may contain considerable wind blown soil. Wash from the drift is effective in eroding and steepening the northeast slopes. The combination of heavy snowfalls, comparitively low incidence of the sun, prevailing southwest winds, sudden thaws, complete absence of trees or brush, and high relief all appear to contribute to the peculiar Palouse topography which resembles ocean waves with a strong southwest wind. The Palouse region may not have always been covered with a heavy mantle of grass as at present, and after the dendritic drainage had intrenched itself but before an ample vegetative cover had developed, the processes described may have helped to produce the characteristic topography.

Russell, I. C., 1898, The great terrace of the Columbia and other topographic features in the neighborhood of Lake Chelan, Washington: American Geologist, v. 22, p. 362-369.

1. Geological periodical.
2. See title.
3. See title.
4. See title.
5. Field observations, aneroid measurements.
6. Discussion of and dispute over another author's (Wm. Dawson) interpretation of geologic history of region and elevation of the great terrace.
7. ---
8. Abstract - The great terrace of the Columbia is a stream terrace. Paper is the answer to a challange by another author (Wm. Dawson) on the height of this terrace. The height of the terrace above the river at the mouth of the Methow River is 550 feet. The terrace only occurs upstream of the Columbia where its canyon is narrow. It was developed where the Columbia discharged into ancient Lake Lewis, building up a delta of coarse material and as a result, the upstream river channel became filled with gravel. After Lake Lewis disappeared, the Columbia excavated its present inner channel through the gravel. Author found evidence of glacial ice from the

source of the Methow River to Winthrup. The Methow glacier didn't reach within 50 miles of the Columbia and therefore had no connection with the origin of the Coulee opposite the mouth of the Methow. Also states Antwine's Coulee was never occupied by ice, nor was Knapps Coulee.

Shedd, Solon, 1923, Topography and geology of the Okanogan Highlands and Columbia Plateau of Washington (abs.): Geol. Soc. America Bull., v. 34, p. 75.

Smith, G. O., 1930, Geology and physiography of central Washington: U.S. Geol. Survey Prof. Paper 19, p. 9-39.

Waitt, R. B., Jr., 1972, Geomorphology and glacial geology of the Methow drainage basin, eastern North Cascade Range, Washington: Univ. of Washington Ph. D. thesis, 154 p.

1. Ph. D. thesis.
2. See title.
3. See title.
4. See title.
5. Field observations, mapping and measurements.
6. Evidence for revised mapping and interpretation of historical geologic processes that have occurred in study area.
7. Index map of streams; map of bedrock geology; chart of stratigraphic relations in Cascade Range and surrounding areas; comparative cross-profiles of Chelan, Yosemite and Methow troughs; time-distance diagram of latest advance of cordilleran ice sheet; maximum extent of glaciers during alpine phase; summary of ice flow directional data; topographic and striation map of Methow trough; topography map of Eight Mile Creek area; maximum extent and surface contours of Cordilleran ice sheet; drainage derangement map of mouth of Methow Valley; major kame terraces along Methow Valley.
8. Abstract - The Methow Valley, excavated in upturned Mesozoic sedimentary and volcanic rocks downfaulted between crystalline blocks, is ideally positioned to have originated as a consequent stream on floor of early Tertiary graben. Boundary scarps vary from resequent to obsequent, however, depending on erosional resistance of rocks juxtaposed across the faults. The Methow-Pasayton lowland is therefore of erosional origin - a rift-block valley, not a graben. Cirques, aretes, and U-shaped hanging troughs characteristic of alpine glaciation

dominate the northern Methow landscape. Surface drift is of northern provenance and mantles high ridge-crests as well valley floors.

Ice-sheet glaciation post-dated most recent alpine advance. Because alpine drift and depositional landforms are absent in Methow region, having been eroded by the ice sheet, the maximum extent of alpine glaciers must be inferred wholly from such erosional evidence as cirque morphology and limits of U-shaped cross-valley profiles. Alpine glaciers ranged from small, steep, independent glaciers in tributary valleys to long, gently inclined trunk glaciers in main valleys. Beveled-off cols and ridges, striations, drift, and hummocky topography at high altitudes are primary modifications of Methow upland by ice sheet. Last glaciation correlated with Fraser Glaciation of western Washington and British Columbia. Ice sheet in Methow valley was sector of Cordilleran Ice Sheet. Cordilleran ice entered Methow drainage basin not only through Harts Pass area, but over cols at heads of all major tributaries. Ice sheet innundated Chelan trough as well. Ice sheet over the northern areas was almost continuous, broken only by few scattered nunataks. Methow Mountains were continuous nunatak which separated Methow and Chelan sectors of ice sheet. Deglaciation did not produce end moraines; instead, kame terraces, associated ice-marginal channels kettles, eskers, and other ice-contact landforms indicate that mountainous terrain deglaciated largely by downwasting and regional stagnation. Alpine glaciers were not significantly regenerated after Cordilleran Ice Sheet melted. A late-glacial alpine phase was lacking. Glaciers fluctuated to changes of climate rather than to glacier dynamics.

Warren, C. R., 1941a, Course of the Columbia River in southern central Washington: Am. Jour. Sci., v. 239, p. 209-232.

Waters, A. C., 1933, Terraces and coulees along the Columbia River near Lake Chelan: Geol. Soc. Am. Bull., vol. 44, p. 783-820.

_____, 1955, Geomorphology of south-central Washington, illustrated by the Yakima east quadrangle: Geol. Soc. America Bull., v. 66, no. 6, p. 663-684, 1 Plate, scale 1:62,500.

1. Geological periodical.
2. See title.
3. See title.

4. Landforms, Ellensburg Formation, Pleistocene and recent sediments, basalt flows in Ellensburg Formation, Yakima Basalt.
5,6. Geologic mapping, review of literature.
7. Geologic map and cross-section of Yakima East Quadrangle, erosion surfaces discordant to structure; map showing anticlinal mountain ridges of south-central Washington; profiles of dissected pediments; spur east of Kelley Hollow.
8. Abstract - Geologic mapping of the Yakima district has been neglected since publication of the Ellensburg and Mount Stuart folios (G. O. Smith, 1903a; 1904; see also Calkins, 1905). Reports on other parts of the Columbia River plateau, however, pose new problems and call for revision of some interpretations. This paper presents the results of extending Smith's mapping eastward into the adjacent Yakima East quadrangle, and of considerable reconnaissance work in adjoining areas. The new mapping shows that to the east and south the lower part of the Ellensburg formation interfingers with the Yakima basalt. It also indicates that local diastrophism and volcanism continuously modified and interrupted deposition of the Ellensburg formation.

   Smith's conclusions that the great topographic ridges are growing anticlines, not fault blocks, and that the major rivers are antecedent to these folds, are confirmed. The anticlines appear to have grown in a single epoch of deformation instead of in two orogenic episodes separated by a period of peneplanation. The "Cascade lowland" is a local pediment formed on the flanks of a growing anticline, not a remnant of a widespread peneplain.

   The new data do not support Warren's hypothesis of defeat and diversion of Columbia River by rise of the Horse Heaven uplift, nor Flint's hypothesis of the cutting of Wallula Gap by a river thus diverted.

Willis, Bailey, 1887, Changes in river courses in Washington Territory due to glaciation: U. S. Geol. Survey Bull. 40, 10 p.

1. U.S. Geological Survey Bulletin.
2. See Title.
3. See Title.
4. Geomorphologic studies.
5. Field observations.
6. See Title.

7. Map of eastern Washington Territory, showing distribution of rocks along lines of observation; pre-glacial channel of the Similkameen River; lower valley of the Okinakane River to the Columbia River; Columbia River from the Okinakane River to Lake Chelan.
8. Abstract - General slope of area is south. Wenatchee, Methow, Okinakane and San Puel Rivers are members of consequent and unmodified system, carved on older surface of granite and crystalline sediment rocks, with broader valleys than Columbia's. Course of Columbia River determined in part by southward, northward and westward basalt flows. Channels, new without great rivers, lead into the basin where they once converged with the ancient Columbia River before it was diverted. The valleys of the Colville, Vermilion and Pack Rivers belonged to the old system, their lower valleys filled with basalt. Their abandonment by great rivers result of later causes of glacial period when valleys were filled with drift and the rivers forced to divert across lowest gap in watershed. Account is given of the glaciation of the region about Lake Pend d' Oreille, how glacial sediments filled old river valleys, forcing abandonment, and showing former existence of glaciers in river valleys of extreme northern part of territory, either as portions of a general ice sheet or as tongues pushed forward from disconnected ice rivers descending from the north.

Winters, H. A.; Stradling, D. F., 1967, The Yakima folds - Some relationships between topography and structures (abs.): Assoc. Am. Geographers Annals, v. 57, no. 1, p. 194-195.

PALEONTOLOGICAL/ARCHAEOLOGICAL INVESTIGATIONS

"A field trip to Washington's petrified forest", The Seattle Times Pictorial, 10 May 1970, Herb Belanger, ed., p. 16-21.

Amstutz, G. C., 1958, Coprolites: A review of the literature and a study of specimens from southern Washington: Jour. Sed. Petrology, v. 28, no. 4, p. 498-508.

Antevs, Ernst, 1955, Varve and radiocarbon chronologies appraised by pollen data: Jour. Geology, v. 63, p. 495-499.

Axelrod, D. I., 1950, Evolution of desert vegetation in western North America, Chapter 6 of Studies in late Tertiary paleobotany: Carnegie Inst. Washington Pub. 590, p. 215-306.

_____, 1966, Potassium-argon ages of some western Tertiary floras: Am. Jour. Sci., v. 264, p. 497-506.

Beck, G. F., 1935, Fossil-bearing basalts, more particularly the Yakima basalts of central Washington: Northwest Sci., v. 9, no. 4, p. 4-7, 3 figs.

_____, 1936, Wood occurring in the Ginkgo and associated petrified forests--Part 1, The Ginkgo: The Mineralogist, v. 4, no. 12, p. 7-8.

_____, 1940, Late Tertiary stratigraphy and paleontology of south-central Washington and adjacent Oregon: Geol. Soc. America Bull., v. 51, no. 12, pt. 2, p. 2018.

_____, 1941, Fossil-bearing basalts: Mineralogist, v. 9, no. 12, p. 462-464.

_____, 1944, Ancient maples of the central Washington region: Northwest Sci., v. 19, no. 4, p. 87-89, 1 fig. (abs.) Geological Abs., v. 19, no. 10, p. 2449, entry 22465, 1945.

_____, 1945, Ancient forest trees of the sagebrush area in central Washington: Jour. Forestry, v. 43, no. 5, p. 334-338.

_____, 1949, Tertiary woods of the Pacific Northwest--their mode of occurrence and stratigraphic significance (abs.): Oregon Acad. Sci. Proc., v. 1, p. 57, 1949.

Beck, R. S., 1946, Highlights of Washington and Oregon biostratigraphy (abs.): Oil and Gas Journal, v. 45, no. 27, p. 92.

Berggren, W. A.; van Couvering, J. A., 1974, The late Neogene-Biostratigraphy, geochronology, and paleoclimatology of the last 15 million years in marine and continental sequences: Palaeogeography, Palaeolimatilogy, Palaeocology, v. 16, p. 1-216.

Berry, E. W., 1928, A caddis case of leaf pieces from the Miocene of Washington: Wash. Acad. Sci. Jour., v. 18, no. 3, p. 60-61.

_____, 1928, A Miocene Paliurus from the State of Washington: Amer. Jour. Sci., series 5, v. 16, no. 91, p. 39-44.

_____, 1929, A revision of the flora of the Latah Formation: U.S. Geol. Survey Prof. Paper 154-H, p. 225-265.

_____, 1929, Gordonia from the Miocene of Idaho and Washington: Am. Jour. Sci., series 5, v. 18, no. 107, p. 429-432.

_____, 1929, Fossil plants and mountain uplift in the Pacific states: Proceedings of the National Academy of Sciences, v. 15, p. 477-480.

_____, 1929, The genus Amygdalus in North America: Washington Acad. Sci. Jour., v. 19, no. 2, p. 41-43.

_____, 1931, A Miocene flora from Grand Coulee, Washington: U.S. Geol. Survey Prof. Paper 170-C, p. 31-42.

_____, 1932, Fossil stipules of Platanus: Washington Acad. Aci. Jour., v. 22, no. 14, p. 413-416.

Britton, E. G., 1899, Fossil mosses: Plant World, v. 2, no. 7, p. 108-109.

_____, 1899, A new Tertiary fossil moss: Torrye Botanical Club Bull., v. 26, no. 2, p. 79-81.

Brockman, C. F., 1952, The story of the petrified forest, Ginkgo State Park, Washington: Washington State Parks and Recreation Commission, Olympia, Washington, 16 p.

Browman, D. L.; Munsell, David, 1969, Columbia Plateau prehistory--Cultural development and impinging influences: American Antiquity, v. 34, no. 3, p. 249-264.

Bryan, Alan, 1955, Excavations at Meyer Caves in east central Washington: Davidson Jour. Anthropology, v. 1, no. 1, p. 11-20.

Bryan, Kirk, 1927, The "Palouse soil" problem, with an account of elephant remains in wind-borne soil on the Columbia Plateau, Washington: U.S. Geol. Survey Bull. 790, p. 21-45, 4 plates.

Bryant, L. J., 1968, A new genus of mustelid from the Ellensburg Formation, Washington: Los Angeles City Museum Contrib. Sci., no. 139, 6 p.

Butler, B. R., 1961, The old Cordilleran culture in the Pacific Northwest: Occasional papers of the Museum, Idaho State College, no. 5.

_____, 1962, Contributions to the prehistory of the Columbia Plateau: Review by H. C. Taylor, Jr.: American Antiquity, v. 30, no. 2, p. 230-231.

_____, 1963, Further notes on the burials and the physical stratigraphy at the Congdon Site, a multi-component Middle Period site at The Dalles on the Lower Columbia River: Tebiwa, Jour. Idaho State University Museum, v. 6, no. 2, p. 16-21.

_____, 1965, Perspectives on the prehistory of the lower Columbia Valley: Tebiwa, Idaho State University Museum, v. 8, no. 1, p. 1-16.

Cain, H. T., 1950, Petroglyphs of central Washington: Univ. of Washington Press, Seattle, 57 p.

Campbell, C. D., 1956, Geology of the site and surrounding areas - late Cenozoic history of the region: In Daugherty, R. D., Archaeology of the Lind Coulee site, Washington: Am. Philos. Soc. Proc., v. 100, no. 3, p. 260-262.

Carpenter, F. M.; Cockerell, T. D. A.; Kennedy, C. H., Snyder, T. E.; Wickham, H. F., 1931, Insects from the Miocene (Latah) of Washington: Entomological Soc. Am. Annals, v. 24, no. 2, p. 307-323.

Chaney, R. W., 1918, The ecological significance of the Eagle Creek flora of the Columbia River Gorge: Jour. Geology, v. 26, no. 7, p. 577-592.

Chaney, R. W.; Axelrod, D. I., 1959, Miocene floras of the Columbia Plateau, Part II. Systematic considerations: Carnegie Inst. Washington Pub. 617, p. 135-237, 44 pls.

_____, 1960, Part I, Composition and interpretation: Jour. Paleontology, v. 34, no. 3, p. 601-602.

Collier, Donald; Hudson, A. E., Ford, Arlo, 1942, Archaeology of the Upper Columbia region: Univ. of Washington pub. in Anthropology, v. 9, no. 2.

Cressman, L. S., 1937, Petroglyphs of Oregon: Univ. of Oregon Studies in Anthropology, no. 2, 78 p.

Cressman, L. S.; Howell, Williams; Krieger, A. D., 1940, Early man in Oregon: archaeological studies in the northern Great Basin: Univ. of Oregon, Mono., Studies in Anthropology, no. 3, 78 p., 16 pls.

Cressman, L. S., 1943, Results of recent archaeological research in the northern Great Basin of south central Oregon: Proc. Am. Philosophical Soc., v. 86, no. 2, p. 236-246.

_____, 1960, Cultural sequences at The Dalles, Oregon: A contribution to Pacific Northwest prehistory: Am. Philos. Soc. Proc.; Trans., v. 50, part 10, p. 7-108.

Dake, H. C., 1940, Latah petrified forests (Washington, Idaho, Oregon): Mineralogist, v. 10, no. 11, p. 339-340, 352-353, illus.

Danner, W. R., 1968, Origin of the siderite coprolite-like bodies of the Wilkes Formation, late Miocene of southwestern Washington (abs.): Canadian Mineralogist, v. 9, pt. 4, p. 571.

_____, 1969, Origin of the siderite coprolite-like bodies of the Wilkes Formation, late Miocene, of southwestern Washington (abs.): Univ. of British Columbia, Dept. of Geology, Rept. 9, p. 6.

Daugherty, R. D., 1952, Archaeological investigations in O'Sullivan Reservoir, Grant County, Washington: Amer. Antiq., v. 17, no. 4, p. 374-383.

_____, 1956, Archaeology of the Lind Coulee site, Washington: Am. Philos. Soc. Proc., v. 100, no. 3, p. 223-278.

_____, 1959, Early Man in Washington: Washington Div. Mines and Geology Inf. Circ. 32, 66 p., 28 figs.

_____, 1962, The intermontane western tradition: American Antiquity, v. 28, no. 2.

_____, 1963, Northwest (Progress in current research). In Borden, C. E., ed., Current research: American Antiquity, v. 28, no. 4, p. 591-594.

Drucker, Philip, 1948, Appraisal of the archaeological resources of Equalizing, Long Lake, and Potholes Reservoirs in east central Washington: Columbia Basin Project, River Basin Surveys, Smithsonian Inst., Washington.

Enbysk, B. J., 1956, Vertebrates and mollusca from Lind Coulee site, Washington. In Daugherty, R. D., Archaeology of the Lind Coulee site, Washington: Am. Philos, Soc. Proc., v. 100, no. 3, p. 267-276, illus.

Evernden, J. F.; Savage, D. E.; Curtis, G. H.; James, G. T., 1964, Potassium-argon dates and the Cenozoic mammalian chronology of North America: Am. Jour. Sci., v. 262, p. 145-198.

Evernden, J. F.; James, G. T., 1964, Potassium-argon dates and the Tertiary flora of North America: Am. Jour. Sci., v. 262, no. 8, p. 945-974.

Fernquist, C. O., 1941, Pleistocene fossils of Washington: Mineralogist, v. 9, no. 9, p. 333-334.

_____, 1941, The geology and paleontology of Spokane and vicinity: Mineralogist, v. 9, no. 3, p. 83-84.

Fisk, L. H.; Biaggi, R.; Barnett, J., 1976, Palynology of the Latah Formation at the Deep Creek locality near Spokane, Washington (abs.): Geol. Soc. Am. Abs. with Programs, v. 8, no. 3, p. 373-374.

Foisy, R. D., 1967, Some fossil mollusks of Yakima County, Washington: Central Washington State College M.Ed. thesis, 58 p.

Freeman, O. W., 1926, Mammoth found in loess in Washington: Science, new ser., v. 64, p. 477.

_____, 1944, Glaciation and some human relationships at Lake Chelan (Washington): Northwest Sci., v. 18, no. 3, p. 59-62.

Fry, W. E., 1969, A paleontological site survey conducted in the Horse Heaven Hills of south-central Washington: Northwest Sci., v. 43, no. 4, p. 72.

Fry, W. E.; Gustafson, E. P., 1972, Cervids from the Pliocene and Pleistocene of Washington (abs.). In Soc. Vertegrate Paleontology, Annual Mtg., 32d, (Program), (p. 9), Nebr., Univ., Lincoln; Jour. Paleontology, v. 48, p. 375-386.

Fryxell, Roald, 1961, Geoarchaeological dating of low-level stream terraces in the lower Snake River canyon, Washington (abs.): Northwest Sci., v. 35, no. 4, p. 159.

_____, 1961, Geologic dating of the Entiat, Stayman, Knapp Coulee, and Orondo rock shelter archaeological sites, Appendix A. In Gunkel, A., A comparative analysis of four archaeological sites in the Rocky Reach Reservoir region, Washington: Wash. State Univ. thesis in Anthropology, no. 1, Pullman, p. 272-283.

Fryxell, R.; Daugherty, R. D., 1962, Interim report: Archaeological salvage in the lower Monumental Reservoir, Washington: Laboratory of Archaeology and Geochronology Report of Investigations No. 21, Washington State Univ., Pullman, Washington.

Fryxell, Roald, 1963, Notes on the occurrence of silicified wood from the Ginkgo flow of the Yakima Basalt Formation, Washington: The XI Transactions of Sigma Gamma Epsilon, XI Chapter, Washington State Univ., v. 1, no. 1, p. 18, 32-36.

_____, 1963, Schematic geoarchaeological chronology for eastern Washington and related areas: Washington State Univ. Lab. of Archaeology and Geochronology Rept. Inv. 11, 1 sheet, revised.

_____, 1963, Through a mirror, darkly: The Record, Publication of the Washington State University Library, p. 1-18.

Fryxell, Roald; Daugherty, R. D., 1963, The development of an integrated late glacial and post glacial geological and archaeological chronology of the Columbia Plateau, Washington; an interim report: Washington State Univ. Lab. of Anthropology Rept. Inv. 23, 22 p.

Fryxell, Roald, 1964, Regional pattern of sedimentation recorded by cave and rock shelter stratigraphy in the Columbia Plateau, Washington (abs.): Geol. Soc. America Spec. Paper 76, p. 273.

Fryxell, Roald; and others, 1968, A human skeleton from sediments of mid-Pinedale age in southeastern Washington: American Antiquity, v. 33, no. 4, p. 511-515.

Fryxell, Roald; Daugherty, R. D.; Baenen, James, 1962, The discovery of early human skeletal remains near Lyons Ferry, Washington (abs.): Northwest Sci., v. 36, no. 4, p. 127.

Fryxell, Roald; Neff, G. E.; Trimble, D. E., 1965, Scabland tracts, loess, soils, and human prehistory. In INQUA, Guidebook for Field Conference E, northern Rocky Mountains: Nebraska Acad. Sci., Lincoln, Nebr., p. 79-89.

Fryxell, Roald, 1973, Salvage of geochronological information in the Wells Reservoir area, Washington (1964-1972): a report to the National Park Service in completion of Contract No. 14-10-0434-1505, Washington State Univ., 35 p., physiographic diagram, 1:125,000.

Ganders, F. R.; Cridland, A. A., 1968, Leaf cuticles of Miocene Taxodium dubium from central Washington (abs.): Am. Jour. Botany, v. 55, no. 6, pt. 2, p. 727.

Garth, Thomas, 1952, The middle Columbia cremation complex: Am. Antiquity, v. 18, no. 1, p. 40-56.

Gilbert, G. K., 1899, Submerged forest of the Columbia River (abs.): Science, new series, v. 10, no. 256, p. 777, 1899; (abs.) Science, new series, v. 11, no. 264, p. 99-100, Jan. 1900.

Grabert. G. F., 1968 , North-central Washington prehistory: reports in archaeology, Univ. of Washington, Seattle, no. 1, 223 p.

Grant, R. Y., 1941, A John Day vertebrate fossil discovered in the Keechelus Series of Washington: Am. Jour. Sci., v. 239, p. 590-593.

Gray, Jane, 1958, Plant microfossils from the Miocene of the Columbia Plateau, Oregon: University of California, Berkeley, Ph.D. thesis.

_____, 1964, Northwest American Tertiary palynology-The Emerging picture. In Ancient Pacific floras-The pollen story: Univ. of Hawaii Press, Honolulu, p. 21-30, illus., table.

Gray, Jane; Kittleman, L. R., 1967, Geochronometry of the Columbia Basalt and associated floras of eastern Washington and western Idaho: Am. Jour. Sci., v. 265, no. 4, p. 257-291. Figure 1, 1:10,454,400.

Grosso, G. H., 1967, Cave life on the Palouse: Natural History, v. 76, no. 2, p. 38-43.

Gunkel, Alexander, 1961, A comparative cultural analysis of four archaeological sites in the Rocky Reach Reservoir region, Washington: Washington State Univ. Theses in Anthropology, Number 1, 312 p.

Gustafson, C. E., 1972, Faunal remains from the Marmes rock shelter and related archaeological sites in the Columbia Basin: Dept. Zoology, Washington State Univ., Ph.D. thesis, Pullman, 183 p.

Gustafson, E. P., 1972, An early Blancan fauna from the White Bluffs, south-central Washington (abs.): In Soc. of Vertebrate Paleontology, Annual Mtg., 32d (Program), (p. 4), Nebr., Univ., Lincoln.

_____, 1973, The vertebrate fauna of the late Pliocene Ringold Formation, south-central Washington (abs.): Univ. of Washington Dept. Geological Sciences Abstracts of Research 1973, p. 40.

_____, 1976, A revised chronology for vertebrate fossil faunas in eastern Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 377-378.

Hansen, H. P., 1941, A pollen study of post-Pleistocene lake sediments in the upper Sonoran life zone of Washington: American Jour. Sci., v. 239, no. 7, p. 503-522.

_____, 1945, Paleoecology of a peat deposit in east-central Washington (abs.): Annot. bibliography Econ. Geology, v. 16, no. 1, p. 58.

_____, 1947, Post-glacial forest succession, climate and chronology in the Pacific Northwest: Am. Philos. Soc. Trans., v. 37, pt. 1.

_____, 1949, Post-glacial climate and chronology (abs.): Oregon Acad. Sci. Proc., v. 1, p. 62-63.

_____, 1967, Chronology of post-glacial pollen profiles in the Pacific Northwest: Review of Palaeobotany and Palynology, v. 4, p. 103-105.

Heusser, C. J., 1965, A Pleistocene phytogeographical sketch of the Pacific Northwest and Alaska. In Wright, H. E., Jr.; Frey, D. G., eds., The Quaternary of the United States: Princeton University Press, p. 469-483.

Hibbard, C. W., 1958, Summary of North American Pleistocene mammalian local faunas: Michigan Acad. Sci. Papers, v. 43, p. 3-32.

Hibbard, C. W.; Ray, D. E.; et al, 1965, Quaternary mammals of North America (abs.): Geoscience Abstracts, v. 7, no. 11, p. 34-35.

Hindman, Jo, 1958, Skeleton and fossil in the Grand Coulee, Washington: Earth Science, v. 11, no. 5, p. 9-12.

Hoffman, A. D., 1932, The Douglas Canyon flora of east central Washington: Jour. Geology, v. 11, p. 735-39, 2 figs; (abs.) Revue de Geologie et des Sciences Connexes, v. 13, nos. 8-9, p. 520.

Hopkins, W. W., Jr., 1968, Subsurface Miocene rocks, British Columbia-Washington, a palynological investigation: Geol. Soc. America Bull., v. 79, p. 763-768.

Kenoyer, Pat, 1974, Yakima Canyon wood: Gems and Minerals, no. 436, p. 20-22.

Kirk, R., 1969, The rescue of Marmes Man: Pacific Discovery, v. 22, no. 4, p. 10-15.

_____, 1970, The oldest man in America: New York, Harcourt Brace Jovanovich, Inc., 96 p., illus.

Klucking, E. P., 1968, A Latah florule from Coleman Creek, Washington (abs.): Northwest Sci., v. 42, no. 1, p. 36-37.

Knowlton, F. H., 1926, Flora of the Latah Formation of Spokane, Washington and Coeur d'Alene, Idaho: U.S. Geol. Survey Prof. Paper 140-A, p. 1-4 + 1-81, pl. 1-31 (incl. 1 map), fig. k-3, Washington; (abs.) Revue de Geologie et des Sciences Connexes, v. 8, no. 1, p. 60, 1927.

Krieger, H. W., 1928, A prehistoric pit house village site on the Columbia River at Wahluke, Grant County, Washington: Proc. United States Natl. Museum, v. 73, art. 11, p. 1-29.

LaMotte, R. S., 1934, Two upper Miocene florules from central Washington (abs.): Pan-American Geologist, v. 62, no. 1, p. 75; (abs.) Geol. Soc. America Proc. for 1934, p. 389-390, June 1935.

_____, 1935, Ellensburg flora of central Washington (abs.): Pan-American Geologist, v. 63, no. 5, p. 379.

_____, 1936, Additions to the Ellensburg flora of central Washington (abs.): Geol. Soc. America Proc. for 1935, p. 417, 1936.

_____, 1938, An upper Cretaceous florule from northwestern Washington (abs.): Geol. Soc. America Proc. 1937, p. 283.

Landye, J. J., 1968, Nonmarine mollusks of late Quaternary age from Lower Grand Coulee, Washington (abs.): Northwest Sci., v. 42, no. 1, p. 47.

Lawrence, D. B., 1936, The submerged forest of the Columbia River gorge: Geogr. Rev., v. 26, no. 4, p. 581-592; (abs.) Revue de Geologie et des Sciences Connexes, v. 17, no. 10, p. 620-621, 1937.

Lawrence, D. B.; Lawrence, E. G., 1958, Bridge of the Gods legend, its origin, history and dating: Mazama, v. 40, no. 13, p. 33-41.

Lee, W. T., 1955, An archaeological survey of the Columbia Basin Project in Grant County, Washington: Davidson Jour. of Anthropology, v. 1, no. 2, p. 141-153.

Leonhardy, F. C., 1970, Artifact assemblages and archaeological units of Granite Point Locality, Diss. Abs. Internat. v. 31, no. 3, sec. B, p. 1030.

Lewis, S. E., 1968, Fossil insects of the Latah Formation (Miocene) of eastern Washington and northern Idaho: Washington State Univ. Ph.D. thesis, 97 p.

Livingston, V. E., Jr., Fossils in Washington: Washington Div. Mines and Geology Inf. Circ. 33, 1959, 35 p., 1 pl., 17 figs.

Mack, R. N.; Bryant, V. M., Jr., 1974, Modern pollen spectra from the Columbia Basin, Washington: Northwest Sci., v. 48, no. 3, p. 183-194.

Mehringer, P. J., Jr.; Blinman, E.; Petersen, K. L., 1977, Pollen influx and volcanic ash: Science, v. 198, no. 4314, p. 257-261.

Mills, John; Osborne, Carolyn, 1952, Material of an Upper Coulee rock shelter: Am. Antiquity, v. 17, no. 4, p. 352-359.

Moody, U. L., 1978, The microstratigraphy and related geology of the Lind Coulee early man site and surrounding area, central Washington: Washington State Univ. Ph.D. thesis (in press).

Moss, J. H., 1951, Early man in the Eden Valley: edt. by Loren C. Eiseley, Univ. Museum, University of Penna., Phila.

Munsell, D. A., 1968, The Rye Grass Coulee Site: Univ. of Washington M.A. thesis, 197 p.

Nelson, C. M., 1965, New evidence for blade production in the southern Columbia Plateau: Washington Archaeologist, v. 9, no. 2, p. 2-15.

_____, 1969, The Sunset Creek Site (45-KT-28) and its place in plateau prehistory: Washington State Univ. Laboratory of Anthropology Rept. Investigations 47, 425 p.

Nering, L. G., 1952, Geology of Lind Coulee. I. Archaeological site, unpub. Honors thesis, State College of Washington, Pullman.

_____, 1956, Stratigraphic, mechanical, chemical, and petrographic analysis of the Lind Coulee site. In Daugherty, R. D., ed., Archaeology of the Lind Coulee site, Washington: Am. Philos. Soc. Proc., v. 100, no. 3, p. 263-266, tables.

Newcomb, R. C.; Repenning, C. A., 1970, Occurrence of mammoth fossils in the Touchet Beds, south-central Washington: Northwest Sci., v. 44, no. 1, p. 16-18.

Newman, K. R., 1969, Palynology of interflow sediments from the Standard Oil Company of California Rattlesnake Hills No. 1 well, Benton County, Washington. In Gilmour, E. H., and Stradling, D., eds., Proceedings of the second Columbia River Basalt symposium: Eastern Washington State College Press, Cheney, Wash., p. 201-207; (abs.) Northwest Sci., v. 43, no. 1, p. 41, Feb. 1969.

_____, 1975, Palynomorph sequence in the early Tertiary Swauk and Roslyn Formations, central Washington: Geosci. Man, v. 11, p. 158.

Oles, F., 1968, Petrified wood in the Rattlesnake Hills: Gems and Minerals, no. 372, p. 28-29.

Osborne, Douglas, 1950, An archaeological survey of the Benham Falls Reservoir, Oregon: Am. Antiquity, v. 16, no. 2, p. 112-119.

_____, 1956, Evidence of the Early Lithic in the Pacific Northwest: Res. Studies, State College of Washington, v. 24, p. 38-44.

Osborne, Douglas; Crabtree, Robert; Bryan, Alan, 1952, Archaeological investigations in the Chief Joseph Reservoir: Am. Antiquity, v. 17, no. 4, p. 360-373.

_____, 1967, Archaeological tests in the Lower Grand Coulee, Washington: Idaho State University Museum Occasional Paper 20, 83 p.

Pardee, J. T.; Bryan, K., 1925, Origin of fossiliferous Latah clays and associated basalts near Spokane (abs.): Pan-American Geologist, v. 43, no. 5, p. 369-370.

Prakash, Uttam; Barghoorn, E. S., 1961, Miocene fossil woods from the Columbia basalts of central Washington (Pt. 1): Arnold Arboretum Jour., v. 42, no. 2, p. 165-195, illus. 1961; (pt. 2), ibid., no. 3, p. 347-358, illus.

Prakash, Uttam, 1968, Miocene fossil woods from the Columbia basalts of central Washington, (Pt. 3): Palaeontographica, ser. B, v. 122, no. 4-6, p. 183-200, illus., tables.

Prakash, Uttam; Boureau, Edouard, 1970, A fossil herbaceous monocotyledon with preserved structure from the Columbia basalts in the Miocene of Vantage, central Washington, USA: Congr. Nat. Soc., Savantes (92d), Sect. Sci., C. R., v. 3 (1967), p. 93-107.

Prochaska, Carol, 1973, A search for man's past at Lind Coulee: U.S. Bureau of Reclamation Era, v. 59, no. 2, p. 5-7.

Ray, V. F., 1932, Pottery on the Middle Columbia: Am. Anthropologist, v. 34, no. 1, p. 127-133.

Rice, D. G., 1968, Archaeological reconnaissance, Hanford Atomic Works, to U.S. Atomic Energy Commission and National Park Service: Washington State University.

_____, 1969, A potential early man locality in south-central Washington: Northwest Sci., v. 43, no. 4, p. 149-155.

_____, 1969, Archaeological reconnaissance, south-central Cascades: Wash. Arch. Soc. Occ. Paper 2, 41 p.

_____, 1976, Log structure at White Bluffs landing, Franklin County, Washington: A case study in historical archaeology: Univ. Idaho, Moscow, Idaho, 60 p.

Royse, C. F., Jr., 1965, Tertiary plant fossils from the Methow Valley, Washington: Northwest Sci., v. 39, no. 1, p. 18-25.

Sanger, D., 1967, Prehistory of the Pacific Northwest Plateau as seen from the interior of British Columbia: American Antiquity, v. 32, no. 2, 1967.

Scheid, V. E., 1940, Significance of a fossil horse tooth found at Moscow, Idaho: Northwest Sci., v. 14, no. 3, p. 55-57.

Scott, R. A.; Barghoorn, E. S.; Prakash, Uttam, 1962, Wood of Ginkgo in the Tertiary of western North America: Am. Jour. Botany, v. 49, no. 10, p. 1095-1101, illus.

Scott, W. F.; Clem, R., 1967, A mammoth from the Touchet beds near Walla Walla, Washington (abs.): Northwest Sci., v. 41, no. 1, p. 60-61.

Shiner, Joel, 1952, The 1950 excavations at Site 45BN6 McNary Reservoir, Washington: Am. Antiquity, v. 17, no. 4, p. 348-351.

Smiley, C. J., 1960, The Ellensburg and Selah floras of central Washington: Univ. of California at Berkeley Ph.D. thesis, 225 p.

_____, 1961, A record of Paulownia in the Tertiary of North America: Am. Jour. Botany, v. 48, no. 2, p. 175-179, illus.

_____, 1963, The Ellensburg flora of Washington: California Univ. Pubs. Geol. Sci., v. 35, p. 159-275.

Smith, H. I., 1910, The archaeology of the Yakima Valley, Am. Mus. Natl. Hist. Anthropological Papers, v. 6, pt. 1, 171 p., 16 pls.

Smith, Marian, 1954, Attributes and the discovery of projectile point types: with data from the Columbia - Fraser region: Am. Antiquity, v. 20, no. 1, p. 15-26.

Snyder, T. E., 1949, A new Ulmeriella (Washington), Entomol. Soc. Washington Proc., v. 51, no. 4, p. 164-165, illus.

Sparks, D. M., 1967, Microfloral zonation and correlation of some lower Tertiary rocks in southwest Washington and some conclusions regarding the paleoecology of the flora: Michigan State Univ. Ph.D. dissertation.

Spurr, J., 1977, Ginkgo petrified forest state park: Pacific Search, Sept. 1977, p. 60-61.

Stallard, Bruce, 1958, Archeology in Washington: Washington Div. Mines and Geology Inf. Circ. 30, 64 p., 1 pl., 34 figs.

Strong, W. D.; Schenck, W. E.; Steward, J. H., 1930, Archaeology of the Dalles-Deschutes region: Univ. of California Pub. in American Archaeology and Ethnology, v. 29, no. 1.

Suess, H. E., 1970, Bristlecone-pine calibration of the radiocarbon time-scale 5200 B. C. to the present. In Olsson, I. U., ed., Radiocarbon variations and absolute chronology -- Nobel Symposium, 12th, Uppsala Univ., 1969, Proc: New York, John Wiley and Sons, Inc., p. 303-311.

Swanson, E. H., Jr., 1957, Archaeological studies in the Vantage region of the Columbia Plateau, northwestern America: Univ. of Washington Ph.D. thesis, 234 p.

_____, 1962, The emergence of Plateau Culture: Idaho State College Museum Occasional Paper 8, 89 p.

_____, 1970, Sources for Plateau prehistory (discussion of "Columbia Plateau prehistory. ." by D. L. Browman and D. A. Munsell, 1969): American Antiquity, v. 35, no. 4, p. 495-496.

Van Landingham, S. L., 1964, Paleoecology and taxonomy of Miocene Chrysophyta cysts from Yakima and Grant Counties, Washington (abs.): Am. Jour. Botany, v. 51, no. 6, pt. 2, p. 678.

_____, 1964, Miocene non-marine diatoms from the Yakima region in south-central Washington. Biehefte Nova Hedwigia, no. 14, 78 p., illus., table; (abs.) Amer. Jour. Botany, v. 50, no. 6, pt. 2, p. 632, July 1963.

Walker, K. R., 1975, The seasonal phytoplankton cycles of two saline lakes in central Washington: Limnol. Oceanogr., v. 20, no. 1, p. 40-53.

Warren, C. N., 1968, The view from Wenas, a study in plateau prehistory: Idaho State Univ. Occasional Paper 24, 89 p.

_____, 1963, The Goldendale Site and its place in Plateau prehistory: Tebiwa (Jour. of the Idaho State Univ. Museum), v. 6, no. 1, p. 1-21.

Young, M. W., 1968, The Ringold fossil area: Gems and Minerals, no. 371, p. 14-16.

ADDITIONAL REFERENCES - PALEONTOLOGICAL/ARCHAEOLOGICAL INVESTIGATIONS

Davis, Margaret B., 1977, Applications of radiocarbon dating to pollen analysis (abs.): Geol. Soc. Am. Abs. with Programs, v. 9, no. 7, p. 945.

Davis, O. K.; Kolva, O. A.; Mehringer, P. J., Jr., 1977, Pollen analysis of Wildcat Lake, Whitman County, Washington: The last 1000 years: Northwest Sci., v. 51, no. 1, p. 13-30.

Fryxell, Roald, 1962, Geologic examination of the Ford Island archaeological site (45-FR-47), Washington: Washington State Univ. Lab. of Anthropology, Rept. of Invest. No. 18, sec. II, Pullman, Washington.

Fryxell, Roald, 1971, The contribution of interdisciplinary research to geologic investigation of prehistory, eastern Washington: Univ. of Idaho Ph.D. thesis, Moscow, Idaho.

Fryxell, Roald; Daugherty, R. D., 1963, Late glacial and post-glacial geological and archaeological chronology of the Columbia Plateau, Washington: interim report: Washington State Univ. Lab. Anthropology Rept. Invest. 23, 22 p.

Leonhardy, F. C., 1970, Artifact assemblages and archaeological units at Granite Point locality (45W T41), southeastern Washington: Washington State Univ., Ph.D. thesis.

Sternberg, C. H., 1903, Elephas columbi and other mammals in the swamps of Whitman County, Washington: Science, new series 17, p. 511-512.

LABORATORY ANALYSES AND METHODS/GEOCHRONOLOGY

Allen, J. E., 1932, Contributions to the structure, stratigraphy, and petrography of the Lower Columbia River Gorge: University of Oregon M.S. Thesis, 96 p. Map, 1:125,000.

Axelrod, D. I., 1966, Potassium-argon ages of some western Tertiary floras: Am. Jour. Sci., v. 264, p. 497-506.

Baldwin, E. M., 1966, Geology of the Columbia River gorge: Northwest Sci., v. 40, no. 4, p. 121-128, illus.

Beeson, M. H.; Moran, M. R.; Olson, F. L., 1976, Geochemical data on Columbia River Basalt stratigraphy in western Oregon: Geol. Soc. America Abstr. with Programs, v. 8, No. 3, p. 354.

Blakely, R. J.; Farooqui, S., 1977, Paleomagnetism of selected basalts near Roosevelt, Washington: Eos (Am. Geophys. Union, Trans.), v. 58, no. 3, p. 169.

Bogue, R. G., 1932, A petrographic study of the Mount Hood and Columbia River basalt formations: Univ. of Oregon M.S. thesis, 88 p.

Borchardt, G. A., 1970, Neutron activation analysis for correlating volcanic ash soils: Ph.D. thesis, Oregon State University, Corvallis, Oregon. 219 numb. leaves. (Diss. Abstr., v. 30, no. 11, Pub. No. 70-7917).

Bottomley, R. J., 1975, Argon-40/argon-39 dating of basalts from the Columbia River Plateau: University of Toronto M.S. thesis.

Brock, M. R.; Grolier, J. J., 1973, Chemical analyses of 305 basalt samples from the Columbia River Plateau, Washington, Oregon, and Idaho: U.S. Geological Survey Open-File Report, 35 p.

Brown, J. C., 1976, Tectonic significance of subsurface chemical-stratigraphic correlation, Pullman/Moscow Basin, Washington and Idaho (abstr.): Geol. Soc. America, Abstr. with Programs, v. 8, no. 3, p. 357-358.

Brown, R. E., 1960, The use of geophysics and geochemistry to confirm geological interpretation at the Hanford Works of the Atomic Energy Commission, U.S.A.: Internat. Geol. Cong., 21st, Copenhagen, 1960, Rept., pt. 2, p. 75-82 incl. sketch map and section.

Camp, V. E., 1976, Petrochemical stratigraphy and structure of the Columbia River Basalt, Lewiston Basin area, Idaho-Washington: Washington State University Ph.D. thesis, 201 p.

Campbell, C. D., 1950, Petrology of the Columbia River Basalts: present status and ideas for future work: Northwest Science, v. 24, no. 2, p. 74-83.

Church, S. E., 1971, The isotopic composition of lead in the Columbia River Basalts (abs.): Eos (Am. Geophys. Union, Trans.), v. 52, no. 11, p. 929.

Cockerham, R. S.; Babcock, R. S., 1972, Petrochemical trends in the Columbia River Basalt Group and the Ellensburg Formation (abs.): Northwest Scientific Association Abstracts of Papers presented at the 45th annual meeting, p. 3.

Coombs, H. A., 1941, Hornblende and magnetite heavies in the Ellensburg of central Washington: Jour. Sed. Petrology, v. 11, no. 3, p. 142-144.

Cripe, J. D.; Wilkerson, W. L., 1973, A comparison of total sulfur in Columbia River Plateau basalts with that of Recent submarine and subaerial basalts (abs.): Geol. Soc. America Abstr. with Programs, v. 5, no. 1, p. 29-30.

Culver, H. E., 1956, Preliminary statement of the geologic age of the beds in lower Lind Coulee, Washington. In Daugherty, R. D., Archaeology of the Lind Coulee site, Washington: Am. Philos. Soc. Proc., v. 100, no. 3, p. 26.

Czamanske, G. K.; Porter, S. C., 1965, Titanium-dioxide in pyroclastic layers from volcanoes in the Cascade Range: Sci., v. 150, no. 3699, pl. 1022-1025.

Damon, P. E., 1977, K-Ar dating applied to Quaternary geochronologic problems (abs): Geol. Soc. America Abstr. with Programs, v. 9, no. 7, p. 941-942.

Davis, Margaret B., 1977, Applications of radiocarbon dating to pollen analysis (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 945.

Davis, O. K.; Kolva, O. A.; Mehringer, P. J., Jr., 1977, Pollen analysis of Wildcat Lake, Whitman County, Washington: The last 1000 years: Northwest Science, v. 51, no. 1, p. 13-30.

Deju, R. A.; Summers, W. K., 1976, Transmissivity and hydraulic conductivity of saturated sedimentary rocks on the Hanford Reservation: Geol. Assoc. Can. - Mineral Assoc. Can., Joint Annual Meet., Program Abs., v. 1, p. 53.

Dodds, R. K., 1969, The age of the "Columbia River Basalts" near Astoria, Oregon. In, Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, p. 239-270.

Doe, B. R., 1967, The bearing of lead isotopes on the source of granitic magma: Jour. of Petrology, v. 8, pt. 1, p. 51-83.

Doe, B. R.; Lipman, P. W.; Hedge, C. E.; Kurasawa, H., 1969, Primitive and contaminated basalts from the southern Rocky Mountains, U.S.A.: Contrib. Mineralogy and Petrology (in press).

Dorn, T. F.; Fairhall, A. W.; Schell, W. E.; Takashima, Y., 1962, Radiocarbon dating at the University of Washington: Radiocarbon, v. 4, p. 1-12.

Easterbrook, D.J., 1977, Paleomagnetic chronology and correlation of Pleistocene deposits (abs.): Geol. Soc. America Abs. Programs, v. 9, no. 7, p. 961.

Engels, J. C.; Tabor, R. W.; Miller, F. K.; Obradovich, J. D., 1976, Summary of K-Ar, Rb-Sr, U-Pb, Pb alpha, and fission-track ages of rocks from Washington State prior to 1975 (exclusive of Columbia Plateau basalts): U. S. Geol. Survey Misc. Field Studies Map. MF-170, geochem. map, 1:1,000,000.

Fairhall, A. W.; Young, A. W.; Erickson, J. L., 1976, University of Washington dates IV: Radiocarbon, v. 18, no. 2, p. 221-239.

Friedman, Irving, 1968, Hydration rind dates rhyolite flows: Science, v. 159, p. 878-880.

Friedman, Irving; Peterson, N., 1971, Obsidian hydration dating applied to dating of basaltic volcanic activity: Science, v. 172, p. 1028.

Friedman, Irving; Smith, R. L., 1960, A new dating method using obsidian: Part 1, the development of the method: American Antiquity, v. 25, no. 4, p. 476-522.

Fryxell, Roald, 1961, Geologic dating of the Entiat, Stayman, Knapp Coulee and Orondo rock shelter archaeological sites, Appendix A. In Gunkel, A., a comparative analysis of four archaeological sites in the Rocky Reach Reservoir region, Washington: Washington State Univ. thesis in anthropology, Pullman, no. 1, p. 272-283.

_____, 1965, Mazama and Glacier Peak volcanic ash layers: relative ages: Science, v. 147. p. 1288-1290.

_____, 1973, Salvage of geochronological information in the Wells Reservoir area, Washington (1964-1972): A report to the National Park Service in completion of Contract No. 14-10-0434-1505, Washington State Univ., 35 p., physiographic diagram, 1:125,000.

Goles, G. G., 1971, Instrumental activation analysis of Columbia River Basalts and of lunar rocks in activation analysis in geochemistry and cosmochemistry: Oslo, Universitatsferlaget, p. 45-50.

Goles, G. G.; Osawa, M., 1971, Petrogenesis of Columbia River basalts (abs.): Eos (Am. Geophys. Union, Trans.), v. 52, no. 4, p. 375.

Goles, G. G.; Leeman, W. P., 1976, Petrogenesis of Picture Gorge Basalts: a preliminary report (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 376.

Gray, Jane; Kittleman, L. R., 1967, Geochronometry of the Columbia Basalt and associated floras of eastern Washington and western Idaho: Am. Jour. Sci, v. 265, no. 4, p. 257-291. Figure 1, 1:10,454,400.

Hare, P. E., 1977, Amino acid dating-limitations and potential (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1004.

Hedge, C. E.; Hildreth, R. A.; Henderson, W. T., 1971, Strontium isotopes in some Cenozoic lavas from Oregon and Washington (abs.): U. S. Geol. Abs. of North American Geology, p. 223.

Helz, R. T.; Swanson, D. A., 1976, Analysis and interpretation of chemical trends in the youngest unit of Yakima basalt, central Columbia Plateau, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 380.

Helz, R. T.; Wright, T. L.; Swanson, D. A., 1976, Petrogenetic significance of chemical trends in the youngest unit of Yakima Basalt on the Columbia Plateau, northwest U. S. A.: Inter. Assoc. Volcan. Problems, Proc., p. 465-481.

Hoffer, J. C., 1966, Compositional variations of plagioclase feldspar from a basaltic lava flow: Am. Mineralogist, v. 51, p. 807-813.

Hoffer, J. M., 1965, Plagioclase variations in a porphyritic flow of the Columbia River Basalt: Washington State University Ph.D. thesis, 127 p.

_____, 1969, Plagioclase mineralogy of the Rock Creek flow, Columbia River Basalt. In, Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, p. 51-54.

Holden, G. S., 1974, Chemical and petrographic stratigraphy of the Columbia River Basalt in the lower Salmon River canyon, Idaho: Washington State Univ. M.S. thesis, 97 p.

Holden, G. S.; Hooper, P. R., 1976, Petrology and chemistry of a Columbia River basalt section, Rocky Canyon, west-central Idaho: Geol. Soc. America Bull., v. 87, no. 2, p. 215-225.

Holmgren, D. A., 1969, K/Ar dates and paleomagnetics of the type Yakima Basalt, central Washington. In, Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, p. 189-199.

_____, 1969, Geochronology of the Columbia River "Yakima" Basalt in central Washington (abs.): Northwest Sci., v. 43, p. 36.

Holmgren, D. A.; Gray, J., 1971, Geochronologic equivalence of type Picture Gorge basalt, central Oregon and type Yakima basalt, central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 2, p. 137.

Hooper, P. R.; Atkins, L., 1969, The preparation of fused samples in X-ray fluorescene analysis: Mineralogical Magazine, v. 37, p. 409-413.

Hooper, P. R.; Rosenberg, P. E., 1970, The petrology of Granite Point, southeastern Washington: Northwest Sci., v. 44, no. 2, p. 131-142.

_____, 1971, Petrology of the Rock Creek flow, Columbia River Basalts, Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 7, p. 603-604.

Hooper, P. R., 1974, Petrology and chemistry of the Rock Creek Flow, Columbia River Basalt, Idaho: Geol. Soc. America Bull., v. 85, p. 15-26.

Hooper, P. R.; Kleck, W. D.; Knowles, C. R., 1976, Composition and differentiation of the Imnaha Basalt, Columbia River Group (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 383-384.

