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WASHINGTON GEOLOGIC NEWSLETTER

Surface of one of the many pyroclastic flows that repeatedly scorched the slopes of Mount St. Helens and the upper Toutle River valley during 1980. Puffs of steam are issuing from small rootless fumaroles in the surface of the flow. Large pumice clasts in foreground are approximately 10 to 15 inches in diameter. View is from near the south shore of Spirit Lake toward Mount St. Helens. Photo courtesy of Brian Saunders, The Daily Olympian.

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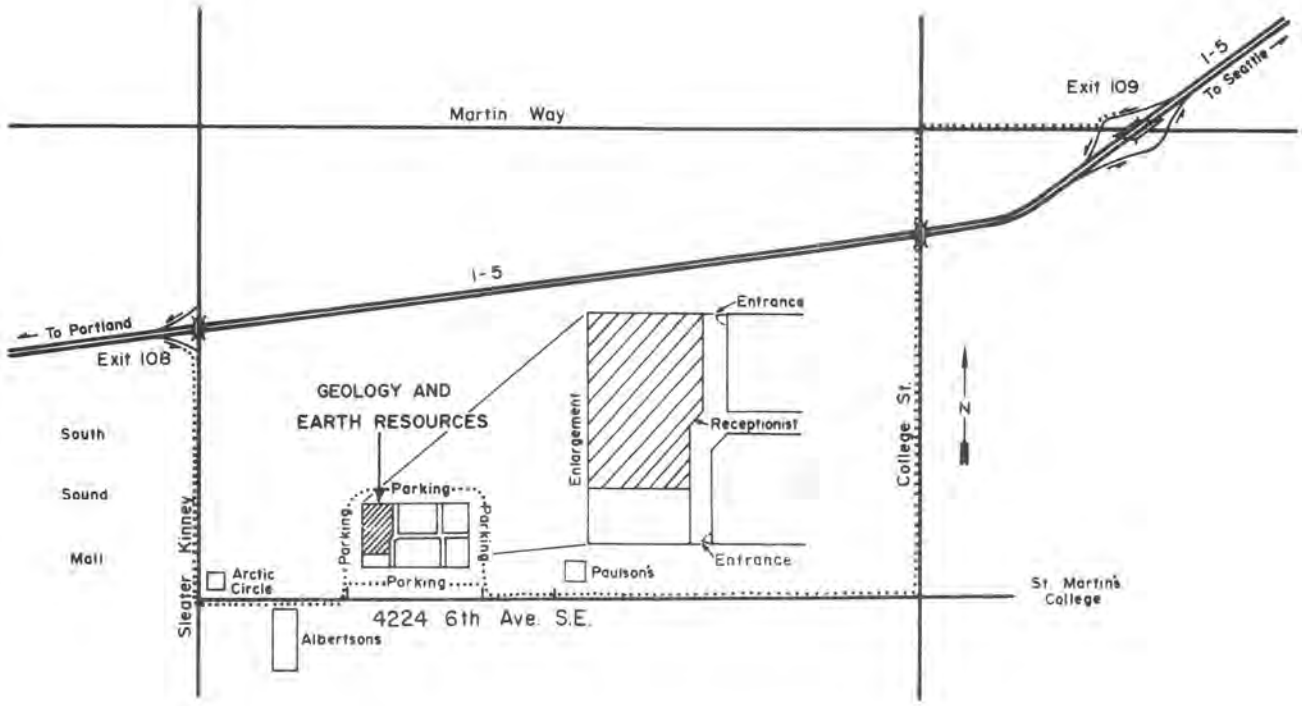

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DIVISION HAS NEW PHONE NUMBER

A new phone system has been installed for all state offices located in Lacey, Washington. You can no longer reach the Division of Geology and Earth Resources by dialing 753-6183. Instead, please dial (206) 459-6372.

The Washington Geologic Newsletter, a quarterly report of geologic articles, is published by the Division of Geology and Earth Resources, Department of Natural Resources. The newsletter is free upon request.

The division also publishes bulletins, information circulars, and geologic maps. A list of these publications will be sent upon request.

SOME PETROGRAPHIC CHARACTERISTICS OF PUMICE FROM THE 1980 MOUNT ST. HELENS PYROCLASTIC FLOWS

by Josh Logan

During the present active period of Mount St. Helens volcano, pyroclastic flows have occurred on at least six separate occasions. The most voluminous pyroclastic deposits were emplaced on May 18, 1980, and were followed by lesser flows on May 25, June 12, July 22, August 7, and October 17, 1980. Subsequent eruptive activity has been restricted to relatively nonexplosive dome-building extrusions on December 28, 1980, and February 10, April 10, June 18, and September 6, 1981.

Extensive erosion of the pyroclastic deposits occurred during the 1980-81 winter, obscuring the location of many of the smaller flows. Fortunately, geologists from the State Division of Geology and Earth Resources were able to extensively sample the deposits prior to their being disturbed by winter erosion. A map showing sample locations and approximate boundaries of flows appears in figure 1.

Sampling during the Fall months of 1980 was limited mostly to pumice blocks lying on the surface of flows. The flows are comprised of coarse pumice clasts in a sandy pumiceous matrix. Deep gullying during the winter months has since allowed sampling at depths of up to several meters in the flows. These samples are grab samples containing larger clasts as well as matrix material.

Preliminary petrographic analyses of 36 thin sections of the pumiceous material have been completed. Xenoliths of varying lithologies were observed within the pumice but are not described here.

The pumice is light gray, has a dacitic chemistry and has fairly constant mineralogy throughout all flows. In addition to glass, minerals present in order of decreasing abundance include plagioclase feldspar, hypersthene, hornblende, and magnetite. The glass is colorless and highly vesiculated.

Plagioclase is the most abundant mineral present in all samples as both phenocrysts and microlites. Although larger phenocrysts are commonly present in hand specimens, the phenocrysts observed in thin sections range in size up to 2.8 mm in length and are generally euhedral. Both normal and reverse zoning are common as are inclusions of pink to colorless glass (see fig. 2). The anorthite content ranges from roughly An_{30} to An_{57}. Carlsbad and albite twinning are common, whereas pericline twinning is only occasionally apparent.

