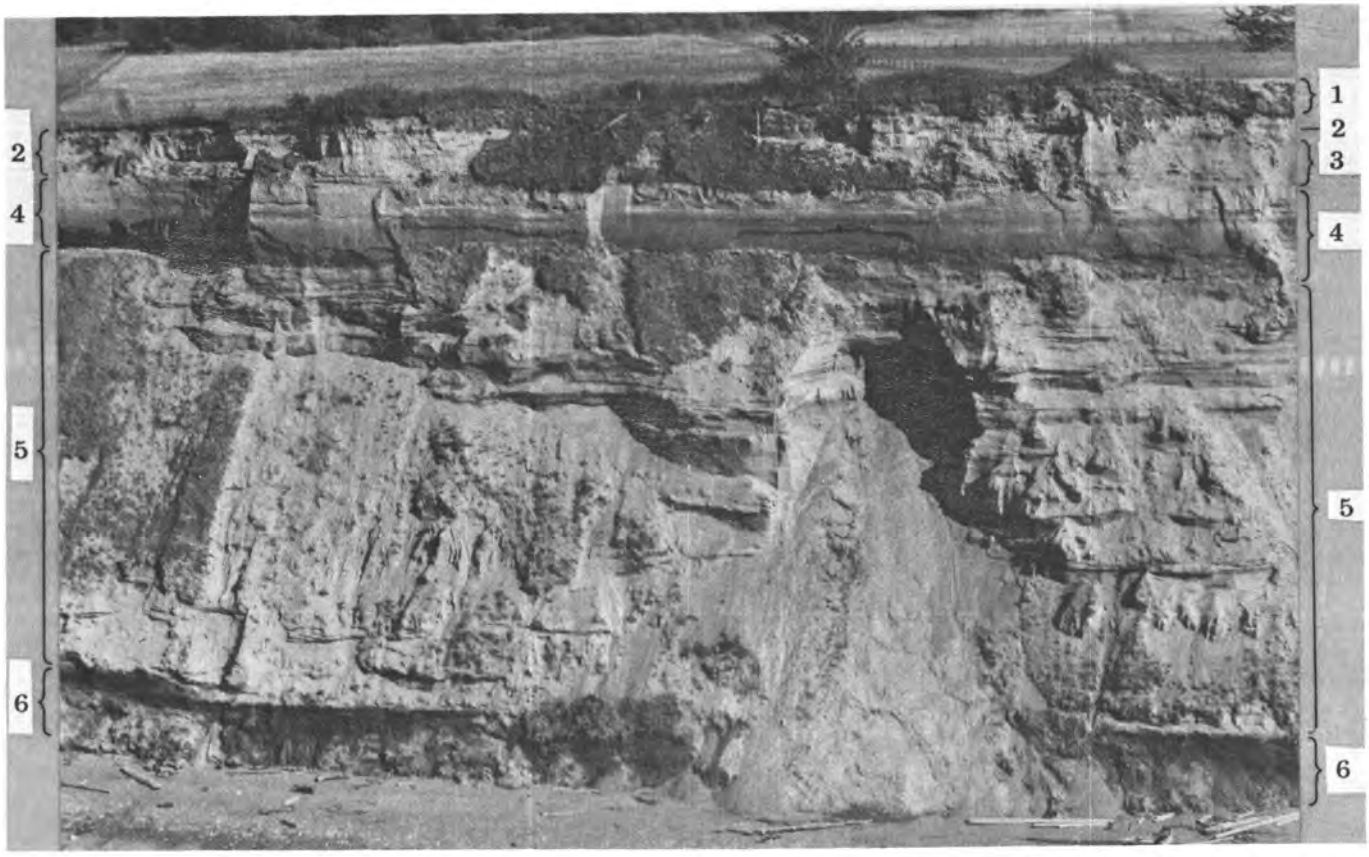
April 1983 Volume 11 Number 2

WASHINGTON GEOLOGIC NEWSLETTER



West Beach on Whidbey Island. Bluff is about 200 feet high on the right.

1. Sand dunes (post glacial)
2. Till (Vashon Drift)
3. Gravelly sand (Vashon advance outwash)
4. Massive silt (loess)
5. Stratified pebbly sand
6. Stratified silt with some sand and peat (Whidbey Formation)