Hooper, P. R.; Reidel, S. P.; and others, 1976, Major element analyses of Columbia River Basalt, Part I: Washington State Univ., Pullman, Washington.

Ives, P. D.; Levin, Betsy; Robinson, R. D.; Rubin, Meyer, 1964, U. S. Geol. Survey Radiocarbon dates VII: Radiocarbon, v. 6, p. 37-76.

Ives, P. C.; Levin, Betsy; Oman, C. L.; Rubin, Meyer, 1967, U. S. Geol. Survey Radiocarbon dates IX: Radiocarbon, v. 9, p. 505-529.

Knowles, C. R.; Bond, J. G.; Johnson, C. A., 1972, Opaque mineral investigation of Columbia River Basalt (abs.): Geol. Soc. America Abs. with Programs, v. 4, no. 3, p. 183.

Knowles, C. R., 1973, Chemical and mineralogic variation within a single basalt flow (abs.): Geol. Soc. America Bull., v. 5, no. 7, p. 696.

Krynine, P. D., 1937, Age of till on "Palouse soil" from Washington: Am. Jour. Sci., 5th ser., v. 33, no. 195, p. 205-216, 2 figs.

Kupfer, M. J., 1970, Atomic absorption and flame emission spectroscopy analysis of basalt core samples from a deep well: Atlantic Richfield Hanford Co. Report ARH-1609, 17 p.

Larson, E. E.; Strangway, D. W., 1968, Discussion: Correlation of petrology and natural magnetic polarity in Columbia Plateau Basalts: Royal Astron. Soc., Geophys. Jour., v. 15, no. 5, p. 437-441.

Lasmanis, R., 1971, A Dana locality, Spokane, Washington: Rocks and Minerals, v. 46, no. 6, whole number 381, p. 372-374.

Laursen, J. M.; Hammond, P. E., 1974, Summary of radiometric ages of Oregon and Washington rocks, through June 1972: Isochron/West, no. 9, 32 p.

Ledbetter, M. T., 1977, Duration of volcanic eruptions: Evidence from deep-sea tephra layers (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1067

Lotspeich, F. B., 1952, A study of the Palouse catena: Washington State College M.S. thesis, 70 p.

Lotspeich, F. B.; Smith, H. W., 1953, Soils of the Palouse loess: Pt. 1. The Palouse Catena: Soil Sci., v. 76, p. 467-480.

McBirney, A. R., 1968, Petrochemistry of the Cascade andesite volcanoes. In Dale, H. M., ed., Andesite Conference Guidebook: Oregon Dept. Geology and Mineral Industries Bulletin 62, p. 101-107.

McDougall, Ian., 1976, Geochemistry and origin of basalt of the Columbia River Group, Oregon and Washington: Geol. Soc. America Bull., v. 87, no. 5, p. 777-792.

McKee, Bates; McKee, P., 1969, Refractive index data for fused glass from basalt of the Columbia Plateau. In Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, Cheney, Washington, p. 39-49.

McKee, E. H., 1968, Refractive index of glass beads distinguishes Tertiary basalts in the Grays River area, southwestern Washington: U. S. Geol. Survey Prof. Paper 600-C, p. C27-C30.

McNary, Samuel, 1976, Petrography and field studies of late Cenozoic basalt flows and intrusions in the Orofino-Elk River area, Idaho: Univ. of Idaho M.S. thesis, 135 p.

Moodie, C. C; Okazaki, R.; Smith, H. W.; Kittrick, J. A., 1966, A note on the clay mineralogy of four samples from the Ringold Formation: Northwest Sci., v. 40, no. 2, p. 43-45, table.

Moore, J. G., 1962, K/Na ratio of Cenozoic igneous rocks of the western United States: Geochim. et Cosmochim. Acta, v. 26, p. 101-130, illus., table.

Moorhouse, W. W., 1970, A comparative atlas of Archean and younger volcanic rocks: Geological Assoc. of Canada, Sp. Paper No. 8, unnumbered.

Mutschler, F. E.; Rougon, D. J.; Levin, O. P.; Hughes, R. D., 1977, PETROS--A data bank of major element chemical analyses of igneous rocks for research and teaching (Version 3.01): NOAA, Boulder, Colorado, magnetic tape.

Nathan, S.; Fruchter, J. S., 1974, Geochemical and paleomagnetic stratigraphy of the Picture Gorge and Yakima Basalts (Columbia River Group) in central Oregon: Geol. Soc. America Bull., v. 85, p. 63-76.

Nelson, D. O.; Swanson, D. A.; Wright, T. L., 1976, Strontium isotopic composition of intracanyon flows of Yakima Basalt, southeast Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 399.

Nering, L. G., 1956, Stratigraphic, mechanical, chemical, and petrographic analysis of the Lind Coulee site. In Daugherty, R. D., ed., Archaeology of the Lind Coulee site, Washington: Am. Philos. Soc. Proc., v. 100, no. 3, p. 263-266, tables.

Osawa, M.; Goles, C., 1969, Trace element abundances in Columbia River Basalts. In Gilmour, E. H.; Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, Cheney, Washington, p. 55-71.

Pearson, R. C.; Obradovich, J. D., 1977, Eocene rocks in northeast Washington-radiometric ages and correlation: U. S. Geological Survey Bull. 1433, 41 p.

Perrault, W. M., 1973, Birefringence of feldspar microlites; a new tool for correlation of Columbia River Basalt flows (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 90.

Peterman, Z. E.; Doe, B. R.; Bartel, Ardith, 1967, Data on the rock GSP-1 (granodiorite) and the isotope-dilution method of analysis for Rb and Sr. In Geological Survey research 1967: U.S. Geological Survey Prof. Paper 575-B, p. B181-B186.

Pongsapich, Wasant, 1970, A petrographic reconnaissance of the Swauk, Chuckanut, and Roslyn Formations, Washington: Univ. of Washington M.S. thesis, 63 p.

Price, S. M., 1973, A preliminary geochemical examination of the Grande Ronde dike swarm and proximate Yakima Basalt flows (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 92-93.

_____, 1973, Dike-flow relations indicated by geochemistry, Grande Ronde dike swarm, Columbia River Basalt (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 7, p. 772-773.

_____, 1974, A geochemical classification of dikes of the Grande Ronde swarm, Columbia River Basalt: ARH-SA-202, Atlantic Richfield Company, Richland, Washington.

_____, 1977, An evaluation of dike-flow correlations indicated by geochemistry, Chief Joseph swarm. Columbia River Basalt: Univ. of Idaho, Ph.D. thesis, 320 p.

Randle, K; Goles, G. G.; Kittleman, L. R., 1971, Geochemical and petrological characterization of ash samples from Cascade Range volcanoes: Quaternary Research, v. 1, p. 261-282.

Reidel, S. P., 1975, Pyroxene composition and subdivision of the Lower Yakima Basalt of the Columbia River Group in the Snake and Salmon River Canyons of Washington, Oregon, and Idaho: Geol. Soc. America Abs. with Programs, v. 7, no. 3, p. 364.

Rietman, J. D., 1966 , Remanent magnetization of the late Yakima Basalt, Washington State: Stanford Univ. Ph.D. thesis.

_____, 1966, Variations in the remanent magnetization of the Late Yakima Basalt, Washington State (abs.): Am. Geophys. Union Trans., v. 47, no. 1, p. 70.

_____, 1967, Magnetic characteristics of widespread basalt flows with intermediate directions of remanent magnetization (abs.): Eos (Am. Geophys. Union, Trans.), v. 48, no. 1, p. 83.

_____, 1968, Remanent magnetization of the Columbia River Group in western Washington and Oregon (abs.): Eos (Am. Geophys. Union, Trans), v. 49, no. 1, p. 127.

Roedder, Edwin; Smith, R. L., 1965, Liquid water in pumice vesicles - a crude but useful dating method (abs.): Geol. Soc. America Special Paper 82, p. 164.

Rose, H. J.; Adler, I.; Flanagan, F. J., 1963, X-ray fluorescence of the light elements in rocks and minerals: Applied Spectroscopy, v. 17, p. 81-85.

Ross, C. S.; Smith, R. L., 1955, Water and other volatiles in volcanic glasses: American Mineralogist, v. 40, p. 1071-1089.

Schmidt, R. G., 1962, Aeroradioactivity survey and areal geology of the Hanford Plant area, Washington and Oregon (ARMS-1): U.S. Atomic Energy Commission, Rept. No. CEX-59.4.11, (abs.), Geoscience Abs., v. 5, no. 5, p. 40, 1963.

Schmincke, H. U., 1964, Petrology, paleocurrents, and stratigraphy of the Ellensburg Formation and interbedded Yakima Basalt flows, south-central Washington: The Johns Hopkins Univ., Ph.D. thesis, 426 p.

_____, 1964, Petrology, current directions, and history of the Upper Late Yakima Basalt flows and interbedded sediments, south-central Washington (abs.): Fourth Ann. Grad. Student Symposium in the Geol. Sci., Univ. Calif., Los Angeles, Calif., 1964, p. 14-15.

_____, 1967, Stratigraphy and petrography of four upper Yakima Basalt flows in south-central Washington: Geol. Soc. America Bull., v. 78, p. 1385-1422.

Schuster, J. E.; Blackwell, D. D.; Hammond, P. E.; Huntting, M. T., 1977, Heat-flow studies in the Steamboat Mountain - Lemei Rock area, Skamania County, Washington. In Keller, G. V., ed., Geothermal Reservoirs: Proceedings CSM-NSF Conference on Geothermal Reservoirs, 1976, Dept. Geophysics, Colo. School Mines, Golden, Colo., (in press).

Sheppard, R. A., 1962, Iddingsitization and recurrent crystallization of olivine in basalts from the Simcoe Mountain, Washington: Am. Jour. Sci., v. 260, no. 1, p. 67-74, illus.

Siems, B. A., 1974, Stratigraphic identification and correlation of basalt aquifers using geophysical and chemical techniques: Washington State Univ. Coll. Eng. Research Rept. 74/15-90, 33 p.

Siems, B. A.; Bush, J. H.; Crosby, J. W., III, 1974, TiO_2 and geophysical logging criteria for Yakima Basalt correlation, Columbia Plateau: Geol. Soc. America Bull., v. 85, no. 7, p. 1061-1068.

Sheppard, R. A., 1960, Petrology of Simcoe Mountains area, Washington: Johns Hopkins Univ. Ph.D. thesis, 153 p. Plate 1, 1:250,000.

Smith, D. G. W.; Westgate, J. A.; Tomlinson, M. C., 1969, Characterization of pyroclastic units - a stratigraphic application of the microprobe. In Proceedings of the 4th National Conference on Electron Microprobe Analysis, Paper 34.

Smith, D. G. W.; Westgate, J. A., 1969, Electron probe technique for characterizing pyroclastic deposits: Earth and Planetary Sciences Letters, p. 313-319.

Smith, H. W.; Okazaki, Rose; Aarstad, John, 1968, Recent volcanic ash in soils of northeastern Washington and northern Idaho: Northwest Sci., v. 42, no. 4, p. 150-160.

Southwick, D. L., 1966, Petrography, chemistry, and possible correlations of the Camas land sill and Teanaway dike swarm, central Washington: Northwest Sci., v. 40, no. 1, p. 1-16. Figure 1, 1:443,520.

Steen-McIntyre, V., 1975, Hydration and superhydration of tephra glass-a potential tool for estimating age of Holocene and Pleistocene ash beds. In Suggate, R. P.; Cresswell, M. M., eds., Quaternary Studies: The Royal Society of New Zealand, Wellington, p. 271-278.

Stevenson, R. E., 1942, Petrology of the Ringold in the Palouse area: Washington State Univ. M.S. thesis, 42 p.

Stuiver, Minze, 1977, Recent developments in C^{14} dating (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1192.

Suess, H. E., 1970, Bristlecone-pine calibration of the radiocarbon time-scale 5200 B. C. to the present. In Olsson, I. U., ed., Radiocarbon variations and absolute chronology - Nobel Symposium, 12th, Uppsala Univ., 1969, Proc.: New York, John Wiley and Sons, Inc., p. 303-311.

Swanson, D. A.; Wright, T. L., 1976, Magnetostratigraphic units in the Yakima Basalt, southeast Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 413-414.

Tatman, J. B., 1972, Geochemical variation of Columbia River basalts beneath the Hanford Reservation, Washington (prepared under contract no. At(45-1)-2130): Atlantic Richfield Hanford Company Rept. ARH-2610, 66 p.

Tatsumoto, Mitsunobu, 1966, Isotopic composition of lead in volcanic rocks from Hawaii, Iwo-Jima and Japan: Jour. Geophys. Research, v. 71, no. 6, p. 1721-1733.

Theisen, A. A.; Borchardt, G. A.; Harward, M. E.; Schmitt, R. A., 1968, Neutron activation for distinguishing Cascade Range pyroclastics: Science, v. 161, p. 1009-1011.

Tilton, G. R.; Gast, P. W.; Hedge, C. E., 1964, Variation in the isotopic composition of lead and strontium from basalts (abs.): Eos (Am. Geophys. Union, Trans.), v. 45, no. 1, p. 109.

Ulmer, G. C.; Zaman, A., 1973, The thermal debit of the Miocene Plateau Basalts (abs.): Eos (Am. Geophys. Union, Trans.), vol. 54, no. 4, p. 512.

Vance, J. A.; Naeser, C. W., 1977, Fission track geochronology of the Tertiary volcanic rocks of the central Cascade Mountains, Washington: Geol. Soc. America Abs. with Programs, v. 9, no. 4, p. 520.

Walker, G. W., 1973, Contrasting compositions of the youngest Columbia River Basalt flows in Union and Wallowa counties of northeastern Oregon: Geol. Soc. America Bull., v. 84, no. 2, p. 425-430.

Ward, A. W., Jr., 1975, Petrology and chemistry of the Huntzinger Flow, Columbia River Basalt, Washington: Univ. of Washington M.S. thesis; (abs.) Geol. Soc. America Abs. with Programs, v. 8, no. 6, p. 1161, 1976.

_____, 1976, Petrology and chemistry of the Huntzinger Flow, Columbia River Basalt, Washington: Atlantic Richfield Hanford Co. Rept. ARH-SA-272, 52 p.

Waters, A. C., 1926, Petrography of Corbaley Canyon: Univ. of Washington B.S. thesis, 77 p.

Watkins, N. D., 1964, A paleomagnetic survey of Miocene lavas in northern Oregon, southeastern Washington, and west-central Idaho (abs.): Am. Geophys. Union Trans., v. 45, no. 1, p. 37.

_____, 1964, Structural implications of paleomagnetism in Miocene lavas of northeastern Oregon, southeastern Washington, and west-central Idaho: Nature, v. 203, no. 4947, p. 830-832.

_____, 1965, Paleomagnetism of the Columbia Plateaus: Jour. Geophys. Res., v. 70, p. 1379-1406.

_____, 1965, Frequency of extrusions of some Miocene lavas in Oregon during an apparent transition of the polarity of the geomagnetic field: Nature, v. 206, no. 4986, p. 801-803, illus., table.

_____, 1966, Variations in paleomagnetic properties of the Columbia Plateau with particular reference to their geological significance: Geol. Soc. Proc., p. 100; (abs.) geol. Soc. America Spec. Paper 82, p. 286, 1965.

_____, 1969, Reply to discussion by E. E. Larson and D. W. Strangway of "Correlation of petrology and natural magnetic polarity of Columbia Plateau basalts" (1967) (abs.): U.S. Geol. Survey Geophys. Abs., no. 266, p. 407; Royal Astron. Soc., Geophys. Jour., v. 15, no. 4, p. 444-447, illus., 1968.

Watkins, N. D.; Wilson, R. D., 1965, Investigation of the possibility of petrological control of magnetic polarity in some Miocene lavas of the Columbia Plateau (abs.): Geol. Soc. America Spec. Paper 82, p. 286-287.

Watkins, N. D.; Baksi, A. K., 1968, The age of the Picture Gorge Basalt at the type section and at Imnaha, and the maximum duration of a Miocene geomagnetic epoch (abs.): Program, Geol. Soc. America (and associated societies) Ann. Mtg., Mexico City, 1968, p. 312-313.

_____; 1974, Magnetostratigraphy and oroclinal folding of the Columbia River, Steens and Owyhee Basalts in Oregon, Washington and Idaho: Am. Jour. Sci., v. 274, p. 148-189.

Wilcox, R. E.; Powers, H. A., 1963, Petrographic characteristics of Recent pumice from volcanoes in the Cascade Range: Geol. Soc. America Abs. 1963, Spec. Paper 76, p. 232.

Wilson, R. L.; Watkins, N. D., 1967, Correlations of petrology and natural magnetic polarity in Columbia Plateau basalts: Geophys. Jour. v. 12, no. 4, p. 405.

_____, 1968, Reply by the authors (to discussion by Larson and Strangway, Geophys. Jour. Royal Astr. Soc., v. 15, no. 4, p. 437-441), of "Correlation of petrology and natural magnetic polarity of Columbia Plateau basalts": Geophys. Jour. Royal Astr. Soc., v. 15, p. 443-447.

Wright, J. B., 1968, Polarity reversals and oxidation state in rocks: Geophys. Jour. Royal Astr. Soc., v. 16, p. 161-167.

Wright, T. L.; Grolier, M. J.; Swanson, D. A., 1973, Chemical variation related to the stratigraphy of the Columbia River Basalt: Geol. Soc. America Bull., v. 84, p. 371-386.

Wright, T. L.; Swanson, D. A.; Fruchter, J., 1976, Petrogenesis of Yakima Basalt in southeastern Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 422.

Wright, T. L.; Hamilton, M. S., 1978, A computer-assisted graphical method for identification and correlation of igneous rock chemistries: Geology, v. 6, p. 16-20.

York, D.; Baksi, A.; Watkins, N. D., 1969, Potassium-argon and paleomagnetic correlation of lavas in the Columbia Plateau (abs.): Eos (American Geophys. Union Trans.), v. 50, no. 11, p. 677.

ADDITIONAL REFERENCES - LABORATORY ANALYSES AND METHODS/GEOCHRONOLOGY

Antevs, Ernst, 1954, Telecorrelation of varves, radiocarbon chronology, and geology: Jour. Geology, v. 62, p. 516-521.

Antevs, Ernst, 1955, Varve and radiocarbon chronologies appraised by pollen data: Jour. Geology, v. 63, p. 495-499.

Brown, J. C., 1976, Well correlation and stratigraphic information: Pullman test and observation well, Pullman, Washington: Washington State Univ. Coll. of Engrng. Res. Div. Rept. 76/15-6, 35 p.

Bush, J. H., Jr.; Anderson, J. V.; Crosby, J. W., III; Siems, B. A., 1972, Test-observation well near Mansfield, Washington, description, stratigraphic relationships and preliminary results: Washington State Univ. Coll. of Engrng. Res. Div. Rept. 72/11-128, 45 p.

Bush, J. H., Jr.; Morton, J. A., 1973, Test-observation well near Walla Walla, Washington: description, stratigraphic relationships and preliminary results: Washington State Univ. Coll. of Engrng. Res. Div. Rept. 73/15-66, 38 p.

Coe, R. S.; Bogue, S.; Myers, C. W., 1978, Paleomagnetism of the Grande Ronde (Lower Yakima) Basalt exposed at Sentinel Gap: potential use for stratigraphic correlation: Rockwell - Hanford Operations Rept. RHO-BWI-ST-2, 24 p.

Crosby, J. W., III; Chatters, R. M., 1965, Water dating techniques as applied to the Pullman-Moscow ground-water basin: Wash. State Univ. Coll. of Engrng. Res. Div. Bull. 296, 21 p.

Crosby, J. W., III; Chatters, R. M., 1965, New technique of water sampling for carbon-14 analysis: Jour. of Geophys. Res., v. 70, no. 12, p. 2839-2844.

Fryxell, Roald; Daugherty, R. D., 1963, Late glacial and post-glacial geological and archaeological chronology of the Columbia Plateau, Washington: interim report: Washington State Univ. Lab. Anthropology Rept. Invest. 23, 22 p.

Fryxell, Roald, 1971, The contribution of interdisciplinary research to geologic investigation of prehistory, eastern Washington: Univ. of Idaho Ph.D. thesis, Moscow, Idaho.

Libby, W. D., 1952, Radiocarbon dating: The Univ. of Chicago Press.

Reidel, S. P., 1978, The stratigraphy and petrogenesis of the Grande Ronde Basalt in the lower Salmon and adjacent Snake River canyons: Washington State Univ. Ph.D. thesis.

Robinette, M. S.; Robinette, M. J.; Brown, J. C., 1977, Geophysical investigations of Washington's ground water resources, annual report 1975/1976: Washington State Univ. Coll. of Engrng. Res. Div. Rept. 77/15-6, 56 p.

Silar, Jan, 1969, Ground water structures and ages in the eastern Columbia Basin, Washington: Washington State Univ. Coll. of Engrng. Res. Div. Bull. 315, 165 p.

GEOPHYSICAL SURVEYS

Alsup, S. A.; Guyton, J. W., 1964, Operational magnification and physical environment of seismograph stations: Geophysics, v. 29, no. 2, p. 188-196, 9 figs.

Anderson, J. V.; Bush, J. H.; Crosby, J. W., III; Kiesler, J. P.; Siems, B. A., 1973, Correlation of Columbia River Basalt by geophysical techniques (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 3.

Anderson, L. A., 1965, Electrical resistivity of the deep crust in the Columbia River basin area (abs.): EOS (Am. Geophys. Union, Trans.), v. 46, no. 1, p. 71.

Batti'e, J. E.; Rush, H., 1976, Gravity survey south of Coulee City, eastern Washington, on the Waterville Plateau (abs.): Eos (Am. Geophys. Union, Trans.), v. 57, no. 3, p. 159.

Berg, J. W., Jr.; King, J. M.; Carlson, P. R., 1966, Seismic reflection studies of buried channels off the Columbia River: Ore Bin, v. 28, no. 8, p. 145-150.

Blackwell, D. D., 1969, Heat-flow determinations in the northwestern United States: Jour. Geophys. Res., v. 74, no. 4, p. 992-1007.

Blackwell, D. D.; and others, 1973, Heat-flow and Cenozoic tectonic history of the northwestern United States (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 12-13.

Blume, John A. and Associates, 1970, Seismic and geologic siting evaluation Fast Flux Test Facility, near Richland, Washington: John A. Blume and Associates, Engineers, San Francisco, Calif., WADCO-03, 90 p.

Bonini, W. E., 1965, Gravity surveys in the northwestern United States: Am. Geophys. Union, Trans., v. 46, no. 3, p. 563-569.

Bonini, W. E.; Hughes, D. W.; Danes, Z. F., 1974, Complete Bouguer gravity anomaly map of Washington: Washington Div. Geology and Earth Resources Geol. Map GM-11, 1:500,000.

Booker, J. R., 1976, Resistivity monitoring at Wooded Island, Washington (abs.): EOS (Am. Geophys. Union Trans.), v. 57, no. 2, p. 90.

Booker, J. R.; Rothe, G. H., III, 1976, Resistivity variation prior to a small earthquake at Wooded Island, Washington: EOS (Am. Geophys. Union Trans.), v. 57, no. 3, p. 153.

Bostrom, R. C., 1967, The world rift system in the Pacific Northwest: Univ. of Washington College of Engrg. Trend in Engrg., v. 19, no. 2, p. 27-32.

Brown, R. E., 1960, The use of geophysics and geochemistry to confirm geological interpretation at the Hanford Works of the Atomic Energy Commission, USA: Internat. Geol. Cong., 21st, Copenhagen, 1960, Rept., pt. 2, p. 75-82 incl. sketch map and section.

Brown, R. E.; Raymond, J. R., 1963, Geophysical seismic evaluation study at the Hanford Works, Washington: Hanford Atomic Products Operation unclassified report HW-SA-3280, 17 p.

_____, 1964, A geophysical seismic evaluation study at Hanford: Battelle Northwest BNWL-47, 22 p. and 3 appendices.

Bush, J. H., Jr.; Crosby, J. W., III; Siems, B. A., 1971, Geophysical contributions to Columbia River basalt stratigraphy: Washington State Univ. Research Div., Pullman, Washington (contract no. AT(45-1)-2221), 9 p.

Cady, J. W.; Meyer, R. F., 1976, Principal facts for gravity stations in the Okanogan, Sandpoint, Ritzville, and Spokane 1^{o} by 2^{o} quadrangles, northeastern Washington and northern Idaho: U.S. Geol. Survey Open-File Report 76-290, 57 p.

_____, 1976, Bouguer gravity map of the Okanogan, Sandpoint, Ritzville, and Spokane 1 by 2 degree quadrangles, northeastern Washington and northern Idaho: U.S. Geological Survey Geophys. Invest. Map GP-914, Grav. Surv. Map 1:250,000.

Camfield, P. A.; Gough, D. I.; Porath, H., 1970, Preliminary results from geomagnetic deep sounding studies in the northwestern United States and southwest Canada (abs.): EOS (Am. Geophys. Union, Trans.) v. 51, no. 4, p. 268.

Campbell, D. L.; Flanigan, V.; 1976, Ground magnetic and VLF studies at Midnite uranium mine, Stevens County, Washington: U.S. Geol. Survey Open-File Report No. 76-230, 17 p.

Caner, B.; Cannon, W. H., 1965, Geomagnetic depth-sounding and correlation with other geophysical data in western North America: Nature, v. 207, no. 5000, p. 927-929.

Cantwell, T.; Nelson, P.; Webb, J., Orange, A. S., 1965, Deep resistivity measurements in the Pacific Northwest: Jour. Geophys. Research, v. 70, no. 8, p. 1931-1937.

Cantwell, T.; Orange, A., 1965, Further deep resistivity measurements in the Pacific Northwest: Jour. Geophys. Res., v. 70, no. 16, p. 4068-4072, illus.

_____, 1965, Deep resistivity results from the Pacific Northwest: Am. Geophys. Union Trans., v. 46, no. 1, p. 71.

Carder, D. S., ed., 1965, Earthquake investigations in the western United States, 1931-1964: U.S. Coast and Geodetic Survey Pub. 41-2, 264 p.

Chiburis, E. F., 1965, Crustal and sub-crustal investigations in the Pacific Northwest states from surface wave dispersion (abs.): Am. Geophys. Union Trans., v. 46, no. 1, p. 156.

_____, 1966, Crustal structures in the Pacific Northwest states from phase-velocity dispersion of seismic surface waves: Oregon State Univ. Ph.D. thesis, 170 p.

Conwell, C. N., 1950, Seismic investigation of the Milton Damsite, Milton Freewater Project - Walla Walla, Washington: U.S. Bur. Reclamation, Eng. Geology Br. Geol. Rept., no. G-108, 4 p., illus.

_____, 1950, Seismic investigation of areas near Soap Lake, Washington - Columbia Basin Project: U.S. Bur. Reclamation, Eng. Geol. Br. Geol. Rept., no. G-111 (2) p., illus.

_____, 1952, Seismic investigation of areas near Ephrata, Washington - Columbia Basin project: U.S. Bur. Reclamation, Eng. Geol. Rept. no. G-120, 23 p., illus (incl. maps); Annot. Bibliography Econ. Geology, v. 25, no. 2, p. 158.

Crosby, J. W., 1971, Some applications of geophysical well logging to basalt hydrogeology: Ground water, v. 9, no. 5, 9 p.

Crosson, R. S., 1977, Seismic studies related to regional tectonics in the Pacific Northwest (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 940.

Daly, R. A., 1926, Our Mobile Earth: Chas. Scribner's Sons, New York, p. 19, 134, 140, 141.

Danes, Z. F., 1969, Gravity results in the state of Washington (abs.): In Gilmour, E. H.; Stradling, eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, Cheney, Washington, p. 327; (abs.) Northwest Sci., v. 43, no. 1. p. 34.

Dehlinger, P.; Chiburis, E. F.; Collyer, M. M., 1964, Pacific Northwest states local travel-time curves and their geologic implications (abs.): Am. Geophys. Union, Trans., v. 45, no. 4, p. 635.

Deju, R. A.; Gephart, R. E.; Richard, B. H., 1976, A regional gravity investigation over the Hanford Reservation (abs.): Geol. Assoc. Can.-Mineral Assoc. Can., Jt. Annual Meeting, Program Abs., v. 1, p. 54.

Donaldson, J. A., 1963, Seismic survey: Hanford Atomic Products Operation, Richland, Washington.

Goman, T. G.; Heglund, R. M., 1966, Preliminary gravity results, Wenatchee Mountains, Washington (abs.): Am. Geophys. Union,Trans., v. 47, no. 1, p. 260.

Gregory, D. I.; Jackson, D. B., 1976, Bouguer gravity map of Moscow, Idaho-Pullman, Washington area: U.S. Geol. Survey Open-File Report No. 76-280, one sheet, 1:62,500.

Hammond, P. E.; Pederson, S. A.; Stricklin, C. R., 1975, Geology and gravimetry of the Quaternary basaltic volcanic field, southern Cascade Range, Washington (abs.): U. N. Symposium Dev. Use Geotherm. Resour., Abs., no. 2, unpaginated.

Hill, D. P., 1965, The U.S. Geological Survey's gravity program in Washington, Idaho, Montana, and Wyoming (abs.): Geophys. Abs., no. 222, p. 557.

_____, 1970, Crustal structure of the Columbia Plateau from the EDZOE events (abs.): Geol. Soc. America Abs. with Programs, v. 2, no. 2, p. 101-102.

_____, 1972, Crustal and upper mantle structure of the Columbia Plateau from long range seismic-refraction measurements: Geol. Soc. America Bull., v. 83, no. 6, p. 1639-1648, illus. (incl. sketch maps).

Jackson, D. B., 1975, Schlumberger soundings in the Moscow, Idaho-Pullman, Washington, area: U.S. Geol. Survey Open-File Report 75-584, 28 p.

_____, 1975, Description of the geoelectric section, Rattlesnake Hills Unit 1 Well, Washington: Jour. Res. U.S. Geol. Surv., v. 3, no. 6, p. 665-669.

Jackson, D. B.; Gregory, D. I., 1976, D.C. resistivity studies near Moscow, Idaho, and Pullman, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 385.

Jackson, D. B.; Senterfit, R. M.; Gregory, D. I., 1976, Principal facts for gravity stations in the Pullman, Washington-Moscow, Idaho, area: U.S. Geol. Survey Open-File Report No. 76-189, 8 p.

Jahns, R. H., 1967, Geologic factors relating to engineering seismology in the Hanford area, Washington: Douglas United Nuclear Inc., DUN-3100, 35 p.

Jaske, R. T., 1964, Large scale quarry blasting on the Hanford Reservation: Hanford Atomic Products Operation, Report HW-79614, 63 p.

Konicek, D.; Danes, Z. F., 1973, Gravity results in the mountains of south-central Washington (abs.): EOS (Am. Geophys. Union, Trans.), v. 54, no. 3, p. 147.

Konicek, D., 1975, Geophysical survey in south-central Washington: Northwest Sci., v. 49, no. 2, p. 106-117; (abs.) EOS (Amer. Geophys. Union Trans.) v. 53, no. 11, p. 966, Nov. 72.

McCollom, R. L.; Crosson, R. S., 1975, An array study of upper mantle velocity in Washington State: Seismol. Soc. America Bull., v. 65, no. 2, p. 467-482.

Meyer, R. F.; Wilson, D. M., 1976, Principal facts for gravity stations in the Spokane area, Washington: U.S. Geol. Survey Open-File Report 75-503.

Moody, J. D., 1966, Crustal shear patterns and orogenesis: Tectonophysics, v. 3, no. 6, p. 479-522.

Neumann, Frank, 1958, Preliminary report on seismological investigations at the Hanford Works: Hanford Works unclassified report GEH-24175.

_____, 1959, Seismological investigation at the Hanford area, 1958-1959: U.S. Atomic Energy Comm. Rept. HW-63832, 50 p. plus Appendices A-E.

Nilsen, Tor, 1976, Washington gravity base station network: Washington Div. Geology and Earth Resources Inv. Circ. 59, 83 p.

Pakiser, L. C.; Robinson, Rhoda, 1966, Composition of the continental crust as estimated from seismic observations. In The earth beneath the continents - A volume of geophysical studies in honor of M.A. Tuve: Am. Geophys. Union Geophys. Mon. 10 (Nat'l. Acad. Sci. -- Nat'l. Research Council Pub. 1467) p. 620-626; Tectonophysics, v. 3, no. 6, p. 543-557, 1966.

Parks, H. W.; Banami, A. M., 1971, Gravity survey of Columbia Plateau ring dikes (abs.): EOS (Am. Geophys. Union, Trans.), v. 52, no. 5, p. 433.

Peterson, D. E., 1966, Variations in earth's gravity field at Hanford: Battelle Memorial Institute, Pacific Northwest Laboratory Report BNWL-235-3, p. 4-6.

Peterson, D. E.; Brown, R. E., 1966, Gravity anomalies and geologic structures of the central part of the Columbia River Basalt Plateau (abs.): Am. Geophys. Union, Trans., v. 47, no. 4, p. 630.

Peterson, D. E., 1968, Bouguer gravity anomalies on the Hanford Reservation: Battelle Memorial Institute, Pacific Northwest Laboratory Report BNWL-481-3, p. 10-14.

Phillipp, L. D.; Sheen, E. M., 1965, Aerial and ground gamma survey monitors: Battelle Northwest Lab. Rept. BNWL-62, 15 p.

Pitt, A. M., 1972, Seismic activity in the Hanford region, Washington, March 23, 1969, to June 30, 1971: U.S. Geol. Survey Open-File Report, 25 p.

Priestley, K. F., 1971, Earth strains observed at the Cascade Geophysical Site using a long base laser interferometer strain meter: Univ. of Washington M.S. thesis, 84 p.

Quarterly Technical Report, no. 1, for Hanford and Central Seismic Networks, July 1, 1975 through Sept. 30, 1975: Geophysics Program, University of Washington, Seattle, Washington, February 1, 1976.

Quarterly Technical Report, no. 2, for Hanford and Central Seismic Networks, October 1, 1975 through Dec. 31, 1975: Geophysics Program, University of Washington, Seattle, Washington, May 1, 1976.

Quarterly Technical Report, no. 3, for Hanford and Central Seismic Networks, Jan. 1, 1976 through March 31, 1976: Geophysics Program, University of Washington, Seattle, Washington, May 1, 1976.

Raymond, J. R., 1958, The magnetic method of geophysical exploration on the Hanford project - interim report: General Electric Report HW-57309, 22 p.

Raymond, J. R.; Ratcliffe, C. A., 1959, A test of the refraction seismic method on the Hanford Project: Hanford Atomic Products Operation Report No. HW-78924, Richland, Washington, 21 p.

Raymond, J. R.; Brown, D. J., 1963, Geophysical investigation with a scintillation well probe: Hanford Atomic Products Operation Report HW-77609, p. 4.45-4.47.

Raymond, J. R.; McGhan, V. L., 1963, Results of an airborne magnetometer survey of the Hanford Project: Hanford Atomic Products Operation Report HW-78924, 15 p.

Raymond, J. R., 1968, Geophysical seismic exploration: Battelle Memorial Institute, Pacific Northwest Laboratory Report BNWL-481-3, p. 5-10.

Robbins, S. L.; Burt, F. J.; Gregg, D. O., 1975, Gravity and aeromagnetic study of part of the Yakima River basin, Washington: U.S. Geol. Survey Prof. Paper 726-E, 7 p.

Roy, R. F.; Decker, E. R.; Blackwell, D. D.; Birch, F., 1968, Heat flow in the United States: Jour. Geophys. Research, v. 73, no. 16, p. 5207-5221.

Sass, J. H.; and others, 1971, Geothermal studies -- Heat-flow map of the western United States: U.S. Geol. Survey Prof. Paper 750-A, p. 109-110.

Sass, J. H.; Lachenbruch, A. H.; Munroe, R. J.; Greene, G. W.; Moses, T. H., Jr., 1971, Heat flow in the western United States: Jour. Geophy. Research, v. 76, no. 26, p. 6376-6413.

Siems, B. A.; Crosby, J. W., III; Anderson, J. V., 1973, Geophysical investigations of Washington's ground water resources: Washington Dept. Ecol., (Tech. Re.), No. 73-034, 45 p.

Siems, B. A., 1973, Surface to subsurface correlation of Columbia River Basalt using geophysical data, in parts of Adams and Franklin counties, Washington: Washington: Washington State Univ. M.S. thesis.

_____, 1974, Stratigraphic identification and correlation of basalt aquifers using geophysical and chemical techniques: Wash. State Univ., Coll. Eng. Research Rept. 74/15-90, 33 p.

Siems, B. A.; Bush, J. H.; Crosby, J. W., III, 1974, TiO_2 and geophysical logging criteria for Yakima Basalt correlation, Columbia Plateau: Geol. Soc. America Bull., v. 85, no. 7, p. 1061-1068.

Simmons, G. C.; Van Noy, R. M.; Zilka, N. T., 1974, Mineral resources of the Cougar Lakes-Mount Aix study area, Yakima and Lewis Counties, Washington, with a section on interpretation of aeromagnetic data, by W. E. Davis: U.S. Geol. Survey Open-File Report, 80 p. plus 3 map sheets.

Steele, J. L., 1975, A heat flow study in the Turtle Lake quadrangle, Washington: Southern Methodist Univ. M.S. thesis.

Swanson, D. A.; Wright, T. L.; Zietz, I., 1976, Geologic interpretation of a aeromagnetic map of the west-central Columbia Plateau, Washington and Oregon: U.S. Geol. Survey Open-File Report 76-51, 28 p., 1 Plate, 3 Figures.

_____, (in press), Geologic interpretation of an aeromagnetic map of the west-central Columbia Plateau, Washington and Oregon: U.S. Geol. Survey G. P. 917.

Ulmer, G. C.; Zaman, A., 1973, The thermal debit of the Miocene Plateau Basalts (abs.): EOS (Am. Geophys. Union, Trans.), vol. 54, no. 4, p. 512.

U.S. Geological Survey, 1973, Aeromagnetic map of parts of Okanogan and Sandpoint 1^{o} by 2^{o} quadrangles, Washington, Idaho, Montana: U.S. Geol. Survey Open-File map, 1 sheet scale 1:250,000.

U.S. Geological Survey, 1974, Aeromagnetic map of parts of Okanogan, Sandpoint, Ritzville, and Spokane 1^{o} by 2^{o} quadrangles, northeastern Washington: U.S. Geol. Survey Open-File map, scale 1:250,000, 1 sheet. Also 23 sheets, scale 1:62,500 of the same area.

U.S. Geological Survey, 1976, Aeromagnetic map for part of southwestern Washington: U.S. Geol. Survey Open-File Report 75-648, 4 sheets, scale 1:62,500.

U.S. Geological Survey, 1977, Aeromagnetic map of part of northern Washington: U.S. Geol. Survey Open-File Report 77-254, 2 plates, scale 1:62,500.

Woollard, G. P., 1958, Results for a gravity control network at airports in the United States: Geophysics, v. 23, no. 3, p. 520-535, 7 figs.

_____, 1965, The bouguer gravity anomaly map of the United States: Am. Geophys. Union Trans., v. 46, no. 1, p. 197-202.

Yost, C. R., 1976, Gravity survey of the Cheney quadrangle, Washington: Eastern Washington State College M.S. thesis, 37 p.

Zietz, I., 1971, Interpretation of an aeromagnetic strip across the northwestern United States: Geol. Soc. America Bull., v. 82, no. 12, p. 3347-3372. Figure 1 includes an aeromagnetic map at scale 1:2,500,000.

ADDITIONAL REFERENCES - GEOPHYSICAL SURVEYS

Berg, J.W.; Thiruvathukal, J.V., 1967, Complete Bouguer gravity anomaly map of Oregon: Oregon Dept. of Geol. and Min. Ind., Geological Map Series GMS 4-b. (Text for this map is in the Ore Bin, v. 29, no. 6, p. 120-126, June 1967).

Bonini, W.E., 1963, Gravity anomalies in Idaho: Idaho Bureau Mines and Geology, Pamphlet 32, 38 p.

Brown, J.C., 1976, Well correlation and stratigraphic information: Pullman test and observation well, Pullman, Washington: Washington State Univ., Coll. of Engrng. Res. Div. Rept. 76/15-6, 35 p.

Brown, D.J.; Raymond, J.R., 1963, Ground-water temperature investigations: Hanford Atomic Products Operation, Rept. HW-77609, p. 4.41-4.42.

Bush, J.H., Jr.; Anderson, J.V.; Crosby, J.W., III; Siems, B.A., 1972, Test observation well near Mansfield, Washington: description, stratigraphic relationships, and preliminary results: Washington State Univ., Coll. of Engrng. Res. Div. Rept. 72/11-128, 45 p.

Bush, J.H., Jr.; Crosby, J.W., III; Siems, B.A., 1972, Geophysical contributions to Columbia River Basalt stratigraphy: Addendum II, in Crosby, J.W., III; Anderson, J.W.; Fenton, R.L.; Kiesler, J.P.; Siems, B.A., Washington State Univ., Coll. of Engrng. Res. Div. Rept. 72/11-71.

Bush, J.H., Jr.; Morton, J.A., 1973, Test-observation well near Walla Walla Washington: description, stratigraphic relationships and preliminary results: Washington State Univ., Coll. of Engrng. Res. Div. Rept. 73/15-66, 38 p.

Cady, J.W., 1976, Regional gravity and aeromagnetic studies applied to uranium exploration in north-eastern Washington and Wyoming: U.S. Geol. Survey Open-file Rept. 76-317, 21 p.

Crosby, J.W., III; Cavin, R.E., 1960, Geologic investigation of the Moscow ground-water basin employing geophysical studies: Washington State Univ., Geo-Hydrologic Res. Group Bull. 250, 23 p.

Crosby, J.W., III; Anderson, J.V.; Kiesler, J.P., 1972, Geophysical investigation of wells in the Horse Heaven Hills area: Addendum III, in Crosby, J.W., III; Anderson, J.V.; Fenton, R.L.; Kiesler, J.P.; Siems, B. A., Washington State Univ. Coll. of Engrng. Res. Div. Rept. 72/11-71.

Danes, Z.F., 1964, Preliminary gravity data, central Cascade Mountains, Washington: Univ. of Puget Sound Res. Inst. Rept.,Univ. of Puget Sound RIP-GP-64-1, 13, p.

Danes, Z.F., 1969, Gravity results in western Washington: EOS, Am. Geophys. Union, Trans., v. 50, no. 10, p. 548-550.

Danes, Z.F., 1975, Bouguer gravity map of Mt. Rainier National Park, Washington: Washington Div. Geol. & Earth Resources Open-file report of 75-5, scale 1:63,360.

Davis, W.E.; Kinoshita, W.T., 1968, Principal facts for gravity stations in northeastern Washington: U.S. Geol. Survey open-file report, 12 p.

Defense Mapping Agency Topographic Center, 1973, Washington regional gravity survey: DMATC report no. 96 - A.

Dehlinger, P.; Chiburis, E.F.; Collver, M.M., 1965, Local travel-time curves and their geologic implications for the Pacific Northwest states: Bull. Seis. Soc. Amer., v. 55, p. 587-607.

Eaton, G.C.; Staatz, M.H., 1971, Aeromagnetic interpretation. IN Staatz, M.H.; and others, Mineral resources of the Pasayten Wilderness Area, Washington:U.S. Geol. Survey Bull. 1325, p. 80-84.

Geodetic Survey Squadron (1st)., 1970, Gravity data for the state of Idaho: 1st G.S.S.

Geodetic Survey Squadron (1st)., 1972, Idaho regional gravity survey: 1st G.S.S.

Gualtieri, J.L.; Simmons, G.C.; Thurber, H.K; Miller, M.S., 1973, Mineral resources of the Alpine Lakes study area, Chelan, King, and Kittitas counties, Washington, with a section on aeromagnetic interpretation, by W.E. Davis: U.S. Geol. Survey open-file rept., 132 p.

Hawaii Inst. of Geophysics, 1967, gravity data in the United States, north-south profiles: Army Map Service, (USATOPOCOM).

Hunting Geophysical Services, 1960, Geological interpretation of airborne magnetometer and scintillometer survey, Mt. Bonaparte, Bodie Mountain, Curlew, Aeneas and Republic quadrangles, Okanogan and Ferry Counties, Washington: Washington Div. Geol. and Earth Resources Rept. Inv. 20, scale 1:62,500.

Johnson, S.H.; Couch, R.W., 1970, Crustal structure in the North Cascade Mts. of Washington and British Columbia from seismic refraction measurements: Bull. Seis. Soc. Amer., v. 60, p. 1259-1269.

Lin, J.W., 1974, A study of upper mantle structure in the Pacific Northwest using P waves from teleseisms: Univ. of Washington, Ph.D. thesis, 98 p.

Lobdell, G.T.; Brown, J.C., 1977, Geophysical investigations of Washington's ground-water resources, annual report 1976/1977: Washington State Univ. Coll. of Engrng. Res. Div. Rept. 77/15, 17 p.

Myers, D.A., 1972, Test-observation well near Davenport, Washington: description and preliminary results: U.S. Geol. Survey open-file rept., Tacoma, Washington.

Newbauer, T.R., 1974, Geomagnetic depth-sounding in the State of Washington: Univ. of Washington M.S. thesis, 49 p.

Peterson, D.E., 1966, Gravity survey of the Hanford Reservation, Washington: Battelle Memorial Inst., Pacific Northwest Lab. Rept.

Peterson, D.L., Gravity data, Rathdrum Prairie, Idaho: U.S. Geol. Survey, unpublished map.

Portland General Electric Co., 1974, Pebble Springs, Nuclear Plant Units 1 & 2, License Application, PSAR, section 2.5 - geology and seismology; section 2.6 references.

Raymond, J.R., 1955, Applicability of geophysical methods of exploration at Hanford Atomic Products Operation: General Electric Co. Rept. HW-38707.

Raymond, J.R., 1962, A logging system for well-water temperature measurement: Hanford Atomic Products Operation, Rept. HW-73337, p. 220-223.

Raymond, J.R.; Tillison, D.D., 1968, Evaluation of a thick basalt sequence in south central Washington, geophysical and hydrological exploration of the Rattlesnake Hills deep stratigraphic test well: Battelle Pacific North-west Lab. Rept. 776, 120 p.

Robinette, Muriel, 1975, Geophysical investigations of Washington's ground-water resources 1974/75: Washington State Univ. Coll. of Engrng. Res. Div. Rept. 75/15-24.

Robinette, M.S.; Robinette, M.J.; Brown, J.C., 1977, Geophysical investigation of Washington's ground-water resources, annual report 1975/76: Washington State Univ. Coll. of Engrng. Res. Div. Rept. 77/15-6.

Siems, B.A.; Crosby, J.W., III; Anderson, J.V.; Bush, J.H., Jr. Weber, T.L., 1973, Final report, 1972/73, Geophysical investigation of Washington's ground-water resources: Washington State University Coll. of Engrng. Res. Div. Rept. 73/15-58.

Swanberg, C.A., 1968, A gravity survey over the central part of the Okanogan Range, Washington: Southern Methodist Univ. M.S. thesis, 51 p.

U.S. Army Topographic Command, 1965, Washington State gravity base network project: USATOPOCOM, 28 pts.

U.S. Army Topographic Command, 1972, Washington regional gravity report: USATOPCOM report no. 27.

U.S. Geological Survey, 1977, Progress report on selected geophysical activities of the United States, 1973-76: U.S. Geol. Survey Circular 763, 37 p.

Univ. of Puget Sound, 1972, Washington regional gravity survey: reports 69, 69 A, 69 B.

Univ. of Washington, Annual Progress report on micro-earthquake monitoring of the Hanford region: Geophysics program, Univ. of Washington, Seattle, 30 March 1976.

Univ. of Washington, Quarterly technical report 75-A for Hanford seismic network, January 1, 1975 through March 31, 1975: Geophysics Program, Univ. of Washington, Seattle, January 21, 1977.

Univ. of Washington, Quarterly technical report 77-A , for Hanford seismic network, January, 1977 through March 31, 1977: Geophys. Program, Univ. of Washington, Seattle, April 29, 1977.

Univ. of Washington, Annual progress report on micro-earthquake monitoring of the Hanford region: Geophysics Program, Univ. of Washington, Seattle, July 15, 1977.

Univ. of Washington, Quarterly technical report 77-B for Hanford seismic network, April 1, 1977 through June 30, 1977: Geophysics Program, Univ. of Washington Seattle, August 1, 1977.

Univ. of Washington, Quarterly technical report 77-C, for Hanford seismic network, July 1, 1977 through September 30, 1977: Geophysics Program, Univ. of Washington, Seattle, November 21, 1977.

Univ. of Washington, Quarterly technical report 77-D, for Hanford seismic network, October 1, 1977 through December 31, 1977: Geophysics Program, Univ. of Washington, Seattle January 31, 1978.

Walters, K. L.; Cline, D.R.; Luzier, J.E., 1972, Test-observation well near Odessa, Washington: description and preliminary results: U.S. Geol. Survey open-file rept., Tacoma, Washington, 25 p.

Walters, K.L., 1973, Test-observation well near Almira, Washington: description and preliminary results: U.S. Geol. Survey open-file rept., Tacoma, Washington, 20 p.

Watkins, N.D., 1965, Paleomagnetism of the Columbia Plateaus: Jour. Geophys. Res., v. 70, p. 1379-1406.

U.S. Geological Survey, 1976, Aeromagnetic map of the Horseshoe Basin quadrangle, Okanogan County, Washington: U.S. Geol. Survey, map. one sheet, 1:62,500.

GEOLOGIC HAZARDS AND DAM-SITE STUDIES

Alt, D.; Chambers, R. L., 1970, Repetition of the Spokane flood (abs.): In American Quaternary Assoc. Mtg., 1st, Yellowstone Park, Wyoming, and Bozeman, Mont., 1970, Abs.: (Mont. State Univ., Bozeman, Mont.), p. 1.

Anderson, D. G.; Bodhaine, G. L., 1956, Floods in 1956 in the Esquatzel Coulee area in Washington: U.S. Geological Survey Open-File Report, 51 p.

Anderson, R. A., Jr.; Schuster, R. L., 1970, Stability of slopes in clay shales interbedded with Columbia River basalt. In Engineering geology and soils engineering symposium, 8th Ann., Pocatello, Idaho, 1970, Proc: Boise, Idaho, Idaho Dept. Highways, p. 273-284, illus.

Berkey, C. P., 1935, Foundation conditions for Grand Coulee and Bonneville projects: Civil Eng., vol. 5, no. 2, p. 67-71.

Bingham, J. W.; Londquist, C. J.; Baltz, E. H., 1970, Geologic investigation of faulting in the Hanford region, Washington: U.S. Geol. Survey Open-File Report, 103 p.

Bostrom, R. C., 1967, The world rift system in the Pacific Northwest: Univ. of Washington College of Engineering, Trends in Engineering, v. 19, no. 2, p. 27-32.

Brown, B. H., 1937, The state-line earthquake at Milton and Walla Walla (abs.): Seismol. Soc. America Bull., v. 231, no. 3, p. 205-209, Northwest Sci., v. 11, no. 2, p. 62-64.

Brown, R. E., 1968, The incidence of earthquakes at Hanford as deduced from geological features: Battelle Memorial Institute Pacific Northwest Laboratory Report BNWL-481-3, p. 3-5.

_____, 1968, A study of reported faulting in the Pasco Basin: Battelle Northwest Report BNWL-662, 55 p.

_____, 1968, Reported faulting in the Pasco Basin: Battelle Northwest Laboratories Report No. BNWL-SA-1704; (abs.) Geol. Soc. America Spec. Paper 121, p. 489, 1969.