Pale pink to pale green pleochroic hypersthene is the most abundant mafic phase, usually making up about 5 percent of the rock. Euhedral crystals with sharp boundaries are the rule. These phenocrysts range in size up to 1.6 mm in length. Many phenocrysts contain inclusions of magnetite (see fig. 3).

Hornblende phenocrysts ranging up to 2.6 mm in length are usually present in amounts of less than 5 percent of total phenocrysts. Pleochroism ranges from light to dark green or dark olive green in phenocrysts from earlier flows, to a generally more brownish hue in

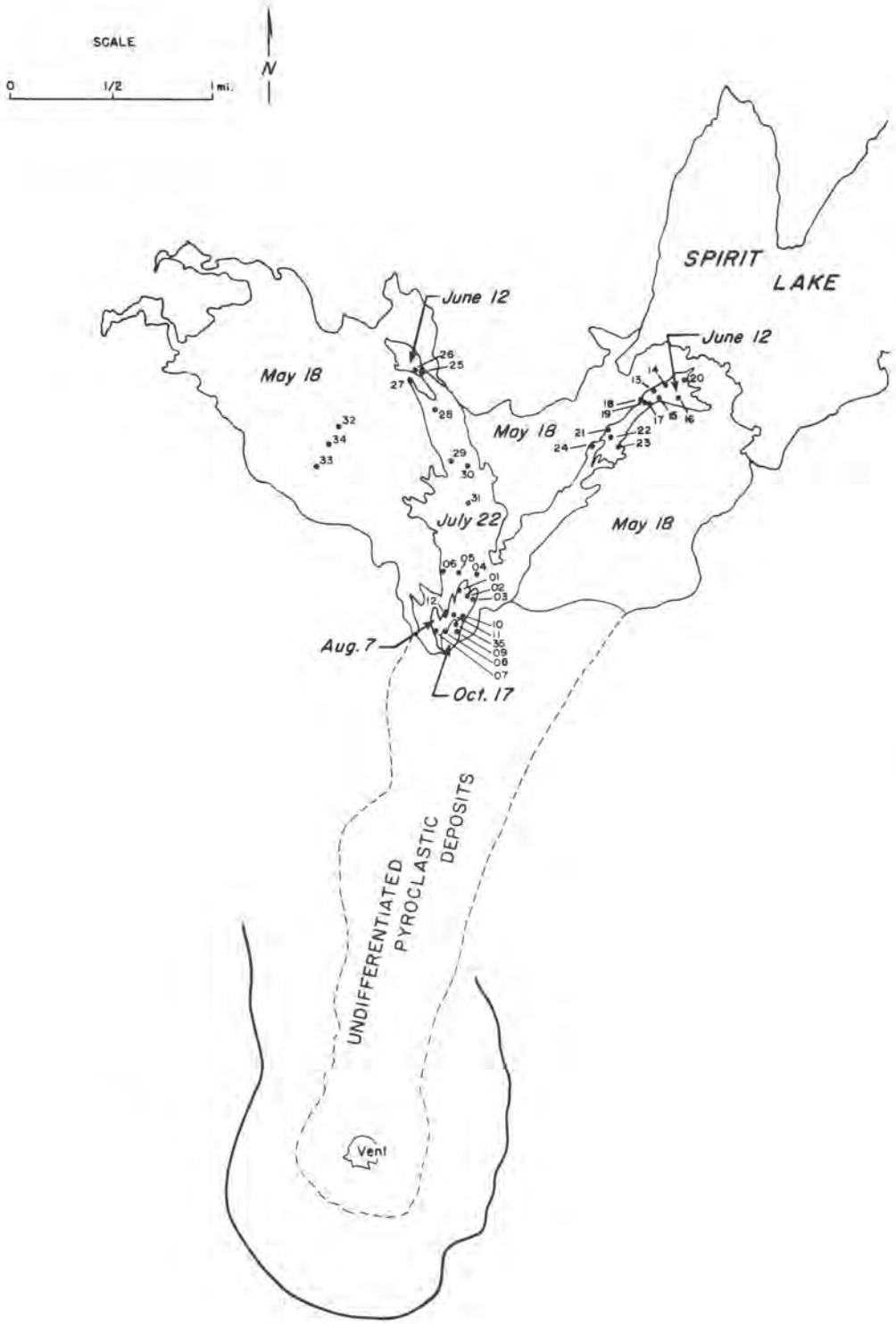

FIGURE 1.—Pyroclastic flow and sample location map, Mount St. Helens, Washington, as of January 1, 1981. Samples 08 and 09 were taken shortly before the October 17th eruption, which covered these sites. Extensive erosion and deposition during the 1980-81 winter season have drastically altered surficial features of many of the deposits. Data on the actual extent of the May 25, 1980 pyroclastic flow is sparse due to bad weather and consequent poor access during the late May-early June time period. The May 25 deposit was reported to have been small enough to have been covered by June 12 and subsequent deposits.

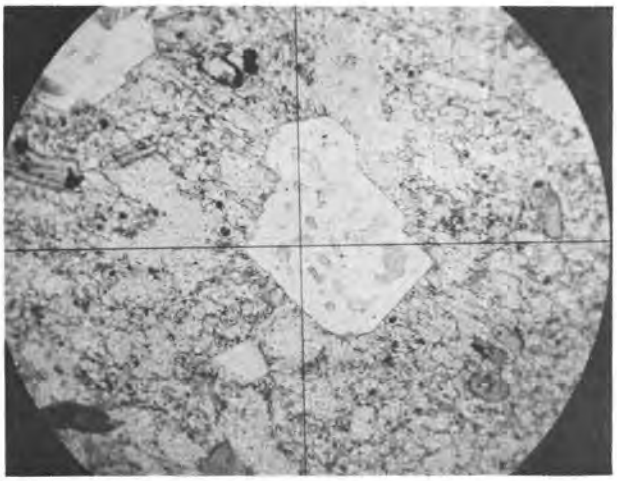

FIGURE 2.—Photomicrograph of a plagioclase crystal with glassy inclusions. Sample is pumice from June 12, 1980 pyroclastic flow. Magnified 30 times normal.

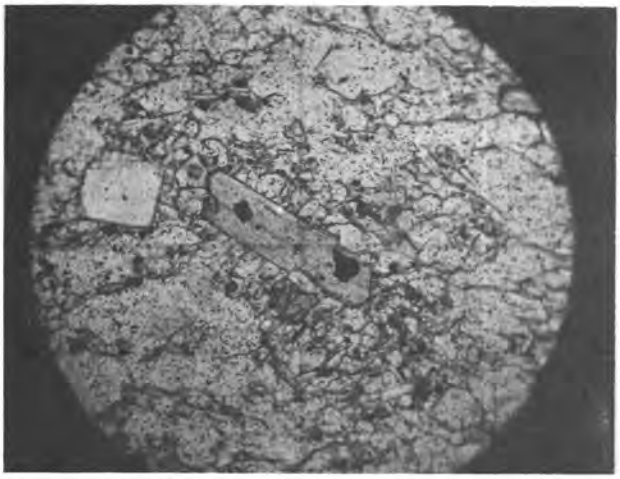

FIGURE 3.—Magnetite inclusions in hypersthene crystal in June 12, 1980 pumice. Magnified 80 times normal.

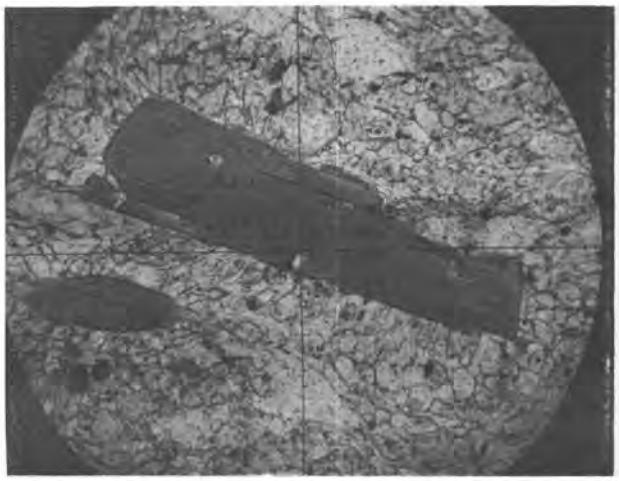

FIGURE 4.—Hornblende phenocrysts with sharp boundaries, typical of this mineral phase in May 18, 1980 pumice. Magnified 80 times normal.

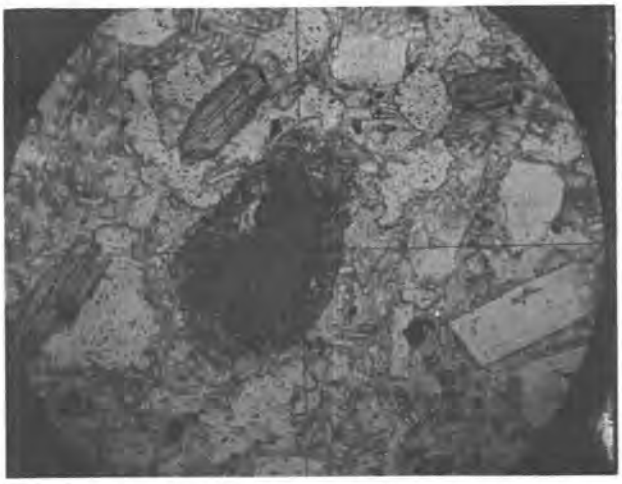

FIGURE 5.—Partial recrystallization of hornblende. The reaction rim consists of hypersthene microlites. Sample is from the October 1980 dome. Magnified 80 times normal.

crystals in later pyroclastic material. Grain boundaries are relatively sharp in May 18th material, but are commonly embayed and partially recrystallized in later pumice (see figs. 4 and 5). Complete recrystallization of the hornblende to hypersthene microlites has resulted in the presence of ghost phenocrysts in many of the post May 18th samples.

Magnetite is commonly present in amounts of 1 percent or less of the total rock and occurs as irregular grains. These grains are commonly scattered throughout the groundmass, but are sometimes concentrated as inclusions within hypersthene phenocrysts (see fig. 3).

Progressive changes in ejecta textures have occurred with time. The most apparent change is in the relative abundance of glass and crystals. Figures 6 and 7 illustrate textural changes between May 18th pumice and April 10, 1981, dome rock. In addition, the progressive recrystallization of the hornblende

phase becomes more apparent within younger flows (fig. 5). The instability of hornblende is likely due to loss of volatiles (mainly water) through the continued degassing of the magma chamber.

The obvious indication of these textural changes is that the magma chamber feeding each of the 1980 eruptions is continuously cooling, and that without injections of new magma, more viscous eruptive products can be expected from future events, as already demonstrated by the shift to dome-building eruptions.

FIGURE 6.—Photomicrograph of a thin section of May 18, 1980 pumice showing relatively few phenocrysts (large crystals) and microlites (small crystals) in an abundant glassy matrix. Compare with figure 7.

FIGURE 7.—Photomicrograph of a thin section of April 10, 1981 dome rock. Note the increase in crystalline phases. Both figures 6 and 7 were photographed under crossed nicols at approximately 30 times normal size.

SUMMARY OF U.S. GEOLOGICAL SURVEY CURRENT ACTIVITIES IN WASHINGTON DURING 1981

These U.S. Geological Survey projects are now in progress and the maps and reports mentioned are not yet available. This listing is only for information about the current work of the U.S. Geological Survey in our state.