Carder, D. S., ed., 1965, Earthquake investigations in the western United States, 1931-1964: U.S. Coast and Geodetic Survey Pub. 41-2, 264 p.

Cluff, Lloyd, 1977, Capable or active faulting (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1243.

Coffman, J. L.; von Hake, C. A., eds., 1973, Earthquake history of the United States, pub. 41-1, revised edition (through 1970): U.S. Dept. Commerce, Nat. Oceanic Atmos. Adm., 208 p.

Coombs, H., 1953, A summary of Washington earthquakes: Bull. Seismol. Soc. America Bull., v. 43, no. 1, p. 1-5, illus.

Cramer, C. H., 1969, A time-lapse presentation of the earthquakes of Washington State 1952-1967 (abs.): EOS (Am. Geophys. Union, Trans.), v. 50, no. 2, p. 61.

Crandell, D. R., 1973, Map showing potential hazards from future eruptions of Mt. Rainier, Washington: U.S. Geol. Survey Misc. Inv. Map I-836, scale 1:250,000.

_____, 1976, Preliminary assessment of potential hazards from future volcanic eruptions in Washington: U.S. Geol. Survey Misc. Field Studies Map MF-774, scale 1:1,000,000.

Crandell, D. R.; Mullineaux, D. R., 1975, Technique and rationale of volcanic hazards appraisals in the Cascade Range, Northwestern United States: Environmental Geology, v. 1, p. 23-32.

_____, 1976, Potential hazards from future eruptions of Mt. St. Helens volcano, Washington: U.S. Geol. Survey Open-File Report 76-491, 25 p.

Danes, Z. F., 1970, Earthquake occurrence in the State of Washington (abs.): U.S. Geol. Survey Geophys. Abs. 281, p. 609.

Dehlinger, P.; Chiburis, E. F.; Collver, M. M., 1965, Local travel-time curves and their geologic implications for the Pacific Northwest States: Seismol. Soc. Am. Bull., v. 55, no. 3, p. 587-607.

Fifer, N. F., 1968, Earthquake studies of the Hanford area: Douglas-United Nuclear, Inc., Report DUN-3625, 69 p.

Foxworthy, B. L.; Washburn, R. L., 1963, Magnitude and frequency of floods in the United States - Part 12, Pacific Slope basins in Washington and upper Columbia River basin: U.S. Geol. Survey Water-Supply Paper 1687, 337 p.

Garber, L. W., 1965, Relationship of soils to earthflows in the Palouse: Jour. Soil and Water Conserv., v. 20, no. 1, p. 21-23, illus.

Hill, D. P., 1970, Crustal structure of the Columbia Plateau from the EDZOE events (abs.): Earthquake Notes, v. 41, no. 2, p. 25-26.

Hodge, E. T., 1931, Columbia River Fault: Geol. Soc. America Bull., v. 42, p. 923-984.

_____, 1931, Columbia River fault-scarp (abs.): Pan-America Geologist, v. 55, no. 1, p. 64; (abs.) Geol. Soc. America Bull., v. 42, no. 1, p. 185-186.

Hodgson, J. H., 1957, Direction of faulting in some of the larger earthquakes of the North Pacific, 1950-1953 (abs.): U.S. Geol. Survey Bull. 1066-A, p. 6.

Hulsing, Harry; Kallio, N. A., 1964, Magnitude and frequency of floods in the United States - Part 14, Pacific Slope basins in Oregon and lower Columbia River basin: U.S. Geol. Survey Water-Supply Paper 1689, 320 p.

Hyde, J. H.; Crandell, D. R., 1975, Origin and age of post-glacial deposits and assessment of potential hazards from future eruptions of Mt. Baker, Washington: U.S. Geol. Survey Open-File Report 75-286, 22 p.

Irwin, W. H., 1938, Geology of the rock foundation of Grand Coulee Dam, Washington: Geol. Soc. America Bull., v. 49, p. 1627-1650.

Jackson, R. E.; Budge, D. R.; Hofmann, R. B., 1977, Interpretation and application of the term "Capable Fault" in Appendix A, 10 CFR Part 100 (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1034.

Jones, F. O., 1961, Landslides along the Columbia River Valley, northeastern Washington: U.S. Geol. Survey Prof. Paper 367, 98 p. Plate 1, 1:9,600; Plate 3, 1:31,680; Plate 5, 1:31,680; Plate 6, 1:31,680; (abs.) Geomorphological Abstracts, no. 19, p. 161-162, 1964.

Jones, F. O.; Deacon, R. J., 1966, Geology and tectonic history of the Hanford area and its relation to the geology and tectonic history of the state of Washington and the active seismic zones of western Washington and western Montana: Douglas United Nuclear, Inc., Consultant agreement CA-00056, Spokane, Washington.

Kardos, L. T.; Vlasoff, P. I.; Twiss, S. N., 1944, Factors contributing to landslides in the Palouse (Washington) region: Soil Sci. Soc. Am. Proc. 1943, v. 8, p. 437-440, illus.

Keefer, D. K., 1977, A model for earthflow (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1045.

Kuentz, O. O., 1934, Geology of Grand Coulee dam site, In Columbia River and minor tributaries: Cong. Doc., 73d. Cong., 1st sess., House Doc. 103, v. 2, p. 726-755.

Lander, J. F., 1964, U.S. earthquakes 1962: U.S. Coast and Geodetic Survey, 114 p. (Wash., p. iv, 6, 7, 41-47, 97, 104, 110, 111, 112).

Lander, J. F.; Cloud, W. K., 1963, United States earthquakes 1961: U.S. Coast and Geodetic Survey, 106 p. (Washington p. iv, 6, 7, 28-32, 47, 50, 82, 89).

Lander, J. R., 1965-1968, Seismological notes: Seismol. Soc. Am. Bull., v. 55-58.

Landes, H., 1929, The dam site at Island Rapids (Vantage), In Columbia River and minor tributaries: Cong. Doc., 73d. Cong., 1st sess., House Doc. 103, v. 2, 1934, p. 1199.

_____, 1929, The dam site at Rocky Reach, In Columbia River and minor tributaries: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, v. 2, 1934, p. 1199-1200.

_____, 1929, The dam site near the mouth of Chelan River, In Columbia River and minor tributaries: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, v. 2, 1934, p. 1201-1202.

_____, 1929, The dam site at the mouth of Foster Creek, near Bridgeport, In Columbia River and minor tributaries: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, v. 2, 1934, p. 1202-1203.

_____, 1930, Rock Lake Reservoir and dam site, In Columbia River and minor tributaries: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, v. 2, 1934, p. 1208-1209.

_____, 1930, The Grand Coulee reservoir, In Columbia River and minor tributaries: Cong. Doc., 73d. Cong., 1st sess., House Doc. 103, v. 2, 1934, p. 1193-1198.

_____, 1930, The dam site on the Columbia River above Rocky Reach, In Columbia River and minor tributaries: Cong. Doc., 73d. Cong., 1st sess., House Doc. 103, v. 2, 1934, p. 1200-1201.

Malone, S. D., 1974, Some characteristics of micro-earthquake swarms in the Columbia River Basin (abs.): EOS (Am. Geophys. Union, Trans.), v. 55, no. 4, p. 347.

Malone, S. D.; Rothe, G. H.; Smith, S. W., 1975, Details of microearthquake swarms in the Columbia Basin, Washington: Seismol. Soc. America Bull., v. 65, no. 4, p. 855-864.

Murphy, L. M.; Cloud, W. K., 1957, United States earthquakes 1954 (abs.): U.S. Geol. Survey Bull. 1066-A, p. 6.

Olson, T. M., 1971, The Colfax landslide; a case history: Society of Mining Engineers of AIME Preprint No. 71-1-305, 16 p.

Palmer, Leonard, 1977, Large landslides of the Columbia River Gorge, Oregon and Washington. In Choates, D. C., ed., Landslides: Geol. Soc. America Case Histories in Engineering Geology, v. 11 (in press).

Pilz, H. A., 1968, Stemilt Creek Basin landslide near Wenatchee. In McKee, B., and Coombs, H. A., eds., Guidebook to Field Trips: Assoc. Engrg. Geologists, 1968 Ann. Mtg., Seattle, Washington, p. 11-13.

Pitt, A. M., 1971, Microearthquake activity in the vicinity of Wooded Island, Hanford Region, Washington: U.S. Geol. Survey, Open-File Report.

_____, 1972, Seismic activity in the Hanford region, Washington, 1969 to 1971: U.S. Geol. Survey Open-File Report, 25 p.

Plummer, F. G., 1893, Recent volcanic activity in Washington: Tacoma Ledger (newspaper), 28 Feb. 1893.

Prescott, W. H.; Savage, J. C., 1973, Progress report on geodolite measurements at Hanford, Washington: Informal Report, National Center for Earthquake Research.

Puget Sound Power and Light, 1974, PSAR, Chpt. 2.5, Appendix 2J, Investigation of the Dec. 14, 1872 Earthquake in the Pacific Northwest, prepared by Bechtel, Inc., San Francisco, California.

Ransome, F. L., 1930, Geological reports on dam and reservoir sites on the upper Columbia River and tributaries, In Columbia River and minor tributaries: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, v. 2, 1934, p. 1178-1186.

Rantz, S. E.; Riggs, H. C., 1949, Floods of May-June 1948 in Columbia River basin, with a section on magnitude and frequency of floods: U.S. Geol. Survey Water-Supply Paper 1080, 476 p.

Rasmussan, Norman, 1967, Washington State earthquakes 1840 through 1965: Seismol. Soc. America Bull., v. 57, no. 3, p. 463-476.

_____, 1967, Registration of earthquakes from University of Washington seismic net 1963: Univ. of Washington Geology Dept. Seismol. Bull. 13, 46 p.

_____, 1969, Seismic trends in Washington State: Univ. of Washington Trend in Engineering, v. 21, no. 3, p. 21-23.

_____, 1976, Seismology report on Washington, Idaho, northern Oregon and western Montana and the Hanford Area: Douglas United Nuclear Report, DUN-1409.

Rothe, G. H., III, 1974, Details of earthquake swarms in the Columbia Basin (abs.): EOS (Am. Geophys. Union, Trans.), v. 56, no. 12, p. 1147.

_____, 1978, Cause of shallow-focus earthquakes near Hanford; University of Washington Ph.D. thesis.

Rothe, G. H.; Malone, S. D.; Smith, S. W., 1975, Details of microearthquake swarms in the Columbia Basin, Washington: Seismol. Soc. America Bull., v. 65, no. 4, p. 855-864, illus.

_____, 1977 (in press), Microearthquake swarms near Wooded Island, Washington: Seismol. Soc. America.

Ryall, A.; Slemmons, D. B.; Gedney, L. D., 1966, Seismicity, tectonics, and surface faulting in the western United States during historic time: Seismol. Soc. America Bull., v. 56, no. 5, p. 1105-1135.

Schmidt, R. G., 1961, Aeroradioactivity of the Hanford Plant area, Washington and Oregon: U.S. Geol. Survey Geophys. Inv. Map 6P-307, scale 1:250,000.

_____, 1962, Aeroradioactivity survey and areal geology of the Hanford Plant area, Washington and Oregon (ARMS-1): U.S. Atomic Energy Commission Report CEX 59.4.11.

Scott, N. H., 1976, Evaluation of the epicenter and intensity of the Pacific Northwest earthquake of Dec. 14, 1872: report prepared for Bechtel, Inc., Sept. 76.

_____, 1976, Letter dated Oct. 14, 1976 from N. H. Scott to M. J. Adair, Bechtel, Inc., San Francisco, CA, re. "The Pacific Northwest Earthquake of Dec. 14, 1872."

Seismological Notes: Seismol. Soc. America Bull. v. 62, p. 875-879, June, 1972, Washington, Oct. 25, 1971, 18h52m49.3s, 46° 42.4'N, 119° 32.9W, focal depth about 3 km (USGS). Felt at Hanford. Magnitude 3.2 (ERL ML).

Shannon and Wilson, Inc., 1976, 1872 earthquake, new data from Oregon: Rept. to Portland General Electric Co., Portland, Oregon.

Slemmons, D. B., 1977, Definitions of fault activity and non-activity (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1179.

Smith, R. B., Sbar, M. L., 1974, Contemporary tectonics and seismicity of the western United States with emphasis on the Intermountain Seismic Belt: Bull. Geol. Soc. Am., 85, p. 1205-1218.

Smith, S. W., 1976, Microearthquake monitoring of the Hanford region, Annual Progress Report: Geophysics Program, University of Washington, Seattle, Washington.

_____. 1977, Seismicity, faulting, and earthquake potential (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1183.

Sowers, G. F., 1977, Engineering problems of fault capability-activity (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1185.

Stover, C. W.;Simon, R. B.; Person, W. J., 1976, Earthquakes in the United States, Oct. - Dec. 1974: U.S. Geol. Survey Circular 723-D, 27 p., Washington, p. 5, 11, 13, 23.

Stradling, D. F., 1970, Landslides of the central Horse Heaven Hills, southern Washington (abs.). In American Quaternary Assoc. Mtg., 1st, Yellowstone Park, Wyoming, and Bozeman, Montana, 1970, Abs.: (Bozeman, Montana, Montana State University?), p. 127.

Stradling, D. F.; Winters, H. A., 1967, Some major landslides of the Yakima folds (abs.): Assoc. Pacific Coast Geographers Yearbook, v. 29, p. 158-159.

Suppe, John; Powell, Christine; Berry, Robert, 1975, Regional topography, seismicity, Quaternary volcanism, and the present-day tectonics of the western United States: Am. Jour. Sci., 275-A, p. 397-436.

Swartz, J. H.; Joyce, J. W., 1933, Contour map of the bedrock topography in the east excavation: submitted to U.S. Bureau of Reclamation, Almira, Washington.

Thomas, C. A.; Broom, H. C.; Cummans, J. E., 1963, Magnitude and frequency of floods in the United States - Part 13, Snake River basin: U.S. Geol. Survey Water-Supply Paper 1688, 150 p.

Thompson, G. A., 1966, The rift system of the western United States. In The World Rift System — International Upper Mantle Committee Symposium, Ottawa, 1965: Canada Geol. Survey Paper 66-14, p. 280-290.

Thorsen, G. W., 1970, Washington's landslide survey (a progress report): Engineering Geology and Soils Engineering, p. 285-293.

Treasher, R. C., 1940, Distribution of historic earthquakes in the Pacific Northwest (abs.): Geol. Soc. America Bull., v. 51, no. 12, part 2, p. 2034.

University of Washington, 1976, Micro-earthquake monitoring of the Hanford region; annual progress report: NTIS, Springfield, VA, 63 p.

Von Thun, J. L., 1977, Establishing active fault classification criteria (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1213.

Waldron, H. H.; Bonilla, M. G., 1968, Field review of possible young faulting in the Hanford area, Washington.

Washington Public Power Supply System, 1976, Report of the review panel on the Dec. 14, 1872 earthquake: WPPSS Nuclear Project No. 1, Richland, Washington.

_____, 1976, December 1972 northwest earthquake: WPPSS Nuclear Project No. 1, Richland, Washington, revised draft report.

_____, 1976, Letter reports by Wolkenhauer, W. C.; Becker, D. L., An assessment of the horizontal ground acceleration required to overturn a large rock located near Omak Lake, Washington: WPPSS Nuclear Project No. 1, Richland, Washington.

_____, 1977, Preliminary safety analysis report, amendment 23: WPPSS Nuclear Project No. 1, Richland, Washington, 13 sub-appendices in 2 volumes, pagination varies.

Washington State Earthquakes, 1840-1965: Seismol. Soc. America Bull., v. 57, no. 3, p. 463-476, 1967.

Weston Geophysical Research, Inc., 1976, The 1872 Earthquake-Significant Data and Conclusions: Report prepared for United Engineers and Constructors, Inc.

Williams, I. S., 1930, Geologic report on the Grand Coulee Reservoir site, In Columbia River and minor tributaries: Cong. Doc. 73d. Cong., 1st sess., House Doc. 103, v. 2, 1934, p. 1187-1193.

Woodward-Clyde Consultants, 1976, Review of the Pacific Northwest Earthquake of Dec. 14, 1872: Report prepared for Washington Public Power Supply System.

Woollard, G. P., 1958, Areas of tectonic activity in the United States as indicated by earthquake epicenters: EOS (Am. Geophys. Union, Trans.), v. 39, no. 6, p. 1135-1150.

ADDITIONAL REFERENCES - GEOLOGIC HAZARDS AND DAM SITE STUDIES

Bechtel, Inc., 1975, Investigation of the December 14, 1872 earthquake in the Pacific Northwest: Preliminary Safety Analysis report, Appendix 2J, Skagit Nuclear Project, Puget Sound Power & Light Co.

Brown, D.J.; Lobdell, G.T.; Neff, George, 1976, Hydrology and engineering geology of the Columbia Basin: Geol. Soc. Am., Cordilleran Section Mtng., Pullman, Washington, Field Guide No. 3, April 1976.

Corps of Engineers, U.S. Army, Portland District, 1946, Definite Project Report on McNary Dam, Columbia River, Oregon - Washington, v. 11 - Appendix B - Geology.

Corps of Engineers, U.S. Army, Portland District, 1951, Letter Report on the Dalles Dam, Columbia River, Oregon - Washington.

Corps of Engineers, U.S. Army, Portland District, 1956, The Dalles Dam, Foundation Report, parts II, III, and IV.

Corps of Engineers, U.S. Army, Portland District, 1976, Bonneville Lock and Dam, Second Powerhouse - geology, excavation, and foundation treatment: Design Memorandum no. 17.

Corps of Engineers, U.S. Army, Seattle District, 1954, Foundation Report, Chief Joseph Project, Bridgeport, Washington, parts I and II.

Corps of Engineers, U.S. Army, Seattle District, 1954, Ben Franklin Lock and Dam, Section III, Geology.

Corps of Engineers, U.S. Army, Walla Walla District, 1946, Report on geology of the lower Snake River for site selection.

Corps of Engineers, U.S. Army, Walla Walla District. 1951, Preliminary report on the geology of part of the lower Snake River Canyon, Washington, by Waldron, H.H., and Gard, L.M.

Corps of Engineers, U.S. Army, Walla Walla District, 1957, Geologic features at McNary Dam, Oregon and Washington, By Monahau, C.J.

Corps of Engineers, U.S. Army, Walla Walla District, 1958, The general geology and geomorphology of the Snake River Canyon in the area of the Lower Monumental Dam site, by Clem, R.H.

Corps of Engineers, U.S. Army, Walla Walla District, 1959, Foundation report, Ice Harbor Lock and Dam, Snake River, Washington.

Corps of Engineers, U.S. Army, Walla Walla District, 1959,General Design Memorandum, Lower Monumental Lock and Dam, Snake River, v. II, Appendix D - Geology.

Corps of Engineers, U.S. Army, Walla Walla District, 1961, General Design Memorandum, Little Goose Lock and Dam, Snake River, Washington, v. II, Appendix A - Geology

Corps of Engineers, U.S. Army, Walla Walla District, 1961, General Design Memorandum, Bruces Eddy Dam and Reservoir, Idaho.

Corps of Engineers, U.S. Army, Walla Walla District, 1962, Foundation Report, John Day Dam, Columbia River, Oregon and Washington, part 1.

Corps of Engineers, U.S. Army, Walla Walla District, 1964, Lower Granite Lock and Dam, Snake River, Oregon, Washington, and Idaho: General Design Memorandum, no. 3, v. 2, Appendix A.

Corps of Engineers, U.S. Army, Walla Walla District, 1969, Lower Monumental Lock and Dam, Foundation Report.

Corps of Engineers, U.S. Army, Walla Walla District, 1971, Foundation Report, Dworshak Dam and Reservoir, Idaho.

Corps of Engineers, U.S. Army, Walla Walla District, 1971, John Day Lock and Dam, Foundation Report, parts II and III.

Corps of Engineers, U.S. Army, Walla Walla District, 1971, General Design Memorandum, Catherine Creek Lake, Catherine Creek, Oregon.

Corps of Engineers, U.S. Army, Walla Walla District, 1973, General Design Memorandum, Zintel Canyon Dam, Kennewick Washington.

Corps of Engineers, U.S. Army, Walla Walla District, 1973, General Design Memorandum, Willow Creek Lake, Oregon, phase II - Project Design.

Douglas County, Washington, P.U.D., Wells Hydroelectric Project Report, Section II - Geology.

Fifer, N.F., 1966, 1918 Corfu earthquake: Douglas United Nuclear Inc. report DUN-1524, 3 p.

Geological Society of America, 1964, Columbia River dams, Rock Island to Grand Coulee, with geology along the way from Seattle: Cordilleran section, Geol. Soc. Am., and Washington Chapter of Association of Engineering Geologists, field trip, 25-26 March 1964, Univ. of Washington, Seattle, 41 p.

Grant County, Washington, P.U.D., 1955, Priest Rapids Hydroelectric Development, Columbia River, v. I-IV.

Meese, R.H.; Wilson, S.D., 1965, Review of Hanford Reservation soils and geology as related to proposed 200 bev accelerator: Report prepared for Tri-City Nuclear Industrial Council, Inc., Pasco, Washington, 17 p.

Mollard, J.D., 1966, Reconnaissance photogeologic fault study, Hanford Project vicinity, In Jones, F.O.; Deacon, R.J., 1966, p. IV 10 - IV 11.

Monahan, C.J., 1957, Geologic features of McNary Dam, Oregon-Washington: Geol. Soc. Am. Engrng. Case Histories, No. 1., p. 33-38.

National Geodetic Survey, Map showing probable annual rates of vertical crustal movements over large regions (U.S.A.): Geotimes, 17, 2 (December 1972), p. 31.

Newcomb, R.C., 1971, Geologic map of proposed Patterson Ridge pumped storage reservoir, south-central Washington: U.S. Geol. Survey Misc. Invest. Map I-653.

Portland General Electric Company, 1974, Pebble Springs Nuclear Plant Units 1 and 2, License Application, PSAR, Section 2.5 - Geology and Seismology, and Section 2.6 - References.

Shannon & Wilson, Inc., 1973, Geologic studies of Columbia River Basalt structures and age of deformation, The Dalles-Umatilla region, Washington-Oregon, Boardman Nuclear Project: Rept. to Portland General Electric Co., Portland Oregon, 55 p.

Shannon & Wilson, Inc., 1974, Ground response studies - Boardman Nuclear Project - Pebble Springs Site - Morrow County, Oregon: Private Report to Portland General Electric Co., Portland, Oregon.

Shannon & Wilson, Inc., 1976, Volcanic Hazard Study - Potential for volcanic ash fall, Pebble Springs Nuclear Plant Site, Gilliam County, Oregon: Private Report to Portland General Electric Co., Portland, Oregon.

U.S. Bureau of Reclamation, Columbia Basin Project, 1934-1950, Reports of boards of consulting engineers, Columbia Basin Project: U.S.B.R., Boise, Idaho.

U.S. Bureau of Reclamation, Columbia Basin Project, 1973, Preconstruction geology report, Cascade Pumping Plant and Intake Canal (near Ellensburg, Washington): U.S.B.R., Boise, Idaho.

U.S. Bureau of Reclamation, Columbia Basin Project, 1973, Preconstruction geology report, Esquatzel Coulee Pumping Plant (near Pasco, Washington): U.S.B.R., Boise, Idaho.

U.S. Bureau of Reclamation, Columbia Basin Project, 1974, Preconstruction geology report, Wahluke Branch Canal Laterals (near Priest Rapids Dam): U.S.B.R., Boise, Idaho.

U.S. Bureau of Reclamation, Columbia Basin Project, 1975, Preconstruction geologic report, water resources development, Spokane Indian Reservation: U.S.B.R., Boise, Idaho.

U.S. Bureau of Reclamation, Columbia Basin Project, 1976, Preconstruction geologic report, Main Canal, Bacon Siphon, and Tunnel no. 2, v. I and II: U.S.B.R., Boise, Idaho, geologic map, 2 sheets, 1:6,000, with cross references.

U.S. Bureau of Reclamation, Grand Coulee Project, General geologic report and suggested stabilization solutions for the area from Grand Coulee Dam to 6 miles downstream: U.S.B.R., Boise, Idaho.

U.S. Bureau of Reclamation, Grand Coulee Project, 1952, Downriver slide investigations, plan geology map, Grand Coulee Dam area, by Wallcott, W.E.: U.S.B.R., Boise, Idaho.

U.S. Bureau of Reclamation, Grand Coulee Project, 1967-68, Surface geology maps of the area from Grand Coulee Dam to 14 miles downstream: U.S.B.R., Boise, Idaho.

U.S. Bureau of Reclamation, Grand Coulee Project, 1968-75 and 1977, Annual Reports - Landslide survey in the vicinity of Grand Coulee Dam: U.S.B.R., Boise, Idaho

U.S. Bureau of Reclamation, Grand Coulee Project, 1974, Lake Roosevelt aerial landslide survey, Third Power-plant Construction drawdown, December 1973 to June 1974: U.S.B.R., Boise, Idaho.

U.S. Bureau of Reclamation, Grand Coulee Project, 1978, Un-edited rough draft of the foundation geology, Grand Coulee Dam, Third Powerhouse: U.S.B.R., Boise, Idaho.

U.S. Bureau of Reclamation, Grand Coulee Project, 1978, Memorandum geologic reports of 5 areas from Grand Coulee Dam to 6 miles downstream (12 areas total): U.S.B.R., Boise, Idaho.

U.S. Coast and Geodetic Survey, U.S. Earthquakes, Annual reports 1928 to 1970: U.S. Gov't. Printing Office, Washington, D.C.

REMOTE SENSING SURVEYS

Edwards, J. R., 1975, Use of aerial photography in the Department of Natural Resources: Washington Dept. Natural Resources publication, 29 p.

Gaydos, L.; Wray, J. R.; Guptill, S. C., 1973, Digital land cover classification of the Washington urban area derived from LANDSAT data. 1972 and 1973: U.S. Geol. Survey, PB-264 650/357.

Godfrey, W. L.; Brown, D. J.; Veatch, M. D., 1972, Remote sensing of southeastern Washington, Part I, Infrared scanning imagery: Atlantic Richfield Hanford Company report ARH-2251, Richland, Washington, 62 p.

Jamison, D. W., 1970, Earth resources observation satellite-image utility at state level: Washington Dept. Natural Resources publication, 138 p., illus., maps.

Klosterman, K. E., 1974, An evaluation of the ERTS-I system imagery in a structural study and a map application, ERTS-I imagery in southeastern Washington, northeastern Oregon, and parts of western Idaho: Univ. of Washington M.S. thesis, 84 p.

National Field Investigations Center: Environmental Protection Agency, 1974, Remote Sensing report, Pacific Northwest area, Washington, Oregon, Idaho: National Field Investigations Center, Denver, CO; Environmental Protection Agency, Seattle, Washington, 156 p.

Richter, D. M., 1967, An airphoto index to physical and cultural features in the western U.S.: Photogrammetric Engineering, v. 23, no. 12, 1967.

Scott, R. G.; Harding, R. A., 1975, Satellite and airplane remote sensing of natural resources in the State of Washington: Int. Symp. Remote Sensing Environ., Proc., no. 10, v. 2, p. 893-900.

Williams, R. S., Jr.; Carter, W. D., eds., 1976, ERTS-1--A new window on our planet: U.S. Geol. Survey Prof. Paper 929, 362 p. (Washington, p. 106-108, 120-122, 173-175).

Washington Dept. of Natural Resources, 1974, Aerial photography project areas and schedule of aerial photography, revised 1976: Washington Dept. Natural Resources, Inventory Section.

Washington Dept. of Natural Resources, 1975, Orthophoto maps, township format, Kittitas, Yakima, and Klickitat Counties: Washington Dept. Natural Resources, scale, 1:24,000.

Washington Dept. of Natural Resources, 1977, Indices of photography by county and group of counties--1958-1976: Washington Dept. Natural Resources, Resource Inventory Section.

Washington Dept. of Natural Resources, 1977, Washington index for aerial photography flown in 1975-1976, 1974-1975, 1972-1974, 1972-1973, 1972, 1970-1971, 1970, 1968, 1967, 1965-1966, 1964-1965, 1964, 1962-1963, 1961-1962, 1960-1961, 1958-1959, 1956-1958, 1948-1960: Washington Dept. Natural Resources, Resource Inventory Section.

HYDROLOGIC INVESTIGATIONS

Ahlstrom, S. W.; Serne, R. J.; Routson, R. C.; Cearlock, D. B., 1974, Methods for estimating transport model parameters for regional groundwater systems: Battelle Northwest Labs report BNWL-1717, Richland, Washington, 26 p.

Baker, V. R., 1971, Paleohydrology of catastrophic Pleistocene flooding in eastern Washington (abs.): Geol. Soc. America, Abs. with Programs, v. 3, no. 7, p. 497.

_____, 1973, Paleohydrology and sedimentology of Lake Missoula flooding in eastern Washington: Geol. Soc. America Spec. Paper 144, 79 p.

Barker, R. A., 1976, Computer simulation of a basalt aquifer system in the Pullman-Moscow Basin, Washington and Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 352.

Barraclough, J. T., 1976, Geohydrologic summary of the Snake River Plain aquifer in southeastern Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 352-353.

Bierschenk, W. H., 1959, Aquifer characteristics and groundwater movement at Hanford (Washington): Hanford Atomic Products Operation Rept. HW-60601, 77 p., incl. sketch map, tables, diagrams, and illus.

Boucher, P. R., 1975, Reconnaissance study of sediment transport by selected streams in the Yakima Indian Reservation, Washington, 1974 water year: U.S. Geol. Survey Open-File Report 75-67, 20 p., 1 figure, 1 table.

Brown, D. J., 1967, Migration characteristics of radionuclides through sediments underlying the Hanford Reservation. In Disposal of radioactive wastes into the ground - Symposium, Vienna, 1967, Proc.: Vienna, Austria, Internat. Atomic Energy Agency, p. 215-228, illus.

Brown, D. J.; Raymond, J. R., 1963, Ground water temperature investigations, in Hanford radiological sciences research and development annual report for 1962: Hanford Atomic Products Operation Rept. HW-77609, p. 4.41-4.42, illus.

Brown, R. E.; Raymond, J. R., 1962, Measurement of geohydrologic features affecting waste movement at Hanford, Washington (abs.): Geol. Soc. America Spec. Paper 68, p. 309.

Brown, R. E.; Brown, D. J., 1963, Geologic features and groundwater flow: Hanford Atomic Products Operation Report HW-77609, p. 4.43-4.44.

Brown, R. E., 1968, The Yakima Basalt Formation and its relationships to the Columbia River in aquifer development: Battelle Memorial Institute, Pacific Northwest Laboratory Report BNWL 481-3, p. 1-5.

_____, 1970, Some effects of irrigation in the Pasco Basin, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 2, no. 5, p. 326-327.

Brown, R. E., and others, 1968, Geology and hydrology of the Pasco Basin: U.S. Atomic Energy Commission report.

Bryan, K., 1924, Geologic features affecting reservoirs and other structures: unpubl. manuscript, submitted to U.S. Bur. Reclamation as Appendix B of the Gault Rept. on Columbia Basin Irrigation Project.

_____, 1929, Geology of reservoir and dam sites: U.S. Geol. Survey-Water Supply Paper 597, p. 1-72.

Calkins, F. C., 1905, Geology and water resources of a portion of east central Washington: U.S. Geol. Survey Water-Supply Paper 118, 96 p.

Cline, Chuck, 1973, Geology and ground water resources, vicinity of Castle Rock, Cowlitz County, Washington: Washington Dept. of Ecology, no. 73-010, 5 p.

Cline, D. R., 1969, Ground water resources and related geology of north-central Spokane and southeastern Stevens Counties, Washington: Washington Dept. Water Res. Water-Supply Bull. 27, 195 p., illus., tables, geol. map.

_____, 1975, Reconnaissance of the water resources of the upper Klickitat River basin, Yakima Indian Reservation, Washington: U.S. Geol. Survey Open-File Report, 75-518, 80 p., 6 figures, 11 tables.

Crosby, J. W., III, 1968, Ground-water hydrology of the Pullman-Moscow Basin, Washington. In Campbell, T. H.; Sylvester, R. D., eds., water resources management and public policy, p. 93-109.

_____, 1971, Some applications of geophysical well logging to basalt hydrogeology: Ground water, v. 9, no. 5, 9 p.

Crosby, J. W., III; Mellott, J. C., 1973, Physical characteristics of basalt aquifers (prepared under contract no. D1-14-31-0001-3548): Washington State Water Research Center, Pullman, Washington.

DeMotts, Henry; Miles, W. F., 1933, Study of the Pullman artesian basin: Washington State College highest honors thesis, 35 p. Map 2, 1:125,000.

Doerksen, H. R., 1975, Regional problem analysis in the Pacific Northwest: Part A-Interstream flow needs, Part B-Basalt ground water aquifers, Part C-Wild and scenic rivers: Washington State Water Research Center, Pullman, Washington; Office of Water Research and Technology, Washington, DC, Report, 121 p.

Eddy, P. A., 1969, Ground water data for Goldendale area, Klickitat County, Washington: Washington Department of Water Resources Monograph 2, 21 p., 1 map sheet.

_____, 1970, Geohydrology of the Columbia Basin Project area, Washington (abs.). In Gilmour, E.; Stradling, D., eds., Columbia River Basalt Symposium, 2d, Proc.: Eastern Washington State College Press, Cheney, Washington, p. 327; Northwest Science, v. 43, no. 1, p. 35, 1969.

_____, 1971, Geology and ground water availability, Selah area, Washington: Washington Dept. of Ecology, no. 71-15, 7 p.

_____, 1971, Geology and ground water resources in vicinity of the Columbia River and Interstate 5, Clark County, Washington, No. 2: Washington Dept. of Ecology, Office of Technical Services, 13 p.

_____, 1971, Geology and ground water resources, Rocky Point interchange vicinity, Cowlitz County, Washington: Washington Dept. of Ecology, no. 71-25, 11 p.

_____, 1971, Geology and ground water resources, vicinity of Toutle River and SR 504, Cowlitz County, Washington: Washington Dept. of Ecology, no. 71-18, 8 p.

_____, 1972, Geohydrology and the digital model, Odessa area, Washington (abs.): Northwest Scientific Assoc. Abs. of Papers presented at the 45th annual meeting, p. 4.

Emmett, W. W., 1976, Bedload transport in two large, gravel-bed rivers, Idaho and Washington: Fed. Inter-Agency Sediment. Conf., Proc., no. 3, p. 4.101-4, 114.

Foxworthy, B. L., 1959, Geology and ground water resources of the Ahtanum Valley, Yakima County, Washington: U.S. Geol. Survey Open-File report, Plate 2, 1:400,000.

_____, 1962, Geology and ground water resources of the Ahtanum Valley, Yakima County, Washington: U.S. Geol. Survey Water-Supply Paper 1598, 100 p. Plate 1, 1:62,500.

Foxworthy, B. L.; Washburn, R. L., 1957, Reconnaissance investigation of ground water in the Wellpinit area, Stevens County, Washington: U.S. Geol. Survey Open-File Report, 14 p. Plate 1, 1:11,400.

_____, 1963, Ground water in the Pullman area, Whitman County, Washington: U.S. Geol. Survey Water-Supply Paper 1655, 71 p. Plate 1, 1:63,360; Plate 2, 1:24,000.

Gilmour, E. H.; Bacon, Marion, 1974, Ground water resources and potential sewage pollution in southern Spokane County: Office of Water Research and Technology Project Completion Report, Eastern Washington State College, 58 p.

Gregg, D. O.; Laird, L. B., 1975, A general outline of the water resources of the Toppenish Creek Basin, Yakima Indian Reservation, Washington: U.S. Geol. Survey Open-File Report 75-19, 46 p., 17 Figures, 1 Table.

Griffin, W. C.; Watkins, F. A., Jr.; Swenson, H. A., 1956, Water resources of the Portland, Oregon, and Vancouver, Washington area: U.S. Geol. Survey Circ. 372, 45 p. Plate 2, 1:253,440.

Hampton, E. R.; Brown, S. G., 1964, Geology and ground water resources of the upper Grande Ronde River basin, Union County, Oregon: U.S. Geol. Survey Water Supply Paper 1597.

Haushild, W. L.; Stevens, H. H., Jr.; Nelson, J. L.; and others, 1971, Radionuclides in transport in the Columbia River from Pasco to Vancouver, Washington: U.S. Geol. Survey, Water Resources Div., Open-File Report, 76 p., illus., Portland, Oregon.

Irwin, W. H.; Aherns, T. P., 1946, Geology and ground water hydrology of the South Dam, Columbia Basin project, Washington (abs.): Geol. Soc. America Bull., v. 57, no. 12, pt. 2, p. 1207-1208.

Jones, R. W.; Ross, S. H., 1972, Moscow basin ground water studies: Idaho Bureau Mines and Geology Pamphlet 153, 95 p.

Kinnison, H. B.; Sceva, J. E., 1963, Effects of hydraulic and geologic factors on stream flow of the Yakima River Basin, Washington: U.S. Geol. Survey Water-Supply Paper 1595, 134 p. Plate 1, 1:250,000.

Ko, Chong An, 1974, Geology and ground water resources of the Hangman Creek drainage basin, Idaho-Washington (abs.): Washington State Univ. Ph.D. thesis; Diss. Abs. Int., v. 35, no. 6, p. 2824B-2825B.

Landes, Henry, 1905, Underground waters of Washington, Preliminary Rept: U.S. Geol. Survey Water-Supply and Irrigation Paper No. 111, 81 p.

Ledgerwood, R. K.; Deju, R. A., 1976, Hydrogeology of the uppermost confined aquifers underlying the Hanford Reservation: Atlantic-Richfield Hanford Co. Rept. ARH-SA-253.

Lupher, R. L.; Warren, W. C., 1942, The Asotin stage of the Snake River canyon near Lewiston, Idaho: Jour. Geology, v. 50, p. 866-881.

Lutz, G. A.; Stevens, H. H., Jr., 1975, Discharge and flow distribution, Columbia River estuary: U.S. Geol. Survey Prof. Paper 433-P, p. P1-P31.

Luzier, J. E., 1969, Ground water occurrence in the Goldendale area, Klickitat County, Washington: U.S. Geological Survey Hydrologic Inv. Atlas HA-313, map and text on 1 sheet, scale 1:62,500.

Luzier, J. E.; Bingham, J. W.; Burt, R. J.; Barker, R. A., 1969, Ground water survey, Odessa-Lind area, Washington: Washington Department of Water Resources Bull. 36, 31 p.

Luzier, J. E.; Skrivan, J. A., 1975, Digital-simulation and projection of water-level declines in basalt aquifers of the Odessa-Lind area, east-central Washington: U.S. Geol. Survey Water-Supply Paper 2036, 48 p., illus.

Macinko, George, 1963, The Columbia Basin Project; expectations, realizations, implications: Geogr. Review, v. 53, no. 2, p. 185-199.

MacNish, R. D., 1976, Mathematical model of an aquifer system in the Columbia River Basalt Group in southeastern Washington and northeastern Oregon (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 391-392.

Maddox, G. E., 1976, A proposed structural control of surface and ground water in the eastern portion of the Columbia River Basalt, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, pa. 392.

Molenaar, Dee, 1968, A geohydrologic reconnaissance of northwestern Walla Walla County, Washington: Washington Dept. Water Resources Monograph 1, map and text on 1 sheet, 1:126,720.

_____, 1977, Outline of the water resources of the Satus Creek B Basin, Yakima Indian Reservation, Washington: U.S. Geological Survey Open-File Report 76-808, 34 p., 1977.

Mundorff, M. J.; Reis, D. J.; Strand, J. R., 1952, Progress report on the ground water in the Columbia Basin Project, Washington: U.S. Geol. Survey Open-File Report, 229 p. Plate 1, 1:79,180; (abs.) Annotated Bibliography Econ. Geology, v. 26, no. 1, p. 91, 1954.

Mundorff, M. J., 1959, Geology and ground water resources of Clark County, Washington: U.S. Geol. Survey Open-File Report.

_____, 1960, Geology and ground-water resources of Clark County, Washington: Washington Div. Water Resources Water-Supply Bull. 9, 660 p. Plate 1, 1:50,000.

_____, 1964, Geology and ground water conditions of Clark County, Washington, with a description of a major alluvial aquifer along the Columbia River: U.S. Geol. Survey Water-Supply Paper 1600, 268 p.

Mundorff, M. J.; MacNish, R. D., 1977, Water Resources of the Satus Creek Basin Yakima Indian Reservation, Washington: U.S. Geol. Survey Open-File Report 76-685.

Nelson, R. W., 1963, Electrical analog simulation of the Hanford ground water flow system: Hanford Atomic Products Operation Report HW-77609, p. 4.28-4.33.

Newcomb, R. C., 1948, Ground water in the Kennewick area, Washington: U.S. Geol. Survey Open-File Report.

_____, 1951, Preliminary report on the ground water resources of the Walla Walla Basin, Washington-Oregon: U.S. Geol. Survey Open-File Report, Pl. 2, 1:95,040.

Newcomb, R. C.; Strand, J. R., 1953, Geology and ground water characteristics of the Hanford Reservation of the Atomic Energy Commission, Washington: U.S. Geol. Survey Water-Supply Paper, p. 12-53.

Newcomb, R. C., 1959, Some preliminary notes on ground water in the Columbia River Basalt: Northwest Sci., v. 33, no. 1, p. 1-18, Figure 1, 1:5,068,800.

_____, 1961, Structural barrier reservoirs of ground water in the Columbia River Basalt: U.S. Geol. Survey Prof. Paper 424-B, p. 213-215. Figure 1, 1:3,752,000.

Newcomb, R. C.; Brown, S. G., 1961, Evaluation of bank storage along the Columbia River between Richland and China Bar, Washington: U.S. Geol. Survey Water-Supply Paper 1539-1, p. 11-113, illus.

Newcomb, R. C., 1961, Storage of ground water behind subsurface dams in the Columbia River Basalt, Washington, Oregon, and Idaho: U.S. Geol. Survey Prof. Paper 383-A, p. 1-15. Figure 1, 1:3,752,000.

_____, 1965, Geology and ground water resources of the Walla Walla River Basin, Washington-Oregon: Washington Div. Water Resources Water-Supply Bull. 21, 151 p. Plate 1, 1:95,040.

Newcomb, R. C.; Strand, J. R.; Frank, F. J., 1966, Geology and ground water characteristics of the Hanford Reservation of the Atomic Energy Commission, Washington: U.S. Geol. Survey draft report.

Newcomb, R. C., 1969, Effect of tectonic structure on the occurrence of ground water in the basalt of the Columbia River Group of The Dalles area, Oregon and Washington: U.S. Geol. Survey Prof. Paper 383-C, 33 p., 19 illustrations.

Newcomb, R. C.; Strand, J. R.; Frank, F. J., 1972, Geology and ground water characteristics of the Hanford Reservation of the U.S. Atomic Energy Commission, Washington: U.S. Geol. Survey Prof. Paper 717, 78 p.

Newcomb, R. C., 1972, Quality of the ground water in basalts of the Columbia River Group, Washington, Oregon and Idaho: U.S. Geol. Survey Water-Supply Paper 1999-N, 71 p. Map 1:1,000,000.

_____, 1976, Some characteristics of aquifers in the Columbia River Basalt (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 399-400.

Olson, T. M., 1975, The geology and ground water resources of part of the Hangman and Marshall Creek drainage basins, Spokane County, Washington: Eastern Washington State College M.S. thesis, 70 p.

Olson, T. M.; Gilmour, E. H.; Bacon, Marion; Gaddy, J. L.; Robinson, G. A.; Parker, O. J., 1975, Geology, ground water, and water quality of part of southern Spokane County, Washington: Office of Water Research and Technology Project Completion Report, Eastern Washington State College, 139 p., 17 tables, 2 plates.

Perkins, R. W., 1963, Effect of a reactor fuel element failure on the Columbia River radionuclide concentrations at Pasco, Washington: Hanford Atomic Products Operation Report HW-77609, p. 3.68.

Piper, A. M., 1932, Geology and ground water resources of The Dalles region, Oregon: U.S. Geol. Survey Water-Supply Paper 659B, p. 107-189.

Piper, A. M.; Thomas, H. E., 1933, Ground water in the Walla Walla Basin, Oregon-Washington: U.S. Geol. Survey Open-File Report.

Price, C. E., 1960, Artificial recharge of a well tapping basalt aquifer, Walla Walla area, Washington: U.S. Geol. Survey Water Supply Bulletin 7, 50 p.

Price, S. M.; Ames, L. L., 1976, Characterization of actinide-bearing sediments underlying liquid waste disposal facilities at Hanford. In Transuranium nuclides in the environment (anonymous): IAEA, Vienna, Austria, p. 191-211, illus., (incl. tables).

Purves, W. J., 1969, Stratigraphic control of the ground water through Spokane Valley: Washington State Univ. M.S. thesis, 213 p.

Ralston, D. R., 1972, Guide for the location of water wells in Latah County, Idaho: Idaho Bureau Mines and Geology Inf. Cir. no. 23, 14 p.

Raymond, J. R.; Bierschenk, W. H., 1957, Hydrologic investigations at Hanford (abs.): Am. Geophys. Union, Trans., v. 38, no. 2, p. 270.

_____, 1957, Hydrologic investigations at Hanford (Washington): Am. Geophys. Union, Trans., v. 38, no. 5, p. 724-729, illus.

Reisenauer, A. E., 1963, Effects of partially saturated flow parameters on infiltration rate: Hanford Atomic Products Operation Report HW-77609, p. 4.33-4.40.

Russell, I. C., 1897, A reconnaissance of southeastern Washington: U.S. Geol. Survey Water-Supply Paper 4, 96 p.

Sceva, J. E., 1953, Ground water in the vicinity of Geiger Field, Spokane County: U.S. Geol. Survey Open-File Report. Plate 1:62,500, by L. M. Huff and J. E. Sceva.

Schwennesen, A. T.; Meinzer, O. E., 1918, Ground water in Quincy Valley, Washington: U.S. Geol. Survey Water-Supply Paper 425-E, p. 131-161.

Siems, B. A.; Crosby, J. W., III; Anderson, J. V., 1973, Geophysical investigations of Washington's ground water resources: Washington Dept. Ecology, (Tech. Re.), No. 73-034, 45 p.

Siems, B. A., 1974, Stratigraphic identification and correlation of basalt aquifers using geophysical and chemical techniques: Washington State Univ., Coll. Eng. Research Rept. 74/15-90, 33 p.

Silar, Jan, 1969, Ground water structures and ages in the eastern Columbia Basin, Washington: Washington State University College of Engineering Research Division Bulletin 315, 165 p.

Smith, G. O., 1901, Geology and water resources of a portion of Yakima County, Washington: U.S. Geol. Survey Water-Supply Paper 55, 68 p.

Tanaka, H. H., 1970, Hydrologic situation north of Snipes Mountain near Sunnyside, Washington: U.S. Geol. Survey Open-File Report.

Tanaka, H. H.; Lum, W. E., 1973, Water-level altitudes in deeper basalt aquifers and shallow gravel aquifers in March 1973 in Columbia Basin Irrigation Project area, Washington: U.S. Geol. Survey Open-File Maps, 2 sheets.

Taylor, G. C., Jr., 1944, Factual data pertaining to wells and springs in the Columbia Basin Project area, Washington: U.S. Geol. Survey Open-File report, 85 p.

_____, 1948, Ground water in the Quincy Basin, Wahluke slope, and Pasco slope subareas of the Columbia Basin Project, Washington: U.S. Geol. Survey Open-File Report, 182 p. Plate 1, 1:190,080.

Tennant, H. E., 1937, The Columbia Basin Project: Univ. of Washington M.A. thesis, 78 p.

U.S. Dept. of War, 1934, Columbia River and minor tributaries - letter from the Secretary of War, vol. 2: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, 1845 p.

U.S. Geological Survey, 1975, Water resources of the Toppenish Creek Basin, Yakima Indian Reservation, Washington: U.S. Geol. Survey Report PB-243 749/AS, available from NTIS, 256 p.

Walters, K. L.; Grolier, M. J., 1960, Geology and ground water resources of the Columbia Basin Project area, Washington, Volume 1: Washington Division Water Resources Water-Supply Bulletin 8, 542 p. Plate 3, 1:205,670.

Walters, K. L.; Glancy, P. A., 1969, Reconnaissance of geology and of ground water occurrence and development in Whitman County, Washington: Washington Dept. Water Resources Water-Supply Bulletin 26, 169 p.

Waring, G. A., 1913, Geology and water resources of a portion of south-central Washington: U.S. Geol. Survey Water-Supply Paper 316, 46 p., (abs.): Washington Acad. of Sciences Jour., v. 4, no. 9, p. 226, 1914.

Watson, D. G.; Cushing, C. E.; Coutant, C. C.; and others, 1971, Cycling of radionuclides in Columbia River biota (with discussion): Trace Subst. Environ. Health, Proc., no. 4, p. 144-157, illus. (incl. sketch map).

ADDITIONAL REFERENCES - HYDROLOGIC INVESTIGATIONS

Adams, M. F., 1958, Water resources of the State of Washington: Washington's State Institute of Technology, Bull. 237.

Arnett, R. C.; Deju, R. A.; Nelson, R. W.; Cole, C. R.; Gephart, R. E., 1976, Conceptual and mathematical modeling of the Hanford ground water flow regime: Atlantic Richfield Hanford Co. Rept. ARH-ST-140.

Brown, D. J.; Lobdell, G. T.; Neff, George, 1976, Hydrology and engineering geology of the Columbia Basin: Geol. Soc. Am., Cordilleran Section Mtg., Pullman, Washington, Field Guide No. 3, April 1976.

Brown, R. E., 1962, Geologic features and ground water flow at Hanford: Hanford Atomic Products Operation Report HW-73337, p. 211-212.

Brown, R. E., 1966, The stratigraphy of the uppermost part of the basalt sequence and its implications: Battelle Pacific Northwest Lab. Rept. BNWL-235 3, p. 1-4.

Byers, H. B., 1901, Water resources of Washington: Annual Rept., Washington Geol. Survey 1901, p. 285-295.

Crosby, J. W., III; 1967, Turn dry coulees into recharge reservoirs: Washington State Univ., Quest, v. 5, no. 4.

Crosby, J. W., III; Cavin, R. E., 1960, Geologic investigation of the Moscow ground water basin employing geophysical studies: Washington State Univ. Geo-Hydrologic Research Group, Bull. 250, 23 p.

Crosby, J. W., III; Chatters, R. M., 1965, New technique of water sampling for carbon-14 analysis: Jour. of Geophysics. Res., v. 70, no. 12, p. 2839-2844.

Crosby, J. W., III; Chatters, R. M., 1965, Water dating techniques as applied to the Pullman-Moscow ground water basin: Washington State Univ., Coll. of Engrng. Res. Div., Bull. 296, 21 p.

Deju, R. A.; Summers, W. K., 1976, Transmissivity and hydraulic conductivity of saturated sedimentary rocks on the Hanford Reservation: Geol. Assoc. Can.-Mineral Assoc. Can., Joint Annual Meeting, Program Abs., v. 1, p. 53.

Eddy, P. A., Ground water hydrology of the Umtanum and Moxee Valley's: Washington Dept. of Ecology, unpublished report.

Garrett, A. A., 1968, Ground water withdrawal in the Odessa area, Adams, Grant, and Lincoln Counties: Washington Water Supply Bull. 31, 84 p.