Glacier Peak Wilderness Area.—Fieldwork was continued during 1981 in the Glacier Peak Wilderness Area, northern Cascades. Geologic mapping was concentrated in one-third of the area, and bedrock geochemical sampling was undertaken throughout the entire study area. Petrographic and petrologic studies will continue of the metamorphic and plutonic units present and mapping data will be compiled leading to publication of a 1:100,000-scale geologic map. [Project chief: A. B. Ford.]

Mineral resources of Spirit Lake quadrangle.—Mapping and sample collecting were continued. Laboratory studies (feldspar staining, X-ray diffraction, optical petrography) on samples collected in 1979-1980 and extraction of minerals from plutonic and volcanic rocks for K-Ar and fission-track geochronology were also continued. Preparation of final maps and reports will begin. [Project chief: R. P. Ashley.]

Mineral resources of Washington.—Existing minerals resource data for Whatcom County were entered in the Computerized Resource Information Bank of the U.S. Geological Survey. Skamania and Lewis Counties

and other counties in the Cascade Range were also scheduled for entry. [Project chief: R. C. Evarts.]

Magnesite Belt.—Geologic mapping of the Stensgar Mountain quadrangle was completed. About 200 samples were submitted for chemical analysis, and field data were compiled and interpreted. [Project chief: J. G. Evans.]

Indian Heaven RARE II.—Geologic mapping and geochemical sampling were completed in the entire study area. Map compilation and report writing will be initiated. [Project chief: E. H. McKee.]

Glacier View/Tatoosh.—Geologic mapping and geochemical sampling in the entire study area were completed. [Project chief: R. C. Evarts.]

Indian Lands Resource Studies.—Compilation reports on the mineral resource potential of Indian Reservations was continued. [Project chief: E. B. Eckel.]

Frontier Tertiary and Mesozoic hydrocarbon basins of the western United States.—Cored rocks from collections from Oregon and Washington were acquired during 1981 for study and analysis. Paleogene sedimentary rocks in eastern Washington will also be collected and analyzed. [Project chief: T. D. Fouch.]

Chemical and isotopic evidence of the origins of natural gases.—Natural gases, cores, and condensates will be sampled and analyzed from a variety of geologic settings in an effort to establish a model for predicting the character and distribution of gases in relatively unexplored areas. The Columbia Basalt was one of the specific sites being investigated in 1981. The influence of factors such as thermal history, depositional environments, type of organic matter present in source rocks, and secondary processes such as migration and oxidation will be considered. Emphasis will be placed on gases generated from coal or carbonaceous beds, gases generated during high temperatures, and gases of biogenic origin. [Project chief: D. D. Rice.]

Roots of calderas and fossil geothermal systems.—A map of the southwestern rift zone of Mauna Loa, Hawaii, will be prepared, along with a report on Mount St. Helens eruptions. [Project chief: P. W. Lipman.]

Mount St. Helens pyroclastic flows and structural deformation.—Mapping and laboratory studies of pyroclastic-flow deposits and ground deformation resulting from 1980 and subsequent eruptions of Mount St. Helens were underway. [Project chief: R. D. Rowley.]

Land-sea geologic transects.—Reconnaissance studies were undertaken along the western part of the Olympic Peninsula to determine the nature of the interface between late Oligocene to middle Miocene melange and Eocene "core rocks" of the Olympic Mountains. Detailed mapping and sampling along new logging roads constructed during 1980 and 1981 in the Cape Flattery area were also done; the geology exposed in these cuts will be integrated with previous mapping in the four 15-minute quadrangles that comprise the Cape Flattery area. [Project chief: P. D. Snavely.]

Puget Sound urban studies.—Basic earth-science data compilations, such as bedrock and surficial geology and regional ground water assessments, in the Port Townsend 1:100,000-scale quadrangle were completed. Similar studies will be initiated for the Seattle 1° quadrangle. Coastal erosion-sedimentation studies will be extended north into the Bellingham 1° quadrangle also. Stratigraphic, textural, and mineralogic studies, with particular emphasis on nature and distribution of West Beach silt and on the occurrence of asbestoform minerals in late glacial sediments were continued. [Project chief: F. Pessl.]

Tephrochronology.—A report on the

areal distribution, thickness, petrography, and composition of downwind ash from the Mount St. Helens 1980 eruptions is in preparation. [Project chief: A. M. Sarna-Wojcicki.]

Sandpoint 2° quadrangle, Washington and Idaho.—Geologic mapping and ground scintillometer surveying of the Smith Peak, Idaho, Wigwams, Gypsy Peak, Metaline, and Orwig Hump, Washington, 15-minute quadrangles were underway in 1981 Detailed geochemical sampling of rocks will be conducted in a large area of northeastern Washington, defined by anomalous gold-silver values in stream sediment samples, and in an area in northern Idaho, defined by anomalous uranium-molybdenum in stream sediments. Petrographic and modal work on two-mica granitic rocks, particularly in regard to their relation to uranium content, will also be accomplished. Preparation of maps and reports will continue. [Project chief: F. K. Miller.]

Seismo-tectonic analysis of Puget Sound province.—Liquefaction potential maps for the Bremerton East, Bremerton West, and Wildcat Lake 7½-minute quadrangles, Washington, were completed during 1981. A regional compilation of the subsurface geology in the Port Townsend for use in conducting seismic ground shaking and liquefaction potential studies will be initiated. [Project chief: J. C. Yount.]

Okanogan geologic map.—Major emphasis was placed on collecting microfossils from chert and limestone lenses and beds within the various exotic terranes of the eugeosynclinal province, and on a reconnaissance study of possible sutures between these terranes. A paleomagnetic study of several known late Triassic localities was completed. The volcanic rocks in the southern half of the Republic 15-minute quadrangle will be mapped at 1:24,000 scale. [Project chief: K. F. Fox.]

Geochemical paleosalinity criteria for selected glacial sediments in the northern Puget Lowland.—The refinement of the physical stratigraphy and chronology of Wisconsinan age glacial and nonglacial sediments in the north-central Puget Lowland will continue. Geochemical, mineralogical, and textural studies were conducted on samples from detailed measured sections in order to characterize the deposits, to aid in correlation and mapping, and to determine provenance and environment of deposition. [Project chief: D. R. Pevear.]

Quaternary geology of the Seattle 1:100,000 quadrangle.—Geologic mapping in the Bothell, Everett, Mukilteo, Edmonds East, and Edmonds West 7½-minute quadrangles was completed. Fieldwork was initiated in the southeast part of the Seattle 1° quadrangle. Map compilation will continue. [Project chief: J. P. Minard.]

Geologic map of the Colville Indian Reservation.—Fieldwork was concentrated on completing the mapping of the Seventeen-mile Mountain and Twin Lakes quadrangles, the north half of the Nespelem quadrangle, and the northwestern two-thirds of the Keller quadrangle. Lab work will be carried out on rocks from all of the above areas. Map compilation on areas mapped during the 1980 field season will be underway. [Project chief: C. D. Rinehart.]

West Wenatchee 2° quadrangle.—Fieldwork was completed in the Skykomish 1° quadrangle. Mapping of the Snoqualmie Pass 1° quadrangle is underway. Compilation of geologic maps for completed areas will be continued. [Project chief: R. W. Tabor.]

Wonder Mountain RARE II.—Reconnaissance geologic mapping and compilation at the 1:62,500 scale were underway, along with collection and analysis of stream sediment

samples [Project chief: R. W. Tabor.]

Geology of the Doe Mountain quadrangle.—Detailed bedrock geologic mapping of the Doe Mountain 15-minute quadrangle was underway. Sampling for petrographic studies, K-Ar and U-Pb isotopic dating of Mesozoic plutonic rocks and geochemical studies were conducted. [Project chief: V. R. Todd.]

Reactor site investigations.—Emphasis was focused on the Hanford area and other sites as requested. Advice and consultation was provided to the Nuclear Regulatory Commission for delineating investigations and research on the various geologic and seismologic factors to be considered in the evaluation and licensing of proposed nuclear facilities. Past experience indicates that knowledge of the various regional and local geologic conditions, when applied to the evaluations of specific sites, allows the engineering design criteria to be adapted closely to the environment. [Project chief: M. H. Hait.]

Volcanic hazards.—Late Quaternary rocks and unconsolidated deposits of volcanic origin are being studied and dated at volcanoes in the western United States to determine the type and frequency of events they represent. These data will be used to evaluate potential volcanic hazards to communities, reservoirs, recreation facilities, and proposed nuclear power plants that could be affected by future eruptions. Maps are being prepared to show the areal distribution of various kinds of hazards. Where appropriate, recommendations are made to responsible authorities concerning actions to be taken prior to and during volcanic eruptions to minimize danger to life and property. One of the areas to be studied is Mount Rainier. [Project chief: D. R. Crandell.]

Tephra hazards from Cascade Range volcanoes.—Contributions to a Professional Paper on the 1980 Mount St. Helens eruptions was prepared. Tephra from the eruptions will be reviewed for information applicable to interpretation of pre-1980 tephras and associated hazards. Study of tephras from Mount St. Helens and from Mount Mazama, Oregon, to identify individual shower beds and determine their thickness-distance relations and age will continue. Preparation and revision of final reports on volcanic hazards and the stratigraphy and age of Mount St. Helens tephras will continue. [Project chief: D. R. Mullineaux.]

Physical properties and slope stability, Port Townsend quadrangle.—Preliminary maps showing the physical properties and relative slope stability of the Port Townsend quadrangle were field checked. Final revisions of the maps will be completed, reviewed, and submitted for publication. [Project chief: R. D. Miller.]

Potential volcanic hazards to nuclear facilities in Washington, Oregon, and California.—Contacts with universities and state geological surveys and emergency preparedness agencies of Washington, Oregon, California, and British Columbia will be established. Literature search to establish a data base on volcanoes and related hazards continues. Preliminary Safety Analysis Reports for established and proposed nuclear powerplants in the project area will be collected and reviewed. Statistical studies on ash fall distribution patterns versus annual climatic patterns will begin. [Project chief: M. H. Hait.]

Ground-failure hazards in the Columbia River valley.—Detailed mapping and geotechnical sampling were conducted in selected landslide areas in the White Bluffs area of Franklin County. A strip map (scale 1:100,000) with accompanying text showing ground-failure hazards in the Columbia River valley between Priest Rapids Dam and Richland will be prepared. Field studies along the Columbia River

from Richland as far downriver as Juniper, Oregon, continue. These studies will include evaluating and mapping ground-failure hazards in preparation for extending the strip map described above. [Project chief: W. H. Hays.]

Engineering implications of Mount St. Helens eruptions.—Initial collection and synthesis of data on the engineering implications of the Mount St. Helens eruptions were underway. [Project chief: R. L. Schuster.]

Mount St. Helens thermal and topographic monitoring.—Initial analyses of thermal infrared observations were underway. [Project chief: H. H. Kieffer.]

Radar analysis of Mount St. Helens.—Initial analyses of radar imagery of the Mount St. Helens area were underway. [Project chief: H. H. Kieffer.]

Middle Tertiary chronostratigraphic framework, Pacific Northwest.—Examination of the distribution of late Eocene-Oligocene faunas and strata in two east-west transects across Washington continued. The northern transect involves Tertiary sections from Seattle to Cape Flattery, northern Olympic Peninsula, and the second transect involves Tertiary sections south of Olympia to Grays Harbor. Many of these sections are the type sections for Pacific Northwest foraminiferal and molluscan zones. [Project chief: K. A. McDougall.]

Genesis of basalt.—Melt models for Hawaiian tholeiites that are geochemically consistent, fit geophysical constraints related to compositional layering and convection, and physical constraints governing collection and transport of partial melts between the site of melting and sites of storage prior to eruption, will continue to be developed. All available chemical data on Columbia River basalt rocks and glasses as a constraint on petrogenesis of this flood basalt province will be summarized. [Project chief: T. L. Wright.]