Gladwell, J. S.; Mueller, A. C., 1967, Water resources atlas of the State of Washington: The State of Washington Water Research Center, Pullman, Rept. No. 2.

Griggs, A. B., 1966, Columbia Basin: Mineral and water resources of Washington: 89th Congress, 2nd Session, Committee Print p. 22-27.

Hanson, P. J., 1967, Vertical distribution of radioactivity in the Columbia River estuary: Oregon State Univ., M.S. thesis, 77 p.

Heine, R. E., 1902, Water resources of Washington: Annual Rept., Washington Geol. Survey 1, p. 308-321.

Libby, W. D., 1952, Radiocarbon dating: The Univ. of Chicago Press.

Lu-Lin, C., 1967, Factors affecting ground water recharge in the Moscow Basin, Latah County, Idaho; M.S. thesis, Washington State Univ.,Pullman, 86 p.

Luzier, J. E.; Burt, R. J., 1973, Hydrology of basalt aquifers and depletion of ground water in east-central Washington: Washington State Water-Supply Bull. 33.

Mellott, J. C., 1973, Preliminary ground water flow system analysis in the Columbia River basalts: Washington State Univ., M.S. thesis, 63 p.

Molenaar, D., 1961, Flowing artesion wells in Washington State: Div. of Water Resources, Water-Supply Bull. 16, 115 p.

Myers, D. A., 1972, Test-observation well near Davenport, Washington: Description and preliminary results: U.S. Geol. Survey open-file rept., Tacoma, Washington, 23 p.

Nelson, R. W.; Haney, W. A., 1962, Electrical analog simulation of Hanford ground water flow: Hanford Atomic Products Operation Rept. HW-73711, 16 p.

Raymond, J. R., 1962, A logging system for well-water temperature measurement: Hanford Atomic Products Operation Report HW-73337, p. 220-223.

Ross, S. H., 1965, Contributions to the geohydrology of Moscow Basin, Latah County, Idaho: Idaho Bureau of Mines and Geol.,Open-file Report.

Rudy, C. A., 1902, The water resources of Washington: Annual Report, Washington Geol. Survey 1, p. 296-307.

Russell, I. C., 1901, Geology and water resources of Nez Perce County, Idaho: U.S. Geol. Survey Water-Supply Papers 53-54, pts. I & II, 141 p.

Russell, I. C., 1902, Geology and water resources of the Snake River plains of Idaho: U.S. Geol. Survey Bull. 199, 192 p.

Signs, L. E., 1968, Bib Bend well area, Crab Creek drainage, Adams, Grant, and Lincoln Counties, Washington: The Federal Land Bank of Spokane Engineering File report (unpublished).

Stevens, P. R., 1960, Ground water problems in the vicinity of Moscow, Latah County, Idaho: U.S. Geol. Survey Water-Supply Paper 1460-H.

Tanaka, H. H.; Hansen, A. J., Jr.; Skrivan, J. A., 1974, Digital-model study of ground water hydrology, Columbia Basin Irrigation Project Area, Washington: Washington State Water-Supply Bull. 40.

U.S. Geological Survey, Surface water records of Washington, 1961-65, 1956-67, Part I of water resource data for Washington: U.S. Geol. Survey, Tacoma, Washington.

U.S. Geological Survey, 1955, Monthly and yearly summaries of hydrographic data in the State of Washington to September 1953: U.S. Geol. Survey Water Resources Div., Water-Supply Bull. No. 6, 836 p.

U.S. Geological Survey, 1962, Monthly and yearly summaries of hydrographic data in the State of Washington, October 1953 to September 1960: U.S. Geol. Survey Water Resources Div., Water-Supply Bull. No. 15, 385 p.

U.S. Geological Survey, 1966, Mineral and water resources of Washington: U.S. Geol. Survey, Committee Print, 89th Congress, 2nd session, 1966.

Van Denburgh, A. S.; Santos, J. F., 1965, Ground water in Washington, its chemical and physical quality: State of Washington, Dept. of Conservation, Div. of Water Resources, Olympia, Washington, Water-Supply Bull. No. 24.

Walters, K. L., 1973, Test-observation well near Almira, Washington: Description and preliminary results: U.S. Geol. Survey open-file rept., Tacoma, Washington, 20 p.

Walters, K. L.; Cline, D. R.; Luzier, J. E., 1972, Test-observation well near Odessa, Washington: Description and preliminary results: U.S. Geol. Survey open-file report, Tacoma, Washington, 25 p.

Newcomb, R. C., 1962, White Salmon quadrangle: U.S. Geol. Survey Research Section, Ground Water Branch, publication.

TEST WELLS

Battelle Pacific Northwest Laboratories, 1977, Hanford Reservation well location map: Battelle Pacific Northwest Laboratories (Richland, Washington), 1 sheet, scale 1:200,000.

Bush, J. H., Jr.; Anderson, J. V.; Crosby, J. W., III; Siems B. A., 1972, Test observation well near Mansfield, Washington - Description, stratigraphic relationships and preliminary results: Washington State Univ. Coll. Engr. Research Rept. 72/11-128, 45 p.

Bush, J. H., Jr.; Morton, J. A.; Anderson, J. V.; Crosby, J. W., III; Siems, B. A., 1973, Test-observation well near Walla Walla, Washington - Description, stratigraphic relationships, and preliminary results: Washington State Univ. Coll. of Engr. Report, 73/15-66, 38 p.

Gregg, D. O.; Lum, W. E., II, 1973, Dry Creek Exploration test well: U.S. Geol. Survey Open-File report, 9 p.

Jackson, D. B., 1975, Description of the geoelectric section, Rattlesnake Hills Unit 1 Well, Washington: Jour. Res. U.S. Geol. Surv., v. 3, no. 6, p. 665-669.

Meyers, D. A., 1972, Test-observation well near Davenport, Washington: description and preliminary results: U.S. Geol. Survey Open-File Report, 23 p.

Pearson, H. E., 1973, Test-observation well near Paterson, Washington: description and preliminary results: U.S. Geol. Survey Water Resources Inv. No. 9-73, 23 p., illus. (incl. sketch maps.)

_____, 1977, Test-well drilling in the upper Satus Creek basin, Yakima Indian Reservation, Washington: U.S. Geol. Survey Open-File Report 77-455, 22 p., 3 Figures.

Snavely, P. D.; Wagner, H. C., 1962, Recent petroleum developments in Oregon and Washington (abs.): The Oil and Gas Journal, 1962, p. 109.

Taylor, G. C., Jr., 1944, Factual data pertaining to wells and springs in the Columbia Basin Project area, Washington: U.S. Geol. Survey Open-File Report, 85 p.

Walters, K. L.; Cline, D. R.; Luzier, J. E., 1972, Test observation well near Odessa Washington: description and preliminary results: U.S. Geol. Survey - Washington Dept. Ecology, 25 p., illus. incl. sketch map.

Youngquist, W. L.; Kiilsgaard, T. H., 1951, Recent test drilling, Snake River Plains, southwestern Idaho: Amer. Assoc. Petroleum Geologists Bull., v. 35, p. 90-96.

Anderson, A. L., 1923, Geology and ore deposits of the Silver Hill district, Spokane County, Washington: Univ. of Idaho M.S. thesis, 100 p. Plate 1, 1:12,000.

_____, 1928, Genesis of the Silver Hill tin deposits: Jour. Geology, v. 36, no. 7, p. 646-664.

Armstrong, R. L.; Harakal, J. E.; Hollister, V. F., 1976, Late Cenozoic porphyry copper deposits of the North American Cordillera: Inst. Min. Metall. London, Trans., Sec. B., v. 85, p. B239-B244.

Beck, G. F., 1936, Lime-rock zone of Columbia Basin: The Mineralogist, v. 4, no. 11, p. 12, 14.

Bennett, W. A. G., 1944, Dolomite resources of Washington: Washington Div. Mines and Geology, Rept. of Inv. 13, 35 p., 12 pls., 2 figs.

_____, 1962, Saline lake deposits in Washington: Washington Div. Mines and Geol. Bull. 49, 129 p, 35 figs.

Blackwell, D. D., 1974, Terrestrial heat flow and its implications on the location of geothermal reservoirs in Washington. In Energy resources of Washington: Washington Div. Geol. and Earth Res., Inf. Circ. 50, p. 21-33.

Buchanan, L. C., 1954, Electrical energy resources of Washington: In Energy resources of Washington: Washington Div. Geol. and Earth Res., Inf. Circ. 50, p. 99-158.

Burlington Northern, Inc., 1971, Diatomite deposits in Washington, Oregon, and California: Burlington Northern, Inc., Industrial and Economic Development Department, Raw Materials Research Div. Report 2, 50 p.

Cady, J. W., 1976, Regional gravity and aeromagnetic studies applied to uranium exploration in northeastern Washington and Wyoming: U.S. Geol. Survey Open-File Report no. 76-317, 21 p.

Campbell, C. D., 1962, Introduction to Washington geology and resources: Washington Div. Mines and Geology, Inf. Circ. 22R, 44 p., 5 figs.

Campbell, Ian; Loofbourow, J. S., Jr., 1957, Preliminary geologic map and sections of the magnesite belt, Stevens County, Washington: U.S. Geol. Survey Mineral Inv. Field Studies Map MF-117, 1:36,000.

_____, 1962, Geology of the magnesite belt of Stevens County, Washington: U.S. Geol. Survey Bull. 1142-F, 53 p. Plate 1, 1:36,000.

Campbell, N. P.; Sorem, R. K., 1969, Sketch map showing geology and mineral deposits in Stevens County, Washington: Washington Div. Geol. and Earth Resources Open-File Report 69-1, 1:250,000, 7 transparencies, 4 p. text.

Carithers, Ward, 1946, Pumice and pumicite occurrences of Washington: Washington Div. Mines and Geology Report Inv. 15, 78 p.

Carter, G. L., 1974, Varieties of siderite occurring in vesicular basalt between Moscow, Idaho, and Pullman, Washington: The Mineralogical Record, v. 5, no. 4, p. 157-159.

Chelikowsky, J. R., 1935, Geologic distribution of fire clays in the United States: Jour. Am. Ceramic Soc., v. 18, no. 12, p. 387-388.

Collier, A. J., 1908, Tin ore at Spokane, Washington. In Contributions to Economic Geology, 1907; Part I: U.S. Geol. Survey Bull. 340, p. 295-305.

Culver, H. E.; Lupher, R. L., 1937, The bearing of the post-Paleozoic sedimentary record on the occurrence of gas in the Rattlesnake field, Washington: Northwest Sci., v. 11, p. 71-74.

Daly, M. R., 1930, The search for oil as applied to Washington: Washington Oil World, v. 1, no. 3-7; Northwest Oil and Gas World, v. 4, no. 6-11, 1934.

_____, 1936, A geological report on the Rattlesnake Hills field, Washington: Northwest Oil and Gas World, v. 6, no. 3, 4, 5.

Deacon, R. J.; Benson, G. T., 1971, Oil and gas potential of eastern Oregon and Washington and Snake River basin of western Idaho. In Cram, I. H., ed., Future petroleum provinces of the U.S.—their geology and potential: Amer. Assoc. Petroleum Geologists Memoir 15, p. 354-359, 1964.

Dickie, P. T., 1934, Mechanical purification of the Glauber's salt found in eastern Washington lakes: Univ. of Washington B.S. thesis, 12 p.

Dubail, G. R., 1938, Bird vein on the copper mining company's property, Yakima County: University of Washington B.S. thesis, 43 p. Plate 12, 1:4,800.

Duncan, W. P., 1939, Mineralogy of the Holden ore body: Univ. of Washington B.S. thesis, 48 p.

Flanigan, V. J., 1976, Geophysical survey of uranium mineralization in alaskitic rocks, eastern Washington: U.S. Geological Survey Open-File Report 76-679, 25 p.

Fowler, C. S., 1935, Origin of the sulphur deposits of Mount Adams: Washington State College M.S. thesis, 23 p.

Fox, K. F., Jr.; Rinehart, C. D., 1970, Distribution of copper and other metals in gully sediments of part of Okanogan County, Washington: U.S. Geol. Survey Open-File Report, 60 p.

Fox, K. F., Jr.; Rinehart, C. D., 1972, Distribution of copper and other metals in gully sediments of part of Okanogan County, Washington: Washington Div. Mines and Geology Bull. 65, 38 p.

Glover, S. L., 1936, Preliminary report on petroleum and natural gas in Washington: Washington Div. Mines and Geology Rept. Inv. 4, 24 p., 1 pl.

_____, 1941, Clays and shales of Washington: Washington Div. Mines and Geology Bull. 24, 368 p.

_____, 1942, Mineral resources of the Wenatchee-Ellensburg-Yakima region: Washington Div. Mines and Geology Rept. Inv. 3, 13 p.

_____, 1949, Origin and occurrence of gem stones in Washington: Washington Div. Mines and Geology Report Inv. 16, 32 p.

Gottfried, David, 1958, Uranium in basalts from Washington and Oregon: U.S. Geol. Survey Report TEI-740, p. 283, 285 incl. table.

Griffith, R. F., 1949, Economic geology of Peacock Mountain, Okanogan County, Washington: Univ. of Washington M.S. thesis, 63 p.

Hammer, A. A., 1934, Rattlesnake Hills gas field, Benton County, Washington: Am. Assoc. Petroleum Geologists Bull., v. 18, p. 847-859; (abs.) Revue de Geologie et des Sciences Connexes, v. 14, no. 11, p. 625-626, 1934; (abs.) Annot. Bibliography Econ. Geology, v. 7, no. 2, p. 324, July 1935.

Heath, M. T., 1966, Mineralization of the Silver Star stock, Skamania County, Washington: Univ. of Washington M.S. thesis, 55 p. Plate 2, 1:62,500.

Hirschfeld, D. E., 1971, Mica white clays, their origin, occurrence, and uses: Soc. Mining Engrs. of AIME, Preprint Number 71-H-352, 6 p.

Hodge, E. T., 1938, Market for Columbia River hydroelectric power using northwest minerals; Sec. 2, northwest silica materials, v. 1: U.S. Army Corps Engrs. North Pacific Division, Portland, Oregon, 175 p. Plate 3, 1:3,168,000; Plate 9, 1:126,720.

Hodge, E. T., 1938, Market for Columbia River hydroelectric power using northwest minerals; Sec. 3, northwest limestones, v. 1, pt. 1, limestones of the northwest states: U.S. Army Corp Engrs., North Pacific Division, Portland, Oregon, 312 p. Plate 4, 1:4,800; Plate 13, 1:4,800; Plate 18, 1:3,168,000; Plate 19, 1:126,720.

_____, 1938, Market for Columbia River hydroelectric power using northwest minerals; Sec. 4, v. 3, part 3, Sources of clay for scheduled uses, northwest sources - Washington and Idaho: U.S. Army Corps Engrs., North Pacific Division, Portland, Oregon, p. 492-804. Plate 72, 1:3,168,000; Plate 73, 1:1,013,760; Plate 78, 1:84,480.

Hodges, L. K., 1967, Mining in the Pacific Northwest; a complete review of the mineral resources of Washington and British Columbia: Shorey Book Store, Seattle, 244 p.

Hosterman, J. W., 1960, Geology of the clay deposits in parts of Washington and Idaho. In clays and clay minerals, 7th Conference, Proc.: Pergamon Press, New York City, p. 285-292. Figure 1, 1:2,280,960.

Hosterman, J. W.; Overstreet, W. C.; Warr, J. J., Jr., 1963, Thorium and uranium in monzonite from Spokane County, Washington: U.S. Geol. Survey Prof. Paper 475-D, p. 128-130.

_____, 1969, Clay deposits of Spokane County, Washington: U.S. Geol. Survey Bull. 1270, 96 p.

Hosterman, J. W.; Scheid, V. E.; Allen, V. T.; Sohn, I. G., 1960, Investigations of some clay deposits in Washington and Idaho: U.S. Geol. Survey Bull. 1091, 147 p. Figure 3, 1:380,160; plate 3, 1:12,000.

Hundhausen, R. J., 1949, Investigation of the Young America lead-zinc deposit, Stevens County, Washington: U.S. Bur. Mines Report Inv. 4556, 13 p. Figure 1, 1:950,400.

Huntting, M. T., 1942, Opal in joint cracks in basalt at Pullman, Washington: Mineralogist, v. 10, no. 1, p. 9-10, 25-29, illus.

_____, 1949, Perlite and other volcanic glass occurrences in Washington: Washington Div. Mines and Geology Report Inv. 17, 77 p. Figure 5, 1:63,360.

_____, 1956, Inventory of Washington minerals Part II, metallic minerals: Washington Div. Mines and Geology Bull. 37, 495 p. 27 pls. (2 volumes—text and maps).

_____, 1966, Washington mineral deposits: Washington Div. Mines and Geology Reprint 10, Reprinted from Canadian Institute of Mining and Metallurgy Special v. 8, 5 p., 1 fig.

Ivanoff, B. B., 1949, The Germania Consolidated Mines, Inc., Stevens County, Washington: Univ. Washington B.S. thesis, 31 p. Plate 2, 1:200,000.

Lamey, C. A.; Hotz, P. E., 1952, The Cle Elum River nickeliferous iron deposits, Kittitas County, Washington: U.S. Geol. Survey Bull. 978-B, p. 27-67.

Leighton, M. M., 1919, The road-building sand and gravel of Washington: Washington Geol. Survey Bull. 22, 307 p.

Livingston, V. E., Jr., 1958, Oil and Gas Exploration in Washington, 1900-1957: Washington Div. Mines and Geology Circ. 29, 61 p., 1 pl. (with update to 1976).

_____, 1966, Diatomite. In Mineral and water resources of Washington: U.S. Cong., 89th, 2d sess., Comm. Interior and Insular Affairs, Comm. Print, p. 185-189, illus.

_____, 1969, Geologic history and rocks and minerals of Washington: Washington Div. Mines and Geology Inf. Circ. 45, 42 p.

_____, 1974, Coal in Washington. In Energy Resources of Washington: Washington Div. Geol. and Earth Res., Info. Circ. 50, p. 35-62, sketch maps.

Lovitt, E. H.; Skerl, A. C., 1958, Geology of the Lovitt gold mine, Wenatchee, Washington: Mining Engineering, v. 10, no. 9, p. 963-966. Map, 1:42,660.

Lucas, J. M., 1976, Washington State exploration roundup, 1976: Washington Div. Geology and Earth Resources (paper delivered before the 82nd Annual Northwest Mining Association Convention, Spokane, Washington).

Mackin, J. H., 1947, Diatomite deposits in eastern Washington (abs.): Northwest Sci., v. 21, no. 1, p. 33.

_____, 1947, Diatomite deposits of Washington: Northern Pacific Railway Company Land Department unpublished report, Pl. 7, 1:24,000.

Marjaniemi, D. K.; Robins, J. W., 1975, Uranium favorability of Tertiary sedimentary rocks of the western Okanogan Highlands and of the upper Columbia River valley, Washington: Report GJBX-2(76) prepared for the U.S. Energy Research and Development Administration, Grand Junction Office, under contract No. AT(05-1)-912, by Luciun Pitkin, Inc., Grand Junction Operations, Grand Junction, Colo., 388 p.

Mills, J. W., 1962, High-calcium limestones of eastern Washington: Washington Div. Mines and Geology Bull. 48, 268 p. Plate 1, 1:609,120; plate 2, 1:79,200; plate 3, 1:79,200; plate 4, 1:6,600; plate 5, 1:269,280; plate 6, 1:79,200; plate 7, 1:28,512; figure 9, 1:19,200; figure 12, 1:24,000; figure 35, 1:36,000; figure 40, 1:31,500; figure 47, 1:332,640; figure 48, 1:54,720; figure 49, 1:39,600; figure 51, 1:39,600; figure 53, 1:39,600; figure 55, 1:50,688; figure 56, 1:50,688; figure 63, 1:14,400.

_____, 1971, Bedded barite deposits of Stevens County, Washington: Econ. Geology, v. 66, no. 8, p. 1157-1163.

_____, 1976, Metamorphism of the zinc-lead sulfide ores of the Yellowhead Horizon, Metaline Limestone Formation, northeastern Washington: Econ. Geology, v. 71, no. 8, p. 1601-1609.

Milne, Clint, 1978, Metallic mineral exploration in Washington, 1977: In Washington Geologic Newsletter, v. 6, no. 1, p. 1-7.

Milne, Scott; Cross, Randy, 1974, Sand and gravel deposits of Klickitat County, Washington: Washington Div. Geology and Earth Resources Open-File Map 74-2, 1:125,000.

Mining World, 1956, Directory of major United States mining operations - Washington: v. 18, no. 5, p. 204-206.

Moen, W. S., 1967, Building stone of Washington: Div. Mines and Geology Bull. 55, 85 p., 20 figs.

_____, 1973, Placer gold mining in Washington: Washington Div. Geology and Earth Resources, 12 p.

_____, 1973, Washington metal mines: Wash. Geol. Newsletter, v. 1, no. 1, p. 3-5.

_____, 1976, Silver occurrences of Washington: Washington Geology and Earth Resources Div. Bull. 69, 188 p. (incl. tables, sketch maps).

Moen, W. S.; Zimmerman, T., 1977, Sand and gravel in Washington: Washington Geol. Newsletter, v. 5, no. 2.

Moody, D. W., 1958, An examination of the ore minerals of the Lovitt mine, Wenatchee, Washington: Univ. of Washington B.S. thesis, 22 p. Plate 5, 1:15,360.

Nash, J. T., 1975, Geology and the Midnite uranium mine, Stevens County, Washington—A preliminary report: U.S. Geol. Survey Open-File Report No. 75-402, 36 p.

Nichols, R. L., 1943, Castle Rock high-alumina clay deposit, near Castle Rock, Cowlitz County, Washington: U.S. Geol. Survey, Prelim. Report, Strategic Min. Invest. (unpublished).

Page, L. R., 1942, Tin and tungsten deposits at Silver Hill, Spokane County, Wash.: U.S. Geol. Survey Bull. 931-H, p. 177-203.

Pardee, J. T., 1918, Geology and mineral deposits of the Colville Indian Reservation, Washington: U.S. Geol. Survey Bull. 677, 186 p.

Pardee, J. T.; Bryan, K., 1925, Origin of fossiliferous Latah clays and associated basalts near Spokane (abs.): Pan-American Geologist, v. 43, no. 5, p. 369-370.

Patton, T. C., 1967, Economic geology of the L-D gold mine, Wenatchee, Wash.: Univ. of Washington M.S. Thesis, 29 p.

Patton, T. C.; Cheney, E. S., 1971, L-D gold mine, Wenatchee, Washington; new structural interpretation and its utilization in future exploration: Soc. of Mining Engrs. (AIME) Trans., v. 250, p. 6-11.

Petkof, B., 1976, The mineral industry of Washington: U.S. Bur. Mines, Minerals Yearbook, v. 1973, v. 2, p. 741-748.

Popenoe, H. L., 1961, Developments in west coast area in 1960: Am. Assoc. Petroleum Geologists Bull., v. 45, no. 6, p. 959-973, 4 figs., 6 tables.

Purdy, C. P., 1954, Molybdenum occurrences of Washington: Washington Div. Mines and Geology Report Inv. 18, 118 p., 13 pls., 4 figs.

Randt, C. H., 1939, Shamrock mine in southern Ferry County: Univ. of Washington B.S. thesis, 47 p.

Rau, W. W.; Wagner, H. C., 1974, Oil and gas in Washington. In Energy Resources of Washington: Washington Div. Geol. and Earth Res., Inf. Circ. 50, p. 60-82.

Rigg, G. B., 1958, Peat resources of Washington: Washington Div. Mines and Geology Bull. 44, 272 p.

Russell, R. H., 1972, Geothermal energy potential of Washington State: Washington Dept. Ecol., Tech. Rep., no. 72-7, 23 p.

Scheid, V. E., 1947, Excelsior clay deposit, Spokane County, Washington: U.S. Geol. Survey, Prelim. Report, Strategic Min. Invest. (unpublished).

_____, 1950, Preliminary report on the geological setting of the clay deposits of Latah County, Idaho, and adjacent areas: U.S. Geol. Survey Open-File Report, 15 p. Plate 1, 1:253,440.

Scheid, V. E.; Hostermann, J. W.; Sohn, I. G., 1954, Excelsior high-alumina clay deposit, Spokane County, Washington: U.S. Geol. Survey Open-File Report, 73 p. Figure 1, 1:253,440; plate 1, 1:6,000.

Schmauch, S.; Conyac, M., 1978, Mineral resources of the Snake River drainage, Washington and Oregon: U.S. Bur. Mines Report, map, 1:62,500, (in press).

Schroeder, M. C., 1947, The genesis of the Turk magnesite deposit of Stevens County, Washington: Washington State College M.S. thesis, 19 p.

Schuster, J. E., 1973, 1971-72 Directory of Washington Mining Operations: Washington Div. Mines and Geology Inf. Circ. 48, 97 p., 3 maps.

_____, 1974, Geothermal energy potential of Washington. In Energy resources of Washington: Washington Div. Geol. and Earth Res., Inf. Circ. 50, p. 1-20.

Scott, J. D., 1933, Property of the Camp Creek Metals Mining Company, Skamania County, Washington: Univ. of Washington B.S. thesis, 49 p.

Shedd, Solon, 1926, Abstract of report on geology and resources of the Pasco and Prosser quadrangles: Washington Div. Geology Report Inv. 1, pl. 1, 1:125,000.

Sheldon, R. F., 1959, Midnite Mine—geology and development: Mining Engineering, v. 11, no. 5, p. 531-534. Figure 1, 1:33,600.

Simmons, G. C.; Van Noy, R. M.; Zilka, N. T., 1974, Mineral resources of the Cougar Lakes-Mount Aix study area, Yakima and Lewis Counties, Washington, with a section on interpretation of aeromagnetic data, by W. E. Davis: U.S. Geol. Survey Open-File Report, 80 p. plus 3 map sheets.

Small, W. D., 1971, Isotopic composition of selected ore leads from northeastern Washington and its geophysical interpretation: U.S. Coast Guard Acad., Dept. Physical and Ocean Sciences Report No. RDCGA-10, 30 p.

Smith, G. O., 1903, Gold mining in Washington: In Contributions to economic geology, 1902: U.S. Geol. Survey Bull. 213, p. 76-80.

Snavely, P. D.; Wagner, H. C., 1962, Recent petroleum developments in Oregon and Washington (abs.): Oil and Gas Jour., p. 109.

Snook, J. R., 1962, Petrology of parts of the Tonasket and Omak Lake quadrangle, north central Washington: Univ. of Washington Ph.D. thesis, 158 p. Plate A, 1:62,500.

_____, 1963, Metamorphic and structural history of gneisses at the western border of the Colville batholithic complex (abs.): Geol. Soc. America Spec. Paper 73, p. 248.

_____, 1965, Metamorphic and structural history of "Colville batholith" gneisses, north-central Washington (abs.): Geoscience Abs., v. 7, no. 10, p. 66.

Sohn, I. G., 1952, Geologic environment map of alumina resources of the Columbia Basin: U.S. Geol. Survey Min. Inv. Resource Map MR-1, scale 1:1,500,000.

Sohn, I. G., 1952, Industrial clays, other than potential sources of alumina of the Columbia Basin: U.S. Geol. Survey Circ. 158, 18 p.

Stephens, E. C., 1961, Eastern Washington-Idaho clay basin: Am. Inst. Mining Metall. and Petrol. Engrs. Trans., 1960, v. 217, p. 405-412, illus.

Thomson, J. P., 1932, Genesis of the Swauk placer gold, Swauk mining district, Washington: Washington State College M.S. thesis, 76 p. Plate 2, 1:253,440.

Thurlow, E. E., 1956, Uranium deposits at the contact of metamorphosed sedimentary rocks and granitic intrusive rocks in western United States: U.S. Geol. Survey Prof. Paper 300, p. 85-89. Figure 10, 1:3,000.

Tozer, W. W., 1965, The history of gold mining in the Swauk, Peshastin, and Cle Elum mining districts of the Wenatchee Mountains, 1853-1899: Washington State Univ. M.S. thesis, 118 p.

Tullis, E. L., 1932, The clays of Tertiary age in northern Idaho and eastern Washington (abs.): Pan-American Geologist, v. 58, no. 2, p. 152-153.

U.S. Bureau of Mines, 1969, Pozzolanic raw materials resources in the central and western United States: U.S. Bur. Mines Inf. Circ. 8421, 117 p.

U.S. Geological Survey, 1966, Mineral and water resources of Washington: Washington Div. Mines and Geology Reprint 9; Committee Print of the 89th U.S. Congress, 2nd Sess., 436 p., illus., tables, geol. map.

Valentine, G. M., 1949, Inventory of Washington minerals. Part 1, Nonmetallic minerals: Washington Div. Mines and Geology Bull 37, 113 p. 39 pls.

_____, 1960, Inventory of Washington minerals. Part 1, Second edition. Nonmetallic minerals, (revised by Marshall T. Huntting): Washington Div. Mines and Geology Bull. 37, 258 p., 39 pls. (2 volumes—text and maps).

Vaux, W. W., 1958, Geology and ore deposits of the Calvin H. Barkdull mining claims, Nigger Creek district, Chelan County, Washington: Univ. of Washington B.S. thesis, 38 p.

Walker, C. W., 1978, Industrial minerals in Washington, 1977: Washington Geologic Newsletter, v. 6, no. 1, p. 7-9.

Walker, W. J., 1957, Geology and ore deposits of the Dolphin mining claims, Kittitas County, Washington: Univ. of Washington B.S. thesis, 47 p.

Washington Division of Geology and Earth Resources, 1970, Geologic time, rocks, fossils, and minerals in Washington: Washington Div. Geol. and Earth Res., 8 p.

Washington Division of Geology and Earth Resources; and others, 1974, Energy Resources of Washington: Washington Div. of Geol. and Earth Res. Inf. Circ. 50, 158 p.

Watson, D. W., 1957, Ore localization at the Holden mine, Chelan County, Washington: Washington State College M.S. thesis, 43 p.

Weaver, C. E., 1913, Geology and ore deposits of the Covada mining district: Washington Geol. Survey Bull. 16, 87 p., pl. 1, 1:62,500.

Weaver, C. E., 1920, The mineral resources of Stevens County: Washington Geol. Survey Bull. 20, 350 p., Plate 1, 1:125,000.

Weaver, C. E.; Fettke, C. R., 1911, Geology and ore deposits of the Blewett mining district: Washington Geol. Survey Bull. 6, 104 p., Pl. 1, 1:21,120.

Weaver, C. E., 1945, Geology of Washington and Oregon and its relation to occurrence of oil and gas: Am. Assoc. Petroleum Geologists Bull., v. 29, no. 10, p. 1377-1415, illus. index maps.

Weissenborn, A. E., 1966, Geology—Introduction. In Mineral and water resources of Washington: U.S. Cong., 89th, 2d Sess., Comm. Interior and Insular Affairs, Comm. Print, p. 13-15, illus.

Weissenborn, A. E.; Moen, W. S., 1974, Uranium in Washington. In Energy Resources of Washington: Washington Div. Geol. and Earth Res. Inf. Circ. 50, p. 83-98.

Welch, J. W., 1974, The Mineral industry of Washington: U.S. Bur. Mines Minerals Yearbook, 9 p.

Wisser, E. H., 1958, Cordilleran ore districts in relation to regional structure. In Symposium on Saturation Prospecting, Annual General Meeting, Vancouver, 1958, p. 4-12.

Youngberg, E. A.; Wilson, T. L., 1952, The geology of the Holden mine: Econ. Geology, v. 47, no. 1, p. 1-12, illus. (incl. geol. sketch map); (abs.) Annot. Bibliography Econ. Geology, v. 25, no. 1, p. 60.

Zoldok, S. W., 1948, Cle Elum iron-nickel deposits, Kittitas County, Washington: U.S. Bur. Mines Report Inv. 4189, 8 p., Fig. 2, 1:4,800; (abs.), Annot. Bibliography Econ. Geology, v. 21, no. 1, p. 18, Jan. 1949.

ADDITIONAL REFERENCES - MINERAL RESOURCES

Bancroft, Howland, 1910, Notes on tungsten deposits near Deer Park, Washington, U.S. Geol. Survey Bull. 430, p. 214-216.

Burnet, F. W., 1976, Felsic volcanic rocks and mineral deposits in the Buck Mountain Formation andesites, Okanogan County, Washington: Univ. of Washington M.S. thesis.

Collier, A. J., 1907, Gold-bearing river sands of north-eastern Washington: U.S. Geol. Survey Bull. 315, p. 56-70.

Gaultieri, J. L.; and others, 1973, Mineral resources of the Alpine Lakes study area, Chelan, King, and Kittitas Counties, Washington, with a section on aeromagnetic interpretation by W. E. Davis: U.S. Geol. Survey, open-file report.

Moen, W. S., 1969, Analysis of stream sediment samples in Washington for copper, molybdenum, lead and zinc: Washington Div. Geol. and Earth Resources, Open-File Report OF 69-2, 86 p.

Shannon, E. V., 1922, Criastobalite from the Columbia River Basalt of Spokane, Washington: Washington Academy Sci. Jour. 12, p. 195-196.

Shannon, E. V., 1923, On siderite and associated minerals from the Columbia River Basalt at Spokane, Washington: U.S. Nat. Mus. Proc. (12) 62, p. 1-19.

Shedd, Solon, 1910, The clays of the State of Washington, their geology mineralogy and technology: Washington State Univ. Ph.D. thesis, Pullman, Washington.

Whitman, A. R., 1907, A tin deposit near Spokane: Mine Sci. Press 94, p. 697-698.

Russell, I. C.; Smith, G. O.; Curtis, G. C.; and others, 1914, Coal fields of Kittitas County: Washington Geol. Survey Bull. 9.

Broughton, W. A., 1944, Economic aspects of the Blewett-Cle Elum iron-ore zone, Chelan and Kittitas Counties: Washington Div. Geol., Rept. of Invest. 12.

Lamey, C. A., 1950, The Blewett iron-nickel deposit, Chelan County, Washington: U.S. Geol. Survey Bull. 969-D, p. 87-103.

Lamey, C. A.; Hotz, P. E., 1946, Cle Elum River iron-nickel ore deposits, Kittitas County: U.S. Geol. Survey Open-File Report.

Lupher, R. L., 1914, Stratigraphic aspects of the Blewett- Cle Elum iron-ore zone, Chelan and Kittitas Counties: Washington Div. Geol., Rept. Invest. 2.

GEOLOGY EXCLUSIVE OF THE COLUMBIA BASIN

Abbott, A. T., 1953, Geology of the northwest portion of the Mount Aix quadrangle, Washington: University of Washington Ph.D. thesis, 256 p. Figure 4, 1:125,000.

Alexander, Frank, 1956, Stratigraphy and structural geology of the Blewett-Swauk area, Washington: University of Washington M.S. thesis, 62 p. Plate 3, 1:71,280.

Armentrout, J. M., 1977, Cenozoic stratigraphy of southwestern Washington (Field Trip No. 9). In Geological Excursions in the Pacific Northwest: Geol. Soc. America 1977 Annual Meeting, Seattle, Washington, p. 227-264.

Barksdale, J. D., 1941, Glaciation of the Methow Valley, Washington: Jour. Geology, v. 49, no. 7, p. 721-737, illus. incl. index maps; (abs.): Northwest Sci., v. 15, no. 4, p. 100.

_____, 1946, Stratigraphy in the Methow quadrangle, Washington: Univ. of Washington Dept. of Geology rept., 18 p.

_____, 1947, Geology of the Methow quadrangle, Washington (abs.): Geol. Soc. America Bull., v. 58, no. 12, pt. 2, p. 1247-1248.

_____, 1948, Stratigraphy in the Methow quadrangle, Washington: Northwest Sci., v. 22, no. 4, p. 164-176.

_____, 1958, Twisp-Pasayton River area: Unpublished map, 1:126,720.

_____, 1975, Geology of the Methow Valley, Okanogan County, Washington: Washington Div. Geology and Earth Resources Bull. 68, 72 p.

Bayley, E. P., Jr., 1965, Bedrock geology of the Twin Peaks area, an intrusive complex near Wenatchee, Washington: University of Washington M.S. thesis, 47 p. Plate 1, 1:15,890.

Becraft, G. E., 1950, Definition of the Tieton Andesite on lithology and structure: Washington State College M.S. thesis, 26 p. Plate 1, 1:125,000; Plate 2, 1:125,000.

_____, 1964, Preliminary geologic map of the Wilmont Creek quadrangle, Ferry and Stevens Counties, Washington: U.S. Geol. Survey Min. Inv. Field Studies Map MF-283, 1:48,000. (Also, see Becraft maps: MF-135, 538.)

_____, 1966, Geologic map of the Wilmont Creek quadrangle, Ferry and Stevens Counties, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-538, 1:62,500.

Bressler, C. T., 1951, Petrology of the Roslyn arkose, central Washington: Pennsylvania State College Ph.D. thesis, 147 p. Plate 1, 1:125,000; Plate 5, 1:500,000.

_____, 1957, The petrology of the Roslyn arkose; a study in tectonic control of sedimentation of the Cascade Range, central Washington: International Geological Congress, 20th Mex., Seccion 5, Tomo 2, p. 439-453. Figure 1, 1:823,680.

Buza, J. W., 1977, Dispersal patterns of lower and middle Tertiary sedimentary rocks in portions of the Chiwaukum graben, east-central Cascade Range, Washington: Univ. of Washington M.S. thesis, 40 p.

Campbell, A. B., 1958, Part of the Hunters quadrangle: U.S. Geol. Survey unpublished map, 1:250,000.

_____, 1965, General geology of the Hunters quadrangle and vicinity, northeastern Washington (abs.): Geol. Soc. America Special Paper 82, p. 322.

Campbell, A. B.; Raup, O. B., 1964, Preliminary geologic map of the Hunters quadrangle, Stevens and Ferry Counties, Washington: U.S. Geol. Survey Min. Inv. Field Studies Map MF-276, 1:48,000.

Campbell, C. D., 1953, Geology of the east-central part of Ferry County: Unpublished map, 1:400,000.

Campbell, Ian; Loofbourow, J. S., Jr., 1957, Preliminary geologic map and sections of the magnesite belt, Stevens County, Washington: U.S. Geol. Survey Min. Inv. Field Studies Map MF-117, 1:36,000.

_____, 1962, Geology of the magnesite belt of Stevens County, Washington: U.S. Geol. Survey Bull. 1142-F, 53 p. Plate 1, 1:36,000.

Cashman, S. M., 1974, Geology of the Peshastin Creek area, Washington: University of Washington M.S. thesis, 29 p.

Cashman, S. M.; Whetten, J. T., 1974, Serpentinized conglomerate in the Swauk Formation near Leavenworth, Washington: (abs.): Geol. Soc. America Abs. with Programs, v. 6, no. 3, p. 153.

_____, 1976, Low-temperature serpentinization of peridotite fanglomerate on the west margin of the Chiwaukim Graben, Washington: Geol. Soc. America Bull., v. 87, no. 12, p. 1773-1776, illus. (incl. geol. sketch map).

Cater, F. W.; Crowder, D. F., 1967, Geologic map of the Holden quadrangle, Snohomish and Chelan Counties, Washington: U.S. Geol. Survey Quad. Map CQ 646, scale 1:62,500.

Cater, F. W.; Wright, T. L., 1967, Geologic map of the Lucerne quadrangle, Chelan County, Washington: U.S. Geol. Survey Geol. Quad. Maps GQ-647.

Chappell, W. M., 1937, Glaciation of Columbia Valley in the Wenatchee-Chelan District (abs.): Geol. Soc. America Proc. 1936, p. 344.

Clayton, D. N., 1975, Volcanic history of the Teanaway Basalt, east-central Cascade Mountains, Washington: Univ. of Washington M.S. thesis, 55 p.

Cline, Chuck, 1973, Geology and ground water resources, vicinity of Castle Rock, Cowlitz County, Washington: Washington Dept. of Ecology, no. 73-010, 5 p.

Cole, T. H., 1960, Geology of the Heidegger Hill area, Stevens County, Washington: Unpublished map, 1:24,000.

Crandell, D. R., 1963, Surficial geology and geomorphology of the Lake Tapps quadrangle, Washington: U.S. Geol. Survey Prof. Paper 388-A.

Crandell, D. R.; Mullineaux, D. R., 1973, Pine Creek volcanic assemblage at Mount St. Helens, Washington: U.S. Geol. Survey Bull. 1383-A, 23 p.

Crowder, D. F.; Tabor, R. W., 1965, Routes and rocks, hiker's guide to the North Cascades from Glacier Peak to Lake Chelan: The Mountaineers, Seattle, Washington, 235 p. Mpa, 1:253,440.

Daly, R. A., 1912, Geology of the North American Cordillera at the forty-ninth parallel: Geol. Survey Canada, Mem. 38, 857 p.

Dixon, R. W., 1959, Geology of the Isabella-Sweetgrass area, Okanogan County, Washington: Univ. of Washington M.S. thesis, 64 p.

Dow, Edson, 1963, Passes to the North; history of the Wenatchee Mountains: Wenatchee, Wash., Wenatchee Bindery and Printing Co., 255 p.

DuBois, R. L., 1954, Petrology and genesis of the ores of the Holden mine area, Chelan County, Washington: Univ. of Washington Ph.D. thesis, 222 p.

Eaton, G. C.; Staatz, M. H., 1971 Aeromagnetic interpretation. In Staatz, M. H.; and others, Mineral resources of the Pasayten Wilderness Area, Washington: U.S. Geol. Survey Bull. 1325, p. 80-84.

Eddy, P. A., 1971, Geology and ground water resources, vicinity of Toutle River and SR 504, Cowlitz County, Washington: Washington Dept. of Ecology, no. 71-18, 8 p.

_____, 1971, Geology and ground water resources, Rocky Point Interchange vicinity, Cowlitz County, Washington: Washington Dept. of Ecology, no. 71-25, 11 p.

Ellingson, J. A., 1969, Geology of the Goat Rocks volcano, southern Cascade Mountains, Washington (abs.): Geol. Soc. America Abs. with Programs, Part 3 (Cordilleran Section), p. 15.

_____, 1969, Late Cenozoic volcanic geology of the White Pass-Goat Rocks area, Cascade Mountains, Washington (abs.): Diss. Abs., v. 29, no. 9, p. 3363B.

Fairbanks, H. W., 1902, Lake Chelan, Washington (abs.): Science, new series, v. 15, no. 376, p. 412-413.

Felts, W. M., 1939, A granodiorite stock in the Cascade Mountains of south-western Washington: Ohio Jour. Sci., v. 39, p. 297-316.

_____, 1939, Keechelus andesitic lava-flows of Washington in southward extension: Pan-American Geologist, v. 71, p. 294-296.

Fisher, R. V., 1961, Stratigraphy of the Ashford area, southern Cascades, Washington: Geol. Soc. America Bull., v. 72, no. 9, p. 1395-1408.

Fiske, R. S.; Hopson, C. A.; Waters, A. C., 1963, Geology of Mount Rainier National Park, Washington: U.S. Geol. Survey Prof. Paper 444, 93 p.

Foster, R. J., 1957, Tertiary geology of a portion of the central Cascade Mountains, Washington: University of Washington Ph.D. thesis, 186 p. Figure 23, 1:125,000: Figure 55, 1:125,000; Geol. Soc. America Bull., v. 71, p. 99-126.

_____, 1958, The Teanaway dike swarm of central Washington: Am. Jour. Sci., v. 256, no. 9, p. 644-653. Figure 2, 1:405,504.

_____, 1960, Tertiary geology of a portion of the central Cascade Mountains, Washington: Geol. Soc. America Bull., v. 71, no. 2, p. 99-125.

_____, 1967, Geology of the Rampart Ridge-Keechelus Ridge area, central Cascade Mountains, Washington: Northwest Sci., v. 41, p. 32-41.

Fox, K. F., Jr.; Rinehart, C. D.; Engels, J. C., 1977, Plutonism and orogeny in north-central Washington-timing and regional context: U.S. Geol. Survey Prof. Paper 989, 27 p.

Fribrock, J. R., 1942, Geology of the Wagonroad Coulee and environs: Univ. of Washington B.S. thesis, 14 p.

Frizzell, V. A., Jr.; Tabor, R. W., 1977, Stratigraphy of Tertiary arkoses and their included monolithologic fanglomerates and breccias in the Leavenworth fault zone, central Cascades, Washington: Geol. Soc. America Abs. with Programs, v. 9, no. 4, p. 421.

Fryklund, V. C., Jr.; Weissenborn, A. E.; Weis, P. L., 1960, Parts of the Newport and Deer Park quadrangles: U.S. Geol. Survey unpublished reconnaissance map, 1:125,000.

Fryxell, Roald, 1973, Salvage of geochronological information in the Wells Reservoir area, Washington (1964-1972): A report to the National Park Service in completion of Contract No. 14-10-0434-1505, Washington State Univ., 35 p., physiographic diagram, 1:125,000.

George, W. V.; Woll, A. M., 1975, Implementation of a land-use plan on the Colville Indian Reservation, Washington State: Am. Soc. Photogramm., Fall Conv., Proc., v. 1975, p. 854-855.

Gibbs, George 1854, Report on the geology of the central portion of Washington Territory; In Report of the Secretary of War, communicating the several Pacific Railroad Explorations, in three volumes, 1855: U.S. 33d Cong., 1st sess., House Ex. Doc. 129, v. 18, pt. 1, 1st v., p. 494-512.

Gresens, R. L.; Whetten, J. T.; Tabor, R. W.; Frizzell, V. A., Jr., 1977, Tertiary stratigraphy of the central Cascade Mountains, Washington State (Field Trip No. 3). In Geological Excursions in the Pacific Northwest: Geol. Soc. America 1977 Annual Meeting, Seattle, Washington, p. 84-126.

Hammond, P. E., 1965, A preliminary study of the Goat Mountain cauldron, a volcanic-tectonic subsidence structure of early Tertiary age, east-central Cascade Range, Washington: Geol. Soc. America Spec. Paper 87, p. 207-208.

_____, Hammond, P. E., 1973, Preliminary geologic map of the southern Cascade Range of Washington: Washington Div. Geology and Earth Resources Open-File Map.

_____, 1973, Quaternary basaltic volcanism in the southern Cascade Range, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 49.

_____, 1974, Regional extent of the Stevens Ridge Formation in the southern Cascade Range, Washington: Geol. Soc. America Abs. with Programs, v. 6, p. 188.

_____, 1975, Preliminary geologic map and cross sections with emphasis on Quaternary volcanic rocks, southern Cascade Mountains, Washington: Washington Div. Geology and Earth Resources Open-File Report No. OF 75-13, scale 1:24,000, 1 map transparency.

Hammond, P. E.; Pedersen, S. A.; Hopkins, K. D.; Aiken, Dan; Harle, D. S.; Danes, Z. F.; Konicek, D. L.; Stricklin, C. R., 1976, Geology and gravimetry of the Quaternary basaltic volcanic field, southern Cascade Range, Washington: Proceedings of the 2d U.N. Geothermal Symposium on the Development and Use of Geothermal Resources, v. 1, p. 397-405.

Hammond, P. E., 1977, Reconnaissance geologic map and cross sections of southern Cascade Range, Washington, lat. 45°30' - 47°15' N., long. 120°45' - 122°22.5' W., scale 1:125,000 (abs): Geol. Soc. Am. Abs. with Programs, v. 9, no. 7, p. 1003.

Hammond, P. E.; Bentley, R. D.; Brown, J. C.; Ellingson, J. A.; Swanson, D. A., 1977, Volcanic stratigraphy and structure of the southern Cascade Range, Washington (Field Trip No. 4). In Geological Excursions in the Pacific Northwest: Geol. Soc. America 1977 Annual Meeting, Seattle, Washington, p. 127-171.

Harle, D. S., 1974, Geology of Babyshoe Ride area, southern Cascades, Washington: Oregon State Univ. M.S. thesis, 71 p.

Hawkins, J. W., Jr., 1963, Geology of the crystalline rocks of the northwestern part of the Okanogan Range, north-central Washington: Univ. of Washington Ph.D. thesis, 173 p.

Hibbard, M. J., 1960, Bedrock geology and petrology of Chopaka Mountain, Okanogan County, Washington: Univ. of Washington M.S. thesis, 64 p.

_____, 1962, Geology and petrology of crystalline rocks of the Toats Coulee Creek region, Okanogan County, Washington: Univ. of Washington Ph.D. thesis, 96 p.

Hopson, C. A., 1955, Petrology and structure of the Chelan Batholith near Chelan, Washington: Johns Hopkins University Ph.D. thesis, 176 p. Plate 2. 1:23,760; Plate 3, 1:63,000.

_____, 1959, Area south of Lake Chelan: Unpublished map, 1:250,000.

_____, 1971, Volcanic rocks and processes - Cyclic eruption pattern of Mount St. Helens, Washington: U.S. Geological Survey Professional Paper 750-A, p. 118.

Houghland, Everett, 1931, Conditions of sedimentation of the "Tertiary" deposits near Republic, Washington: Washington State College B.S. thesis, 44 p.

_____, 1932, Structure of the Natapoc Formation north of Leavenworth, Washington: Washington State College Geology Dept. Seminar Report, 25 p. Map, scale 1:125,000.

Jones, R. H. B., 1928, Geologic Map of the Chewelah quadrangle: Washington Div. Mines and Geology unpublished map, 1:96,000.

Landes, H., 1929, The dam site at Little Dalles. In Columbia River and minor tributaries: Cong. Doc. 73d Cong., 1st sess., House Doc. 103, U.S. Dept. of War, v. 2, 1934, p. 1204-1205.

_____, 1930, Geology of the Columbia River. In Columbia River and minor tributaries: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, U.S. Dept. of War, vol. 2, 1934, p. 1197-1198.

_____, 1930, The Chiwawa dam site. In Columbia River and minor tributaries: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, U.S. Dept. of War, v. 2, 1934, p. 1207-1208.

_____, 1930, The dam site near Camden. In Columbia River and minor tributaries: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, U.S. Dept. of War, v. 2, 1934, p. 1209-1210.

_____, 1930, The dam site near Plain on the Wenatchee River. In Columbia River and minor tributaries: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, U.S. Dept. of War, v. 2, 1934, p. 1205-1206.

Laravie, J. A., 1976, Geologic field studies along the eastern border of the Chiwaukum graben, central Washington: Univ. of Washington M.S. thesis, 56 p.

Lawrence, D. B., 1954, Diagrammatic history of the northeast slope of Mt. St. Helens, Washington: Mazama, v. 36, no. 13, p. 41-44.

Lawrence, R. D., 1968, The Eightmile Creek fault, northeastern Cascade Range, Washington: Stanford Univ. Ph.D. thesis, 66 p.

LeConte, J. L., 1873 and 1874, On the great lava flood of the Northwest; and on the structure and age of the Cascade Mountains: Calif. Acad. Sci., v. 3, no. 7, p. 167-180, 259-267.

Lemke, R. W.; Mudge, M. R.; Wilcox, R. E.; Powers, H. A., 1975, Geologic setting of the Glacier Peak and Mazama ash-bed markers in west-central Montana: U.S. Geol. Survey Bull. 1395-H, 31 p., 1975.

Livingston, E., 1977, Torrential deposits in southern B. C. and northern Washington (abs.): Geol. Assoc. Canada; Mineralogical Assoc. Canada; Soc. Econ. Geologists; Canadian Geophys. Union 1977 Annual Meeting, Abs. with Programs, v. 2, p. 33.