Experimental petrology of basalt.—Petrographic studies and analysis of microprobe data will be completed to prepare a report on an occurrence of sulfide in the Columbia River basalts in Washington. [Project chief: R. T. Helz.]

Regional volcanology.—The nature of the relationship between volcanism and geothermal resources continued to be studied. These studies will try to determine if any systematic relationships exist between specific types of volcanic systems and hydrothermal and geothermal anomalies. Criteria that may be useful as guides for geothermal exploration for better understanding of volcanic activity and geothermal processes and for the conceptualization of magma chamber models will continue to be developed. The Oregon-Washington map showing the distribution, composition, and age of late Cenozoic volcanic centers is now in press. [Project chief: R. L. Smith.]

Regional volcanology of the Columbia River basalt.—New volume and area estimates for all the stratigraphic units of the Columbia River Basalt Group are being prepared. [Project chief: D. A. Swanson.]

Geologic map of the Columbia Plateau.—Reconnaissance geologic mapping of the Columbia River Basalt Group is being completed in southwestern Washington and western and northeastern Oregon. [Project chief: D. A. Swanson.]

Goat Rocks Wilderness RARE II area.—Geochemical sampling was completed; final geologic maps and summary reports will be prepared for publication. [Project chief: D. A. Swanson.]

Mount Adams RARE II area.—Final reports and maps summarizing the mineral and geothermal resources of the study area will be prepared and submitted for publication. [Project chief: E. W. Hildreth.]

Mount St. Helens volcano monitoring.—Volcano monitoring at Mount St. Helens and other Cascade Range volcanoes includes the following activities: (1) determination of volcano deformation horizontal strain from on-site laser-electronic measurements; tilt changes, using both telemetered continuously operating tiltmeters and on-site measurements at spirit-level tilt stations; (2) measurements of the magnetic field; and (3) measurement of volcanic gas emissions, using both airborne instruments and on-site sampling. [Project chief: D. W. Peterson.]

Cascade volcano observations.—Detailed geologic mapping of Mount St. Helens and vicinity continued as a supplement to earlier geologic maps. New exposures of old rocks revealed during current eruptions will shed new light on the areal geology and permit a more detailed understanding of relations among the deposits from the 1980 eruptions. Paleomagnetic dating techniques will permit refinements of the stratigraphy of the volcano. Comprehensive studies of specific rock units erupted in 1980, such as pyroclastic flows, debris flows, surge deposits, and air-fall ash, are underway; these studies will continue. Geochemical studies will be aimed at following the changing trends of magmatic evolution through the current eruptive cycle. [Project chief: D. W. Peterson.]

Geoelectrical sounding studies.—Geothermal studies in the Snake River Plain and Cascade Range continued in 1981. Additional magnetotelluric profiling will be acquired for the Cascade Range. [Project chief: W. D. Stanley.]

Geophysics of young volcanic systems.—A preliminary gravity map of the Cascade Range will be compiled. [Project chief: D. L. Williams.]

Radiocarbon and geothermal studies.—The dating of Glacier Peak tephra marker beds B and G (11,000-13,000 years BP) will be refined. [Project chief: S. W. Robinson.]

Radiometric age data bank.—The entry of radiometric ages for Washington in the Radiometric Age Data Bank is continuing, and age records are being revised where necessary. [Project chief: R. F. Marvin.]

Geochemical survey of coal-bearing rocks of western energy regions.—Results of the geochemical survey of the Cretaceous rocks that are the overburden to minable coal in western coal regions will be prepared for formal publication. The primary goal in this work is to assess the magnitude of regional geochemical variation in rocks, and in the soils and dusts derived from them, and to provide realistic baseline data on the present-day geochemical environment. A report on the short-range dispersal of uranium and associated elements from tailing piles at uranium mills in Washington is also being prepared. [Project chief: T. K. Hinkley.]

Repeat magnetic surveys.—Repeat magnetic survey measurements were made at Washington and other states during 1981. [Project chief: J. D. Wood.]

Wilderness area geophysical studies.—Gravity surveying was done in the Glacier Peak Wilderness area during 1981. [Project chief: M. D. Kleinkopf.]

Electrical techniques for shallow to medium depth exploration geothermal systems.—Airborne electromagnetic surveys in the Cascade Range were flown in early 1981 and the data are being evaluated. Ground electrical studies are being carried out in California and a small drilling program is planned in order to better understand the nature of the electrical anomalies observed in geothermal areas. [Project chief: D. B. Hoover.]

Geomagnetic-telluric array investigations of geoelectrical structure in the crust and upper mantle.—The geomagnetic array installed along the Cascade Range during 1980 is being maintained. [Project chief: J. N. Towle.]

Thermal infrared geothermal data.—Data obtained for the northern Cascades by the experimental satellite, "Heat Capacity Mapping Mission (HCMM)," will be analyzed and compared with regional geologic, magnetic, gravity, topographic, and Landsat data. The results of these studies will be used to evaluate the quality of the geologic data that can be derived from thermal satellite data and how such data can be applied to geothermal resource assessment. [Project chief: K. Watson.]

Gamma-ray spectrometry in uranium exploration.—During 1981, data obtained in Washington in 1980 were analyzed. [Project chief: J. S. Duval.]

Gamma-ray spectrometry for uranium exploration in crystalline terranes.—Major emphasis during 1981 was on preparing reports for publication. These reports will deal with interpretations of aerial radiometric surveys of Indian Mountain, Mount Spokane, and the Togo Formation, as well as other areas. Data from these surveys will be synthesized and used as a basis for a report on the implications of using aerial radiometric data for identifying uranium mineralization in crystalline terranes. [Project chief: J. A. Pitkin.]

Geomagnetic secular variation and volcanic timing and episode correlations, geothermal—During 1981, work continued on various young volcanic centers in the United States. Paleointensity measurements will be completed on specimens from several localities in the Cascades. Sampling at Mount St. Helens will be devoted to dating its early geology history. [Project chief: S. Gromme.]

Remote sensing studies of the Cascade Range.—Twelve Landsat scenes adequately cover the entire Cascade Range; eight of the scenes have been digitally processed and the linear features mapped on them. The remaining four scenes were digitally processed and enhanced and the linear features mapped during 1981. The completed linear feature data set will be digitized and entered on the computer for subsequent statistical analysis for preferred orientation characteristics. Based on the results of the statistical analysis, a set of contour maps of linear feature concentrations in statistically important trend intervals will be prepared. These maps will be interpreted for patterns suggestive of regional structure, and the interpretations will be correlated with available geological and geophysical data to help find geological controls for the linear feature patterns. [Project chief: D. H. Knepper.]

Benthic processes in west coast estuaries.—Initial analyses of data from the long-term study of Puget Sound benthos is underway, including preparing a report for publication on results and interpretation of long-term patterns in the structure of a benthic community. [Project chief: F. H. Nichols.]

Continental margin petroleum resources framework.—An open-file report on geophysical studies in Puget Sound will be completed during 1981. [Project chief: T. H. McCulloh.]

Linear island chains and their relation to horizontal and vertical tectonic movements of the Pacific crust.—A study of the tectonics and petrology of the Juan de Fuca Ridge was initiated. [Project chief: D. A. Clague.]

Remote deep-water sensing vehicle.—Plans for a study of deep-sea mineralization and hydrothermal activity in the Juan de Fuca spreading center off the northwestern United

States were developed. A short cruise in the summer of 1981 collected multichannel seismic data to study the upper crustal structure of the Juan de Fuca Ridge and adjacent oceanic plates. [Project chief: W. R. Normark.]

Geologic framework and resources assessment of Oregon-Washington continental margins.—An 8-day geophysical cruise took place on the continental shelves of Washington and Vancouver Island during 1981. Geologic interpretation of seismic-reflection profiles of the Oregon, Washington, and southern Vancouver Island shelves continues. [Project chief: P. D. Snavely.]

Seismological observatories.—Operation and maintenance of seismological observatories in Newport, Washington; Cayey, Puerto Rico; Agana, Guam; and Adak, Alaska, continues. Observatories at Guam and Newport, Washington, provide input on a 24-hour standby basis to the Tsunami Warning Service in Honolulu. [Project chief: H. S. Whitcomb.]

Geothermal tectonic seismic studies.—Investigations focused on Mount St. Helens and the Cascade Range in southern Washington. A detailed study of post-eruption earthquake swarms at Mount St. Helens and a study of teleseismic p-wave delay in the southern Cascade Range in western Washington are planned. A report on northwest-striking seismic zones in western Washington will be completed. Crustal structure studies on the Olympic Peninsula and in southwestern Washington will continue. [Project chief: C. S. Weaver.]

Crustal strain.—All major Geodolite networks in California were resurveyed during 1981. In addition, it is planned to resurvey the following networks: Shumagin Islands, Alaska; Seattle, Washington; Ogden, Utah; Hebgen Lake, Montana; and Mexicala, Mexico. [Project chief: J. C. Savage.]

Magnetic field observations.—Installation, maintenance, and monitoring of magnetic and strain-measuring equipment continued during 1981. Major emphasis was on sites in southern California and Mount St. Helens. [Project chief: M. J. Johnston.]

Tectonic analysis.—Completion of a report on the results of photoelastic modeling of stress distribution in the northwestern United States and the compilation of the tectonic map of Washington at a scale of 1:500,000 are in progress. [Project chief: K. F. Fox.]

Pacific States geophysical studies.—Geophysical studies to support assessment of the mineral resource potential of Wilderness areas were in progress. [Project chief: A. Griscom.]

Geochronology.—The geochronology and geochemistry of volcanic ash from the Cascade Range will be studied. [Project chief: C. W. Naeser.]

PUBLISHED REPORTS OF THE U.S. GEOLOGICAL SURVEY

Reports on Washington geology, by the U.S. Geological Survey, published since June 1980, are listed below:

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DIVISION REVISES OIL AND GAS REPORT

I.C. 67, "Oil and gas exploration in Washington 1900-1978," has been revised and brought up to date. It is now available for purchase from us.

Information Circular 67R

McFarland, Carl R., 1981, Oil and gas exploration in Washington 1900-1981: Washington Division of Geology and Earth Resources Information Circular 67R, 43 oil and gas test well maps, 119 p. Price $2.50.

DIVISION OPEN-FILE REPORTS FOR SALE IN OLYMPIA OFFICE

The following open-file reports have recently been released for sale and may also be used for reference work in our library:

Rigby, J. G., 1981, Bibliographies of the geology and volcanic hazards of the Cascade Range volcanoes of Washington and Mount Hood, Oregon: Washington Division of Geology and Earth Resources Open-File Report 81-5, 42 p. Price $5.

Stoffel, K. L., 1981, Preliminary report on the geology of the Grande Ronde lignite field, Asotin County, Washington: Washington Division of Geology and Earth Resources Open-File Report 81-6, 30 p., 1 plate. Price $4.

Biggane, J. H., 1981, The low temperature geothermal resource of the Yakima region—A preliminary report: Washington Division of Geology and Earth Resources Open-File Report 81-7, 70 p., 3 plates. Price $8.50.

THESES ADDED TO DIVISION LIBRARY

The following theses were recently added to our division library and are now available for reference work:

Rady, Paul M., 1980, Structure and petrology of the Goat Mountain area, north Cascades, Washington: Western Washington University Master of Science thesis, 133 p., 1 plate.

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PLATE TECTONIC MAPS NOW AVAILABLE

Five new plate tectonic maps of the Circum-Pacific region have just been published by the American Association of Petroleum Geologists. Covering more than half of the surface of the earth, these full-color maps depict active plate boundaries, plate motion vectors, major intraplate faults, seismic epicenters, Holocene volcanic activity, and magnetic lineations. Accretionary terrane along the Pacific rim is shown on the Northeast map sheet.