Lowther, J. S., 1970, Silica sandstone in the Swauk Formation near Wenatchee, Washington (abs.): Northwest Sci., v. 44, no. 1, p. 65.

Lupe, R. D., 1971, Stratigraphy and petrology of the Swauk Formation in the Wenatchee Lake area, Washington: Univ. of Washington M.S. thesis, 27 p.

Lyons, D. J., 1967, Structural geology of the Boulder Creek metamorphic terrane, Ferry County, Washington: Washington State Univ. Ph.D. thesis, 115 p.

McKee, Bates, 1968, The Olympic-Wallowa lineament in western and central Washington (abs.): Geol. Soc. America Spec. Paper 115, p. 340.

McKee, Bates; Whetten, J. T., 1972, The Chiwaukum graben (abs.): Univ. of Washington Dept. of Geological Sciences Abs. of Research, p. 19.

McLeod, A. A., 1923, Geology of the Silver Hill district, Spokane County, Washington: Idaho Unviersity B.S. thesis, 33 p. Map, 1:12,000.

Menzer, F. J., Jr., 1969, Crustal evolution of the central Okanogan Range, Washington (abs.): Geol. Soc. America and Associated Societies, Program with Abs. (Part 7) of the 1969 Annual Meetings, Atlantic City, N. J. p. 148.

_____, 1970, Geochronologic study of granitic rocks from the Okanogan Range, north-central Washington: Geol. Soc. America Bull. v. 81, no. 2, p. 573-578.

Miller, F. K., 1969, Preliminary geologic map of the Loon Lake quadrangle, Stevens and Spokane Counties, Washington: Washington Div. Mines and Geology Geologic Map GM-6, 1 sheet accompanied by 7 pages of text, scale 1:62,500.

_____, 1971, The Newport Fault and associated mylonites, northeastern Washington: U.S. Geol. Survey Prof. Paper 750-D, p. 77-79.

_____, 1974, Preliminary geologic map of the Newport Number 1 quadrangle, Pend Oreille County, Washington, and Bonner County, Idaho: Washington Div. Geology & Earth Resources Geologic Map GM-7, map accompanied by 6 pages of text, 1:62,500.

_____, 1974, Preliminary geologic map of the Newport Number 2 quadrangle, Pend Oreille and Stevens Counties, Washington: Washington Div. Geology and Earth Resources Geologic Map GM-8, map accompanied by 6 pages of text, 1:62,500.

_____, 1974, Preliminary geologic map of the Newport Number 3 quadrangle, Pend Oreille, Stevens and Spokane Counties, Washington: Washington Div. Geology and Earth Resources Geologic Map GM-9, map accompanied by 7 pages of text, 1:62,500.

_____, 1974, Preliminary geologic map of the Newport Number 4 quadrangle, Spokane and Pend Oreille Counties, Washington and Bonner County, Idaho: Washington Div. Geology and Earth Resources Geologic Map GM-10, map accompanied by 6 pages of text, 1:62,500.

Miller, F. K.; Clark, L. D., 1975, Geology of the Chewelah-Loon Lake area, Stevens and Spokane Counties, Washington; with a section on potassium-argon ages of the plutonic rocks, by Joan C. Engels: U.S. Geol. Survey Prof. Paper 806, 74 p.

Miller, F. K.; Yates, R. G., 1976, Geologic map of the west half of the Sandpoint 1^{o} by 2^{o} quadrangle, Washington: U.S. Geol. Survey Open-File Report 76-327, 2 Plates, 1:125,000.

Mills, J. W., 1955, Geologic map of the area between Valley and Chewelah, Stevens County, Washington: Washington State College unpublished field map, 1:24,000.

_____, 1973, Deformed early folds, Stevens County, Washington (abs.): Northwest Scientific Assoc. Abs. of Papers presented at the 46th annual meeting, p. 27.

Misch, Peter, 1966, Tectonic evolution of the northern Cascades of Washington State - A west-Cordilleran case history. In A symposium on the tectonic history and mineral deposits of the western Cordillera in British Columbia and neighboring part of the United States, Vancouver, B.C., October 25-28, 1964: Canadian Institute of Mining and Metallurgy Special Volume 8, p. 101-148.

_____, 1978, Dextral displacements at some major strike faults in the North Cascades (abs.): Ann. Mtg. Geol. Soc. Canada, (in press).

Morisson, M. E., 1954, Petrology of the Phelps Ridge-Red Mountain area, Chelan County, Washington: Univ. of Washington M.S. thesis, 95 p.

Morrison, R. F., 1964, Upper Jurassic mudstone unit named in Snake River Canyon, Oregon-Idaho boundary: Northwest Sci., v. 38, no. 3, p. 83-87.

Mullineaux, D. R., 1974, Pumice and other pyroclastic deposits in Mount Rainier National Park, Washington: U.S. Geol. Survey Bull. 1326, 83 p.

Mullineaux, D. R.; Hyde, J. H.; Rubin, Meyer, 1975, Widespread late glacial and postglacial tephra deposits from Mount St. Helens volcano, Washington: Jour. Research U.S. Geol. Survey, v. 3, no. 3, p. 329-335.

Mundorff, M. J., 1960, Geology and ground water resources of Clark County, Washington: Washington Div. Water Resources Water-Supply Bull. 9, 660 p. Plate 1, 1:50,000.

_____, 1964, Geology and ground water resources of Clark County, Washington, with a description of a major alluvial aquifer along the Columbia River: U.S. Geol. Survey Water-Supply Paper 1600, 268 p. Plate 2, 1:48,000.

Newcomb, R. C., 1937, Geology of a portion of the Okanogan Highlands, Washington: Univ. of Cincinnati M.S. thesis, 62 p.

Newman, K. R., 1971, Age ranges of strata mapped as Swauk Formation, central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 6, p. 397-398.

Othberg, Kurt, 1975, Geomorphology of the Colockum Pass area, Kittitas County, Washington: Washington Div. Geology and Earth Resources Open-File Report No. OF 75-8, 3 p.

Page, B. M., 1939, Geology of part of the Chiwaukum quadrangle, Washington: Stanford Univ. Ph.D. thesis, 203 p.

Pardee, J. T., 1918, Geology and mineral deposits of the Colville Indian Reservation, Washington: U.S. Geol. Survey Bull. 677, 186 p.

Pearson, R. C.; Obradovich, J. D., 1977, Eocene rocks in northeast Washington; radiometric ages and correlation: U.S. Geol. Survey Bull. no. 1433, 41 p., illus.

Pedersen, S. A., 1973, Intraglacial volcanoes of the Crazy Hills area, northern Skamania County, Washington: Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 89.

Pelton, H. A., 1957, Geology of the Loomis-Blue Lake area, Okanogan County, Washington: Univ. of Washington M.S. thesis, 92 p.

Phetteplace, T. M., 1954, Geology of the Chesaw area, Okanogan County, Washington: Univ. of Washington M.S. thesis, 82 p.

Pitard, A. M., 1958, Geology of the Mazama area, Methow Valley, Washington: Univ. of Washington M.S. thesis 61 p.

Plummer, C. C., 1969, Geology of the crystalline rocks, Chiwaukum Mountains and vicinity, Washington Cascades: Univ. of Washington Ph.D. thesis, 137 p.

Porter, S. C., 1976a, Pleistocene glaciation in the southern part of the north Cascade Range, Washington: Geol. Soc. America Bull., v. 87, no. 1, p. 61-75.

Pratt, R. M., 1958, Geology of the Mount Stuart area, Washington: Univ. of Washington Ph.D. thesis, 228 p. Plate 7, 1:62,500.

Raisz, Erwin, 1945, The Olympic-Wallowa lineament: Am. Jour. Sci., v. 243A, p. 479-485.

Rector, R. J., 1962, Geology of the east half of the Swauk Creek mining district: Univ. of Washington M.S. thesis, 73 p. Plate 2, 1:24,000.

Rice, G. R., 1952, Kelly Camp prospect, Ferry County, Washington: Univ. of Washington B.S. thesis, 48 p.

Rinehart, C. D.; Fix, K. F., Jr., 1972, Geology and mineral deposits of the Loomis quadrangle, Okanogan County, Washington: Washington Div. Mines and Geology Bull. 64, 124 p.

Robinson, P. T., 1973, John Day Formation. In Geologic Field Trips in northern Oregon and southern Washington; Trip 1, Cretaceous and Cenozoic, north-central Oregon: Oregon, Dep. Geol. Min. Ind., Bull., no. 77, p. 19-22.

Rosenberg, E. A., 1961, Geology and petrology of the northern Wenatchee Ridge area, northern Cascades, Washington: Univ. of Washington M.S. thesis, 99 p. 9 plates.

Rosenmaier, F. J., 1968, Stratigraphy and structure of the Table Mountain-Mission Peak area in the Wenatchee Mountains, central Washington: University of Washington M.S. thesis, 44 p. Plate 1, 1:24,000.

Runner, J. J., 1921, Origin and history of Lake Chelan (abs.): Geol. Soc. America Bull., v. 32, p. 87-88.

Russell, I. C., 1897, Geology of northeastern Washington (abs.): Science, new series, v. 5, no. 107, p. 94.

_____, 1898, The great terraces of the Columbia and other topographic features in the neighborhood of Lake Chelan, Washington: Am. Geologist, v. 22, p. 362-369.

_____, 1900, A preliminary paper on the Geology of the Cascade Mountains in northern Washington: U.S. Geol. Survey 20th Ann. Rept., pt. 2, p. 83-210, pl. 9, 1:1,500,000.

Russell, R. H., 1948, Preliminary geologic report of limestone belt, Okanogan County, Washington: Univ. of Washington Geology Dept. Seminar Report, 24 p.

_____, 1971, Generalized geology and hydrology of Stevens County, Washington: Washington Dept. Ecology, Office of Technical Services, 16 p.

Ryason, D. J., 1959, Stratigraphy and structure of the Pipestone Canyon area in north-central Washington: Univ. of Washington M.S. thesis, 45 p.

Saunders, E. J., 1915, Relation between the Tertiary sedimentaries and lavas in Kittitas County, Washington (abs.): Geol. Soc. America Bull., v. 26, p. 137.

Schroeder, M. C., 1952, Geology of the Bead Lake district, Pend Oreille County, Washington: Washington Div. Mines and Geol. Bull. no. 40, 57 p., illus. (incl. colored geol. map 1:63,360); (abs.) Annot. Bibliography Econ. Geology, v. 25, no. 2, p. 25, 1954.

Search, M. A., 1931, Winthrop sandstone, Methow Valley, Washington: Washington State College M.S. thesis, 35 p.

Seifert, K. E., 1974, Contact metamorphism of the Keechelus andesitic series (abs.): Eos (Am. Geophys. Union, Trans.), v. 55, no. 2, p. 74.

Shedd, Solon, 1923, Topography and geology of the Okanogan Highlands and Columbia Plateau of Washington (abs.): Geol. Soc. America Bull., v. 34, p. 75.

Sheppard, R. A., 1964, Geologic map of the Husum quadrangle, Washington: U.S. Geol. Survey Min. Inv. Field Studies Map MF-280, 1:62,500.

_____, 1967, Geology of the Simcoe Mountains volcanic area, Washington: Washington Div. Mines and Geology Geologic Map GM-3, scale 1:125,000.

Simon, R. B., 1972, Geology of the Camp Creek area, northern Skamania County, Washington: Univ. of Washington M.S. thesis, 33 p.

Skehan, J. W., 1965, The Olympic-Wallowa lineament: A major deep-seated tectonic feature of the Pacific Northwest (abs.): Am. Geophys. Union, Trans., v. 46, no. 1, p. 71.

Smith, G. O., 1904, Mount Stuart folio: U.S. Geol. Survey Geol. Atlas, Folio 106, Map 1:125,000.

Smith, G. O.; Calkins, F. C., 1906, Description of the Snoqualmie quadrangle (Washington): U.S. Geol. Survey Geol. Atlas, Folio 139.

Staatz, M. H., 1959, Bald Knob quadrangle: U.S. Geol. Survey unpublished map, 1:250,000.

_____, 1964, Geology of the Bald Knob quadrangle, Ferry and Okanogan Counties, Washington: U.S. Geol. Survey Bull. 1161-F, 79 p.

Stout, M. L., 1957, Geology of the southwestern portion of the Mount Stuart quadrangle, Washington: Univ. of Washington M.S. thesis, 115 p. Plate 1, 1:63,360.

_____, 1959, Geology of a part of the south-central Cascade Mountains of Washington: Univ. of Washington Ph.D. thesis, 183 p. Plate 2, 1:63,360; Geol. Soc. America Bull., v. 75, no. 4, p. 317-334, 1964. Plate 1, 1:62,500.

Suppe, John; Powell, Christine; Berry, Robert, 1975, Regional topography, seismicity, Quaternary volcanism, and the present-day tectonics of the western United States: Am. Jour. v. 275-A, p. 397-436.

Swanson, D. A., 1966, Tieton volcano, a Miocene eruptive center in the southern Cascade Mountains, Washington: Geol. Soc. America Bull., v. 77, no. 11, p. 1293-1314, plate 1, scale 1:55,440.

Symons, T. W., 1882, The upper Columbia River and the Great Plain of the Columbia: U.S. 47th Cong., 1st sess., Senate Ex. Doc. 186, 133 p., maps.

U.S. Dept. of War, 1934, Columbia River and minor tributaries - letter from the Secretary of War, v. 2: Cong. Doc., 73d Cong., 1st sess., House Doc. 103, 1845 p.

U.S. Geological Survey, 1976, Aeromagnetic map of the Horseshoe Basin quadrangle, Okanogan County, Washington: U.S. Geological Survey Open-File Report no. 76-359, map and explanation on 1 sheet, 1:62,500.

University of Washington Geology Dept., 1963, A Geologic Trip Along Snoqualmie, Swauk, and Stevens Pass Highways (revised by V. E. Livingston, Jr.): Washington Div. of Mines and Geology Inf. Circ. 38, 51 p.

U.S. Geological Survey, 1977, Aeromagnetic map of part of northern Washington: U.S. Geol. Survey Open-File Report 77-254, 2 plates, scale 1:62,500.

Vance, J. A.; Naeser, C. W., 1977, Fission track geochronology of the Tertiary volcanic rocks of the central Cascade Mountains, Washington: Geol. Soc. America Abs. with Programs, v. 9, no. 4, p. 520.

Van Diver, B. B., 1964, Petrology of the metamorphic rocks, Wenatchee Ridge area, central northern Cascades, Washington: Univ. of Washington, Ph.D. thesis, 140 p.

Verhoogen, J., 1937, Mount St. Helens, a Recent Cascade volcano: California Univ. Pubs., Dept. Geol. Sci., Bull., v. 24, p. 263-302.

Waitt, R. B., 1972, Geomorphology and glacial geology of the Methow drainage basin, eastern North Cascade Range, Washington: Univ. of Washington Ph.D. thesis, 154 p.

_____, R. B., 1973, Deglaciation of the Methow drainage basin, North Cascade Range, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 7, p. 853.

_____, 1977, Guidebook to Quaternary geology of the Columbia, Wenatchee, Peshastin, and upper Yakima Valleys, west-central Washington: U.S. Geol. Survey Open-File Report 77-753, prepared for GSA 1977 Annual Mtg. (Seattle), Field Trip No. 13, Nov. 77, 25 p.

Walker, G. W., 1973, Reconnaissance geologic map of the Pendleton quadrangle, Oregon and Washington: U.S. Geol. Survey Misc. Inv. Ser., Map I-727, geol. map 1:250,000.

Warren, C. R., 1941, The Hood River conglomerate in Washington: Am. Jour. Sci., v. 239, p. 106-127.

Warren, W. C., 1933, Age of certain andesites in the Mount Aix quadrangle, Washington: Washington State College M.S. thesis, 24 p. Plate 2, 1:125,000.

_____, 1936, Geology of Cascade Mountains of Washington (abs.): Pan-American Geologist, v. 65, no. 1, p. 77.

Washington Div. of Mines and Geology staff, 1958, Reconnaissance map of the Mt. Adams area: Unpublished map, 1:125,000.

Waters, A. C., 1927, Concerning the differentiation of a lamprophyre magma at Corbaley Canyon, Washington: Jour. Geol. v. 35, p. 158-170, 3 fig.; (abs.) Revue de Geologie et des Sciences Connexes, v. 8, no. 8-9, p. 418, 1927.

_____, 1931, Pre-Ordovicic gneiss of Wenatchee-Chelan district, Washington (abs.): Pan-American Geologist, v. 55, no. 5, p. 370.

_____, 1932, Structural and metamorphic history of a pre-Ordovician gneiss in the Wenatchee-Chelan district, Washington (abs.): Geol. Soc. America Bull., v. 43, no. 1, p. 234.

_____, 1932, A petrologic and structural study of the Swakane Gneiss, Entiat Mountains, Washington: Jour. Geology, v. 40, p. 604-634, 9 figs.; (abs.) Revue de Geologie et des Sciences Connexes, v. 13, no. 10, p. 579, 1933.

_____, 1933, Terraces and coulees along the Columbia River near Lake Chelan: Geol. Soc. America Bull., v. 44, p. 783-820.

_____, 1940, Geology of the Okanogan Valley, Washington (abs.): Geol. Soc. America Bull., v. 51, no. 12, part 2, p. 2035.

_____, 1961, Keechelus problem, Cascade Mountains, Washington: Northwest Sci., v. 35, no. 2, p. 39-57.

_____, 1969, Geology of the southern half of the Chelan quadrangle, Washington (abs.): Diss Abs. Int., v. 30, no. 5, p. 2259B-2260B.

Weis, P. L.; Richmond, G. M., 1965, Maximum extent of late Pleistocene Cordilleran glaciation in northeastern Washington and northern Idaho: U.S. Geol. Survey Prof. Paper 525-C, p. 128-132.

Weissenborn, A. E., 1960, Geology of the Mount Spokane quadrangle: U.S. Geol. Survey unpublished reconnaissance map, 1:380,160.

Weissenborn, A. E.; Weis, P. L.; Fryklund, Jr., V. C., 1960, Reconnaissance geology of eastern Washington: Washington Div. Geology and Earth Resources library, 3 sheets (Spokane, Newport and Chewelah quadrangles), scale 1:125,000.

Weissenborn, A. E., 1969, Geologic map of Washington, lat. 46° to 49°, long, 118° to 124°: U.S. Geol. Survey Misc. Inv. Map I-583, scale 1:2,000,000.

_____, 1974, Geologic map of the Mount Spokane quadrangle, Washington and Idaho: U.S. Geol. Survey Open-File Report 74-211, map and text on one sheet, 1:31,680.

Weissenborn, A. E.; Weis, P. L., 1976, Geologic map of the Mount Spokane quadrangle, Spokane County, Washington, and Kootenai and Bonner Counties, Idaho: U.S. Geol. Survey Quad. Map GQ-1336, map and text on one sheet, scale 1:62,500.

Whetten, J. T., 1967, Lake Chelan, Washington: Bottom and sub-bottom topography: Limnology and Oceanography, v. 12, p. 253-259.

_____, 1976, Tertiary sedimentary rocks in the central part of the Chiwaukum Graben, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 420.

_____, 1976, Sedimentology and structure of part of the Chiwaukum graben, Washington: Geol. Soc. America Abs. with Programs, v. 9, p. 527.

Whetten, J. T.; Laravie, J. A., 1976, Preliminary geologic map of the Chiwaukum 4 northeast quadrangle, Chiwaukum graben, Washington: U.S. Geol. Survey Misc. Field Studies, Map MF-794, scale 1:24,000.

Willis, Bailey, 1903, Physiography and deformation of the Wenatchee-Chelan district, Cascade Range: U.S. Geol. Survey Prof. Paper 19, p. 41-101.

Willis, C. L., 1950, Geology of the northeastern quarter of the Chiwaukum quadrangle, Washington: Univ. of Washington Ph.D. thesis, 158 p.

_____, 1953, The Chiwaukum Graben, a major structure of central Washington: Am. Jour. Sci., v. 251, no. 11, p. 789-797, illus.

Wise, W. S., 1961, The geology and mineralogy of the Wind River area, Washington, and the stability relations of celadonite: Johns Hopkins Univ. Ph.D. thesis, Baltimore, Md., 258 p.

_____, 1970, Cenozoic volcanism in the Cascade Mountians of southern Washington: Washington Div. Mines and Geology Bull. 50, 45 p., illus., tables, geol. map.

Yeats, R. S.; Erikson, E. H.; Frost, B. R.; Hammond, P. E.; Miller, R. B., 1977, Structure, stratigraphy, plutonism, and volcanism of the central Cascades, Washington (Field trip no. 10). In Geological Excursions in the Pacific Northwest: Geological Society of America 1977 Annual Meeting, Seattle, Washington, p. 265-308.

Young, R. E., 1963, Geology of the Swauk Formation in the Leavenworth, Washington, area: Univ. of Washington B.S. thesis, 49 p.

ADDITIONAL REFERENCES - GEOLOGY EXCLUSIVE OF THE COLUMBIA BASIN

Campbell, N. E.; Sorem, R. K., 1969, Sketch map showing geology and mineral deposits in Stevens County, Washington: Washington Div. Geol. & Earth Resources, Open-File Report OF 69-1, 1:250,000.

Gualtieri, J. L.; and others, 1973, Mineral resources of the Alpine Lakes study area, Chelan, King, and Kittitas Counties, Washington, with a section on aeromagnetic interpretation by W. E. Davis: U.S. Geol. Survey Open-File Report.

Simmons, G. C., 1950, Geologic map of the southern half of the Mt. Aix 30' quadrangle: Washington Div. Geol. & Earth Resources unpub. map, 1:125,000.

McKague, H. L., 1960, Petrology of the Hatchery Creek serpentinite, Chelan County, Washington: Washington State Univ. M.S. thesis, 42 p.

Pratt, R. M., 1954, Geology of the Deception Pass area, Chelan, King, and Kittitas Counties, Washington: Univ. of Washington M.S. thesis, 58 p.

GENERAL BASALT REFERENCES

Aswathanaraiana, U., ed., 1972, International symposium on Deccan Trap and other flood eruptions, Proceedings, Part I, Sagar, M. P., India, 1969: Bull. Volcanologique, v. 35, no. 3, 296 p.

Bowen, N. L., 1928, Evolution of the igneous rocks: New York, Dover, 332 p.

Chayes, F., 1969, The chemical composition of Cenozoic andesite, In Proceedings of the Andesite Conference, A. R. McBirney, ed., Oregon State Dept. Geology and Mineral Industries Bull. 65, p. 1-11.

Danes, Z. F., 1972, Dynamics of lava flows: Jour. Geophys. Research, v. 77, no. 8, p. 1430-1432.

Doell, R. R.; Cox, Allen, 1967, Measurement of natural remnant magnetization at the outcrop. In Methods in palaeomagnetism: Amsterdam, Elsevier Publishing Co.

Fisher, R. V., 1958, Definition of volcanic breccia: Geol. Soc. America Bull., v. 69, p. 1071-1073.

_____, 1960, Classification of volcanic breccias: Geol. Soc. America Bull., v. 71, p. 973-982.

Fisher, R. V.; Waters, A. C., 1969, Bed forms in base surge deposits: Lunar implications: Science, v. 165, p. 1349-1352.

_____, 1970, Base Surge bed forms in Maar volcanoes: Am. Jour. Sci., v. 268, p. 157-180.

Fisk, H. N., 1935, Microscopic study of basalt flows: Univ. of Cincinnati Ph.D. thesis, 129 p.

Friedman, Irving; Smith, R. L.; Long, W. D., 1966, Hydration of natural glass and formation of perlite: Geol. Soc. America Bull. 77, p. 323-328.

Fuller, R. E., 1927, The closing phase of a fissure eruption: Am. Jour. Sci., 5th ser., v. 14, p. 228-230.

_____, 1932, Concerning basaltic glass: Am. Mineralogist, v. 17, no. 3, p. 104-107.

_____, 1939, Graviational accumulation of olivine during the advance of basaltic flows: Jour. Geology, v. 47, no. 3, p. 303-313.

_____, 1949, Basaltic fan jointing induced by aqueous chilling (abs): Am. Mineralogist, v. 34, nos. 3-4, p. 276.

Green, D. H. Ringwood, A. W., 1964, Fractionation of basalt magmas at high pressures: Nature, v. 201, p. 1276-1279.

Green, D. H., 1967, The genesis of basaltic magmas: Contributions Mineral Petrology, v. 15, p. 103-190.

_____, 1968, Origin of basaltic magmas. In Hess, H. H. and Poldervaart, Arie, eds., Basalts: The Poldervaart Treatise on Rocks of Basaltic Composition: John Wiley and Sons, Inc., New York, v. 2, p. 835-862.

Green, J.; Short, N. M., (eds.); 1971, Volcanic landforms and surface features, a photographic atlas and glossary: Springer-Verlag Publ., New York, Library of Congress Card No. 70-144791, 519 p., illus.

Hess, H. H.; Poldervaart, Arie, eds., 1968, Basalts: The Poldervart treatise on rocks of basaltic composition, v. 2: Interscience Publishers, New York and London, p. 483-862.

James, A. V. G., 1920, Factors producing columnar structure in lavas and its occurrence near Melbourne, Australia: Jour. Geology, v. 28, p. 458-469.

Jones, A. E., 1943, Classification of lava surfaces: Am. Geophys. Union, Trans., 24th Ann. Meeting. pt. 1, p. 265-268.

Kennedy, W. Q., 1933, Trends of differentiation in basaltic magmas: Am. Jour. Sci., 5th Ser., v. 25, p. 239-256.

Knox, J. B.; Short, N. M., 1964, A diagnostic model using ashfall data to determine eruption characteristics and atmospheric conditions during a major volcanic event: Bull. Volcanologique, v. 26, p. 455-469.

Kuno, Hisashi, 1960, High-alumina basalt: Jour. Petrology, v. 1, pt. 2, p. 121-145.

_____, 1965, Fractionation trends of basalt magmas in lava flows: Jour. Petrology, v. 6, pt. 2, p. 302-321.

_____, 1966, Lateral variation of basalt magma across continental margins and island arcs: Geol. Survey of Canada Paper 66-15, p. 317-336.

_____, 1969, Andesite in time and space, In Proceedings of the Andesite Conference, A. R. McBirney, ed., Oregon state Dept. Geology and Mineral Industries Bull. 65, p. 13-20.

_____, 1969, Plateau basalts: Am. Geophy. Union, Am. Geophys. Mon. Ser. 13, p. 495-501.

Lewis, J. V., 1914, Origin of pillow lavas: Bull. Geol. Soc. Am., 25,646.

MacDonald, G. A., 1953, Pahoehoe, aa, and block lava: Am. Jour. Sci., v. 251, no. 3, p. 169-191.

_____, 1967, Forms and structures of extrusive basaltic rocks. In Hess, H. H.; Poldervaart, Arie, eds., Basalts: The Poldervaart Treatise on Rocks of Basaltic Composition: Interscience Publishers, New York, v. 1, p. 1-61.

Moore, J. G., 1967, Base surge in recent volcanic eruptions: Bull. Vocanologique, v. 30, p. 337-363.

Murty, C. R. K.; Sahasrabude, P. W., 1972, Paleomagnetism and basalts. In International Symposium on Deccan Trap and other flood eruptions, Proceedings, Part I: Bull. Volcanologique, v. 35, no. 3, p. 736-742.

Nichols, R. L., 1936, Flow-units in basalt: Jour. Geology, v. 44, p. 617-630.

Osborn, E. F., 1959, Role of oxygen pressure in the crystallization and differentiation of basaltic magma: Am. Jour. Sci., v. 257, p. 609-647.

Peck, D. L.; Wright, T. L.; Moore, James G., 1966, Crystallization of tholeiitic basalt in Alae lava lake, Hawaii; Bull. Volcanologique, v. 4, no. 29, p. 629-656.

Poldervaart, Arie; Hell, H. H., 1951, Pyroxenes in the crystallization of basaltic magma: Jour. Geology, v. 59, p. 472-489.

Ross, C. S.; Smith, R. L., 1955, Water and other volatiles in volcanic glasses: Am. Mineralogist, v. 40, p. 1071-1089.

_____, 1960, Ash flow tuffs: their origin, goelogic relations, and identification: U.S. Geol. Surv. Prof. Paper 366, 81 p.

Rutten, M. G., 1964, Formation of a plateau basalt series (From the example of Iceland): Bull. Volcanologique, v. 27, p. 93-112.

Ryan, M. P., 1974, Fracture mechanics and columnar basalts. In Boight, Barry; and others, eds., Rock mechanics, the American Northwest: Pennsylvania State Univ. Press, University Park, Pennsylvania, p. 247-251.

Smith, R. L., 1960, Ash flows: Geol. Soc. America Bull., v. 71, p. 795-842.

Spry, Alan, 1962, The origin of columnar jointing, particularly in basalt flows: Geol. Soc. Australia Jour., v. 8, pt. 2, p. 191-216.

Tilley, C. E., 1950, Some aspects of magmatic evolution: Geol. Soc. London, Q. J., v. 106, p. 37-61.

Turekian, K. K., 1963, The chromium and nickel distribution in basaltic rocks and eclogites: Geochimica Acta, v. 27, p. 835-846.

Turner, F. J.; Verhoogen, J., 1960, Igneous and metamorphic petrology, 2nd ed.: New York, McGraw-Hill, 694 p.

Tyrrell, G. W., 1937, Flood basalts and fissure eruption: Bull. Volcanologique, v. 2, p. 89-111.

Waters, A. C., 1941, Collapsed vesicles, alteration banding, and platy jointing of basalt (abs.): Geol. Soc. America Bull., v. 52, p. 1958- 1959.

_____, 1955 , Volcanic rocks and the tectonic cycle: Geol. Soc. America Spec. Paper 62, p. 703-722.

_____, 1960, Determining directions of flow in basalts: Am. Jour. Sci. Bradley Volume 258-A, p. 350-366.

_____, 1962, Basalt magma types and their tectonic associations: Pacific Northwest of the United States: Am. Geophysical Union Mon. 6, p. 158-170.

Wentworth, C. K.; Williams, H., 1932, The classification and terminology of the pyroclastic rocks: Natl. Research Council Bull. 89, Dept. Comm. Sedimentation, p. 19-53.

_____, 1954, The physical behavior of basaltic lava flows: Jour. Geology, v. 62, no. 5, p. 425-438.

Williams, H., 1941, Calderas and their origin: California Univ. Pubs., Dept. Geology Sci. Bull., v. 25, no. 6, p. 239-346.

Wright, J. B., 1968, Polarity reversals and oxidation state in rocks: Geophys. Jour. Royal Abs. Soc., v. 16, p. 161-167.

Wright, T. L.; Hamilton, M. S., 1978, A computer-assisted graphical method for identification and correlation of igneous rock chemistries: Geology, v. 6, p. 16-20.

Yoder, H. S., Jr.; Tilley, C. E., 1962, Origin of basalt magmas: an experimental study of natural and synthetic rock systems: Jour. Petrology, v. 3, no. 3, p. 342-532.

GENERAL PACIFIC NORTHWEST GEOLOGY, INCLUDING FIELD TRIP GUIDEBOOKS.

Atwater, Tanya, 1970, Implications of plate tectonics for the Cenozoic tectonic evolution of western North America: Geol. Soc. America Bull., v. 81, no. 12, p. 3513-3535.

Atwater, Tanya; Molnar, P., 1973, Relative motion of the Pacific and North American plates deduced from sea-floor spreading in the Atlantic, Indian and South Pacific Oceans. In Proceedings of the Conference on Tectonic Problems of the San Andreas Fault System: Stanford University Publications, Dept. Geol. Sci., Bull. 13, 136-148.

Avent, J. C., 1969, Reinterpretation of the origin of some basalt magmas of the Pacific Northwest (abs.): Geol. Soc. America Spec. Paper 121, p. 13.

Beaulieu, J. D., Field Trip Committee Chairman, 1973, Geologic field trips in northern Oregon and southern Washington: Oregon Dept. Geology and Min. Ind. Bull. 77, 206 p., illus.

Blackwell, D. D.; Roy, R. F., 1971, Geotectonics and Cenozoic history of the western United States (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 2, p. 84-85.

Bretz, J H., 1932, Channeled scabland: 16th Internat. Geol. Cong. Guidebook 22.

Brown, E. H.; Ellis, R. C., eds., 1977, Geological excursions in the Pacific Northwest (Field trips of the Geological Society of America 1977 Annual Meeting, Seattle, Washington): Western Washington Univ. Dept. of Geology, Bellingham, Washington, 414 p.

Buwalda, J. P.; Moore, B. N., 1928, Age of Dalles Beds and "Satsop" Formation and history of the Columbia River Gorge: Pan-American Geologist, v. 49, no. 4, p. 313; (abs.): Geol. Soc. America Bull., v. 40, no. 1, p. 176-177, 1929.

Campbell, C. D., 1953, Washington geology and resources: Washington State Coll. Research Studies, v. 21, p. 114-153; Washington Div. Mines and Geology Inf. Circ. 22, 42 p., 1953; (abs.) Annot. Bibliography Econ. Geology 1953, v. 26, no. 1, p. 14, 1954.

_____, 1962, Introduction to Washington Geology and resources: Washington Div. Mines and Geology Inf. Circ. 22R, 44 p.

Campbell, M. R., 1915, Guidebook of the western United States Part A, The Northern Pacific route, with a side trip to Yellowstone Park: U.S. Geol. Survey Bull. 611, p. 156-196.

Campbell, N. P., 1975, A geologic road log over Chinook, White Pass, and Ellensburg to Yakima highways: Washington Div. Geology and Earth Resources Inf. Circ. 54, 82 p.

Corbett, M. K., 1977, Cenozoic tectonics of northwest United States as a function of plate interaction (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 935.

Culver, H. E., 1936, The geology of Washington: Part I, general features of Washington geology: Washington Dept. Conserv. and Dev., Div. of Geology, Bull. 32, 70 p.

Curtis, G. H.; Savage, D. E.; Evernden, J. F., 1961, Critical points in the Cenozoic: New York Acad. Sci. Ann., v. 81, p. 159-594.

Daly, R. A., 1912, Geology of the North American Cordillera at the forty-ninth parallel: Geol. Survey Canada, Mem. 38, 857 p.

Dana, James D., 1849, Geologic observations on Oregon and northern California. In United States exploring expedition during the years 1838-1842, under the command of Charles Wilkes, U.S.N., v. 10, Geology, p. 611-675: Printed by C. Sherman, Phila., 1844-1874, 756 p.

Dickerson, W. R., 1962, Petrogenetic significance of geosynclinal andesitic volcanism along the Pacific margin of North America: Geol. Soc. Am. Bull. 73, p. 1241-1256.

Dickerson, W. R.; Hatherton, T., 1967, Andesitic volcanism and seismicity around the Pacific: Science, v. 157, p. 801-803.

Dickerson, W. R., 1968, Circum-Pacific andesite types: Jour. Geophysical Research, 73, p. 2261-2269.

Diller, J. S.; and others, 1915, Shasta route and coast line guidebook: U.S. Geol. Survey Bull. 614, Maps 1:500,000.

Easterbrook, D. J.; Rahm, D. A., 1970, Landforms of Washington--The geologic environment: Western Washington State College, Dept. of Geology, Bellingham, Washington, 156 p.

_____, 1976, Quaternary geology of the Pacific Northwest. In Mahaney, W., ed., Quaternary Stratigraphy of North America: Dowden, Hutchinson, and Ross, Inc., Stroudsburg, Pennsylvania, p. 441-462.

Emmons, S. F., 1879, The volcanoes of the Pacific coast of the United States: Am. Geog. Soc. Jour., v. 9, p. 45-65.

Fischer, A. G.; and others, 1970, Geological history of the western North Pacific: Science, v. 168, no. 3936, p. 1210-1214.

Gibbs, George, 1854, Report upon the geology of the central portion of Washington Territory. In Report of the Secretary of War, communicating the several Pacific railroad explorations, in three volumes, 1855: U.S. 33d Cong., 1st sess., House Ex. Doc. 129, v. 18, pt. 1, 1st v., p. 494-512.

Hall, E. M., 1977, Lower Columbia River field trip: Geological Society of the Oregon Country Geological Newsltr., v. 43, no. 6, p. 78-81.

Halliday, W. R., 1963, Caves of Washington: Washington Div. Mines and Geology Inf. Circ. 40, 132 p.

Hamilton, W.; Myers, W. B., 1966, Cenozoic tectonics of the western United States: Rev. Geophys., v. 4, p. 509-549.

_____, 1968, Cenozoic tectonic relationships between the western United States and the Pacific Basin. In Dickinson, W. R.; Grantz, A., eds., Proceedings of Conf. on Geol. Problems of San Andreas Fault System: Stanford Univ. Pubs. Geol. Sciences, v. 11, p. 342-357.

Hershey, O. H., 1912, Some Tertiary and Quaternary geology of western Montana, northern Idaho, and eastern Washington: Geol. Soc. America Bull. 23, p. 517-536; (abs.) v. 23, p. 75, 1912.

Hoover, Linn, Jr., 1951, A summary of the stratigraphy and structural geology of Oregon and Washington: Univ. of Michigan M.S. thesis, 50 p.

Huntting, M. T.; Bennett, W. A. G.; Livingston, V. E., Jr.; Moen, W. W., 1961, Geologic map of Washington: Washington Div. Mines and Geology, scale 1:500,000.

Inqua, 1965, Guidebook for Field Conference E, northern and middle Rocky Mountains: The Nebraska Acad. Sci., Lincoln, Nebraska, 129 p.

King, A. T., 1871, On the discovery of actual glaciers on the mountains of the Pacific Slope: Am. Jour. sci., 3d ser., v. 1, p. 157-167.

King, P. B., 1958, Evolution of modern surface features of western North America. In Hubbs, C. L., ed., Zoogeography: Am. Assoc. Advancement Science Pub. 51.

_____, compiler, 1969, Tectonic map of North America: U.S. Geol. Survey, 2 sheets, scale 1:5,000,000.

_____, 1969, The tectonics of North America--a discussion to accompany the tectonic map of North America, scale 1:5,000,000: U.S. Geol. Survey Prof. Paper 628, 95 p.

King, P. B.; Beikman, H. M., 1974, Geologic map of the United States: U.S. Geol. Survey, scale 1:2,500,000.

Kirkham, V. R. D., 1927, The general geology of eastern Washington and northern Idaho: Northwest Sci., v. 1, no. 2, p. 25-30.

Kiver, E. P., 1976, Man and volcanoes in Washington State: Pacific Search, v. 10, no. 4, p. 8-11.

Lawrence, D. B.; Lawrence, E. G., 1958, Bridge of the Gods legend, its origin, history and dating: Mazama, v. 40, no. 13, p. 33-41.

LeConte, J. L., 1873-74, On the great lava flood of the Northwest; and on the structure and age of theCascade Mountains: California Acad. Sci. Proc., v. 5, p. 214-220 (1873); Am. Jour. Sci., v. 3, no. 7, p. 167-180, 259-267 (1874).

Livingston, V. E., Jr., 1969, Geologic history and rocks and minerals of Washington: Washington Div. Mines and Geology Inf. Circ. 45, 42 p.

Mackin, J. H.; Cary, A. S., 1965, Origin of Cascade landscapes: Washington Div. Mines and Geology, Inf. Circ. No. 41, 35 p.

Macready, G. A., 1931, Geology of Washington state: Oil Bull., v. 17, no. 12, p. 812-814.

Mathews, W. H.; Fyles, J. G.; Nasmith, H. W., 1970, Postglacial crustal movements in southwestern British Columbia and adjacent Washington State: Can. Jour. Earth Sci., v. 7, no. 2, part 2, p. 690-702.

McDougall, K. A., 1971, Marine Oligocene formations, Washington: Univ. of Washington B.S. thesis, 89 p.

McKee, Bates, 1972, Cascadia; the geologic evolution of the Pacific Northwest: McGraw-Hill Book Company, New York, xvii, 394 p.

Menard, H. W., 1955, Deformation of the northeastern Pacific basin and the west coast of North America: Geol. Soc. America, v. 66, p. 1149.

Moody, J. D., 1966, Crustal shear patterns and orogenesis: Tectonophysics, v. 3, no. 6, p. 479-522.

Niem, A. R.; Van Atta, R. O., 1973, Cenozoic stratigraphy of northwestern Oregon and adjacent southwestern Washington. In Beaulieu, J. D., Geologic field trips in northern Oregon and southern Washington: Oregon Dept. Geology and Mineral Ind. Bull. 77, p. 75-132.

Oestreich, Karl, 1915, Die Grande Coulee (Washington): Am. Geol. Soc. Mem. Vol. of Transcontinental Excursion of 1912.

Pakiser, L. C., 1963, Structure of the crust and upper mantle in the western United States: Jour. Geophys. Res., v. 68, no. 20, p. 5745-5756.

Pakiser, L. C.; Robinson, Rhoda, 1966, Composition of the continental crust as estimated from seismic observations: In The earth beneath the continents--a volume of geophysical studies in honor of H. A. Tuve: Am. Geophys. Union Geophys. Mon. 10 (Nat'l. Acad. Sci.--Nat'l. Research Council Pub. 1467), p. 620-626, Tectonophysics, v. 3, no. 6, p. 543-557, 1966.

Reynolds, M. W.; Kleinkopf, M. D., 1977, The Lewis and Clark line, Montana-Idaho: A major intraplate tectonic boundary (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1140.

Roy, R. F.; Decker, E. R.; Blackwell, D. D.; Birch, F., 1968, Heat flow in the United States: Jour. Geophys. Research, v. 73, no. 16, p. 5207-5221.

Russell, I. C., 1893, A geological reconnaissance in central Washington: U.S. Geol. Survey Bull. 108.

Skehan, J. W., 1965, A continental-oceanic crustal boundary of the Pacific Northwest: Air Force Cambridge Research Lab., Scientific Rept. 3, AFCRL-65-904.

_____, 1965, The Olympic-Wallowa lineament: A major deep-seated tectonic feature of the Pacific Northwest (abs.): Am. Geophys. Union, Trans., v. 46, no. 1, p. 71.

Smith, G. O.; Calkins, F. C., 1903, Contributions to the geology of Washington: U.S. Geol. Survey Prof. Paper 19, 101 p.

Snyder, W. S.; Dickinson, W. R.; Silberman, M. L., 1976, Tectonic implications of space-time patterns of Cenozoic magmatism in the western United States: Earth Planet. Sci. Lttrs., 32, p. 91-106.

Suppe, John; Powell, Christine; Berry, Robert, 1975, Regional topography, seismicity, Quaternary volcanism, and the present-day tectonics of the western United States: Am. Jour. Sci., v. 275-A, p. 397-436.

Symons, T. W., 1882, The upper Columbia River and the Great Plain of the Columbia: U.S. 47th Cong., 1st sess., Senate Ex. Doc. 186, 133 p., maps.

Taubeneck, W. H., 1966, An evaluation of tectonic rotation in the Pacific Northwest: Jour. Geophys. Research, v. 71, p. 2113-2120.

_____, 1967, Reply to comments on a paper by William H. Taubeneck, "An evaluation of tectonic rotation in the Pacific Northwest," made by N. D. Watkins: Jour. Geophys. Research, v. 72, p. 1415-1421.

Thompson, G. A., 1966, The rift system of the western United States. In The World rift system--Internat. Upper Mantle Committee Symposium, Ottawa, 1965: Canada Geol. Survey Paper 66-14, p. 280-290.

Tolmie, W. F., 1833 (Diary of W. F. Tolmie, excerpts Aug. 28 to Sep. 5, 1833, describing first attempts to ascend Mount Rainier). In Washington Hist. Quart.: v. 1, no. 1, p. 77-81.

U.S. Dept. of War, 1934, Columbia River and minor tributaries--letter from the Secretary of War, v. 2: Cong. Doc. 73d Cong., 1st sess., House Doc. 103, 1845 p.

U.S. Secretary of War, 1860, Reports of explorations and surveys to ascertain the practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean, made under the direction of the Secretary of War, in 1853-1855: U.S. 36th Cong., 1st sess., Ex. Doc., v. 12, book 1.

Washington State Univ. Geology Dept., Field Trip to the northern Wallowa Mountains, 10 p.

Waters, A. C., 1955, Volcanic rocks and the tectonic cycle: Geol. Soc. America Spec. Paper 62, p. 703-722.

Watkins, N. D., 1967, Comments on a paper by W. H. Taubeneck "An evaluation of tectonic rotation in the Pacific Northwest": Jour. Geophys. Research, v. 72, no. 4, p. 1411-1414.

Weaver, C. E., 1945, Geology of Washington and Oregon and its relation to occurrence of oil and gas: Am. Assoc. Petroleum Geologists Bull., v. 29, no. 10, p. 1377-1415.

Weissenborn, A. E., 1969, Geologic map of Washington, lat. 46° to 49°, long. 118° to 124°: U.S. Geol. Survey Misc. Geol. Inv. Map I-583, scale 1:2,000,000.

Wheeler, H. E.; Mallory, V. S., 1963, Regional Tertiary sequences in the Pacific Northwest (abs.): Geol. Soc. America Spec. Paper 73, p. 73-74.

Wood, H. E., II; and others, 1941, Nomenclature and correlation of the North American continental Tertiary: Geol. Soc. America Bull., v. 52, p. 1-48.

ADDITIONAL REFERENCES - GENERAL PACIFIC NORTHWEST GEOLOGY, INCLUDING FIELD TRIP GUIDEBOOKS

Brown, D. J.; Lobdell, G. T.; Neff, George, 1976, Hydrology and engineering geology of the Columbia Basin: Geol. Soc. Am., Cordilleran Section Mtg., Pullman, Wash., Field Guide No. 3, April 1976.

Calkins, F. C., 1905, Geology and water resources of the portion of east-central Washington: U.S. Geol. Survey Water Supply Paper 118.

Carlson, R. L., 1976, Cenozoic plate convergence in the vicinity of the Pacific Northwest: a synthesis and assessment of plate tectonics in the Northwestern Pacific: Univ. of Wash. Ph.D. thesis.

Condon, Thomas, 1879, Geological formations of Washington Territory and Oregon: MacFarlane's Am. Geol. Railroad Guide, p. 172-173.

Darton, N. H., 1909, Our Pacific Northwest: Nat. Geog. Mag. 20, p. 645-663, (July 1909).

Dawson, W. L., 1898, Glacial phenomena in Okanogan County, Washington: Am. Geologist, v. 22, p. 203-217.

Geological Society of America, 1964, Columbia River dams, Rock Island and Grand Coulee, with geology along the way from Seattle: Cordilleran section, Geol. Soc. Am., and Wash. Chapter of Association of Engin. Geologists, field trip, 25-26 March 1964, Univ. of Wash., Seattle, 41 p.

Greenhow, Robert, 1845, Geography of Oregon and Washington.

Hyndman, D. W.; Talbot, J. L., 1976, The Idaho Batholith and related subduction complex: Geol. Soc. Am., 72nd Annual Mtg., Pullman, Wash., Field Guide No. 4, April 1976.

Ingalls, A. O., 1909, Geology of Washington with an attempt to classify the vein system: Northwest Min. Jour. 7, (June 1909).

Landes, Henry, 1901, Physical geography and geology of Washington: State Bur. of Stat., Dept. of Ag. and Imm., p. 43-74, Olympia.

Landes, Henry, 1900, Geogrpahy of Washington: Rand, McNally & Co.

Landes, Henry, 1902, An outline of the geology of Washington: Ann. Rept., Washington Geological Survey 1, p. 161-213.

MacFarlane, James, 1890, American Geological Railway Guide: Appleton, New York.

Newberry, J. S., 1885, Notes on the geology and botany of the country bordering the Northern Pacific Railroad: New York Acad. Sci. An. 3, p. 242-270.

Newberry, J. S., 1885, Notes on the surface geology of the country bordering the Northern Pacific Railroad: Am. Jour. Sci., 3rd Ser. 30, p. 337-346.

Russell, I. C., 1897, Reconnaissance in southeastern Washington: U.S. Geol. Survey Water Supply and Irrigation Paper 4, 96.

Shelton, J. S., 1966, Geology Illustrated: W. H. Freeman and Co., c 1966, p. 338-351.

Smith, G. O., 1903, Geology and physiography of central Washington: U.S. Geol. Survey Prof. Paper 19, p. 9-39.

Stevens, Isaac, 1858, The Northwest - Washington.

Swanson, D. A.; Wright, T. L., 1976, Guide to field trip between Pasco and Pullman, Washington, emphasizing stratigraphy, vent areas, and intracanyon flows of Yakima Basalt: Geol. Soc. Am., Cordilleran Section Mtg., Pullman, Wash., Field Guide No. 1, 33 p., April 1976.

Upham, Warren, 1904, Outer glacial drift in the Dakotas, Montana, Idaho, and Washington: Amer. Geologist 34, p. 151-160.

Vallier, T. L.; Hooper, P. R., 1976, Geologic guide to Hells Canyon, Snake River: Geol. Soc. Am., Cordilleran Section Mtg., Pullman, Wash., Field Guide No. 5, April 1976.

Webster, G. D.; Baker, V. R.; Gustafson, Carl, 1976, Channeled scablands of southeastern Washington, a road log via Spokane - Coulee City - Vantage - Washtucna - Lewiston - Pullman: Geol. Soc. Am., Cordilleran Section Mtg., Pullman, Wash., Field Guide No. 2, April 1976.

Willis, Bailey, 1887, Changes in river courses in Washington Territory due to glaciation: U.S. Geol. Survey Bull. 40.

REFERENCES ON IDAHO GEOLOGY

Anderson, A. L., 1927, Some Miocene and Pleistocene drainage changes in northern Idaho: Idaho Bureau Mines and Geology, Pamphlet 18, 29 p.

Barker, R. A., 1976, Computer simulation of a basalt aquifer system in the Pullman-Moscow basin, Washington and Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 352.

Barraclough, J. T., 1976, Geohydrologic summary of the Snake River Plain aquifer in southeastern Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 352-353.

Berry, E. W., 1929, A revision of the flora of the Latah Formation: U.S. Geol. Survey Prof. Paper 154-H, p. 225-265.

_____, 1929, Gordonia from the Miocene of Idaho and Washington: Am. Jour. Sci., series 5, v. 18, no. 107, p. 429-432.

_____, 1929, Fossil plants and mountain uplift in the Pacific states: Proc. of the National Acad. Sci., v. 15, p. 477-480.

_____, 1929, The genus Amygdalus in North America: Wash. Acad. Sci. Jour., v. 19, no. 2, p. 41-43.

_____, 1932, Fossil stipules of Platanus: Wash. Acad. Sci. Jour., v. 22, no. 14, p. 413-416.

Bishop, D. T., 1969, Stratigraphy and distribution of basalt, Benewah County, Idaho: Idaho Bureau Mines and Geology Pamphlet 140, 22 p.

Bond, J. G., 1963, Geology of the Clearwater embayment: Idaho Bureau Mines and Geology Pamphlet 128, 83 p.; Univ. of Washington Ph.D. thesis.

Bond, J. G.; Price, S. M.; Breeser, P. J., 1972, Deformational history of the Columbia River basalts of western Idaho as interpreted from drainage development analysis (abs.): Geol. Soc. America Abs. with Programs, v. 4, no. 3, p. 129.

Brock, M. R.; Grolier, M. J., 1973, Chemical analyses of 305 basalt samples from the Columbia River Plateau, Washington, Oregon, and Idaho: U.S. Geol. Survey Open-File Report, 35 p.

Brown, J. C., 1976, Tectonic significance of sub-surface chemical-stratigraphic correlation, Pullman/Moscow Basin, Washington and Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 357-358.

Camp, V. E., 1975, Structure and basalt stratigraphy of the "Lewiston Downwarp", Idaho-Washington: Geol. Soc. America Abs. with Programs, v. 7, no. 3, p. 300-301.

_____, 1976, Petrochemical stratigraphy and structure of the Columbia River Basalt, Lewiston basin area, Idaho-Washington: Washington State Univ. Ph.D. thesis, 201 p.

Campbell, M. R., 1915, Guidebook of the western United States — Part A, The Northern Pacific route, with a side trip to Yellowstone Park: U.S. Geol. Survey Bull. 611.

Carter, G. L., 1974, Varieties of siderite occurring in vesicular basalt between Moscow, Idaho, and Pullman, Washington: The Mineralogical Record, v. 5, no. 4, p. 157-159.

Crosby, J. W., III, 1968, Groundwater hydrology of the Pullman-Moscow basin, Washington. In Campbell, T. H.; Sylvester, R. D., eds., Water Resources Management and Public Policy, p. 93-109.

Culver, H. E.; Kirkham, V. R. D., 1927, General geology of eastern Washington and northern Idaho: Northwest Sci., vol. 1, p. 25-30, map, 1:500,000.

Dake, H. C., 1940, Latah petrified forests (Washington, Idaho and Oregon): Mineralogist, v. 10, no. 11, p. 339-340, 352-353, illus.

Deacon, R. J.; Benson, G. T., 1971, Oil and gas potential of eastern Oregon and Washington and Snake River basin of western Idaho. In Cram, Ira H., ed., Future petroleum provinces of the United States — their geology and potential: Amer. Assoc. Petroleum Geologists Mem. 15, p. 354-359, 1964.

Dort, Wakefield, Jr., 1962, Glaciation of the Coeur d'Alene district, Idaho: Geol. Soc. America Bull., v. 73, p. 889-906.

Emmett, W. W., 1976, Bedload transport in two large, gravel-bed rivers, Idaho and Washington: Fed. Inter-Agency Sediment. Conf., Proc., no. 3, p. 4.101-4, 114.

Gilbert, G. K., 1890, Lake Bonneville: U.S. Geol. Survey Monogr. 1, 438 p.

Gray, Jane; Kittleman, L. R., 1967, Geochronometry of the Columbia Basalt and associated floras of eastern Washington and western Idaho: Am. Jour. Sci., v. 265, no. 4, p. 257-291. Figure 1, 1:10,454,400.

Gregory, D. I.; Jackson, D. B., 1976, Bouguer gravity map of Moscow, Idaho-Pullman, Washington area: U.S. Geol. Survey Open-File Report No. 76-280, one sheet, 1:62,500.

Griggs, A. B., 1973, Geologic map of the Spokane quadrangle, Washington, Idaho, and Montana: U.S. Geol. Survey Misc. Geol. Inv. Map I-768, map and text on one sheet, 1:250,000.

_____, 1976, The Columbia River Basalt Group in the Spokane quadrangle, Washington, Idaho, and Montana, with a section on petrography by D. A. Swanson: U.S. Geol. Survey Bull. 1413.

Hamilton, Warren, 1962, Late Cenozoic structure of west-central Idaho: Geol. Soc. America Bull., v. 73, p. 511-516.

_____, 1963, Columbia River Basalt in the Riggins quadrangle, western Idaho: U.S. Geol. Survey Bull. 1141-L, p. L28-L31, 9 figs., map.

Hershey, O. H., 1912, Some Tertiary and Quaternary geology of western Montana, northern Idaho, and eastern Washington (abs.): Geol. Soc. America Bull., v. 23, p. 75.

Hill, D. P., 1963, Gravity and crustal structure in the western Snake River plain: Jour. Geophys. Research, v. 68, p. 5807-5819.

Hill, D. P.; Baldwin, H. L., Jr.; Pakiser, L. C., 1961, Gravity, volcanism, and crustal deformation in the Snake River plain, Idaho: U.S. Geol. Survey Prof. Paper 424-B, p. 248-250.

Hill, D. P., 1965, The U.S. Geological Survey's gravity program in Washington, Idaho, Montana, and Wyoming (abs.): Geophys. Abs., no. 222, p. 557.

Hoffman, M. G., 1932, Geology of Bald Butte Ridge: Jour. Geology, v. 40, fig. 3, 1:160,000, p. 634-650.

Holden, G. S., 1974, Chemical and petrographic stratigraphy of the Columbia River Basalt in the lower Salmon River canyon, Idaho: Washington State Univ. M.S. thesis, 97 p.

Holden, G. S.; Hooper, P. R., 1976, Petrology and chemistry of a Columbia River basalt section, Rocky Canyon, west-central Idaho: Geol. Soc. America Bull., v. 87, no. 2, p. 215-225.

Hollenbaugh, K. M., 1959, Geology of Lewiston and vicinity, Nez Perce County, Idaho: Univ. of Idaho, M.S. thesis, 53 p.

Hooper, P. R.; Rosenberg, P. E., 1971, Petrology of the Rock Creek flow, Columbia River Basalts, Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 7, p. 603-604.

Hooper, P. R.; Holden, G. S.; Kleck, W. D., 1973, Correlation and petrochemistry of the Columbia River Basalt flows in parts of west-central Idaho and northeastern Oregon (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 56.

Hooper, P. R., 1974, Petrology and chemistry of the Rock Creek Flow, Columbia River Basalt, Idaho: Geol. Soc. America Bull., v. 85, p. 15-26.

Hosterman, J. W., 1960, Geology of the clay deposits in parts of Washington and Idaho. In clays and clay minerals, 7th Conference, Proc.: Pergamon Press, New York City, p. 285-292. Figure 1, 1:2,280,960.

Hosterman, J. W.; Scheid, V. E.; Allen, V. T.; Sohn, I. G., 1960, Investigations of some clay deposits in Washington and Idaho: U.S. Geol. Survey Bull. 1091, 147 p. Figure 3, 1:380,160; Plate 3, 1:12,000.

Hosterman, J. W.; Overstreet, W. D.; Warr, J. J., Jr., 1963, Thorium and uranium in monzonite from Spokane County, Washington: U.S. Geol. Survey Prof. Paper 475-D, p. D128.

_____, 1969, Clay deposits of Spokane County, Washington: U.S. Geol. Survey Bull. 1270, 96 p.

Jackson, D. B., 1975, Schlumberger soundings in the Moscow, Idaho-Pullman, Washington, area: U.S. Geol. Survey Open-File Report 75-584, 28 p.

Jackson, D. B.; Gregory, D., 1976, D. C. resistivity studies near Moscow, Idaho and Pullman, Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 385.

Jackson, D. B.; Senterfit, R. M.; Gregory, D. I., 1976, Principal facts for gravity stations in the Pullman, Washington-Moscow, Idaho, area: U.S. Geol. Survey Open-File Report No. 76-189, 8 p.

Jones, R. W.; Ross, S. H., 1972, Moscow basin ground water studies: Idaho Bureau Mines and Geology Pamphlet 153, 95 p.

Jones, R. W., 1976, Early Tertiary age(?) of intermediate and silicic volcanic rocks in the eastern Columbia Plateau, Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 386-387.

Kirkham, V. R. D., 1927, The general geology of eastern Washington and northern Idaho: Northwest Sci., v. 1, no. 2, p. 25-30.

Kirkham, V. R. D.; Johnson, M. M., 1929, The Latah Formation of Idaho: Jour. Geology, v. 37, no. 5, p. 483-504; (abs.) Revue de Geologie et des Sciences connexes, v. 10, no. 10, p. 415-416, 1929.

Knowlton, F. H., 1926, Flora of the Latah Formation of Spokane (Washington) and Coeur d'Alene, Idaho, with a note on the fossil diatom deposited at Spokane, by Alb. Mann: U.S. Geol. Survey Prof. Paper 140-A, p. 1-4 + 1-81, pl. 1-31 (incl. 1 map), fig. k-s, Washington; (abs.) Revue de Geologie et des Sciences Connexes, v. 8, no. 1, p. 60, 1927.

Ko, Chong An, 1974, Geology and groundwater resources of the Hangman Creek drainage basin, Idaho-Washington (abs.) Washington State Univ. Ph.D. thesis; (Diss. Abs. Int., v. 35, no. 6, p. 2824B-2825B).

Large, Thomas, 1924, Drainage changes in northeastern Washington and northern Idaho since extravasation of Columbia basalts: Pan-American Geologist, v. 41, no. 4, p. 259-270, 4 plates.

Lewis, S. E., 1968, Fossil insects of the Latah Formation (Miocene) of eastern Washington and northern Idaho: Washington State Univ. Ph.D. thesis, 97 p.

Lupher, R. L., 1940, Origin of clastic dikes in the Lewiston basin, Washington and Idaho (abs.): Geol. Soc. America Bull., v. 51, no. 12, part 2, p. 2027.

_____, 1940, Pleistocene history of the Lewiston basin of Washington and Idaho (abs.): Geol. Soc. America Bull., v. 51, no. 12, part 2, p. 2027-2028.

Lupher, R. L.; Warren, W. C., 1942, The Asotin stage of the Snake River Canyon near Lewiston, Idaho: Jour. Geology, v. 50, p. 866-881. Figure 1, 1:187,500.

Lupher, R. L., 1944, Clastic dikes of the Columbia Basin region, Washington and Idaho: Geol. Soc. America Bull., v. 55, p. 1431-1462.

Lynch, Maurice B., 1976, Remanent paleomagnetism in the Miocene basalts of north Idaho: Univ. of Idaho M.S. thesis, 150 p.

Malde, H. E., 1959, Fault zone along northern boundary of western Snake River plain, Idaho: Science, v. 130, p. 272.

_____, 1960, Evidence in the Snake River plain, Idaho, of a catastrophic flood from Pleistocene Lake Bonneville: U.S. Geol. Survey Prof. Paper 400-B, p. 295-297.

Malde, H. E.; Powers, H. A., 1962, Upper Cenozoic stratigraphy of western Snake River plain, Idaho: Geol. Soc. America Bull., v. 73, p. 1197-1220.

Malde, H. E.; Powers, H. S.; Marshal, C. H., 1963, Reconnaissance geologic map of west-central Snake River plain, Idaho: U.S. Geol. Survey Misc. Inv. Map I-373.

Malde, H. E., 1965, Snake River plain. In Wright, H. E.; Frey, D. G., eds., The Quaternary of the United States: Princeton Univ. Press, Princeton, p. 255-263.

_____, 1968, The catastrophic late Pleistocene Bonneville flood in the Snake River plain, Idaho: U.S. Geol. Survey Prof. Paper 596, 52 p.

McKee, E. H.; Swanson, D. A.; Wright, T. L., 1977, Duration and volume of Columbia River basalt volcanics, Washington, Oregon, and Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 4, p. 463-464.

McNary, Samuel, 1976, Petrography and field studies of late Cenozoic basalt flows and intrusions in the Orofino-Elk River area, Idaho: Univ. of Idaho M.S. thesis, 135 p.

Morrison, R. F., 1963, The Pre-Tertiary geology of the Snake River Canyon between Cache Creek and Dug Bar, Oregon-Idaho boundary: Oregon Univ. Ph.D. thesis, 195 p.

Newcomb, R. C., 1961, Storage of ground water behind subsurface dams in the Columbia River Basalt, Washington, Oregon, and Idaho: U.S. Geol. Survey Prof. Paper 383-A, p. 1-15. Figure 1, 1:3,752,000.

_____, 1962, Hydraulic injection of clastic dikes in the Touchet beds, Washington, Oregon, and Idaho (abs.): Geol. Soc. Oregon Country Geol. Newsletter, v. 28, no. 10, p. 70.

_____, 1969, The Columbia River Group: Its tectonic structure in Washington, Oregon, and Idaho. In Gilmour, E. H.; Stradling, D., eds., Proceedings of the second Columbia River Basalt symposium: Eastern Washington State College, Cheney, p. 173-175.

_____, 1970, Tectonic structure of the main part of the basalt of the Columbia River Group, Washington, Oregon, and Idaho: U.S. Geol. Survey Misc. Geol. Inv. Map I-587.

_____, 1972, Quality of the ground water in basalts of the Columbia River Group, Washington, Oregon and Idaho: U.S. Geol. Sur. Water-Supply Paper 199-N, 71 p. Map 1:1,000,000.

Peterson, D. W., 1955, The pre-basalt surface in the vicinity of Peck, Idaho: Northwest Sci., v. 29, no. 1, p. 1-9.

Powers, H. A., 1960, A distinctive chemical characteristic of Snake River basalts of Idaho: U.S. Geol. Survey Prof. Paper 400-B, p. 298.

Powers, H. A.; Malde, H. E., 1961, Volcanic ash beds as stratigraphic markers in basin deposits near Hagerman and Glenns Ferry, Idaho: U.S. Geol. Survey Prof. Paper 424-B, p. 167-170.

Price, W. H.; Knowles, C. R.; Bond, J. G., 1973, Columbia River basalt dikes of the Camas Prairie area, Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 7, p. 773.

Ptacek, A. D., 1965, Cenozoic geology of the Seven Devils Mountains, Idaho: Univ. of Washington Ph.D. thesis, 96 p.

Ralston, D. R., 1972, Guide for the location of water wells in Latah County, Idaho: Idaho Bureau Mines and Geology Inf. Circ. no. 23, 14 p.

Rasmussen, N. H., 1976, Seismology report on Washington, Idaho, northern Oregon and western Montana and the Hanford Area: Douglas United Nuclear Report, DUN-1409.

Reidel, S. P., 1975, Pyroxene composition and subdivision of the lower Yakima Basalt of the Columbia River Group in the Snake and Salmon River canyons of Washington, Oregon, and Idaho: Geol. Soc. America Abs. with Programs, v. 7, no. 3, p. 364.

Ross, C. P.; Forrester, J. D., 1958, Outline of the Geology of Idaho: Idaho Bur. Mines and Geology Bull. 15, 72 p.

_____, 1959, Geologic map of the State of Idaho: U.S. Geol. Survey and Idaho Bur. Mines and Geology, scale 1:500,000.

Russell, I. C., 1901, Geology and water resources of Nez Perce County, Idaho: U.S. Geol. Survey Water-Supply Papers 53 and 54, pts. I and II, 141 p.

_____, 1902, Geology and water resources of the Snake River plains of Idaho: U.S. Geol. Survey Bull. 199, 192 p.

Savage, C. N., 1965, Economic geology of carbonate rocks adjacent to the Snake River south of Lewiston, Idaho: Idaho Bur. Mines and Geology Mineral Resources Rept. 10, 26 p., 2 pls., 8 figs.

_____, 1973, A geological field trip in Benewah and Whitman Counties, Idaho and Washington, respectively: In Bishop, D. T.; Powell, J. D., co-chairmen. Belt Symposium 1973, Volume 1: Univ. of Idaho Dept. Geology, and Idaho Bur. Mines and Geol., Moscow, p. 253-320.

Scheid, V. E., 1940, Significance of a fossil horse tooth found at Moscow, Idaho: Northwest Sci., v. 14, no. 3, p. 55-57.

_____, 1945, Deary high-alumina clay deposit, Latah County, Idaho: U.S. Geol. Survey Prelim. Rept.

_____, 1950, Preliminary report on the geological setting of the clay deposits of Latah County, Idaho, and adjacent areas: U.S. Geol. Survey Open-File Report, 15 p. Plate 1, 1:253,440.

Shea, M. C., 1970, Geology and highway location considerations in the Orofino-Kamiah-Nez Perce area, Idaho: Univ. of Idaho M.S. thesis, 88 p.

Simons, W. D.; and others, 1953, Spokane-Coeur d'Alene River basin, Washington-Idaho: Chap. 10 of U.S. Cong., House Comm. Interior and Insular Affairs, Subsurface facilities of water management and patterns of supply - type area studies, p. 162-185, illus.

Smith, H. W.; Okazaki, R.; Aarstad, J., 1968, Recent volcanic ash in soils of northeastern Washington and northern Idaho: Northwest Sci., v. 42, no. 4, p. 150-160.

Stearns, H. T.; Crandall, L.; and Steward, W. G., 1938, Geology and ground water resources of the Snake River plain in southeastern Idaho: U.S. Geol. Survey Water-Supply Paper 774, 268 p.

Strand, J. R., 1949, Structural geology of pre-Tertiary rocks in southeastern Washington and adjacent portions of Idaho: Washington State College M.S. thesis, 25 p.

Suppe, John; Powell, Christine; Berry, Robert, 1975, Regional topography, seismicity, Quaternary volcanism, and the present-day tectonics of the western United States: Am. Jour. Sci., 275-A, p. 397-436.

Swanson, D. A.; and others, 1977, Reconnaissance geologic map of the Columbia River Basalt Group, Pullman and Walla Walla quadrangles, southeast Washington and adjacent Idaho: U.S. Geol. Survey Open-File Report 77-100, 11 p. 2 plates.

Taubeneck, W. H., 1969, Dikes of Columbia River Basalt in northeastern Oregon, western Idaho, and southeastern Washington: In Gilmour, E. H.; Stradling, D., eds., Proceedings of the second Columbia River Basalt symposium: Cheney, Washington, Eastern Washington State College, 333 p.

_____, 1969, Feeder dikes for Columbia River Basalt in northeastern Oregon, western Idaho, and southeastern Washington (abs.): Northwest Sci., v. 43, no. 1, p. 43.

_____, 1973, Field relationships near the trans-Idaho discontinuity, western Idaho and eastern Washington (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 115.

Taubeneck, W. H.; Armstrong, R. L., 1974, The Precambrian continental margin in western Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 6, no. 5, p. 477-478.

_____, 1974, The Trans-Idaho Discontinuity viewed as a transform fault (abs.): Geol. Soc. America Abs. with Programs, v. 6, no. 5, p. 478.

Tullis, E. L., 1932, The clays of Tertiary age in northern Idaho and eastern Washington (abs.): Pan-American Geologist, v. 58, no. 2, p. 152-153.

_____, 1944, Contribution to the geology of Latah County, Idaho: Geol. Soc. America Bull., v. 55, p. 131-163.

Vallier, T. L., 1967, The geology of part of the Snake River canyon and adjacent areas in northeastern Oregon and western Idaho: Oregon State Univ. Ph.D. thesis, 267 p., 3 pls., 57 figs.

_____, 1974, A preliminary report on the geology of part of the Snake River canyon, Oregon and Idaho: Oregon Dept. of Geol. and Min. Ind. Geol. Map series 6, p. 7.

_____, 1976, Pre-Tertiary stratigraphy in the Snake River canyon and adjacent Seven Devils and Wallowa Mountains, northeastern Oregon and western Idaho: Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 417.

Vallier, T. L.: Hooper, P. R., 1976, Geologic guide to Hells Canyon, Snake River: Geological Soc. America Abs. with Programs, v. 8, no. 3.

Wagner, W. R., 1945, A geologic reconnaissance between the Snake and Salmon Rivers north of Riggins, Idaho: Id. Bur. Mines and Geol. Pamph. 74.

Walker, E. H., 1967, Varved lake beds in northern Idaho and northeastern Washington: U.S. Geol. Survey Prof. Paper 575-B, p. 83-97.

Waters, A. C., 1963, The Columbia River Basalt of Washington, Oregon and Idaho: The XI Transactions of Sigma Gamma Epsilon, XI Chapter, Washington State Univ., v. 1, no. 1, p. 16.

Watkins, N. D., 1964, A paleomagnetic survey of Miocene lavas in northern Oregon, southeastern Washington, and west-central Idaho (abs.): Am. Geophys. Union, Trans., v. 45, no. 1, p. 37.

_____, 1964, Structural implications of paleomagnetism in Miocene lavas of northeastern Oregon, southeastern Washington and west-central Idaho: Nature, v. 203, no. 4947, p. 830-832.

Watkins, N. D.; Wilson, R. D., 1965, Investigation of the possibility of petrological control of magnetic polarity in some Miocene lavas of the Columbia Plateau (abs.): Geol. Soc. America Spec. Paper 82, p. 286-287.

Watkins, N. D.; Baksi, A. K., 1974, Magnetostratigraphy and oroclinal folding of the Columbia River, Steens and Owyhee Basalts in Oregon, Washington and Idaho: Am. Jour. Sci., v. 274, p. 148-189.

Weis, P. L.; Richmond, G. M., 1965, Maximum extent of late Pleistocene Cordilleran glaciation in northeastern Washington and northern Idaho: U.S. Geol. Survey Prof. Paper 525-C, p. 128-132.

Weissenborn, A. E., 1974, Geologic map of the Mount Spokane quadrangle, Washington and Idaho: U.S. Geol. Survey Open-File Report 74-211, map and text on one sheet, 1:31,680.

Weissenborn, A. E.; Weis, P. L., 1976, Geologic map of the Mount Spokane quadrangle, Spokane County, Washington, and Kootenai and Bonner Counties, Idaho: U.S. Geol. Survey Quad. Map GQ-1336, map and text on one sheet, scale 1:62,500.

Yates, R. G.; Becraft, G. E.; Campbell, A. B.; Pearson, R. C., 1964, The tectonic framework of northeastern Washington, northern Idaho, and northwestern Montana (abs.): American Institute of Mining and Metallurgical Engineers and the Canadian Institute of Mining and Metallurgy Joint Meeting, Vancouver, B. C.

Yates, R. G., 1967, Discontinuity in central Idaho (abs.): Geol. Soc. America Spec. Paper 115, p. 361-362.

_____, 1968, The Trans-Idaho discontinuity. In International Geol. Congress, 23d, Prague, 1968, Proc., Section 1, Upper mantle (geological processes): Academia Prague, p. 117-123.

ADDITIONAL REFERENCES - IDAHO GEOLOGY

Bond, J.C., 1962, Geology of the Clearwater embayment in Idaho: University of Washington, Ph.D. thesis.

Bonini, W.E., 1963, Gravity anomalies in Idaho: Idaho Bureau, Mines and Geology, Pamphlet 132, 38 p.

Cavin, R.E., 1964, Significance of the interbasalt sediments in the Moscow Basin, Idaho: unpublished M.S. thesis, Washington State Univ.

Davis, W.M., 1920, Features of glacial origin in Montana and Idaho: Annals Assoc. Am. Geog. 10, p. 75-147.

Geodetic Survey Squadron (1st), 1970, gravity data for the state of Idaho: 1st G.C.S.

Geodetic Survey Squadron (1st), 1972, Idaho regional gravity survey: 1st G.C.S.

Hyndman, D.W.; Talbot, J.L., 1976, The Idaho Batholith and related subduction complex: Geol. Soc. Am., Cordilleran Section Mtng., Pullman, Washington, Field Guide No. 4, April 1976.

Ross, S.H., 1965, Contributions to the geohydrogeology of Moscow Basin, Latah County, Idaho: Idaho Bureau of Mines and Geol., Open-file report.

Stevens, P.R., 1960, Ground-water problems in the vicinity of Moscow, Latah County, Idaho: U.S. Geol. Survey Water-Supply Paper 1460-H.

REFERENCES ON OREGON GEOLOGY

Allen, J. E., 1932, Contributions to the structure, stratigraphy, and petrography of the Lower Columbia River Gorge: University of Oregon M.S. thesis, 96 p. Map, 1:125,000.

_____, 1958, Columbia River Gorge--Portland to the Dalles: University of Oregon Guidebook for Field Trip Excursions of the Geol. Soc. America Cordilleran Section, p. 4-23. Figure 2, 1:633,600.

_____, 1975, The Wallowa "Ice Cap" of northeastern Oregon, an exercise in the interpretation of glacial landforms: Ore Bin, v. 37, no. 12, p. 189-202.

Avent, J. C., 1969, Correlation of the Steens-Columbia River Basalts: Some Tectonic and Petrogenetic Implications. In Gilmour, E. H., and Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, p. 133-156.

_____, 1969, Reinterpretation of the origin of some basalt magmas of the Pacific Northwest (abs.): Geol. Soc. America Spec. Paper 121, p. 13.

Baksi, A. K., 1972, The age of the Picture Gorge Basalts, central Oregon (abs.): Geol. Soc. America Abs. with Programs, v. 4, p. 441.

Barnes, F. F.; Butler, J. W., 1930, Structure and stratigraphy of the Columbia River Gorge and Cascade Mountains in the vicinity of Mt. Hood: Univ. of Oregon M.A. thesis, 136 p., Map 1, 1:125,000.

Barr, E. M., 1939, Founder's Day trip (Geological Soc. of the Oregon Country): Geol. Soc. of Oregon Country News Letter, v. 5, no. 13, p. 121-126.

Beaulieu, J. D., Field Trip Committee Chairman, 1973, Geologic field trips in northern Oregon and southern Washington: Oregon Dept. Geol. and Min. Ind., Bull. 77, 206 p., illus.

Beck, George F., 1940, Late Tertiary stratigraphy and paleontology of south-central Washington and adjacent Oregon (abs.): Geol. Soc. America Bull., v. 51, no. 12, pt. 2, p. 2018.

Beck, R. S., 1946, Highlights of Washington and Oregon Biostratigraphy (abs.): Oil and Gas Journal, v. 45, no. 27, p. 92.

Beeson, M. H.; Moran, M. R.; Olson, F. L., 1976, Geochemical data on Columbia River Basalt stratigraphy in western Oregon: Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 354.

Beeson, M. H.; Bentley, R. D.; Moran, M. R., 1976, Preliminary correlation of lower Yakima Basalt flows in western Oregon with the type area in central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 353-354.

Bentley, R. D.; Cockerham, R. S., 1973, The stratigraphy of the Picture Gorge Basalt (PGB), north central Oregon (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 9.

Bogue, R. G., 1932, A petrographic study of the Mount Hood and Columbia River basalt formations: Univ. of Oregon M.S. thesis, 88 p.

Borchardt, G. A.; Norgren, J. A.; Harward, M. E., 1973, Correlation of ash layers in peat bogs of eastern Oregon: Geol. Soc. America Bull., v. 84, no. 9, p. 3101-3108.

Bretz, J H., 1917, Satsop Formation of Washington and Oregon (abs.): Geol. Soc. America Bull., v. 28, p. 170-171.

_____, 1921, Stratigraphic problems in the Columbia Valley between Snake River and Willamette River (abs.): Geol. Soc. America Bull., v. 32, no. 1, p. 36-37.

_____, 1924, The Dalles type of river channel: Jour. Geol., v. 32, p. 139-149.

Brock, M. R.; Grolier, M. J., 1973, Chemical analyses of 305 basalt samples form the Columbia River Plateau, Washington, Oregon, and Idaho: U.S. Geol. Survey Open-File Report, 35 p.

Brown, C. E.; Thayer, T. P., 1966, Geologic map of the Canyon City quadrangle, northeastern Oregon: U.S. Geol. Survey Misc. Geol. Invest. Map 1-447.

Burlington Northern, Inc., 1971 Diatomite deposits in Washington, Oregon and California: Burlington Northern, Inc., Industrial and Economic Development Department, Raw Materials Research Div. Report 2, 50 p.

Butler, B. R., 1963, Further notes on the burials and the physical stratigraphy at the Congdon Site, a multi-component Middle Period site at The Dalles on the Lower Columbia River: Tebiwa, Jour. Idaho Stat Univ. Museum, v. 6, no. 2, p. 16-21.

Buwalda, J. P., Moore, B. N., 1928, Age of Dalles Beds and "Satsop" Formation and history of Columbia River gorge: Pan-American Geologist, v. 49, no. 4, p. 313; (abs.) Geol. Soc. America Bull., v. 40, no. 1, p. 176-177, 1929.

Callaghan, Eugene, 1933, Some features of the volcanic sequence in the Cascade Range in Oregon: Am. Geophys. Union Ann. Meg., 14th, Trans., p. 243-249.

Campbell, C. D.; Runcorn, S. I., 1956, Magnetization of the Columbia River Basalts in Washington and northern Oregon: Jour. Geophys. Research, v. 61, p. 449-458.

Collier, A. J., 1914, The geology and mineral resources of the John Day region: Oregon Bur. Mines and Geology, v. 1, no. 3, 47 p., map, scale 1:500,000.

Cressman, L. S., 1960, Cultural sequences at The Dalles, Oregon: A contribution to Pacific Northwest prehistory: Philos. Soc. Proc., Trans., v. 50, part 10, p. 7-108.

Dake, H. C., 1940, Latah petrified forests (Washington, Idaho, Oregon): Mineralogist, v. 10, no. 11, p. 339-340, 3520 353, illus.

Deacon, R. J.; Benson, G. T., 1971, Oil and gas potential of eastern Oregon and Washington and Snake River basin of western Idaho. In Cram, Ira H., ed., Future petroleum provinces of the U.S.--their geology and potential: Amer. Assoc. Petroleum Geologist Mem. 15, p. 354-359, 1964.

Diller, J. S.; and others, 1915, Shasta route and coast line guidebook: U.S. Geol. Survey Bull. 614, maps 1:500,000.

Dodds, R. K., 1969, The age of the "Columbia River Basalts" near Astoria, Oregon. In Gilmour, E. H., and Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, p. 239-270.

Farooqui, S. M.; Kienle, C. F., Jr., 1976, Structural implications of the Yakima Basalt in north-central Oregon and south-central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 372-373.

Fisher, R. V., 1967, Early Tertiary deformation in north-central Oregon: Am. Assoc. Petroleum Geologists Bull., v. 51, p. 111-123.

Franklin, J. F.; Dyrness, C. T., 1969, Vegetation of Oregon and Washington: U.S. Dept. Agriculture Forest Service Research Paper PNW-80, 216 p.

Free, M. R., 1976, Evidence for magmatic assimilation in several diorites of the middle Columbia River Gorge: Univ. of Utah, M.S. thesis, 65 p.

Fruchter, J. S.; Nathan, S., 1973, Relation between the Yakima Basalt and Picture Gorge Basalt (Columbia River Group) in north-central Oregon (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 45-46.

Fruchter, J. S.; Baldwin, Stuart F., 1975, Correlations between dikes of the Monument Swarm, central Oregon, and Picture Gorge Basalt flows: Geol. Soc. America Bull., v. 86, p. 514-516.

Glenn, J. L., 1965, Late Quaternary sedimentation and geologic history of the north Willamette valley, Oregon: Oregon State Univ. Ph.D. thesis, 231 p.

Gottfried, David, 1958, Uranium in basalts from Washington and Oregon: U.S. Geol. Survey Report TE1-740, p. 283, 285 incl. table.

Gray, Jane, 1958, Plant microfossils from the Miocene of the Columbia Plateau, Oregon: Univ. of California, Berkeley, Ph.D. thesis.

Griffin, W. C.; Watkins, F. A., Jr.; Swenson, H. A., 1956, Water resources of the Portland, Oregon, and Vancouver, Washington area: U.S. Geol. Survey Circ. 372, 45 p. Plate 2, 1:253,440.

Gunn, B. M.; Watkins, N. D., 1970, Geochemistry of the Steens Mountain basalts, Oregon: Geol. Soc. America Bull., v. 81, p. 1497-1516.

Hall, Effie M., 1977, Lower Columbia River field trip: Geol. Soc. of the Oregon Country Geol. News Letter, v. 43, no. 6, p. 78-81.

Hampton, E. R.; Brown, S. G., 1964, Geology and ground water resources of the Upper Grande Ronde River Basin, Union County, Oregon: U.S. Geol. Survey Water Supply Paper 1597.

Hansen, H. P., 1957, Chronology of postglacial volcanic activity in Oregon and Washington (abs.): Geol. Soc. America Bull., v. 58, no. 12, part 2, p. 1252.

_____, 1947, "Postglacial forest succession, climate and chronology in the Pacific Northwest": Am. Philosophical Soc. Trans., v. 37, pt. 1.

Harper, W. G.; and others, 1948, Soil survey of the Umatilla area, Oregon: U.S. Dept. Agriculture and Oregon Agr. Expt. Sta., series 1937, no. 21, 125 p., map.

Hedge, C. E.; Hildreth, R. A.; Henderson, W. T., 1971, Strontium isotopes in some Cenozoic lavas from Oregon and Washington (abs.): U.S. Geol. Abs. of North American Geology, p. 223.

Hodge, E. T., 1931, Exceptional moraine-like deposits in Oregon: Geol. Soc. Am. Bull., v. 42, p. 985-1010.

_____, 1932, History of Columbia River gorge (abs.): Pan-American Geologist, v. 57, no. 1, p. 62; (abs.) Geol. Soc. America Bull., v. 43, no. 1, p. 131-132.

_____, 1932, Geological map of north-central Oregon: Univ. Oregon Publication, Supplement to Geology series v. 1, no. 5, 7 p., scale 1:250,000.

_____, 1933, Age of Columbia River and lower canyon (abs.): Geol. Soc. America Bull., v. 44, no. 1, p. 156-157; (abs.) Pan-American Geologist, v. 58, no. 1, p. 70.

_____, 1938, Geology of the lower Columbia River: Geol. Soc. America Bull., v. 49, p. 831-930.

_____, 1942, Geology of north-central Oregon: Oregon State College Mon., Studies in Geology, no. 3, 76 p.

Hogenson, G. M., 1964, Geology and ground water of the Umatilla Basin, Oregon: U.S. Geol. Survey Water-Supply Paper 1620, 102 p., 16 illustrations.

Holmgren, D. A., 1969, Columbia River Basalt stratigraphic patterns near Yakima, and Columbia Gorge areas Washington and Oregon (abs.): Geol. Soc. America Abs. with Programs, part 3, Cordilleran Sect., p. 26.

_____, 1969c, Columbia River Basalt patterns from central Washington to northern Oregon: Univ. of Washington Ph.D. thesis, 55 p.; (abs.) Dissertation Abs. Internation, v. 31, no. 2, sec. B, p. 759.

Holmgren, D. A.; Gray, J., 1971, Geochronologic equivalence of type Picture Gorge basalt, central Oregon and type Yakima basalt, central Washington (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 2, p. 137.

Hooper, P. R.; Holden, G. S.; Kleck, W. D., 1973, Correlation and petrochemistry of the Columbia River Basalt flows in parts of west-central Idaho and northeastern Oregon (abs.): Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 56.

Hoover, Linn, Jr., 1951, A summary of the stratigraphy and structural geology of Oregon and Washington: Univ. of Michigan M.S. thesis, 50 p.

Irving, E.; Roy, J. L., 1968, Intensite et stabilite d'aimantation des basaltes de l'Oregon et Washington et leurs applications a l'expansion du fond de l'Ocean et a autres problemes geophysiques: Canadian Jour. Earth Sciences, v. 5, p. 907.

Kienle, Clive, 1971, The Yakima Basalt in western Oregon and Washington: Univ. of California at Santa Barbara Ph.D. thesis, 171 p.; (abs.) Geol. Soc. America Abs. with Programs, v. 4, no. 7, p. 561-562.

Kiver, E. P., 1973, Neoglaciation in the Wallowa Mountain, Oregon (abs.): Northwest Sci. Abs. of 46th annual meeting of Northwest Scientific Assoc.

Kleck, W. D., 1973, Geology of the Columbia River Basalts in and near the Imnaha River Valley, Oregon: Geol. Soc. America Abs. with Programs, v. 5, no. 1, p. 67-68.

Klock, G. O., 1969, Forest and range soils research in Oregon and Washington, a bibliography with abs. from 1964 through 1968: Pacific Northwest Forest and Range Experiment Station Report no. FSRP-PNW-90, 31 p.

Laursen, J. M.; Hammond, P. E., 1974, Summary of radiometric ages of Oregon and Washington rocks, through June 1972: Isochron West, no. 9, 32 p.

Lewis, P. F., 1960, Linear topography in the southwestern Palouse, Washington-Oregon: Assoc. Am. Geographers Annals, v. 50, no. 2, p. 98-111 incl. sketch maps, diagrams, and illus.

Lindsley, D. H., 1960, The geology of the Spray Quadrangle, Oregon, with special emphasis on petrography and magnetic properties of the Picture Gorge Basalt: The Johns Hopkins Univ., Baltimore, Ph.D. thesis.

Lowry, W. D.; Baldwin, E. M., 1952, Late Cenozoic geology of the lower Columbia River valley, Oregon and Washington: Geol. Soc. America Bull., v. 63, pt. 1, p. 1-24.

Mac Nish, R. D., 1976, Mathematical model of an aquifer system in the Columbia River Basalt Group in southeastern Washington and northeastern Oregon (abs.): Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 391-392.

McBirney, A. R.; Sutter, J. F.; Naslund, H. R.; Sutton, K. G.; White, C. M., 1974, Episodic volcanism in the central Oregon Cascade Range: Geology, v. 2, p. 585-589.

McDougall, Ian., 1976, Geochemistry and origin of basalt of the Columbia River Group, Oregon and Washington: Geol. Soc. America Bull., v. 87, no. 5, p. 777-792.

McKee, E. H.; Swanson, D. A.; Wright, T. L., 1977, Duration and volume of Columbia River basalt volcanics, Washington, Oregon, and Idaho (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 4, p. 463-464.

Merriam, J. C., 1901, A contribution to the geology of the John Day Basin: California Univ. Dept. Geol. Sci. Bull., v. 2, p. 269-314.

Monahan, C. J., 1962, John Day lock and dam: foundation investigations: Jour. Power Division, Proc. Soc. Civil Engrs., v. 3344, P04, p. 29-45.

_____, 1962, Geologic features at McNary Dam, Oregon-Washington: U.S. Army Corps Engrs. Pub., p. 33-38.

Morrison, R. F., 1961, Angular unconformity marks Triassic-Jurassic boundary in Snake River area of northeastern Oregon: The Ore Bin, v. 23, no. 11, p. 106-111.

_____, 1963, The Pre-Tertiary geology of the Snake River Canyon between Cache Creek and Dug Bar, Oregon-Idaho boundary: Oregon Univ. Ph.D. thesis, 195 p.

Nathan, S.; Fruchter, J. S., 1974, Geochemical and paleomagnetic stratigraphy of the Picture Gorge and Yakima Basalts (Columbia River Group) in central Oregon: Geol. Soc. America Bull., v. 85, p. 63-76.

Newcomb, R. C., 1951, Preliminary report on the ground water resources of the Walla Walla Basin, Washington-Oregon: U.S. Geol. Survey Open-File Report, Pl. 2, 1:95,040.

_____, 1961, Storage of ground water behind subsurface dams in the Columbia River Basalt, Washington, Oregon, and Idaho: U.S. Geol. Survey Prof. Paper 383-A, p. 1-15. Figure 1, 1:3,752,000.

_____, 1965, Geology and ground water resources of the Walla Walla River Basin, Washington-Oregon: Washington Div. Water Resources Water-Supply Bull. 21, 151 p. Plate 1, 1:95,040.

_____, 1966, Lithology and eastward extension of The Dalles Formation, Oregon and Washington: U.S. Geol. Survey Prof. Paper 550-D, p. 59-63. Figure 1, 1:1,267,200.

_____, 1967, The Dalles-Umatilla syncline, Oregon and Washington: U.S. Geol. Survey Prof. Paper 575-B, p. B88-93

_____, 1969, The Columbia River Group: Its tectonic structure in Washington, Oregon, and Idaho. In Gilmour, E. H., and Stradling, D., eds., Proceedings of the second Columbia River Basalt symposium: Cheney, Washington, Eastern Washington State College, p. 173-175.

_____, 1969, Effect of tectonic structure on the occurrence of ground water in the basalt of the Columbia River Group of The Dalles area, Oregon and Washington: U.S. Geol. Survey Prof. Paper 383-C, 33 p., 19 illustrations.

_____, 1970, Tectonic structure of the main part of the basalt of the Columbia River Group, Washington, Oregon, and Idaho: U.S. Geol. Survey Misc. Geol. Inv. Map I-587.

_____, 1971, Relation of the Ellensburg Formation to extensions of the Dalles Formation in the area of Arlington and Shutler Flat, north-central Oregon: The Ore Bin, v. 33, no. 7, p. 133-142.

_____, 1972, Quality of the ground water in basalts of the Columbia River Group, Washington, Oregon and Idaho: U.S. Geol. Survey Water-Supply Paper 1999-N, 71 p. Map 1:1,000,000.

Newton, V. C., Jr., 1969, Subsurface geology of the lower Columbia and Willamette basins: Oregon Dept. Geol. and Min. Ind., Oil and Gas Invest. no. 2, 121 p.

Niem, A. R.; Van Atta, R. O., 1973, Cenozoic stratigraphy of northwestern Oregon and adjacent southwestern Washington. In Beaulieu, John D., Geologic field trips in northern Oregon and southern Washington: Oregon Dept. Geology and Min. Ind. Bull. 77, p. 75-132.

Nolf, B., 1966, Structure and stratigraphy of part of the Northern Wallowa Mountains, Oregon: Princeton Univ. Ph.D. thesis, 138 p.

Norgren, J. A.; Borchardt, G. A.; Harward, M. E., 1970, Mount St. Helens Y ash in northeastern Oregon and south-central Washington (abs.): Northwest Sci., v. 44, no. 1, p. 66.

Palmer, Leonard, 1977, Large landslides of the Columbia River Gorge, Oregon and Washington. In Choates, D. C., ed., Landslides: Geol. Soc. America Case Histories in Engineering Geology, v. 11 (in press).

Peck, D. L.; Griggs, A. B.; Schlicker, H. G.; Wells, F. G.; Dole, H. M., 1964, Geology of the central and northern parts of the Western Cascade Range in Oregon: U.S. Geol. Survey Prof. Paper 449, 56 p.

Peck, D. L.; Wolfe, J. A.; Griggs, A. B., 1969, Remarks on Oregon Cascades in relation to Cenozoic stratigraphy by H. E. Wheeler and V. S. Mallory. In Gilmour, E. H., and Stradling, D., eds., Proceedings of the second Columbia River Basalt symposium: Eastern Washington State College Press, Cheney, Washington, p. 125-130.

Piper, A. M., 1932, Geology and ground water resources of The Dalles region, Oregon: U.S. Geol. Survey Water-Supply Paper 659B, p. 107-189.

Reidel, S. P., 1975, Pyroxene composition and subdivision of the Lower Yakima Basalt of the Columbia River Group in the Snake and Salmon River Canyons of Washington, Oregon, and Idaho: Geol. Soc. America Abs. with Programs, v. 7, no. 3, p. 364.

Reitman, Jan D., 1968, Remanent magnetization of the Columbia River Group in western Washington and Oregon (abs.): Eos (Am. Geophys. Union, Trans.), v. 49, no. 1, p. 127.

Robinson, P. T., 1969, High-titania alkali-olivine basalts of north-central Oregon, U.S.A.: Contr. Mineral. and Petrol. 22, 349-360.

_____, 1975, Reconnaissance geologic map of the John Day Formation in the southwestern part of the Blue Mountains and adjacent areas, north-central Oregon: U.S. Geol. Survey Misc. Invest. Ser., no. 1-872, Geol. map 1:125,000.

Ross, M. E., 1975, The structure of Yakima basalts in a portion of the Grand Ronde River region of northeastern Oregon and southeastern Washington (abs.): Geol. Soc. America Abs. with Programs, v. 7, no. 5, p. 638-639.

Russell, I. C., 1901, Geology and water resources of Nez Perce County, Idaho: U.S. Geol. Survey Water-Supply Paper 53, p. 28.

Shannon and Wilson, Inc., 1976, 1872 earthquake, new data from Oregon: Report to Portland General Electric Co., Portland, Oregon.

Smedes, H. W., 1959, Geology of part of the northern Wallowa Mountains: Univ. of Washington Ph.D. thesis.

Smith, W. D.; Allen, J. E., 1941, Geology and physiography of the northern Wallowa Mountains, Oregon: Oregon Dept. Geology and Min. Ind. Bull. 12, 64 p., 16 figs.

Snavely, P. D.; Wagner, H. C., 1962, Recent petroleum developments in Oregon and Washington (abs.): Oil and Gas Jour., p. 109.

_____, 1963, Tertiary geologic history of western Oregon and Washington: Washington Div. Mines and Geology Report Invest. 22, 25 p.

Snavely, P. D.; MacLeod, N. S.; Wagner, H. C., 1971, Consanguinity of Miocene basalts in coastal Oregon and Washington and on the Columbia Plateau (abs.): Geol. Soc. America Abs. with Programs, v. 3, no. 2, p. 197-198.

_____, 1973, Miocene tholeiitic basalt of coastal Oregon and Washington and its relation to coeval basalts of the Columbia Plateau: Geol. Soc. America Bull., v. 84, no. 2, p. 387-424.

Suchanek, Ron, 1974, The Columbia River Gorge; the story of the river and the rocks: The Ore Bin, v. 36, no. 12, p. 197-214, illus. (incl. sketch map).

Suppe, John; Powell, Christine; Berry, Robert, 1975, Regional topography, seismicity, Quaternary volcanism, and the present-day tectonics of the western United States: Am. Jour. Sci., 275-A, p. 397-436.

Swanson, D. A.; Robinson, P. T., 1968, Base of the John Day Formation in and near the Horse Heaven mining district, north-central Oregon: U.S. Geol. Survey Prof. Paper 600D, p. D154-D161.

Swanson, D. A.; Wright, T. L.; Zietz, I., 1976, Geologic interpretation of a aeromagnetic map of the west-central Columbia Plateau, Washington and Oregon: U.S. Geol. Survey Open-File Report 76-51, 28 p., 1 Plate, 3 Figures.

_____, (in press), Geologic interpretation of an aeromagnetic map of the west-central Columbia Plateau, Washington and Oregon: U.S. Geol. Survey G. P. 917.

Taubeneck, W. H., 1963, Wallawa Mountain uplift, northeastern Oregon; Geol. Soc. America Spec. Paper 73, 97 p.

_____, 1969, Feeder dikes of Columbia River Basalt in northeastern Oregon, western Idaho, and southeastern Washington (abs.): Northwest Sci., v. 43 no. 1, p. 43.

_____, 1970, Dikes of Columbia River Basalt in northeastern Oregon, western Idaho, and southeastern Washington. In Gilmour, E. H., and Strading, D., eds., Proceedings of the second Columbia River Basalt symposium: Cheney, Washington, Eastern Washington State College, p. 73-96.

Thayer, T. P.; Ray, R. L., 1950, Preliminary notes on later Miocene volcanism in the John Day region, Oregon: Northwest Sci., v. 24, no. 2, p. 89-90.

Thayer, T. P., 1957, Some relations of later Tertiary volcanology and structure in eastern Oregon. In Tomo 1 of Vulcanologia del Cenozoico: Internat. Geol. Cong., 20th, Mexico, D. F., 1956 (Trabajos), sec. 1, p. 231-245, illus. inc. geol. map.

Thayer, T. P.; Brown, C. E., 1964, Pre-Tertiary orogenic and plutonic intrusive activity in central and northeastern Oregon: Geol. Soc. America Bull., v. 75, p. 1255-1262.

_____, 1966, Local thickening of basalts and late Tertiary silicic volcanism in the Canyon City quadrangle, northeastern Oregon: U.S. Geol. Survey Prof. Paper 550C, p. C73-C78.

Trauba, W. C., 1975, Petrography of pre-Tertiary rocks of the Blue Mountains, Umatilla County, northeast Oregon: Oregon State Univ. M.S. thesis.

Trimble, D. E., 1957, Geology of the Portland quadrangle, Oregon-Washington: U.S. Geol. Survey Geol. Quad. Map GQ-104, 1:62,500.

_____, 1963, Geology of Portland, Oregon, and adjacent areas: U.S. Geol. Survey Bull. 1119, 119 p. Plate 1, 1:62,500.

Uppuluri, V. R., 1973, A stratigraphic and compositional study of basalts of the Columbia River Group near Prineville, central Oregon: Univ. of Oregon M.S. thesis, 87 p.

Vallier, T. L., 1967, The geology of part of the Snake River canyon and adjacent areas in northeastern Oregon and western Idaho: Oregon State Univ. Ph.D. thesis, 267 p., 3 pls., 57 figs.

_____, 1974, A preliminary report on the geology part of the Snake River Canyon, Oregon and Idaho: Oregon Dept. of Geology and Min. Ind. Geol. Map series 6, p. 7.

_____, 1976, Pre-Tertiary stratigraphy in the Snake River canyon and adjacent Seven Devils and Wallowa Mountains, northeastern Oregon and western Idaho: Geol. Soc. America Abs. with Programs, v. 8, no. 3, p. 417.

Wagner, N. S., 1958, Important rock units of northeastern Oregon: The Ore Bin, v. 20, no. 7, p. 63-68, map.

Walker, G. W., 1969, Some comparisons of basalts of southeast Oregon with those of the Columbia River Group. In Gilmour, E. H., and Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College Press, Cheney, p. 223-238.

Walker, G. W.; King, P. B., 1969, Geologic map of Oregon: U.S. Geol. Survey Misc. Geol. Invest. Map I-595.

Walker, G. W., 1973, Contrasting compositions of the youngest Columbia River Basalt flows in Union and Wallowa counties of northeastern Oregon: Geol. Soc. America Bull., v. 84, no. 2, p. 425-430.

Washington State Univ. Geology Dept., Field Trip to the Northern Wallowa Mountains, 10 p.

Waters, A. C., 1958, Part of the Columbia River gorge: U.S. Geol. Survey unpublished map, 1:125,000 (based in part on independent work by A. C. Waters).

_____, 1963, The Columbia River Basalt of Washington, Oregon, and Idaho: The XI Transactions of Sigma Gamma Epsilon, XI chapter, Washington State Univ., v. 1, no. 1, p. 1-6.

_____, 1973, The Columbia River Gorge--Basalt stratigraphy, ancient lava dams, and landslide dams. In Beaulieu, J. D., Chairman, Geologic field trips in northern Oregon and southern Washington: Oregon Dept. of Geology and Min. Ind. Bull. 77, p. 133-162.

Watkins, N. D., 1964, A paleomagnetic survey of Miocene lavas in northern Oregon, southeastern Washington, and west-central Idaho (abs.): Am. Geophys. Union, Trans., v. 45, no. 1, p. 37.

_____, 1964, Structural implications of paleomagnetism in Miocene lavas of northeastern Oregon, southeastern Washington and west-central Idaho: Nature, v. 203, no. 4947, p. 830-832.

_____, 1965, Frequency of extrusions of some Miocene lavas in Oregon during an apparent transition of the polarity of the geomagnetic field: Nature, v. 206, no. 4986, p. 801-803, illus., table.

Watkins, N. D.; Wilson, R. D., 1965, Investigation of the possiblity of petrological control of magnetic polarity in some Miocene lavas of the Columbia Plateau (abs.): Geol. Soc. America Spec. Paper 82, p. 286-287.

Watkins, N. D.; Baksi, A. K., 1974, Magnetostratigraphy and oroclinal folding of the Columbia River, Steens and Owyhee Basalts in Oregon, Washington and Idaho: Am. Jour. Sci., v. 274, p. 148-189.

Weaver, C. E., 1945, Geology of Washington and Oregon and its relation to occurrence of oil and gas: Am. Assoc. Petroleum Geologists Bull., v. 29, no. 10, p. 1377-1415, illus. index maps.

Wells, F. G.; Peck, D. L., 1961, Geologic map of Oregon, west of the 121st meridian: U.S. Geol. Survey Misc. Geol. Invest. Map I-325, scale 1:500,000.

Wheeler, H. E.; Coombs, H. A., 1967, Late Cenozoic Mesa Basalt sheet in northwestern United States: Bull. Volcanologique, v. 31, p. 21-44 (Rome).