The basic Circum-Pacific Map series consists of five 1:10 million scale maps: The Northwest, Northeast, Southeast, and Southwest Quadrants and the Antarctica Region.

The plate-tectonic maps are available from the AAPG Bookstore, P. O. Box 979, Tulsa, OK 74101, at $8 each or $26 for a set of all five maps.

Index Map Showing 1:10 Million Scale Map Sheets

NORTHWEST MINING ASSOCIATION PLANS ANNUAL CONVENTION

Howard J. Adams, Inspiration Development Co., will serve as convention chairman for the Northwest Mining Association 87th annual convention on December 3-5, in Spokane, Washington.

More than 2,500 mining industry members from around the world are expected to meet to

listen to papers structured around the convention theme, "Moving ahead with America."

The Precious Metals session will feature discussions of newly developed deposits. Dr. Desmond Pretorius of South Africa is one of the featured speakers and will also address the convention at the welcoming luncheon on December 3.

A drilling short course will precede the convention short course on November 30-December 2. Registration information for the convention and(or) short course is available from the Northwest Mining Association, 633 Peyton Bldg., Spokane, WA 99201, (509) 624-1158.

PICTORIAL LANDFORM MAP OF MOUNT ST. HELENS PUBLISHED BY DEE MOLENAAR

An oblique-view pictorial landform map of the volcano and surrounding countryside presents the "before and after" story of Mount St. Helens and the cataclysmic eruption of May 18, 1980. The map shows the locations of towns, roads, airports, campgrounds, recreation areas, volcano viewpoints, peaks, streams, and lakes in the area. The map, "Mount St. Helens Country, Washington," is on one sheet, 24 by 17 inches. It is for sale by Molenaar Pictorial Maps, P. O. Box 62, Burley, WA 98322, for $3.95, plus a $1 mailing charge.

STATE GEOLOGIC MAP NOW AVAILABLE ONLY AS OPEN FILE

The colored "Geologic Map of Washington" (1961 edition, scale 1:500,000) has been reprinted by us several times in the past because of the continuing demand for it. However, all our copies have been sold again, and we have to list the map as out of print. Because of budgetary problems, we are unable to revise and update the map at this time. In order to respond to the requests for a state geologic map, we have made blueline copies of the 1961 edition. These copies are now available from us as a Division of Geology and Earth Resources unnumbered open-file report for $3.

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The following U.S. Geological Survey Open-File Reports are now available for inspection in our division library. However, if you wish to purchase any of these reports, please write or call:

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ACTIVE PERMITS AND APPLICATIONS FOR OIL AND GAS DRILLING

Operator	Permit no.	County	Well name	Location	Ground elevation (feet)	Estimated total depth (feet)	Spud date	Date permit issued
Shell Oil Co.	334	Kittitas	Yakima Mineral Co. No. 1-33	927 FNL and 1,440 FWL[1/] of sec. 33 (15-19E)	1,305.8	16,199 (T.D.)	6-23-80	4-15-80
Shell Oil Co.	335	Kittitas	Yakima Mineral Co. No. 1-34	706 FSL and 2,250 FEL of sec. 34 (15-19E)	2,980	20,000		4-15-80
Sunburst Petroleums Ltd.	336	Jefferson	Sunburst No. 1	SE¼NE¼ sec. 16 (26-13W)	600	7,500 (T.D.)	6-24-81	5-14-81
Snowbird Resources Ltd.	337	Grant	Moses Lake No. 1	1,202 FSL and 2,451 FEL of sec. 13 (20-26E)	1,275	Abandoned at shallow depth	5-16-81	5-14-81
Snowbird Resources Ltd.	337	Grant	Moses Lake No. 1A	Same as above, except 50 ft. north of original site		3,200	6-10-81	
Shell Oil Co.	338	Kittitas	BISSA No. 1-29	1,318 FEL and 1,928 FSL of sec. 29 (18-21E)	3,880	20,000	7-26-81	5-22-81
Shell Oil Co.	339	Grant	BN 1-15	1,946 FNL and 2,528 FWL of sec. 15 (17-25E)	1,720	20,000		5-22-81
Shell Oil Co.	340	Grant	BN 1-9	965 FWL and 1,869 FNL of sec. 9 (15-25E)	2,400	20,000		5-22-81
Snowbird Resources Ltd.	341	Grant	Moses Lake No. 6	2,287 FEL and 1,595 FSL of sec. 14 (20-26E)	1,270	3,200		6-29-81
Snowbird Resources Ltd.	342	Grant	Moses Lake No. 5	1,303 FSL and 668 FEL of sec. 14 (20-26E)	1,275	3,200		6-29-81
Snowbird Resources Ltd.	343	Grant	Moses Lake No. 4	2,339 FEL and 1,418 FSL of sec. 13 (20-26E)	1,270	3,200		6-29-81
Snowbird Resources Ltd.	344	Grant	Moses Lake No. 3	870 FEL and 3,153 FNL of sec. 13 (20-26E)	1,270	3,200		6-29-81
Snowbird Resources Ltd.	345	Grant	Moses Lake No. 2	829 FEL and 315 FSL of sec. 13 (20-26E)	1,275	3,200		6-29-81
Horseheaven Drilling Co.	346	Benton	State No. 1	331 FEL and 293 FSL of SE¼SE¼ sec. 36 (7-25E)	830	2,000		6-29-81
Sunburst Petroleums Ltd.	347	Jefferson	Sunburst No. 16-10	660 FWL and 755 FSL of sec. 10 (26-13W)	995.3	7,000		9-1-81
Shell Oil Co.	348	Kittitas	Yakima Mineral Co. No. 2-33	668 FNL and 1,734 FWL of sec. 33 (15-19E)	1,305.8	5,500		Pending

1/ Land description indicates that the location is 927 ft. from the north line and 1,440 ft. from the west line of sec. 33, township 15 north, range 19 east, Willamette meridian.

Department of Natural Resources
Division of Geology and Earth Resources
Olympia, WA 98504

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