Wheeler, H. E.; Mallory, V. S., 1969, Oregon Cascades in relation to Cenozoic stratigraphy. In Gilmour, E. H., and Stradling, D., eds., Proceedings of the Second Columbia River Basalt Symposium: Eastern Washington State College, Press, Cheney, p. 97-124.

Williams, Howell, 1957, A geologic map of the Bend quadrangle, Oregon, and a reconnaissance geologic map of the central portion of the High Cascade Mountains (1:125,000): Oregon Dept. Geology and Mineral Industries.

Williams, I. A., 1916, The Columbia Gorge: Its geologic history interpreted from the Columbia River Highway: Min. Res. Oregon, Oregon Bur. Mines and Geol., v. 2, no. 3, 130 p.

BIBLIOGRAPHIES OF COLUMBIA BASIN GEOLOGY

Abstracts of research, 1971, Univ. Washington, Dept. of Geological Sciences, Abs. Res., v. 1971, 65 p.

Abstracts of research, 1972, Univ. Washington, Dept. of Geological Sciences, Abs. Res., v. 1972, 44 p.

Abstracts of research, 1973, Univ. Washington, Dept. of Geological Sciences, Abs. Res., v. 1973, 42 p.

Abstracts of research and annual report, 1974: Univ. Washington Dept. Geological Sciences, 47 p.

Arnold, Ralph, 1902, Bibliography of the literature referring to the geology of Washington: Washington Geological Survey Annual Report, Part 6, 16 p.

Bennett, W. A. G., 1939, Bibliography and index of geology and mineral resources of Washington 1814-1936: Washington Dept. Conserv. and Dev., Div. Geology, Bull. 35, 140 p.

Boardman, Leona, 1949, Geologic map index of Washington: U.S. Geol. Survey, 1:750,000.

Brown, R. E., 1959, Bibliography of the geology of south-central Washington and pertinent adjacent areas: Hanford Works unclassified report HW-51030, Revision 1, 21 p.

Daubenmire, R., 1962, Vegetation of the State of Washington: A Bibliography: Northwest Sci. v. 36, no. 2, p. 50-54.

___, 1977, A bibliography on vegetation of the State of Washington: Supplement 1: Northwest Sci. v. 51, no. 2, p. 111-113.

Kirkham, V. R. D., 1927, Abstract of important papers dealing with the geology of the Inland Empire and adjacent country (Idaho-Washington): Northwest Sci., v. 1, no. 2, p. 30-33.

_____, 1927, Bibliography of chief publications on the geology and geography of the Inland Empire (Idaho-Washington): Northwest Sci., v. 1, no. 2, p. 33-38.

Reichert, W. H., 1960, Bibliography and index of the geology and mineral resources of Washington, 1937-1956: Washington Div. Mines and Geology, Bull. 46, 721 p.

_____, 1969, Compilation of geologic mapping in Washington through 1968—A continuation of Leona Boardman's index to geologic mapping in Washington; also, geologic maps from theses on Washington geology: Washington Div. Geology and Earth Resources Open-File Report, 43 p.

_____, 1974, List of theses that deal with the geology and mineral resources of Washington: Washington Div. Geology and Earth Resources Open-File Report, 63 p.

_____, 1976, Selected geologic reports of Washington for the period 1969 through 1976: Washington Div. Geology and Earth Resources Open-File Report, 19 p.

U.S. Geological Survey, 1975, Index to topographic maps of Washington: U.S. Geol. Survey index map 1:1,000,000.

ADDITIONAL REFERENCES - BIBLIOGRAPHIES OF COLUMBIA BASIN GEOLOGY

Fischer, A. H., 1918, A summary of mining and metalliferous resources in the State of Washington, with a bibliography: Univ. of Washington M.S. thesis, 170 p.

Pestana, H. R., 1972, Bibliography of Congressional geology: Hafner Pub. Co., New York, 285 p.

Washington Division of Geology & Earth Resources, 1978, Open-File reports: Washington Department of Natural Resources, listing, May, 1978, Olympia.

RADIOACTIVE WASTE DISPOSAL INVESTIGATIONS

Angino, Ernest E., 1977, High-level and long-lived radioactive waste disposal: Science, v. 198, no. 4320, p. 885-890.

Atlantic Richfield Hanford Company, Research and Engineering Division, 1976, Preliminary feasibility study on storage of radioactive wastes in Columbia River basalts, two volumes (prepared for U.S. Energy Research and Development Administration, under Contract E(45-1)-2130): Atlantic-Richfield Hanford Co., Richland, Washington, v. 1, 168 p.; Vol. 11 consists of four appendices individually paged.

Bishop, W. P.; Hollister, C. D., 1975, A program on the ocean basin floors and radioactive materials—Data basis for assessing preliminary concepts: Report SLA-73-0596, Sandia Laboratories, Albuquerque, NM.

Blume, John A. and Associates, 1971, Seismic analysis of underground waste storage tanks 241-Az-101 and -102 at Hanford, Washington: John A. Blume and Associates, Engineers, San Francisco, Report JABE-ARHCO-01, 75 p.

_____, 1972, Phase II seismic review—Waste storage tank ventilation system, 241-a-farm, Hanford, Washington: John A. Blume and Associates, Engineers, San Francisco, Report JABE-ARHCO-01, 29 p.

_____, 1974, Analysis of underground waste storage tanks 241-Sy at Hanford, Washington: John A. Blume and Associates Research Div., Report ARH-R-172, San Francisco, 97 p.

Brookins, D. G., 1977, Prediction of radioactive element behavior in aqueous systems from Eh-pH diagrams (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 911.

Brown, D. J.; Brown, R. E.; Haney, W. A., 1962, Appraising Hanford waste disposal by integration of field techniques (abs.): Am. Geophys. Union Trans., v. 43, no. 4, p. 453.

Brown, G. D.; McConiga, M. W., 1960, Inventory, radioactive liquid wastes to ground, 200 areas, 1945-1959—Hanford Atomic Products Operation Report HW-66147. Updated by W. A. Haney in July 1961.

Brown, R. E., 1957, Determination of the geological conditions at Hanford regulating the ground disposal of radioactive liquid wastes (abs.): Am. Geophys. Union Trans., v. 38, no. 3, p. 269.

Brown, R. E.; Bierschenk, W. H., 1958, Geologic and hydrologic guides to the ground containment and control of wastes at Hanford: (Presented at the Nuclear Engineering and Science Conference, March 1958, Chicago, IL). Published by the American Institute of Chemical Engineers, New York, N. Y., 12 p.

Brown, R. E., 1959, The rate of land usage at Hanford for waste disposal (A guide for future disposal plans): Hanford Atomic Products Operation Report HW-60450.

Brown, R. E.; and others, 1958, Experience in the disposal of radioactive wastes to the ground at two production sites (South Carolina and Washington). In United Nations Waste treatment and environmental aspects of atomic energy: Internat. Conf. Peaceful Uses Atomic Energy, 2d Geneva, Sept. 1958, Proc., v. 18, p. 95-100, illus.

Brown, R. E., 1957, Role of geology at the Hanford Works, Washington (abs.): Geol. Soc. America Bull., v. 67, no. 12, pt. 2, p. 1762, 1956; Am. Geophys. Union Trans., v. 38, no. 2, p. 269.

Brown, R. E.; McConiga, M. W.; Rowe, P. P., 1956, Geological and hydrological aspects of the disposal of liquid radioactive wastes (Washington): U.S. Atomic Energy Comm. Report TID-7517 (pt. 1b), p. 413-425, p. 503.

Brown, R. E., 1960, Desirable new geologic research in support of radioactive waste disposal as indicated by Hanford (Washington) experience. In Disposal of radioactive wastes, v. 2: Internat. Atomic Energy Agency, Sci. Conf. on Disposal of Radioactive Wasters, Monaco, Nov. 16-21, 1959, Proc., v. 2.

Brown, R. E.; Raymond, J. E., 1962, The measurement of Hanford's geohydrologic features affecting waste disposal. In Second Ground Disposal of Radioactive Wastes Conference, Atomic Energy of Canada Limited, Chalk River Canada, 1961: U.S. Atomic Energy Comm., Div. Tech. Inf. Report TID-7628, Book 1, p. 77-98.

Cook, N. G. W., 1977, Rock mechanics problems of an underground repository (abs): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 933.

Deju, R. A., 1976, Feasibility of storing radioactive wastes in Columbia River Basalts: Atlantic-Richfield Hanford Co., Report ARH-SA-281, 6 p.

Dillon, R. T.; Pearson, F. J., 1977, Development of a methodology for risk analysis of the disposal of high-level radioactive wastes (abs): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 950.

Final Environmental Statement, Waste Management Operations, Richland, Washington: U.S. Energy Research and Development Administration, v. 2, Appendix II.3-B and II.3-C.

Foster, R. F., 1972, The history of Hanford and its contribution of radionuclides to the Columbia River. In The Columbia River estuary and adjacent ocean water; bioenvironmental studies, p. 3-18.

Fyfe, W. S., 1977, Container stability and permeability control (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 983.

Hess, H. H.; Thurston, W. R., 1958, Disposal of radioactive waste on land: Am. Geophys. Union Trans., v. 39, no. 3, p. 467-468.

Housner, G. W., 1967, Recommended seismic design criteria for Hanford nuclear facility—revised: Douglas United Nuclear Report, DUN-3130, 26 p.

Irish, E. R., 1961, A comparison of ground waste disposal status at Hanford, 1959-1961: Hanford Atomic Products Operation unclassified report HW-SA-2236, 15 p.

Linderoth, C. E.; Pearch, D. W., 1959, Waste disposal to ground, operating practices and experiences at Hanford: Waste Disposal Conference, Berkeley, Aug. 1959.

Lomenick, T. F., 1977, Geologic investigations of the National Waste Terminal Storage Program (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1073.

Maini, Tidu, 1977, Experimental and field observations of transport in fractured media and their relevance to potential high level radioactive repositories (abs.): Geol. Sco. America Abs. with Programs, v. 9, no. 7, p. 1083.

Marine, I. W., 1977, The use of helium to estimate ground-water velocities for studies of geologic storage of radioactive waste (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1085.

McHenry, J. R.; Honstead, J. F., 1957, Evaluation of sites for the disposal of radioactive waste solutions: Hanford Atomic Products Operation Report HW-53219.

Mercer, J. W.; Faust, C. R., 1977, Analysis of fluid flow and heat transport associated with level radioactive waste disposal (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1093.

Morgan, J. M., Jr.; and others, 1963, Ground disposal of radioactive wastes, Second Conference Proceedings (Held at Atomic Energy of Canada Ltd., Chalk River Canada, 1961), (abs.): Geoscience Abs., v. 5, no. 5, p. 69-70.

National Academy of Sciences, 1970, Disposal of solid radioactive wastes in bedded salt deposits: Committee on Radioactive Waste Management, National Acad. Sci. National Research Council, Washington, D. C.

Nelson, J. L., 1959, Recent studies at Hanford on soil and mineral reactions in waste disposal: Proc. of Conf. on Ground Disposal of Radioactive Wastes, Berkeley, p. 70-82.

Nelson, J. L.; Ames, L. L., 1961, Mineral reactions with radioactive waste solutions: Proc. of the Tenth Pacific Northwest Industrial Waste Conference.

Newcomb, R. C., 1973, Requirements of an optimum site for subsurface storage or disposal of radioactive wastes: Assoc. Eng. Geol. Bull., 10, no. 3, p. 219-230.

Parker, G. G.; Piper, A. M., 1949, Geologic and hydrologic features of the Richland area, Washington, relevant to the disposal of waste at the Hanford Operations: U. S. Atomic Energy Commission Hanford Works unclassified report GEH-15045, 101 p.

Parker, H. M., 1959, Hanford radioactive waste management: Hearings, Special Subcom., Joint Com., Atomic Energy, Radioactive Waste Disposal, 1:202-241.

Perkins, R. W., 1963, Effect of a reactor fuel element failure on the Columbia River radionuclide concentrations at Pasco, Washington: Hanford Atomic Products Operation Report HW-77609, p. 3.68.

Pinder, G. F.; O'Neill, K., 1977, Species transport in fractured porous media (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1131

Price, S. M.; Ames, L. L., 1976, Characterization of actinide-bearing sediments underlying liquid waste disposal facilities at Hanford. In Transuranium nuclides in the environment (anonymous), p. 191-211, illus. (incl. tables), IAEA, Vienna, Austria, 1976.

Roedder, E. W., 1957, Report on twelve samples of sediments from the Hanford site: U.S. Geol. Survey informal report to D. W. Pearch, General Electric Co.

Schneider, K. J.; Platt, A. M., eds., 1974, High-level radioactive waste management alternatives, sections 1-6: Report BNWL-1900, Battelle Pacific Northwest Laboratories, Richland, Washington, v. 1-3.

Schwendiman, L. C., 1960, Disposal of industrial radioactive waster water at Hanford (Washington). In Symposium on technical developments in the handling and utilization of water and industrial waste waters: Am. Soc. Testing Materials Spec. Tech. Pub. 273, p. 3-21.

Theis, C. V., 1956, Disposal of nuclear waste underground (abs.). In New Mexico Geol. Soc. Guidebook, 10th Field Conf., 1959, p. 161.

_____, 1956, A review of the ground-water geology of the major waste-producing sites: U.S. Atomic Energy Comm. Report TID-7517 (pt. 1a), p. 116-131, incl. cross-sections and sketch map.

Towse, D., 1977, A computer simulation model of a nuclear waste facility (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1204.

Watson, D. G.; Cushing, C. E; Coutant, C. C.; and others, 1971, Cycling of radionuclides in Columbia River biota (with discussion). Trace Subst. Environ. Health, Proc., no. 4, p. 144-157, illus. (incl. sketch map).

Winograd, I. J., 1974, Radioactive waste storage in the arid zone: EOS Trans. Am. Geophys. Union, v. 55, no. 10, p. 884-894.

_____, 1977, Geologic containment of high-level radioactive wastes—What time frames are pertinent and predictable? (abs.): Geol. Soc. America Abs. with Programs, v. 9, no. 7, p. 1231.

Zeller, E. J.; Saunders, D. F.; Angino, E. E., 1973, Putting radioactive wastes on ice—A proposal for an international radionuclide depository in Antarctica: Bull. of Atomic Scientists, v. 29, no. 1, p. 4-9, 50-52.

ADDITIONAL REFERENCES - RADIOACTIVE WASTE DISPOSAL INVESTIGATIONS

Brown, R. E.; Ruppert, H. G., 1948, Underground waste disposal at Hanford Works: Hanford Atomic Products Operation Rept. HW-9671.

Cohen, B. L., 1977, The disposal of radioactive wastes from fission reactors: Sci. Am., June 1977, p. 21-31.

Deju, R. A.; Eddy, P. A.; Grutzeck, M. W.; Myers, C. W.; 1977, Environmental factors needed to establish the geotechnical feasibility of storing radioactive waste in Columbia River Basalt: Rockwell-Hanford Operations Rept. RHO-ST-8, 114 p.

Deju, R. A., 1978, Basalt Waste Isolation Program Monthly Reports (Report RHO-BWI-78-100 FEB, for February 1978): Rockwell-Hanford Operations, Waste Isolation Program.

Hambleton, W., 1972, The unsolved problem of nuclear wastes: Technology Review, p. 15-19, March-April, 1972.

Marsily, G.; Ledoux, E.; Barbreau, A.; Margat, J., 1977, Nuclear waste disposal: can the geologist guarantee isolation?: Science, v. 197, p. 519-527, August 1977.

McCarthy, G. J., 1977, High-level waste ceramics: materials considerations, process simulation and product characterization: Nuclear Technology, v. 32, p. 92-105.

National Academy of Sciences, 1957, Disposal of radioactive wastes on land: National Acad. Sci., National Research Council, Publication 519, Washington, D. C.

National Academy of Sciences, 1978, Radioactive wastes at the Hanford Reservation, a technical review: National Academy of Sciences National Research Council Committee on Radioactive Waste Management report, 269 p., Washington, D. C.

Nuclear Regulatory Commission, 1976, Final generic environmental statement on the use of recycled plutonium in mixed oxide fuel in light-water cooled reactors: (NUREG-0002) U.S. Nuclear Regulatory Commission, Washington, D. C., Aug., 1976.

O'Connell, M. F.; and Holcomb, W. F., 1974, A summary of low-level radioactive waste buried at commercial sites between 1962-1973, with projection to the year 2000: EPA, Radiation Data and Reports, v. 15, no. 12.

Potomac Research Inc., 1978, Workshops for state review of site suitability criteria for high-level radioactive waste repositories, analysis and recommendations: Potomac Res. Inc., Report NUREG-0354, v. 1 and 2, prepared for U.S. Nuclear Regulatory Comm.

Robertson, J. B., 1974, Digital Modeling of radioactive and chemical waste trnasport in the aquifer underlying the Snake River Plain at the National Reactor Testing Station, Idaho: U.S. Geol. Survey Open-file rept. 19 p.

Staff, Department of Waste Isolation, 1977, Basalt Waste Isolation Program Annual Report: Rockwell-Hanford Operations Rept. RHO-ST-9, 56 p.

The Comptroller General of the United States, 1976, Report to the Congress, Improvements needed in the land disposal of radioactive wastes - a problem of centuries, RED-76-54.

The Comptroller General of the United States, 1977, Report to the Congress, Nuclear energy's dilemma: disposal of hazardous radioactive waste safely, EMD-77-41.

U.S. Atomic Energy Commission, 1973, Radioactive Waste Management: Atomic Energy Commission Manual, Chapter 0511 with Appendix, Washington, D. C., U.S. Government Printing Office.

U.S. Energy Research and Development Administration, 1974, Hanford Waste Management Operations Draft Environmental Impact Statement: Rept. WASH-1538, Springfield, Va.; National Technical Information Service.

U.S. Energy Research and Development Administration, 1975, Final Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington: ERDA-1538, v. 1 and 2, Springfield, Va.; National Technical Information Service.

U.S. Energy Research and Development Administration, 1976, Technical alternatives document, alternatives for managing waste from reactors and port-fission operations in the LWR fuel cycle: ERDA document 76-43, May 1976, Washington, D.C.

U.S. Energy Research and Development Administration, 1977, Alternatives for Long-Term Management of Defense High-Level Waste, Savannah River Plant: ERDA 77-42, Springfield, Va.; National Technical Information Service.

U.S. Energy Research and Development Administration, 1977, Alternatives for Long-Term Management of Defense High-Level Radioactive Waste, Hanford Reservation: ERDA 77-44, Springfield, Va., National Technical Information Service.

Wodrich, D. D., 1976, Hanford Long-Term High-Level Waste Management Program. Presented to the Hanford Panel, Committee on Radioactive Waste Management, NAS-NAE-NRC, Richland, Wash.; June 24, 1976. ARH-LD-142, Richland, Wash.; Atlantic Richfield Hanford Company.

Zerby, C. D.; Asher, J. M., (ed.), 1978, National waste terminal storage program progress report, for period October 1, 1976, to September 30, 1977: Union Carbide Corp. - Nuclear Div. Rept. Y/OWI-9, prepared for U.S. Dept. of Energy, 403 p., Oak Ridge, Tennessee.

Apps, J.A., 1977, Waste isolation safety assessment program. Collection and generation of transport data, IN National Waste Terminal Storage Program Conference on Waste-Rock Interactions, July 6-7, 1977: Pennsylvania State Univ., Materials Research Lab. Rept. Y/OWI/SUB-77/14268, p. 21-22.

Bloomeke, J.O.; Kee, C.W., 1976, Projections of wastes to be generated, In Proceedings of the International Symposium on the Management of Wastes from the LWR Fuel Cycle, Denver, Colorado, July 11-16, 1976: U.S. Energy Research and Devel. Adm. Rept. CONF-76-0701, p. 96-117.

Boffy, P.M., 1975, Radioactive waste site search gets into deep water: Science, v. 190, no. 4212, p. 361.

Breckhoeft, J.D.; England, A.W.; Stewart, D.B.; Trask, N.J.; Winograd, I.J., 1978, Geologic disposal of high-level radioactive wastes-Earth science perspectives: U.S. Geol. Survey, Circular 779, 15 p.

Brunton, G.D.; Laughon, R.B.; McClain, W.C., 1978, Screening specifications for bedded salt, Salina Basin, New York and Ohio: Union Carbide Corp., Nuclear Div., Offices of Waste Isolation Rept. Y/OWI/TM-54, 11 p.

Gera, Ferruccio, 1975, Geochemical behavior of long-lived radioactive wastes: U.S. Energy Research and Devel. Adm., Oak Ridge Natl. Lab., Rept. ORNL-TM-4481, 99 p.

Gera, Ferruccio; Jacobs, D.G., 1972, Considerations in the long-term management of high-level radioactive wastes: U.S. Atomic Energy Comm., Oak Ridge Natl. Lab., Rept. ORNL-4762, 151 p.

Katayama, Y.B., 1976, Leaching of irradiated LWR fuel pellets in deionized and typical ground water: Battelle Mem. Inst., Pacific Northwest Lab. Rept. BNWL-2507, 78 p.

Kisner, R.A.; Marshall, J.R.; Turner, D.W.; Vath, J.E., 1978, Nuclear waste projections and source-term data for FY 1977: Union Carbide Corp., Nuclear Div., Office of Waste Isolation Rept. Y/OWI/TM-34, 84 p.

Pigford, T.H.; Choi, Jor-Shan, 1976, Effect of fuel cycle alternatives on nuclear waste management, IN Post, R.G., ed., Proceedings of the Symposium on Waste Management, Tuscon, AZ, October 3-6, 1976: U.S. Energy Research and Devel. Adm. Rept. CONF-761020, p. 39-57.

Ramspott, L.D.; Borg, I.Y., 1977, Underground nuclear tests below the water table as waste disposal pilot plants (abs.): Geol. Soc. Am. Abs. with programs, v. 9, no. 7, p. 1136.

Ratigan, J.L., 1976, Preliminary analysis of the potential for thermally induced rock fracture around high level waste containers: Union Carbide Corp., Nuclear Div.,Office of Waste Isolation Rept. ORNL/SUB-4269/20, 49 p.

Union Carbide Corporation, Nuclear Division, Office of Waste Isolation, 1977, Summary review of Workshop on Movement of Fluids in Largely Impermeable Rocks: Union Carbide Corp., Nuclear Div., Office of Waste Isolation Rept. Y/OWI/SUB-77/14223, 57 p.

Union Carbide Corporation, Nuclear Division, Office of Waste Isolation, 1978, Office of Waste Isolation Progress Report, April 1978: Union Carbide Corp., Nuclear Div., Office of Waste Isolation Rept. Y/OWI/TM-43/7, 54 p.

Yardly, D.H.; Goldich, S.S., 1975, Preliminary review of Precambrian shield rocks for potential waste repository: Union Carbide Corp., Nuclear Div.,Office of Waste Isolation Rept. Y/OWI/SUB-4367/2, 43 p.

APPENDIX A

COMPILATION OF GEOLOGIC MAPPING IN THE COLUMBIA BASIN AND SURROUNDING AREAS OF WASHINGTON

This compilation of pertinent geologic mapping in the Columbia Basin of Washington was prepared by the Washington Division of Geology and Earth Resources (WDGER), in partial fulfillment of a contract with the U.S. Department of Energy, administered by Rockwell International, Rockwell-Hanford Atomic Products Operation, Richland, Washington. The contract is part of a study to determine the feasibility of interring nuclear wastes within the Columbia River Basalt Group. This study, the Basalt Waste Isolation Program, is to examine the stratigraphic, structural, seismic, tectonic, and hydrologic environment of the Columbia Basin, to provide criteria for possible site selection of a waste repository.

The entries in this compilation represent all published, unpublished and open-file reference material containing geologic maps dealing with the geology of the Columbia Basin that were available to the authors. The services of the WDGER and the Washington State Library were utilized in this compilation.

The authors relied heavily on Leona Boardman's Index to Geologic Mapping in Washington, and William H. Reichert's Compilation of Geologic Mapping in Washington through 1968, although several maps from these sources were not included because they were outdated, schematic, involved too small a scale, or have been superseded by a published geologic map of the same area. A separate list of these excluded map references is attached (see pages 428-435).

Other compilations of Columbia Basin geologic data will follow this one, including: geophysical surveys; locations of stratigraphic cross-sections and columnar sections; location of oil and gas wells; locations of tunnels, trenches and other excavations in the basalt; and geographic localities where specific types of geologic data have been collected (e.g. type localities, chemical analyses, paleomagnetic analyses, radiometric dates, and petrographic descriptions).

The index maps for this compilation have been produced from Army Map Service $1^{o} \times 2^{o}$ quadrangle sheet base maps at a scale of 1:250,000, and include the following:

MAP SHEET	BASE MAP
A	Okanogan
B	Ritzville
C	Spokane
D (3 sheets)	Wenatchee
E	Yakima
F	Walla Walla
G	Pullman
H	The Dalles
I	Pendleton

The references used in the formulation of the index maps are keyed by an alpha-numeric system to both the index maps and the Bibliography

of the Geology of the Columbia Basin and Surrounding Areas of Washington with Selected References to Columbia Basin Geology of Idaho and Oregon, WDGER Open-File Report 78-3, which preceded this compilation. For example, the study area to which the third reference listed in this compilation (Hanson, L.G., 1970) pertains, would be found on Index Sheet A, the Okanogan sheet, and would be the area indicated by the number (3).

Some mapping in this compilation was derived from WDGER field maps on file in the Division library. While many of these maps do not have a known author or date, and remain unpublished, they are valuable reference material and were therefore made available to field mappers associated with the Basalt Waste Isolation Program.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
A	1	-	Okanogan	Hougland, Everett, date unknown, Geology of part of the Okanogan quadrangle: Washington Div. Geology and Earth Resources unpublished map, 1:125,000.
A	2	300	Okanogan	Jones, F. O., 1961, Landslides along the Columbia River valley, northeastern Washington: U.S. Geol. Survey Prof. Paper 367, 98 p. Plate 1, 1:9,600; Plate 3, 1:31,680; Plate 5, 1:31,680; Plate 6, 1:31,680.
A	3	207	Okanogan	Hanson, L. G., 1970, The origin and development of Moses Coulee and other scabland features of the Waterville Plateau, Washington: Univ. of Washington Ph.D. thesis, 140 p. Map 1:633,600.
A	4	328, 343	Okanogan	Pardee, J. T., 1918, Geology and mineral deposits of the Colville Indian Reservation, Washington: U.S. Geol. Survey Bull. 677, 186 p. Plate 7, 1:62,500.
A	6	328, 343	Okanogan	Pardee, J. T., 1918, Geology and mineral deposits of the Colville Indian Reservation, Washington: U.S. Geol. Survey Bull. 677, 186 p. Plate 9, 1:62,500.
A	7	328, 343	Okanogan	Pardee, J. T., 1918, Geology and mineral deposits of the Colville Indian Reservation, Washington: U.S. Geol. Survey Bull. 677, 186 p. Plate 10, 1:62,500.
A	13	323, 334	Okanogan	Campbell, Ian; Loofbourow, J. S., Jr., 1962, Geology of the magnesite belt of Stevens County, Washington: U.S. Geol. Survey Bull. 1142-F, 53 p. Plate 1, 1:36,000.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
A	14	334	Okanogan	Campbell, A. B.; Raup, O. B., 1964, Preliminary geologic map of the Hunters quadrangle, Stevens and Ferry Counties, Washington: U.S. Geol. Survey Mineral Investigations Field Studies Map FM-276, 1:48,000.
A	17	334	Okanogan	Becraft, G. E., 1966, Geologic map of the Wilmont Creek quadrangle, Ferry and Stevens Counties, Washington: U.S. Geol. Survey Geologic Quadrangle Map GQ-538, 1:62,500.
A	19	347	Okanogan	Waitt, R. B., 1972, Geomorphology and glacial geology of the Methow drainage basin, eastern North Cascade Range, Washington: Univ. of Washington Ph.D. thesis, 154 p., 1:633,600.
B	20	339	Ritzville	Hopson, C. A., 1955, Petrology and structure of the Chelan batholith near Chelan, Washington: Johns Hopkins Univ. Ph.D. thesis, 176 p. Plate 2, 1:23,760.
B	21	182	Ritzville	Waters, A. C., 1933, Terraces and coulees along the Columbia River near Lake Chelan: Geol. Soc. America Bull. 44, p. 783-820. Map, 1:380,160.
B	22	200	Ritzville	Bretz, J. H., 1932, Channeled scabland: 16th Internat. Geol. Cong. Guidebook 22. Plate 2, 1:348,000.
B	24	322	Ritzville	Bennett, W. A. G., 1944, Dolomite resources of Washington: Washington Div. Mines and Geology, Rept. Investigations 13, 35 p. Plates 8 and 9, 1:2,400.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
B	25	38	Ritzville	Tengesdal, J. L.; Bagleby, D. N.; Lockhart, A. C.; Burk, J. D., 1976, Preconstruction geologic report, Main Canal, Bacon Siphon & Tunnel No. 2, v. I and II: U.S. Bureau of Reclamation, Boise,Idaho, Geologic map, 2 sheets, 1:600.
B	28	5	Ritzville	Becraft, G. E.; Weis, P. L., 1963, Geology and mineral deposits of the Turtle Lake quadrangle, Washington: U.S. Geol. Survey Bull. 1131, 73 p. Plate 1, 1:62,500.
B	30	17	Ritzville	Grolier, M. J.; Bingham, J. W., 1971, Geologic map and sections of parts of Grant, Adams, and Franklin Counties, Washington: U.S. Geol. Survey Miscellaneous Geologic Investigations Map I-589. 6 sheets, 1:62,500.
B	31	200	Ritzville	Bretz, J H.; Smith, H. T. U.; Neff, G. E., 1956, Channeled scabland of Washington: New data and interpretations: Geol. Soc. America Bull., v. 67, no. 8, p. 957-1059. Plate 1, 1:506,880.
B	32	20	Ritzville	Irwin, W. H., 1938, Geology of the rock foundation of Grand Coulee Dam, Washington: Geol. Soc. America Bull. v. 49, p. 1627-1650. Figure 4, 1:240.
B	33	17	Ritzville	Grolier, M. J.; Bingham, J. W., 1965, Geologic map and sections of the Columbia Basin Project area, Washington: U.S. Geol. Survey Open-File maps, 1:62,500.
B	34	314	Ritzville	Mundorff, M. J.; Reiss, D. J.; Strand, J. R., 1952, Progress report on the ground water in the Columbia Basin Project, Washington: U.S. Geol. Survey Open-File Report, 229 p. Plate 1, 1:79,180.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
B	35	318	Ritzville	Taylor, G. C., Jr., 1948, Ground water in the Quincy Basin, Wahluke Slope, and Pasco Slope subareas of the Columbia Basin Project, Washington: U.S. Geol. Survey Open-File Report, 182 p. Plate 1, 1:190,080.
B	36	17	Ritzville	Grolier, M. J.; Foxworthy, B. L., 1961, Geology of the Moses Lake North quadrangle, Washington: U.S. Geol. Survey Miscellaneous Geologic Investigations Map I-330, 1:24,000.
C	37	40	Spokane	Walters, K. L.; Glancy, P. A., 1969, Reconnaissance of geology and of ground water occurrence and development in Whitman County, Washington: Washington Dept. Water Resources Water-Supply Bull. 26, 169 p. Map, 1:47,520.
C	38	4	Spokane	Barnes, V. E., 1927, Geology of the Oakesdale quadrangle, Washington: Washington State College M.S. thesis, 51 p. Plate 2, 1:316,800.
C	39	240	Spokane	Treasher, R. C., 1926, Stratigraphic aspects of loess of Palouse region: Pan-American Geologist, v. 46, no. 4, p. 305-314. Plate 17, 1:312,500.
C	40	323, 335	Spokane	Campbell, N. P.; Sorem, R. K.; 1969, Sketch map showing geology and mineral deposits in Stevens County, Washington: Washington Div. Geology and Earth Resources Open-File report OF 69-1, 1:250,000.
C	47	44	Spokane	Weissenborn, H. F., 1955, Study of the Columbia River basalts at Spokane, Washington, with a comparison of the "Rimrock and Valley" flows: Smith College M.A. thesis, 64 p. Plate 2, 1:250,000.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
C	48	20	Spokane	Huff, L. C., date unknown, Medical Lake, Clayton, and Deerpark quadrangles: U.S. Geol. Survey Ground Water Branch, Tacoma, unpublished maps, 1:62,500.
C	49	--	Spokane	Washington Division of Geology and Earth Resources, date unknown, Geology of parts of the Spokane quadrangle: unpublished map, 1:125,000.
C	50	4, 322	Spokane	Anderson, A. L., 1923, Geology and ore deposits of the Silver Hill district, Spokane County, Washington: Univ. of Idaho M.S. thesis, 100 p. Plate 1, 1:12,000.
C	53	--	Spokane	Scheid, V. E., 1946, Excelsior high-alumina clay deposit, Spokane, County: U.S. Geol. Survey Open-File report. Plate 1, 1:6,000.
C	54	325	Spokane	Hosterman, J. W., 1969, Clay deposits of Spokane County, Washington: U.S. Geol. Survey Bull. 1270, 96 p. Map, 1:24,000.
C	55	43	Spokane	Weis, P. L., 1968, Geologic map of the Greenacres quadrangle, Washington and Idaho: U.S. Geol. Survey Geologic Quadrangle Map GQ-734, 1 sheet accompanied by 4 pages of text, 1:62,500.
C	56	11, 310	Spokane	Cline, D. R., 1969, Ground water resources and related geology of north-central Spokane and southeastern Stevens Counties, Washington: Washington Dept. Water Resources Water-Supply Bull. 27, 195 p. Plate 2, 1:126,720.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
C	57	16	Spokane	Griggs, A. B., 1973, Geologic map of the Spokane quadrangle, Washington, Idaho, and Montana: U.S. Geol. Survey Misc. Geol. Inv. Map I-768, 1:250,000.
C	58	44, 374	Spokane	Weissenborn, A. E.; Weis, P. L., 1976, Geologic map of the Mount Spokane quadrangle, Spokane County, Washington, and Kootenai and Bonner Counties, Idaho: U.S. Geol. Survey Quadrangle Map GQ-1336, map and text on one sheet, 1:62,500.
C	59	80	Spokane	Flint, R. F., 1936, Stratified drift and deglaciation of eastern Washington: Geol. Soc. America Bull., v. 47, no. 12, p. 1849-1884. Figure 2, 1:84,480.
C	60	312	Spokane	Foxworthy, B. L.; Washburn, R. L., 1957, Reconnaissance investigation of ground water in the Wellpinit area, Stevens County, Washington: U.S. Geol. Survey Open-File report, 14 p. Plate 1, 1:11,400.
C	63	325, 367	Spokane	Hosterman, J. W.; Scheid, V. E.; Allen, V. T.; Sohn, I. G., 1960, Investigations of some clay deposits in Washington and Idaho: U.S. Geol. Survey Bull. 1091, 147 p. Plate 3, 1:12,000.
C	77	17	Spokane	Griggs, A. B., 1976, The Columbia River Basalt Group in the Spokane quadrangle, Washington, Idaho, Montana, with a section on petrology by D. A. Swanson: U.S. Geol. Survey Bull. 1413, 39 p. Map, 1:250,000.
D-1	64	156, 344	Wenatchee	Porter, S. C., 1976, Pleistocene glaciation in the southern part of the north Cascade Range, Washington: Geol. Soc. America Bull., v. 87, no. 1, p. 61-75.Map , 1:380,160.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
D-1	65	346	Wenatchee	Smith, G. O.; Calkins, F. C., 1906, Description of the Snoqualmie quadrangle (Washington): U.S. Geol. Survey Geol. Atlas, Folio 139. Map, 1:125,000.
D-1	66	41	Wenatchee	Warren, W. C., 1941, Relation of the Yakima Basalt to the Keechelus andesitic series: Jour. Geology, v. 49, no. 8, p. 795-814. Figure 2, 1:500,000.
D-1	67	335	Wenatchee	Clayton, D. N., 1975, Volcanic history of the Teanaway Basalt, east-central Cascade Mountains, Washington: Univ. of Washington M.S. thesis, 55 p. Map, 1:62,500.
D-1	68	--	Wenatchee	Russell, I. C.; Smith, G. O.; Curtis, G. C.; and others, 1914, Coal fields of Kittitas County: Washington Geol. Survey Bull. 9. Plate 1, 1:125,000.
D-1	69	10, 357	Wenatchee	Campbell, N. P., 1975, A geologic road log over Chinook, White Pass, and Ellensburg to Yakima highways: Washington Div. Geology and Earth Resources Inf. Circ. 54, 82 p. Map, 1:250,000.
D-1	70	--	Wenatchee	Broughton, W. A., 1944, Economic aspects of the Blewett-Cle Elum iron-ore zone, Chelan and Kittitas Counties: Washington Div. Geology Rept. Investigations 12. Plate 1, 1:84,480.
D-1	71	--	Wenatchee	Lupher, R. L., 1914, Stratigraphic aspects of the Blewett-Cle Elum iron-ore zone, Chelan and Kittitas Counties: Washington Div. Geology Rept. Investigations 2. Plate 2, 1:3,200.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
D-1	72	346	Wenatchee	Smith, G. O., 1904, Mount Stuart folio: U.S. Geol. Survey Geol. Atlas, Folio 106. Map, 1:125,000.
D-1	73	116	Wenatchee	Laval, W. N., 1948, An investigation of the Ellensburg Formation: Univ. of Washington M.S. thesis, 52 p. Map, 1:125,000.
D-1	74	102	Wenatchee	Hopkins, K. D., 1966, Glaciation of Ingalls Creek Valley, east-central Cascade Range, Washington: Univ. of Washington M.S. thesis, 79 p. Map, 1:63,360.
D-1	76	331	Wenatchee	Weaver, C. E.; Fettke, C. R., 1911, Geology and ore deposits of the Blewett mining district: Washington Geol. Survey Bull. 6, 104 p. Plate 1, 1:21,120.
D-1	78	37	Wenatchee	Tabor, R.; Waitt, R. B., Jr.; Frizzell, V. A., Jr.; Swanson, D. A.; Byerly, G. R., 1977, Preliminary geologic map of the Wenatchee 1:100,000 quadrangle, Washington: U.S. Geol. Survey Open-File Report 77-531, 24 p. 1 plate, 4 figures, Map, 1:100,000.
D-1	79	--	Wenatchee	Washington Division of Geology and Earth Resources, date unknown, Geology and structure of Colockum Pass: unpublished map, 1:125,000.
D-1	80	154	Wenatchee	Porter, S. C., 1976, Stratigraphy and distribution of tephra from Glacier Peak (of 12,000 years ago) in the northern Cascade Range, Washington: U.S. Geol. Survey Open-File Report 76-186, map and text on one sheet, 1:5,280.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
D-1	81	--	Wenatchee	Houghland, Everett, date unknown, Geologic and structure maps of the Wenatchee quadrangle: Washington Div. Geology and Earth Resources unpublished map, 1:62,500.
D-1	82	--	Wenatchee	Huntting, M. T., 1947, Geologic map of the Wenatchee area: Washington Div. Geology and Earth Resources unpublished map, 1:31,680.
D-1	83	16	Wenatchee	Gresens, R. L., 1975, Geologic mapping of the Wenatchee area: Washington Div. Geology and Earth Resources Open-File Report OF 75-6, 1:1,000.
D-1	84	--	Wenatchee	Washington Division of Geology and Earth Resources, date unknown, Geology of part of the Malaga quadrangle (along the Columbia River): unpublished map, 1:62,500.
D-3	85	41	Wenatchee	Waters, A. C., 1930, Geology of the southern half of the Chelan quadrangle, Washington: Yale Univ. Ph.D. thesis, 256 p. Plate 1, 1:72,410.
D-1	86	348	Wenatchee	Waters, A. C., 1932, A petrologic and structural study of the Swakane Gneiss, Entiat Mountains, Washington: Jour. Geology, v. 40, p. 604-634. Figure 3, 1:250,000.
D-1	87	42	Wenatchee	Waters, A. C., 1939, Resurrected erosion surface in central Washington: Geol. Soc. America Bull., v. 50, p. 635-660. Map, 1:126,720.
D-1	88	--	Wenatchee	Hopson, C. A., 1959, Geologic mapping in area south of Lake Chelan: Washington Div. Geology and Earth Resources unpublished map, 1:250,000.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
D-1	89	350	Wenatchee	Willis, C. L., 1953, The Chiwaukum graben, a major structure of central Washington: Am. Jour. Sci., v. 251, no. 11, p. 789-797. Figure 1, map, 1:126,720.
D-1	91	48	Wenatchee	Barker, P. A., 1968, Glaciation of the Chelan Trough; Washington State Univ. M.S. thesis, 52 p. Map, 1:39,600.
D-1	93	341	Wenatchee	Lupe, R. D., 1971, Stratigraphy and petrology of the Swauk Formation in the Wenatchee Lake area, Washington: Univ. of Washington M.S. thesis, 27 p., Map, 1:126,720.
D-1	94	340	Wenatchee	Laravie, J. A., 1976, Geologic field studies along the eastern border of the Chiwaukum graben, central Washington: Univ. of Washington M.S. thesis, 56 p. map, 1:31,680.
D-1	96	--	Wenatchee	Houghland, Everett, 1933-1934, Geology and structure of Chiwaukum quadrangle: Washington Div. Geology and Earth Resources unpublished map, 1:125,000.
D-3	97	346	Wenatchee	Stout, M. L., 1964, Geology of a part of the south-central Cascade Mountains, Washington: Geol. Soc. America Bull., v. 75, no. 4, p. 317-334. Plate 1, 1:62,500.
D-3	99	346	Wenatchee	Stout, M. L., 1957, Geology of the southwestern portion of the Mount Stuart quadrangle, Washington: Univ. of Washington M.S. thesis, 115 p. Plate 1, 1:63,360.
D-3	100	334	Wenatchee	Bressler, C. T., 1951, Petrology of the Roslyn arkose, central Washington: Pennsylvania State College Ph.D. thesis, 147 p. Plate 1, 1:125,000.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
D-2	101	337	Wenatchee	Foster, R. J., 1958, The Teanaway dike swarm of central Washington: Am. Jour. Science, v. 256, no. 9, p. 644-653. Figure 2, 1:405,504.
D-2	103	337	Wenatchee	Foster, R. J., 1960, Tertiary geology of a portion of the central Cascade Mountains, Washington: Geol. Soc. America Bull., v. 71, no. 2, p. 99-125. Plate 1, 1:126,720.
I-2	105	283	Wenatchee	Southwick, D. L., 1966, Petrography, chemistry, and possible correlations of the Camas Land Sill and Teanaway dike swarm, central Washington: Northwest Science, v. 40, no. 1, p. 1-16, Figure 1, 1:443,520.
D-3	106	33, 253	Wenatchee	Smith, G. O., 1930, Geology and physiography of central Washington: U.S. Geol. Survey Prof. Paper 19, p. 9-39. Plate 3, 1:125,000.
D-2	107	--	Wenatchee	Broughton, W. A., 1944, Economic aspects of the Blewett-Cle Elum iron-ore zone, Chelan and Kittitas Counties: Washington Div. Geology Rept. Investigations 12. Plates 2-7 and Figures 2-14, 1:2,400.
D-2	108	--	Wenatchee	Lamey, C. A.; Hotz, P. E., 1946, Cle Elum River iron-nickel ore deposits, Kittitas County: U.S. Geol. Survey Open-File Report, Plate 1, 1:4,800; Plates 2-A, 2-B, 2-C, 2-D, 1:1,200.
D-2	109	--	Wenatchee	Lamey, C. A., 1950, The Blewett iron-nickel deposit, Chelan County, Washington: U.S. Geol. Survey Bull. 969-D, p. 87-103. Plate 17, 1:1,200.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
D-2	110	344	Wenatchee	Pratt, R. M., 1958, Geology of the Mount Stuart area, Washington: Univ. of Washington Ph.D. thesis, 228 p. Plate 7, 1:62,500.
D-3	112	--	Wenatchee	Chappell, W. M., 1931, Endogenetic alteration of the Camas Land irruptive, Chelan County, Washington: Univ. of Washington M.S. thesis, 37 p. Figure 1, 1:63,360.
D-3	113	--	Wenatchee	Southwick, D. L., 1962, Mafic and ultramafic rocks of the Ingalls-Peshastin area, Washington, and their geologic setting: Johns Hopkins Univ., Ph.D. thesis, 287 p. Plate 1, 1:62,500.
D-3	114	344	Wenatchee	Rector, R. J., 1962, Geology of the east half of the Swauk Creek mining district: Univ. of Washington M.S. thesis, 73 p. Plate 2, 1:24,000.
D-3	115	333	Wenatchee	Alexander, Frank, 1956, Stratigraphy and structural geology of the Blewett-Swauk area, Washington: Univ. of Washington M.S. thesis, 62 p. Plate 3, 1:71,280.
D-2	117	345	Wenatchee	Rosenmaier, F. J., 1968, Stratigraphy and structure of the Table Mountain-Mission Peak area in the Wenatchee Mountains, central Washington: Univ. of Washington M.S. thesis, 44 p. Plate 1, 1:24,000.
D-3	118	11	Wenatchee	Chappell, W. M., 1936, Geology of the Wenatchee quadrangle, Washington: Univ. of Washington Ph.D. thesis, 249 p. Plate 1, 1:62,500.
D-3	119	333	Wenatchee	Bayley, E. P., Jr., 1965, Bedrock geology of the Twin Peaks area, an intrusive complex near Wenatchee, Washington: Univ. of Washington M.S. thesis, 47 p. Plate 1, 1:15,840.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
D-2	120	325	Wenatchee	Huntting, M. T., 1949, Perlite and other volcanic glass occurrences in Washington: Washington Div. Mines and Geology Rept. Inv. 17, 77 p. Figure 5, 1:63,360.
D-3	122	328	Wenatchee	Patton, T. C., 1967, Economic geology of the L-D mine, Wenatchee, Washington: Univ. of Washington M.S. thesis, 29 p. Plate 1, 1:56,740.
D-3	123	324	Wenatchee	Gualtieri, J. L.; Simmons, G. C.; Thurber, H. K.; Miller, M. S., 1973, Mineral resources of the Alpine Lakes study area, Chelan, King, and Kittitas Counties, Washington, with a section on aeromagnetic interpretation by W. E. Davis: U.S. Geol. Survey Open-File Report. Plate 1, 1:62,500.
D-2	124	147	Wenatchee	Page, B. M., 1939, Multiple alpine glaciation in the Leavenworth area: Jour. Geology, v. 47, p. 785-815. Figure 2, 1:125,000.
D-2	125	343	Wenatchee	Page, B. M., 1939, Geology of a part of the Chiwaukum quadrangle, Washington: Stanford Univ. Ph.D. thesis, 203 p. Figure 3, 1:62,500.
D-2	126	--	Wenatchee	Parrott, Gwynn, 1932, Study of the fresh water sediments north of Leavenworth: Washington State College B.S. thesis, 21 p. Map, 1:25,000.
D-2	129	350	Wenatchee	Willis, C. L., 1950, Geology of the northeastern quarter of the Chiwaukum quadrangle, Washington: Univ. of Washington Ph.D. thesis, 158 p. Plate 46, 1:62,500.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
D-3	131	347	Wenatchee	Van Diver, B. B., 1964, Petrology of the metamorphic rocks, Wenatchee Ridge area, central northern Cascades, Washington: Univ. of Washington Ph.D. thesis, 140 p. Plate 2, 1:46,080.
D-3	132	--	Wenatchee	Oles, K. F., 1956, Geology and petrology of the crystalline rocks of the Beckler River-Mason Ridge area, Washington: Univ. of Washington Ph.D. thesis, 192 p. Plate B., 1:76,000.
D-3	133	--	Wenatchee	Pratt, R. M., 1954, Geology of the Deception Pass area, Chelan, King, and Kittitas Counties, Washington: Univ. of Washington M.S. thesis, 58 p. Map, 1:31,680.
D-3	134	--	Wenatchee	Merrill, D. E., 1966, Glacial geology of the Chiwaukum Creek drainage basin and vicinity: Univ. of Washington M.S. thesis, 36 p. Figure 2, 1:125,000.
D-3	135	--	Wenatchee	McKague, H. L., 1960, Petrology of the Hatchery Creek serpentinite, Chelan County, Washington: Washington State Univ. M.S. thesis, 42 p. Plate 5, 1:250,000.
D-2	136	147	Wenatchee	Page, B. M., 1939, Multiple alpine glaciation in the Leavenworth area, Washington: Jour. Geology, v. 47, p. 685-815. Figure 9, 1:72,000.
D-1	137	335	Wenatchee	Cashman, S. M., 1974, Geology of the Peshastin Creek area, Washington: Univ. of Washington M.S. thesis, 29 p. Map, 1:15,840.
D-1	138	--	Wenatchee	Russell, I. C.; Smith, G. O.; Curtis, G. C.; and others, 1914, Coal fields of Kittitas County: Washington Geol. Survey Bull.9. Plate 23, 1:8,400.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
D-3	139	350	Wenatchee	Young, R. E., 1963, Geology of the Swauk Formation in the Leavenworth, Washington, area: Univ. of Washington B.S. thesis, 49 p. Map, 1:63,360.
E	140	333	Yakima	Abbott, A. T., 1953, Geology of the northwest portion of the Mount Aix quadrangle, Washington: Univ. of Washington Ph.D. thesis, 256 p. Fig. 4, 1:125,000.
E	141	329	Yakima	Simmons, G. C.; Van Noy, R. M.; Zilka, N. T., 1974, Mineral resources of the Cougar Lakes-Mount Aix study area, Yakima and Lewis Counties, Washington, with a section on interpretation of aeromagnetic data by W. E. Davis: U.S. Geol. Survey Open-File Report 74-243, 80 p. Plate 1, 1:62,500.
E	142	--	Yakima	Warren, W. C., 1939, Geology of the southeast Mount Aix quadrangle: Washington Div. Geology and Earth Resources unpublished map 1:125,000.
E	143	348	Yakima	Warren, W. C., 1933, Age of certain andesites in the Mount Aix quadrangle, Washington: Washington State College M.S. thesis, 24 p. Plate 2, 1:125,000.
E	144	33, 253	Yakima	Smith, G. O., 1930, Geology and physiography of central Washington: U.S. Geol. Survey Prof. Paper 19, p. 9-39. Plate 4, 1:125,000.
E	145	33	Yakima	Smith, G. O., 1903, Geologic folio of the Ellensburg quadrangle, Washington: U.S. Geol. Survey Geol. Folio 86, 7 p. Map, 1:125,000.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
E	146	12	Yakima	Diery, H. D., 1967, Stratigraphy and structure of Yakima Canyon between Roza Gap and Kittitas Valley, central Washington: Univ. of Washington Ph.D. thesis, 116 p. Plate 1, 1:24,000.
E	147	12	Yakima	Diery, H. D.; McKee, Bates, 1969, Stratigraphy of the Yakima Basalt in the type area: Northwest Science, v. 43, no. 2, p. 47-64. Map, 1:126,720.
E	148	19	Yakima	Holmgren, D. A., 1969, Columbia River Basalt patterns from central Washington to northern Oregon: Univ. of Washington Ph.D. thesis, 55 p. Map, 1:31,680.
E	149	4	Yakima	Alto, B. R., 1955, Geology of a part of the Boylston quadrangle and adjacent areas in central Washington: Univ. of Washington M.S. thesis, 38 p. Plate 5, 1:44,352.
E	150	11	Yakima	Campbell, N. P., 1977, Geology of the Selah area, Yakima County, Washington: Washington Div. Geology and Earth Resources Open-File Report OF 77-7. Geologic map, 1:24,000; Flood Hazards Map, 1:24,000; Slope Stability Map, 1:24,000.
E	151	19	Yakima	Holmgren, D. A., 1967, The Yakima-Ellensburg unconformity, central Washington: Univ. of Washington M.S. thesis, 69 p. Plate 1, 1:142,560.
E	152	10	Yakima	Campbell, N. P., 1976, Preliminary geologic map of Yakima area: Washington Div. Geology and Earth Resources Open-File Report OF 76-11, 1:24,000.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
E	153	10	Yakima	Campbell, N. P., 1976, Relative slope stability of the Yakima core area and surrounding slopes, Yakima County, Washington: Washington Div. Geology and Earth Resources Open-File Report OF 77-2, 1:24,000 (Modified by Artim, E. R., 1977).
E	154	338	Yakima	Hammond, P. E., 1975, Preliminary geologic map and cross-sections with emphasis on Quaternary volcanic rocks, southern Cascade Mountains, Washington: Washington Div. Geol. and Earth Resources Open-File Report OF 75-13, 1:24,000.
E	156	33, 318	Yakima	Smith, G. O., 1901, Geology and water resources of a portion of Yakima County, Washington: U.S. Geol. Survey Water-Supply Paper 55, 68 p. Plate 2, 1:250,000.
E	157	254	Yakima	Waters, A. C., 1955, Geomorphology of south-central Washington, illustrated by the Yakima east quadrangle: Geol. Soc. America Bull., v. 66, no. 6, p. 663-684. Plate 1, 1:62,500.
E	158	30	Yakima	Robinson, C. G., 1966, Stratigraphy and structural geology of Ahtanum Ridge, Yakima, Washington: Univ. of Washington M.S. thesis, 35 p. Plate 1, 1:72,412.
E	159	14, 312	Yakima	Foxworthy, B. L., 1962, Geology and ground water resources of the Ahtanum Valley, Yakima County, Washington: U.S. Geol. Survey Water-Supply Paper 1598, 100 p. Plate 1, 1:62,500.
E	160	333	Yakima	Becraft, G. E., 1950, Definition of the Tieton Andesite on lithology and structure: Washington State College M.S. thesis, 26 p. Plate 1, 1:125,000; Plate 2, 1:125,000.

Sheet	Map	Bibliography Page Number	Base Map
E	162	2	Yakima
E	163	347	Yakima
E	164	35	Yakima
E	165	347	Yakima
E	166	346	Yakima
E	167	338	Yakima
E	168	42	Yakima

Reference and Scale

Simmons, G. C., 1950, Russell Ranch Formation: Washington State College M.S. thesis, 26 p. Plate 1, 1:125,000.

Swanson, D. A., 1966, Tieton volcano, a Miocene eruptive center in the southern Cascade Mountains, Washington: Geol. Soc. America Bull., v. 77, no. 11, p. 1293-1314. Plate 1, 1:55,440.

Swanson, D. A., 1964, The middle and late Cenozoic volcanic rocks of the Tieton River area, south-central Washington: Johns Hopkins Univ. Ph.D. thesis, 329 p. Plate 1, 1:50,688.

Swanson, D. A., 1967, Yakima Basalt of the Tieton River area, south-central Washington: Geol. Soc. America Bull., v. 78, no. 9, p. 1077-1109. Figure 2, 1:190,080.

Simmons. G. C., 1950, Geologic mapping of the southern half of the Mount Aix 30' quadrangle: Washington Div. Geology and Earth Resources unpublished map, 1:125,000.

Hammond, P. E., 1973, Preliminary geologic map of the southern Cascade Range of Washington: Washington Div. Geology and Earth Resources Open-File Report OF 73-3, 1:792,000.

Waters, A. C., 1958, Part of the Columbia River Gorge: U.S. Geol. Survey unpublished map, 1:125,000 (based in part on independent work by A.C. Waters).

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
E	169	346	Yakima	Sheppard, R. A., 1967, Geology of the Simcoe Mountains volcanic area, Washington: Washington Div. Mines and Geology Geologic Map GM-3, 1:125,000.
E	170	327	Yakima	Milne, Scott; Cross, Randy, 1974, Sand and gravel deposits of Klickitat County, Washington: Washington Div. Geology and Earth Resources Open-File Map 74-2, 1:125,000.
E	171	283	Yakima	Sheppard, R. A., 1960, Petrology of Simcoe Mountains area, Washington: Johns Hopkins Univ. Ph.D. thesis, 153 p. Plate 1, 1:250,000.
E	172	--	Yakima	Livingston, V. E., Jr., 1958, Geologic mapping in the southwest portion of the White Swan quadrangle: Washington Div. Geology and Earth Resources unpublished map, 1:96,000.
E	173	22	Yakima	Laval, W. N., 1956, Stratigraphy and structural geology of portions of south-central Washington: Univ. of Washington Ph.D. thesis, 223 p. Plate 21, 1:62,500; Plate 23, 1:126,720; Plate 24, 1:62,500; Plate 27, 1:62,500; Plate 28, 1:62,500; Plate 29, 1:62,500; Plate 30, 1:62,500; Plate 31, 1:62,500.
E	174	11	Yakima	Campbell, N. P., 1977, Geology of the Snipes Mountain area, Yakima County, Washington: Washington Div. Geology and Earth Resources Open-File Report OF 77-8. Slope stability and flood hazards maps, 1:24,000.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
E	175	--	Yakima	Yeager, and others, 1932, Geologic and structure map of the Zillah quadrangle: Washington Div. Geology and Earth Resources unpublished map, 1:125,000.
E	176	45	Yakima	Yeaton, W. J., 1923, Geology of the Zillah quadrangle, Washington: Univ. of Chicago M.S. thesis, 88 p. Map, 1:125,000.
E	177	--	Yakima	Shannon and Wilson, Inc., 1973, Geologic studies of Columbia River Basalt and age of deformation, the Dalles-Umatilla region, Washington and Oregon, Boardman Nuclear Project: Report to Portland General Electric Co., 55 p. Figure 3, 1:63,360.
E	178	--	Yakima	Shannon and Wilson, Inc., 1973, Geologic studies of Columbia River Basalt and age of deformation, the Dalles-Umatilla region, Washington and Oregon, Boardman Nuclear Project: Report to Portland General Electric Co., 55 p. Figure 6, 1:253,440.
F	179	40	Walla Walla	Walters, K. L.; Grolier, M. J., 1960, Geology and ground water resources of the Columbia Basin Project area, Washington, volume 1: Washington Div. Water Resources Water-Supply Bull. 8, 542 p. Plate 3, 1:205,670.
F	180	--	Walla Walla	Washington Division of Geology and Earth Resources, date unknown, Geologic map of part of the Othello quadrangle: unpublished map, 1:62,500.
F	181	39	Walla Walla	Twiss, S. N., 1933, Stratigraphy of the Saddle Mountains, Washington: Washington State College M.S. thesis, 74 p. Plate 1, 1:125,000.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
F	182	24	Walla Walla	Mason, G. W., 1953, Interbasalt sediments of south-central Washington: Washington State College M.S. thesis, 116 p. Figure 6, 1:62,500; Figure 7, 1:62,500; Figure 8, 1:62,500.
F	183	39	Walla Walla	Twiss, S. N., 1933, Geologic map of the Saddle Mountains region: Washington Div. Geology and Earth Resources unpublished map, 1:62,500.
F	185	6, 297	Walla Walla	Bingham, J. W.; Londquist, C. J.,; Baltz, E. H., 1970, Geologic investigation of faulting in the Hanford region, Washington: U.S. Geol. Survey Open-File Report, 103 p. Map, 1:31,680.
F	186	--	Walla Walla	Houghland, Everett, date unknown, structure and geologic map of Red Rock quadrangle (Smyrna): Washington Div. Geology and Earth Resources unpublished map, 1:62,500.
F	189	--	Walla Walla	U.S. Army Corps of Engineers, 1947, Priest Rapids Dam project: Washington Div. Geology and Earth Resources unpublished map, 10 sheets, scale varies.
F	190	--	Walla Walla	Washington Division of Geology and Earth Resources, date unknown, Structure map of Gable Mountain and geologic map along the Columbia River in the Hanford quadrangle: unpublished map, 1:125,000.
F	191	142	Walla Walla	Newcomb, R. C., 1958, Ringold Formation of Pleistocene age in type locality, the White Bluffs, Washington: Am. Jour. Science, v. 256, no. 5, p. 328-340; Washington Div. Mines and Geology Reprint 1, p. 328-340. Figure 1, 1:1,013,760.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
F	192	63	Walla Walla	Brown, R. E.; Brown, D. J., 1961, The Ringold Formation and its relationships to other formations: Hanford Atomic Products Operation Report HW-SA-2319, 17 p. Map, 1:316,800.
F	193	--	Walla Walla	Washington Division of Geology and Earth Resources, date unknown, Structure map of Coyote Rapids quadrangle: unpublished map, 1:125,000.
F	196	8	Walla Walla	Brooks, W. E., 1974, Stratigraphy and structure of the Columbia River basalt in the vicinity of Gable Mountain, Benton County, Washington: University of Washington M.S. thesis, 39 p. Map, 1:21,120.
F	197	--	Walla Walla	Bennett, W. A. G., date unknown, Geologic map of the Prosser quadrangle: Washington Div. Geology and Earth Resources unpublished map, 1:125,000.
F	198	27, 316	Walla Walla	Newcomb, R. C.; Strand, J. R.; Frank, F. J., 1972, Geology and ground water characteristics of of the Hanford Reservation of the U.S. Atomic Energy Commission, Washington: U.S. Geol. Survey Prof. Paper 717, 78 p. Map, 1:62,500.
F	199	--	Walla Walla	Washington Division of Geology and Earth Resources, date unknown, Geologic map of the Pasco quadrangle: unpublished map, 1:125,000.
F	200	--	Walla Walla	Shannon and Wilson, Inc., 1973, Geologic studies of Columbia River Basalt and age of deformation, the Dalles-Umatilla region, Washington and Oregon, Boardman Nuclear Project: Report to Portland General Electric Co., 55 p. Figure 7, 1:63,360.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
F	201	--	Walla Walla	Warren, W. C., date unknown, Structure map of Badger Mountain in the Pasco quadrangle: Washington Div. Geology and Earth Resources unpublished map, 1:125,000.
F	202	--	Walla Walla	Livingston, V. E.; Bennett, W. A. G., Geologic mapping and structure map of Wallula quadrangle: Washington Div. Geology and Earth Resources unpublished map, 1:125,000.
F	203	27, 315	Walla Walla	Newcomb, R. C., 1965, Geology and ground water resources of the Walla Walla Basin, Washington-Oregon: Washington Div. Water Resources Water Supply Bull. 21, 151 p. Plate 1, 1:95,040.
F	204	314	Walla Walla	Molenaar, Dee, 1968, A geohydrologic reconnaissance of northwestern Walla Walla County, Washington: Washington Dept. Water Resources Monograph 1, map and text on 1 sheet, 1:126,720.
F	205	15	Walla Walla	Gard, L. M., Jr., date unknown, Geology of Washtucna quadrangle: U.S. Geol. Survey unpublished map, 1:62,500.
F	206	23	Walla Walla	Livingston, V. E., Jr., 1957, Reconnaissance map of the Clyde-Alto area, Columbia and Walla Walla Counties: Washington Div. Mines and Geology unpublished map, 1:125,000.
F	207	--	Walla Walla	Shannon and Wilson, Inc., 1973, Geologic studies of Columbia River Basalt and age of deformation, the Dalles-Umatilla region, Washington and Oregon, Boardman Nuclear Project: Report to Portland General Electric Company, 55 p. Figure 8, 1:316,800.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
F	208	203	Walla Walla	Flint, R. F., 1938, Origin of the Cheney-Palouse scabland tract, Washington: Geol. Soc. America Bull., v. 49, no. 3, p. 461-563. Figure 3, 1:31,680; Figure 9, 1:62,500.
F	210	28	Walla Walla	Pardee, J. T., 1928, Geology of reservoir sites near Wastucna and Kahlotus, Washington: U.S. Geol. Survey Open-File Report, 15 p. Figure 4, 1:125,000.
F	211	15	Walla Walla	Gard, L. M., Jr., date unknown, Geology of the Benge quadrangle: U.S. Geol. Survey unpublished map, 1:62,500.
F	212	38	Walla Walla	Trimble, D. E., 1954, Geology of the Haas quadrangle, Washington: U.S. Geol. Survey Geologic Quadrangle Map GQ-43, 1:62,500.
F	213	197	Walla Walla	Bretz, J H., 1928, Bars of channeled scabland: Geol. Soc. America Bull., v. 39, p. 643-701. Figures 2 and 3, 1:187,500; Figure 6, 1:95,040.
F	214	15	Walla Walla	Gard, L. M., Jr.; Waldron, H. H., 1954, Geology of the Starbuck quadrangle, Washington: U.S. Geol. Survey Geologic Quadrangle Map GQ-38, 1:62,500.
F	216	40	Walla Walla	Waldron, H. H.; Gard, L. M., Jr., 1951, Preliminary report on the geology of part of the Lower Snake River Canyon, Washington: U.S. Geol. Survey Open-File Report, 66 p. Plate 1, 1:24,000.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
F	217	--	Walla Walla	Washington Division Geology and Earth Resources, date unknown, Structure and geologic map of the Beverly quadrangle: unpublished map, 1:62,500.
F	218	--	Walla Walla	Washington Division Geology and Earth Resources, date unknown, Structure and geologic map of the Corfu quadrangle: unpublished map, 1:62,500.
F	219	38	Walla Walla	Taylor, T. L., 1976, The basalt stratigraphy and structure of the Saddle Mountains of south-central Washington: Washington State Univ. M.S. thesis, 116 p. Map, 1:21,120.
F	220	--	Walla Walla	Warren, W. C., date unknown, Structure map of the southern half of the Priest Rapids quadrangle: Washington Div. Geology and Earth Resources, unpublished map, 1:62,500.
G	221	15	Pullman	Gard, L. M., Jr., date unknown, Geology of the La Crosse quadrangle: U.S. Geol. Survey unpublished map, 1:62,500.
G	222	15	Pullman	Gard, L. M., Jr., date unknown, Geology of the Endicott quadrangle: U.S. Geol. Survey unpublished map, 1:62,500.
G	223	40	Pullman	Waldron, H. H.; Gard, L. M., Jr., 1955, Geology of the Penawawa quadrangle, Washington: U.S. Geol. Survey Geologic Quadrangle Map GQ-56, 1:62,500.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
G	224	38	Pullman	Treasher, R. C., 1925, Geology of the Pullman quadrangle, Washington: Washington State College M.S. thesis, 74 p. Plate 1, 1:125,000.
G	226	312	Pullman	Foxworthy, B. L.; Washburn, R. L., 1963, Ground water in the Pullman area, Whitman County, Washington: U.S. Geol. Survey Water-Supply Paper 1655, 71 p. Plate 1, 1:63,360.
G	228	370	Pullman	Russell, I. C., 1901, Geology and water resources of Nez Perce County, Idaho: U.S. Geol. Survey Water-Supply Papers 53 and 54, pts. 1 and II, 141 p. Plate 2, 1:937,500.
G	229	18	Pullman	Hoffman, M. G., 1932, The geology of Bald Butte Ridge, Washington: Jour. Geology v. XL, p. 634-51. Figure 3, 1:160,000.
G	230	368	Pullman	Lupher, R. L.; Warren, W. C., 1942, The Asotin stage of the Snake River Canyon near Lewiston, Idaho: Jour. Geology, v. 50, p. 866-881. Figure 1, 1:187,500.
G	231	126	Pullman	Lupher, R. L.; Warren, W. C., 1945, Clarkston stage of the northwest Pleistocene: Jour. Geology, v. 53, no. 5, p. 337-338. Figure 1, 1:168,960.
G	232	10, 274	Pullman	Camp, V. E., 1976, Petrochemical stratigraphy and structure of the Columbia River basalt, Lewiston Basin area, Idaho-Washington: Washington State University Ph.D. thesis, 201 p. Map, 1:63,360.
G	234	32	Pullman	Shumway, R. D., 1960, Geology of the Lime Hill area, Asotin County, Washington: Washington State Univ. M.S. thesis, 54 p. Figure 11, 1:15,600.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
G	235	20	Pullman	Huntting, M. T., 1942, Geology of the middle Tucannon area: Washington State College M.S. thesis, 33 p. Figure 4, 1:96,000.
H	236	--	Pendleton	Bennett, W. A. G., date unknown, Geology of Umatilla quadrangle (Washington): Washington Div. Geology and Earth Resources unpublished map, 1:125,000.
H	237	197	Pendleton	Bretz, J H., 1928, Bars of channeled scabland; Geol. Soc. America Bull., v. 39, p. 643-701. Figure 12, 1:221,760.
H	238	27	Pendleton	Newcomb, R. C., 1971, Geologic map of the proposed Paterson Ridge pumped-storage reservoir, south-central Washington: U.S. Geol. Survey Misc. Geol. Inv. Map, no. I-653, 1:31,680, sections, explanatory text.
H	239	--	Pendleton	Twiss, S. N., date unknown, Geology of Blalock Island: Washington Div. Geology and Earth Resources unpublished map, 1:125,000.
H	240	100, 379	Pendleton	Hodge, E. T., 1931, Exceptional morainelike deposits in Oregon: Geol. Soc. Bull., v. 42, p. 985-1010. Figure 2, 1:422,400.
I	241	4, 273	The Dalles	Allen, J. E., 1932, Contributions to the structure, stratigraphy, and petrography of the Lower Columbia River Gorge: University of Oregon M.S. thesis, 96 p. Map, 1:125,000.
I	242	43	The Dalles	Waters, A. C., 1973, The Columbia River Gorge-basalt stratigraphy, ancient lava dams, and landslide dams. In Beaulieu, J. D., Chairman, Geologic field trips in northern Oregon and southern Washington: Oregon Dept. of Geology and Mineral Ind. Bull. 77, p. 133-162. Map, 1:62,500.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
I	243	44	The Dalles	Williams, I. A., 1916, The Columbia Gorge: Its geologic history interpreted from the Columbia River Highway: Min. Res. Oregon, Oregon Bur. Mines and Geology, v. 2, no. 3, 130 p.Map,1:126,720
I	245	--	The Dalles	Barnes, F. F.; Butler, J. W., 1930, Structure and stratigraphy of the Columbia River Gorge and Cascade Mountains in the vicinity of Mount Hood: Univ. of Oregon M.A. thesis, 136 p. Map, 1, 1:125,000.
I	246	379	The Dalles	Hodge, E. T., 1932, Geological map of north-central Oregon: Univ. Oregon Publication, Supplement to Geology series v. 1, no. 5, 7 p., 1:250,000.
I	247	346	The Dalles	Sheppard, R. A., 1964, Geologic map of the Husum quadrangle, Washington: U.S. Geol. Survey Mineral Investigations Field Studies Map MF-280, 1:62,500.
I	248	--	The Dalles	Newcomb, R. C., 1962, White Salmon quadrangle: U.S. Geol. Survey Research Section, Ground Water Branch, publication, 1:62,500.
I	249	19	The Dalles	Holmgren, D. A., 1969, Columbia River Basalt patterns from central Washington to northern Oregon: Univ. of Washington Ph.D. thesis, 55 p. Map, 1:55,440.
I	250	383,316	The Dalles	Piper, A. M., 1932, Geology and ground water resources of The Dalles region, Oregon: U.S. Geol. Survey Water-Supply Paper 659B, p. 107-189. Plate II, 1:62,500.
I	251	--	The Dalles	U.S. Army Corps of Engineers, 1945, Reconnaissance map of The Dalles Reservoir site: U.S. Army Corps of Engineers, 13 sheets, 1:7,200.

Sheet	Map	Bibliography Page Number	Base Map	Reference and Scale
I	252	27, 382, 315	The Dalles	Newcomb, R. C., 1969, Effect of tectonic structure on the occurrence of ground water in the basalt of the Columbia River Group of The Dalles area, Oregon and Washington: U.S. Geol. Survey Prof. Paper 383-C, 33 p., 19 illustrations, map, 1:62,500.
I	253	--	The Dalles	Bennett, W. A. G.; Twiss, S. N.; Cram, , 1933, Geologic mapping of the Arlington, Oregon-Washington quadrangle: Washington Div. Geology and Earth Resources unpublished map, 1:125,000.
I	255	--	The Dalles	Portland General Electric Company, 1974, Pebble Springs Nuclear Plant Units 1 and 2, License Application, PSAR, section 2.5 - Geology and Seismology, section 2.6 - References, Figure 2.5-11, 1:506,880.

ADDITIONAL REFERENCES EXCLUDED FROM COMPILATION OF COLUMBIA BASIN GEOLOGIC MAPPING

Allen, J. E., 1958, Columbia River Gorge - Portland to The Dalles: Univ. of Oregon Guidebook for Field Trip Excursions of the Geological Society of American Cordilleran Section, p. 423. Figure 2, 1:633,600.

American Association of Petroleum Geologists and the United States Geological Survey, 1967, Basement map of North America between latitudes 24° and 60° north: U.S. Geol. Survey, 1:5,000,000.

Bancroft, Howland, 1914, Ore deposits of northeastern Washington: U.S. Geol. Survey Bull. 550. Figure 22, 1:19,200.

Barnes, V. E., 1927, Geology of the Oakesdale quadrangle, Washington: Washington State College M.S. thesis, 44 p. Plate 2, 1:253,440.

Bayley, R. W.; Muehlenberger, W. R., 1968, Basement rock map of the United States exclusive of Alaska and Hawaii: U.S. Geol. Survey, 2 sheets, 1:2,500,000.

Becraft, G. E., 1956, Geologic mapping, Pacific Region - Turtle Lake quadrangle, Washington: U.S. Atomic Energy Commission Report TEI-640, p. 146-150. Figure 36, 1:138,600.

Becraft, G. E.; Weis, P. L., 1957, Preliminary geologic map of part of the Turtle Lake quadrangle, Lincoln and Stevens Counties, Washington: U.S. Geol. Survey Mineral Investigations Field Studies Map MF-135, 1:48,000.

_____, 1957, Turtle Lake quadrangle, Washington: U.S. Atomic Energy Commission Report TEI-700, p. 98-110. Figure 22, 1:190,080.

Becraft, G. E., 1959, Geology of the southern part of the Turtle Lake quadrangle, northeastern Washington: Univ. of Washington Ph.D. thesis, 95 p. Plate 1, 1:48,000; Plate 2, 1:2,400; Plate 3, 1:1,200.

Becraft, G. E., 1964, Preliminary geologic map of the Wilmont Creek quadrangle, Ferry and Stevens Counties, Washington: U.S. Geol. Survey Mineral Investigations Field Studies Map MF-283, 1:48,000.

Bennett, W. A. G., 1941, Magnesite deposits of Stevens County: Washington Div. Geology Rept. Investigations 5. Plates 1 and 2, 1:62,500.

Bingham, J. W.; Walters, K. L., 1965, Stratigraphy of the upper part of the Yakima Basalt in Whitman and eastern Franklin Counties, Washington: U.S. Geol. Survey Prof. Paper 525-C, p. 87-90. Figure 1, 1:7,920,000.

Bingham, J. W.; Grolier, M. J., 1966, The Yakima Basalt and Ellensburg Formation of south-central Washington: U.S. Geol. Survey Bull. 1224-G, 15 p. Figure 2, 1:7,000,000.

Bressler, C. T., 1957, The petrology of the Roslyn arkose; a study in tectonic control of sedimentation in the Cascade Range, central Washington: International Geol. Congress, 20th, Mexico, Seccion 5, Toma 2, p. 439-453. Figure 1, 1:823,680.

Bretz, J H., 1928, Bars of channeled scabland: Geol. Soc. America Bull., v. 39, p. 643-702. Figure 10, 1:937,500; Figure 11, 1:2,000,000; Figure 12, 1:221,760.

_____, 1928, Channeled scabland of eastern Washington: Geog. Review, v. 18, p. 446-477. Plate 5, 1:500,000.

_____, 1959, Washington's channeled scabland: Washington Div. Mines and Geol. Bull. 45, 57 p. Plate 1, 1:570,240; Plate 3, 1:342,144.

Bretz, J H.; Smith, H. T. U.; Neff, G. E., 1956, Channeled scabland of Washington; new data and interpretations: Geol. Soc. America Bull., v. 67, no. 8, p. 957-1049. Plate 1, 1:506,880.

Broughton, W. A., 1945, Some magnetite deposits of Stevens and Okanogan Counties: Washington Div. Geology Rept. Investigations 14. Plate 2, 1;2,160; Plate 3, 1:2,000.

Bryan, Kirk, 1929, Geology of reservoir and dam sites: U.S. Geol. Survey Water-Supply Paper 597, p. 1-72. Figure 2, 1:9,000.

Calkins, F. C., 1905, Geology and water resources of a portion of east-central Washington: U.S. Geol. Survey Water-Supply Paper 118. Plate 1, 1:750,000.

Campbell, Ian; Loofbourow, J. S., Jr., 1957, Preliminary geologic map and sections of the magnesite belt, Stevens County, Washington: U.S. Geol. Survey Mineral Investigations Field Studies Map MF-117, 1:36,000.

Campbell, M. R.; and others, 1915, Northern Pacific guidebook: U.S. Geol. Survey Bull. 611. Sheets 21-27, 1:500,000.

Creasey, S. C., 1945, Winesap nickel prospect, Chelan County: U.S. Geol. Survey Open-File Report. Map, 1:480.

Culver, H. E.; Kirkham, V. R. D., 1927, General geology of eastern Washington and northern Idaho: Northwest Sci., v. 1., p. 25-30. Map, 1:500,000.

Danner, W. R., 1966, Limestone resources of western Washington: Washington Div. Mines and Geology Bull. 52, 474 p. Various figures.

DeMotts, Henry; Miles, W. F., 1933, Study of the Pullman artesian basin: Washington State College highest honors thesis, 35 p. Map 2, 1:125,000.

Diller, J. S.; and others, 1915, Shasta route and coast line guidebook: U.S. Geol. Survey Bull. 614. Sheets 1-3, 1:500,000.

Flint, R. F., 1936, Stratified drift and deglaciation of eastern Washington: Geol. Soc. America Bull., v. 47, p. 1849-1884. Plate 1, 1:625,000; Figure 2, 1:84,480.

_____, 1937, Pleistocene drift border in eastern Washington: Geol. Soc. America Bull., v. 48, p. 203-232. Plate 5, 1:875,000.

Foster, R. J., 1960, Tertiary geology of a portion of the central Cascade Mountains, Washington: Univ. of Washington Ph.D. thesis, 186 p. Figure 23, 1:125,000; Figure 55, 1:125,000.

Gilluly, James, 1965, Volcanism, tectonism, and plutonism in the western United States: Geol. Soc. America Special Paper 80, 69 p. Figure 1, 1 inch = 933 miles; Figure 2, 1 inch = 233 miles; Figure 3, 1 inch = 280 miles; Figure 4, 1 inch = 280 miles; Figure 5, 1 inch = 280 miles; Figure 6, 1 inch = 280 miles; Figure 7, 1 inch = 280 miles.

Glover, S. L., 1945, Tungsten resources of Washington: Washington Div. Geology Bull. 34. Plate 21, 1:12,000.

Gray, Jane; Kittleman, L. R., 1967, Geochronometry of the Columbia River Basalt and associated floras of eastern Washington and western Idaho: Am. Jour. Sci., v. 265, no. 4, p. 257-291. Figure 1, 1:10,454,400.

Griggs, A. B., 1966, Reconnaissance geologic map of the west half of the Spokane quadrangle, Washington and Idaho: U.S. Geol. Survey Misc. Geol. Invest. Map I-464, 1:125,000.

Hobbs, S. W., 1943, Copper Mining Company property, Bumping Lake mining district, Yakima County: U.S. Geol. Survey Open-File Report. Figure 1, 1:1,200.

Hodge, E. T., 1938, Geology of the lower Columbia River: Geol. Soc. America Bull., v. 49, p. 831-930. Figure 4, 1:687,500.

_____, 1938, Market for Columbia River hydroelectric power using Northwest minerals; Section 1, Northwest magnesia ores, volume 1: U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon, 173 p. Plate 2, 1:63,360.

_____, 1938, Market for Columbia River hydroelectric power using Northwest minerals; Section 2, Northwest silica materials, volume 1: U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon, 175 p. Plate 9, 1:126,720.

_____. 1938. Market for Columbia River hydroelectric power using Northwest minerals; Section 3, Northwest limestones, volume 1, part 1, Limestones of the Northwest States: U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon, 312 p. Plate 4, 1:4,800; Plate 13, 1:4,800; Plate 18, 1:3,168,000; Plate 19, 1:126,720.

_____, 1938, Market for Columbia River hydroelectric power using Northwest minerals; Section 4, vol. 3, part 3, Sources of clay for scheduled uses, Northwest sources - Washington and Idaho: U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon, p. 492-804. Plate 72, 1:3,168,000; Plate 73, 1:1,013,760; Plate 78, 1:84,480.

Houghland, Everett, 1932, Structure of the Natapoc Formation north of Leavenworth, Washington: Washington State College Geology Dept. seminar report, 25 p. Map, 1:125,000.

Hosterman, J. W., 1960, Geology of the clay deposits in parts of Washington and Idaho: In Clays and clay minerals, 7th Conf. Proc.: Pergamon Press, New York City, p. 285-292. Figure 1, 1:2,280,960.

Hundhausen, R. J., 1949, Investigation of the Young America lead-zinc deposit, Stevens County, Washington: U.S. Bur. Mines Rept. Inv. 4556, 13 p. Figure 1, 1:950,400; Figure 2, 1:1,440.

Huntting, M. T.; Bennett, W. A. G.; Livingston, V. E. Jr.,; Moen, W. S., 1961, Geologic map of Washington: Washington Div. Mines and Geol., 1 sheet, 1:500,000.

Ivanoff, B. B., 1949, The Germania Consolidated Mines, Inc., Stevens County, Washington: Univ. of Washington B.S. thesis, 31 p. Plate 2, 1:200,000.

Jenkins, O. P., 1924, Lead deposits of Pend Oreille and Stevens Counties: Washington Div. Geology Bull. 31. Plate 3, 1:6,000.

King, P. B., 1958, Evolution of modern surface features of western North America. In Zoogeography, edited by C. L. Hubbs: Am. Assoc. Advancement of Science Pub. 51, p. 3-60, Figure 2-5,9. Figure 2, 1 inch = 500 miles; Figure 3, 1 inch = 500 miles; Figure 4, 1 inch = 500 miles; Figure 5, 1 inch = 500 miles; Figure 9, 1 inch = 160 miles.

King, P. B.; Beikman, H. M., 1974, Geologic map of the United States, exclusive of Alaska and Hawaii: U.S. Geol. Survey, 1:2,500,000.

Kinnison, H. B.; Sceva, J. E., 1963, Effects of hydraulic and geologic factors on streamflow of the Yakima River Basin, Washington: U.S. Geol. Survey Water-Supply Paper 1595, 134 p. Plate 1, 1:250,000.

Lamey, C. A.; Metz, P. E., 1945, Blewett iron-nickel deposit, Chelan County: U.S. Geol. Survey Open-File Report. Plate 1, 1:1,200.

Lobeck, A. K., 1941, Geologic map of the United States: Geographic Press, New York City, 4 sheets, 1:5,000,000.

Lovitt, E. H.; Skerl, A. C., 1958, Geology of the Lovitt gold mine, Wenatchee, Washington: Mining Engineering, v. 10, no. 9, p. 963-966. Map, 1:42,660.

McLeod, A. A., 1923, Geology of the Silver Hill district, Spokane County, Washington: Univ. of Idaho B.S. thesis, 33 p. Map, 1:12,000.

Mills, J. W., 1962, High-calcium limestone of eastern Washington: Washington Div. Mines and Geol. Bull. 48, 268 p. Various plates.

Moody, D. W., 1958, An examination of the ore minerals of the Lovitt mine, Wenatchee, Washington: Univ. of Washington B.S. thesis, 22 p. Plate 5, 1:15,360.

National Research Council Committee for the Study of Eolian Deposits, 1952, Pleistocene eolian deposits of the United States, Alaska, and parts of Canada: Geol. Soc. America, New York City, 2 sheets, 1:2,500,000.

Newcomb, R. C., 1958, Corral Canyon, Coyote Rapids, Hanford, and Richland quadrangles: U.S. Geol. Survey unpublished maps, 1:62,500.

_____, 1959, Some preliminary notes on ground water in the Columbia River Basalt: Northwest Science, v. 33, no. 1, p. 1-18. Figure 1, 1:5,068,800.

_____, 1961, Storage of ground water behind subsurface dams in the Columbia River Basalt, Washington, Oregon, and Idaho: U.S. Geol. Survey Prof. Paper 383-A, p. 1-15. Figure 1, 1:3,752,000.

_____, 1961, Structural barrier reservoirs of ground water in the Columbia River Basalt: U.S. Geol. Survey Prof. Paper 424-B, p. 213-215. Figure 1, 1:3,752,000.

Newcomb, R. C.; Strand, J. R.; Frank, F. J., 1966, Geology and ground water characteristics of the Hanford Reservation of the Atomic Energy Commission, Washington: U.S. Geol. Survey Water Resource Div. Open-File Report, 260 p. Map, 1:62,500.

Newcomb, R. C., 1966, Lithology and eastward extension of The Dalles Formation, Oregon and Washington: U.S. Geol. Survey Prof. Paper 550-D, p. 59-63. Figure 1, 1:1,267,200.

North American Geologic Map Committee, 1965, Geologic map of North America: U.S. Geol. Survey, 2 sheets, 1:5,000,000.

Page, L. R., 1942, Tin and tungsten deposits of Silver Hill, Spokane County, Washington: U.S. Geol. Survey Bull. 931-H, p. 177-203. Plate 32, 1:2,400.

Pardee, J. T., 1918, Geology and mineral deposits of the Colville Indian Reservation: U.S. Geol. Survey Bull. 677. Plate 1, 1:250,000; Plate 8, 1:62,500.

Piper, A. M.; Thomas, H. E., 1933, Ground water in the Walla Walla Basin, Oregon-Washington: U.S. Geol. Survey Open-File Report, Plate 1, 1:48,000.

Popenoe, W. P.; Imlay, R. W.; Murphy, M. A., 1960, Correlation of the Cretaceous formations of the Pacific Coast (U.S. and northwestern Mexico): Geol. Soc. America Bull., v. 71, no. 10, p. 1491-1540. Figure 5, 1:2,534,400.

Randt, C. H., 1939, Shamrock mine in southern Ferry County: Univ. of Washington B.S. thesis, 47 p. Map, 1:1,200; map, 1:600.

Raymond, J. R.; Tilson, D. D., 1968, Evaluation of a thick basalt sequence in south-central Washington - geophysical and hydrological exploration of the Rattlesnake Hills deep stratigraphic test well: Battelle Mem. Inst. Pacific Northwest Lab AEC Research and Development Rept. BNWL-776, 125 p. Figure 1, general geologic map of Washington, 1:60 miles.

Russell, I. C., 1893, Geological reconnaissance in central Washington: U.S. Geol. Survey Bull. 108. Plate 2, 1:792,000.

Schmidt, R. G., 1962, Aeroradioactivity survey and areal geology of the Hanford Plant area, Washington and Oregon: U.S. Atomic Energy Commission Civil Effects Test Operations Study CEX-59.4.11, 25 p. Figure 4, 1:1,140,480.

Schroeder, M. C., 1947, Genesis of the Turk magnesite deposit of Stevens County, Washington: Washington State College M.S. thesis, 19 p. Figure 2, 1:62,500.

Shedd, Solon, 1913, Cement materials and industry in the State of Washington: Washington Geol. Survey Bull. 4. Figure 1, 1:93,750; Figure 7, 1:125,000.

_____, 1926, Abstract of report on geology and resources of the Pasco and Prosser quadrangles: Washington Div. Geol. Rept. Investigations 1. Plate 1, 1:125,000.

Sheldon, R. F., 1959, Midnite mine - geology and development: Mining Engineering, v. 11, no. 5, p. 531-534. Figure 1, 1:33,600.

Smith, G. O.; Willis, Bailey, 1901, The Clealum iron ores: Am. Inst. Min. Met. Eng., Trans., v. 30, p. 356-366. Map, 1:170,000.

Sohn, I. G., 1952, Geologic environment map of alumina resources of the Columbia Basin: U.S. Geol. Survey Mineral Investigations Resource Appraisals Map MR-1, map and text on 1 sheet, 1:1,500,000.

Stout, M. L., 1959, Geology of a part of the south-central Cascade Mountains of Washington: Univ. of Washington Ph.D. thesis, 183 p. Plate 2, 1:63,360.

Swanson, D. A.; and others, 1977, Reconnaissance geologic map of the Columbia River Basalt Group, Pullman and Walla Walla quadrangles, southeast Washington and adjacent Idaho: U.S. Geol. Survey Open-File Report 77-100, 11 p. 2 Plates, 1:250,000.

Thomson, J. P., 1929, Source of the Swauk placers: Washington State College Res. Studies, v. 1, p. 5-9, Figure 1, 1:187,500.

_____, 1932, Genesis of the Swauk placer gold, Swauk mining district, Washington: Washington State College M.S. thesis, 76 p. Plate 2, 1:253,440.

Vaux, W. W., 1958, Geology and ore deposits of the Calvin H. Barksull mining claims, Nigger Creek district, Chelan County, Washington: Univ. of Washington B.S. thesis, 38 p. Plate 1, 1:126,720.

Walker, W. J., 1957, Geology and ore deposits of the Dolphin mining claims, Kittitas County, Washington: Univ. of Washington B.S. thesis, 47 p. Plate 2, 1:360; Plate 3, 1:1,200.

Waring, G. A., 1913, Geology and water resources of a portion of south-central Washington: U.S. Geol. Survey Water-Supply Paper 316. Plate 1, 1:750,000.

Washington Division of Geology and Earth Resources, date unknown, Geologic map of the Chiwaukum quadrangle: unpublished map, 1:125,000.

Waters, A. C., 1930, Geology of the southern half of the Chelan quadrangle, Washington. Yale Univ. Ph.D. thesis, 256 p. Plate 1, 1:72,410.

_____, 1938, Petrology of the contact breccias of the Chelan batholith: Geol. Soc. America Bull., v. 49, p. 763-794. Plate 1, 1:187,500.

_____, 1955, Volcanic rocks and the tectonic cycle. In Crust of the Earth, edited by A. Poldervaart: G.S.A. Sp. Paper 62, p. 703-722. Plate 1, 1:75 miles.

_____, 1962, Basalt magma types and their tectonic associations; Pacific Northwest of the United States: Am. Geophysical Union Geophysical Monograph 6, p. 158-170. Figure 1, Miocene-Quaternary volcanic rocks and associated tectonic features of the Pacific Northwest, 1 inch = 80 miles.

Weaver, C. E., 1916, Tertiary formations of western Washington: Washington Geol. Survey Bull. 13, Plates 2-4d.

_____, 1920, Mineral resources of Stevens County: Washington Geol. Survey Bull. 20. Plate 1, 1:125,000.

Weissenborn, A. E.; Weis, P. L., 1976, Geologic map of the Mount Spokane quadrangle, Washington and Idaho: U.S. Geol. Survey Open-File Report 74-211, map and text on one sheet, 1:31,680.

Yeager; and others, 1932, Geologic and structure map of the Zillah quadrangle: Washington Div. Geology and Earth Resources unpublished map, 1:125,000.

Zapffe, Carl, 1944, Memorandum report on iron ores of the Cle Elum district, Washington: Washington Div. Mines and Mining Rept. Inv. 5, 27 p. Plate 1, 1:960; Plate 2, 1:960.

Zoldok, S. W., 1948, Cle Elum iron-nickel deposits, Kittitas County, Washington: U.S. Bur. Mines Rept. Inv. 4189, 8 p. Figure 2, 1:4,800.

APPENDIX B

COMPILATION OF GEOPHYSICAL SURVEYS IN THE COLUMBIA BASIN AND SURROUNDING AREAS OF WASHINGTON

This compilation of pertinent geologic mapping in the Columbia Basin of Washington was prepared by the Washington Division of Geology and Earth Resources (WDGER) in partial fulfillment of a contract with the U.S. Department of Energy, administered by Rockwell International, Richland, Washington. The contract is part of a study to determine the feasibility of interring nuclear waste within the Columbia River Basalt Group. This study, the Basalt Waste Isolation Program, is to examine the stratigraphic, structural, seismic, tectonic, and hydrologic environment of the Columbia Basin, to provide criteria for possible site selection of a waste repository.

The entries in this appendix represent all published, unpublished, and open-file reference material containing geophysical surveys of eastern Washington that were available to the authors. The services of the WDGER, Washington State, Battelle Pacific Northwest Laboratory, and Rockwell-Hanford Atomic Products Operation libraries were used extensively in this compilation.

The base map used for this compilation was based on the film-positive transparency of the 1:1,000,000 scale Index to Topographic Maps of Washington sheet. The indexing was done on a mylar overlay to this base map then photographically combined to yield the present index map: Index to Geophysical Surveys - Washington - Sheet J.

The references used in the formulation of this appendix are keyed by an alpha-numeric system to both the index map and the WDGER Open-File Report 78-3, "Bibliography of the Geology of the Columbia Basin and Surrounding Areas of Washington with Selected References to Columbia Basin Geology of Idaho and Oregon."

A number of pertinent geophysical survey references are not indexed on the map (Sheet J), as they covered too large an area (as the entire State, or several states), or they were not available to the authors at the time of this compilation. For these and other additional references on geophysical surveys, the reader may refer to the Bibliography proper, Geophysical Surveys section.

Sheet	Map Number	Bibliography Page Number	References
J	1	296a	Brown, J.C., 1976, Well correlation and stratigraphic information: Pullman test and observation well, Pullman, Washington: Washington State Univ., Coll. of Engrng. Res. Div. Rept. 76/15-6, 35 p.
J	2	288	Brown, R.E.; Raymond, J.R., 1963, Geophysical seismic evaluation study at the Hanford Works, Washington: Hanford Atomic Products Operation unclassified report HW-SA-3280, 17 p.
J	3	288	Brown, R.E.; Raymond, J.R., 1964, A geophysical seismic evaluation study at Hanford: Battelle Northwest Report BNWL-47, 22 p.
J	4	296a	Bush, J.H., Jr.; Anderson, J.V.; Crosby, J.W., III; Siems, B.A., 1972, Test observation well near Mansfield, Washington: description, stratigraphic relationships, and preliminary results: Washington State Univ., Coll. of Engrng. Res. Div. Rept. 72/11-128, 45 p.
J	5	296a	Bush, J.H., Jr.; Morton, J.A., 1973, Test-observation well near Walla Walla, Washington: description, stratigraphic relationships and preliminary results: Washington State Univ., Coll. of Engrng. Res. Div. Rept. 73/15-66, 38 p.
J	6	296a	Cady, J.W., 1976, Regional gravity and aeromagnetic studies applied to uranium exploration in north-eastern Washington and Wyoming: U.S. Geol. Survey Open-file Rept. 76-317, 21 p.
J	7	288	Cady, J.W.; Meyer, R.F., 1976, Principal facts for gravity stations in the Okanogan, Sandpoint, Ritzville, and Spokane 1^{o} by 2^{o} quadrangles, northeastern Washington and northern Idaho: U.S. Geol. Survey Open-file Rept. 76-290, 57 p.

Sheet	Map Number	Bibliography Page Number	References
J	8	288	Cady, J.W.; Meyer, R.F., 1976, Bouguer gravity map of Okanogan, Sandpoint, Ritzville, and Spokane 1^{o} by 2^{o} quadrangles, northeastern Washington and northern Idaho: U.S. Geol. Survey, Geophys. Invest. Map GP-914, Grav. Surv. Map, 1:250,000.
J	9	289	Campbell, D.L.; Flanigan, V., 1976, Ground magnetic and VLF studies at Midnite uranium mine, Stevens County, Washington: U.S. Geol. Survey Open-file Rept. 76-230, 17 p.
J	10	296a	Crosby, J.W., III; Cavin, R.E., 1960, Geologic investigation of the Moscow ground water basin employing geophysical studies: Washington State Univ., Geo-Hydrologic Res. Group Bull. 250, 23 p.
J	11	296a	Danes, Z.F., 1964, Preliminary gravity data, central Cascade Mountains, Washington: Univ. of Puget Sound, Res. Inst. Rept., UPS RIP-GP-64-1, 13 p.
J	12	290	Donaldson, J.A., 1963, Seismic survey - Hanford Atomic Products Operation, Richland, Benton County, Washington: Geophysical Service, Inc. Rept. (Dallas, TX) submitted to General Electric Co., 32 p.
J	13	290	Gregory, D.I.; Jackson, D.B., 1976, Bouguer gravity map of Moscow, Idaho-Pullman, Washington area: U.S. Geol. Survey Open-file Rept. 76-280, one sheet, 1:62,500.
J	14	296b	Gualtieri, J.L.; Simmons, G.C.; Thurber, H.K.; Miller, M.S., 1973, Mineral resources of the Alpine Lakes study area, Chelan, King, and Kittitas counties, Washington, with a section on aeromagneitc interpretation, by W.E. Davis: U.S. Geol. Survey Open-file Rept., 132 p.

Sheet	Map Number	Bibliography Page Number	References
J	15	296c	Hunting Geophysical Services, 1960, Geological interpretation of airborne magnetometer and scintillometer survey, Mt. Bonaparte, Bodie Mountain, Curlew, Aeneas and Republic quadrangles, Okanogan and Ferry Counties, Washington: Washington Div. Geol. and Earth Resources, Rept. Invest. 20, 1:62,500.
J	16	291	Jackson, D.B., 1975, Schlumberger soundings in the Moscow, Idaho-Pullman, Washington, area: U.S. Geol. Survey Open-file Rept. 75-584, 28 p.
J	17	291	Jackson, D.B., 1975, Description of the geoelectric section, Rattlesnake Hills Unit 1 well, Washington: Jour. Res., U.S. Geol. Survey, v. 3, no. 6, p. 665-669.
J	18	291	Jaske, R.T., 1964, Large scale quarry blasting on the Hanford Reservation: Hanford Atomic Products Operation, Rept. HW-79614, 63 p.
J	19	292	Konicek, D., 1975, Geophysical survey in south-central Washington: Northwest Sci., v. 49, no. 2, p. 106-117; (abs.) EOS (Amer. Geophys. Union Trans.), v. 53, no. 11, p. 966; Univ. of Puget Sound M.S. thesis (1974).
J	20	296c	Myers, D.A., 1972, Test-observation well near Davenport, Washington: description and preliminary results: U.S. Geol. Survey Open-file Rept., Tacoma, 20 p.
J	21	293	Peterson, D.E., 1968, Bouguer gravity anomalies on the Hanford Reservation: Battelle Memorial Institute, Pacific Northwest Laboratory Rept. BNWL-481-3, p. 10-14.
J	22	293	Priestley, K.F., 1971, Earth strains observed at the Cascade Geophysical Site using a long base laser interferometer strain meter: Univ. of Washington M.S. thesis, 84 p.

Sheet	Map Number	Bibliography Page Number	References
J	23	294	Raymond, J.R.; Ratcliffe, C.A., 1959, A test of the refraction seismic method on the Hanford Project: Hanford Atomic Products Operation Rept. HW-78924, 21 p.
J	24	294	Raymond, J.R.; McGhan, V.L., 1963, Results of an airborne magnetometer survey of the Hanford project: Hanford Atomic Products Operation Rept. HW-78924, 15 p.
J	25	296c	Raymond, J.R.; Tillison, D.D., 1968, Evaluation of a thick basalt sequence in south central Washington, geophysical and hydrological exploration of the Rattlesnake Hills deep stratigraphic test well: Battelle Pacific Northwest Lab. Rept. 776, 120 p.
J	26	294	Robbins, S.L.; Burt, F.J.; Gregg, D.O., 1975, Gravity and aeromagnetic study of part of the Yakima River basin, Washington: U.S. Geol. Survey Prof. Paper 726-E, 7 p.
J	27	294	Siems, B.A., 1973, Surface to subsurface correlation of Columbia River Basalt using geophysical data, in parts of Adams and Franklin counties, Washington: Washington State Univ. M.S. thesis; Washington State Univ., Coll. of Engrng. Res. Div. Bull. 331, 65 p (1973).
J	28	295	Simmons, G.C.; Van Noy, R.M.; Zilka, N.T., 1974, Mineral resources of the Cougar Lakes-Mount Aix study area, Yakima and Lewis Counties, Washington, with a section on interpretation of aeromagnetic data, by W.E. Davis: U.S. Geol. Survey Open-file Rept. 74-243, 80 p., plus 3 map sheets.
J	29	296d	Swanberg, C.A., 1968, A gravity survey over the central part of the Okanogan Range, Washington: Southern Methodist Univ. M.S. thesis, 51 p.

Sheet	Map Number	Bibliography Page Number	References
J	30	295	Swanson, D.A.; Wright, T.L; Zietz, I., 1976, Geologic interpretation of an aeromagnetic map of the west-central Columbia Plateau, Washington and Oregon: U.S. Geol. Survey Open-file Rept. 76-51, 28 p., 1 plate, 3 figures.
J	31	295	U.S. Geological Survey, 1973, Aeromagnetic map of parts of Okanogan and Sandpoint 1^{o} by 2^{o} quadrangles, Washington, Idaho, Montana: U.S. Geol. Survey Open-file map. 1 sheet, scale 1:250,000.
J	32	295	U.S. Geological Survey, 1974, Aeromagnetic map of parts of Okanogan, Sandpoint, Ritzville, and Spokane 1^{o} by 2^{o} quadrangles, northeastern Washington: U.S. Geol Survey Open-file map, scale 1:250,000, 1 sheet. Also 23 sheets, scale 1:62,500 of the same area.
J	33	295	U.S. Geological Survey, 1976, Aeromagnetic map for part of southwestern Washington: U.S. Geol. Survey Open-file Rept. 75-648, 4 sheets, scale 1:62,500.
J	34	296e	U.S. Geological Survey, 1976, Aeromagnetic map of the Horseshoe Basin quadrangle, Okanogan County, Washington: U.S. Geol. Survey map, 1:62,500.
J	35	296	U.S. Geological Survey, 1977, Aeromagnetic map of part of northern Washington: U.S. Geol. Survey Open-file Rept. 77-254, 2 plates, scale 1:62,500.
J	36	296e	Walters, K.L.; Cline, D.R.; Luzier, J.E., 1972, Test-observation well near Odessa, Washington: description and preliminary results: U.S. Geol. Survey Open-file Rept., Tacoma, Washington, 25 p.
J	37	296e	Walters, K.L., 1973, Test-observation well near Almira, Washington: description and preliminary results: U.S. Geol. Survey Open-file Rept., Tacoma, Washington, 20 p.

Sheet	Map Number	Bibliography Page Number	References
J	38	296	Woollard,G.P., 1958, Results for a gravity control network at airports in the United States: Geophysics, v. 23, no. 3, p. 520-535, 7 figs.
J	39	296	Yost, C.R., 1976, Gravity survey of the Cheney quadrangle, Washington: Eastern Washington State College M.S. thesis, 37 p.
J	40	296	Zietz, I.; others, 1971, Interpretation of an aeromagnetic strip across the northwestern United St tes: Geol. Soc. Am. Bull., v. 82, no. 12, p. 3347-3372. Figure 1 includes an aeromagnetic map at scale 1:2,500,000.