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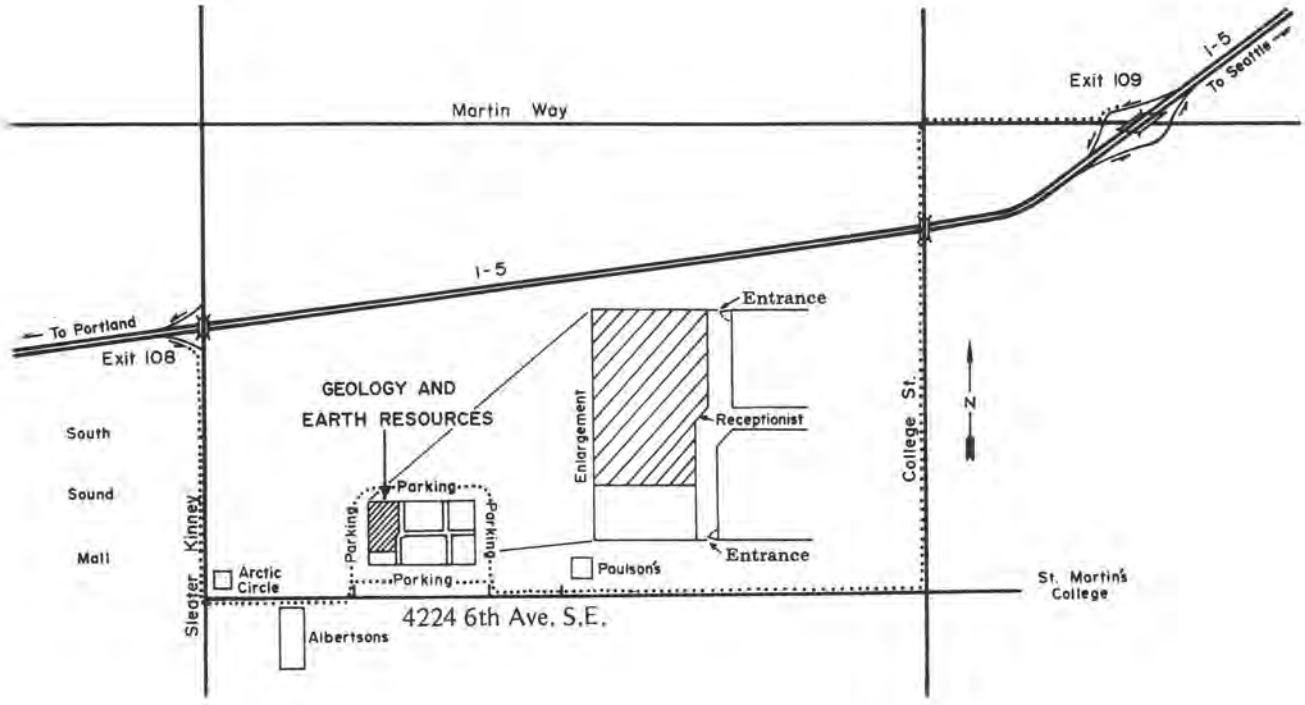

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The Washington Geologic Newsletter, a quarterly report of geologic articles, is published by the Division of Geology and Earth Resources, Department of Natural Resources. The newsletter is free upon request.

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

WEST BEACH SILT – A LATE PLEISTOCENE LOESS, CENTRAL PUGET LOWLAND, WASHINGTON

By
Gerald W. Thorsen

INTRODUCTION

Vast areas of Asia, Europe, and North America are covered with blankets of massive (unstratified) silt called loess. Loess tends to be cohesive and stands well in vertical cuts. In fact, thousands of people in China live in homes carved in loess, probably one of the best examples of "earth sheltered housing." Fertile soils can develop on loesses, and the Palouse Hills of southeastern Washington produce some of the greatest wheat yields in the world. Loess is gray where unweathered but weathers rapidly and deeply to a buff, gray yellow, or orangish-tan color. (China's Yellow River is pigmented with oxidized silt from eroding loess deposits.)

There has been much controversy over the origin of loess in the geologic literature. Researchers now agree that most loess is eroded by wind from areas of "cold desert" environment, but may be carried long distances before deposition. Expanses of unvegetated cold desert areas are common in association with continental glaciation. Barren plains crisscrossed by silt-laden streams can be seen bordering even relatively small modern glaciers. Other potential silt sources may be extensive unvegetated areas left by retreating ice sheets or by the coastal plains uncovered by lowered sea levels resulting from ice buildup on the continents.

Because of this link with glaciation, one might expect multiple loess layers in areas of multiple glaciation. Such multiple loesses interbedded with glacial and nonglacial sediments have long been recognized in many parts of the Northern Hemisphere. In Illinois, for example, these have been studied in great detail. Some were exposed on the earth's surface long enough to develop a soil profile and even vegetation before being buried by subsequent deposits. These "fossil" soils (paleosols) may, in some cases, be recognizable from place to place and can be of value in differentiating one loess from another. The combination of a depositionally unusual material such as loess, together with a means for differentiating one such unit from another, is very valuable in the study of stratigraphy, as the sequence of geologic units is commonly incomplete or obscured from place to place.

DISCUSSION

Origin – In the fall of 1979, when loess was first recognized along the bluffs of West Beach on Whidbey Island, it was thought to be an isolated occurrence. Later, in returning to other perplexing geologic sections, it was recognized in numerous areas. In places, however, the loess drapes down and intermingles with water-laid material and

Fred Pessl, U.S. Geological Survey geologist, pondering a thrust fault in the loess. It may be difficult to tell, in some instances, if such features are of glacial or tectonic origin. Note massive nature of deposit. Angle-of-repose slope below shovel blade is sand.

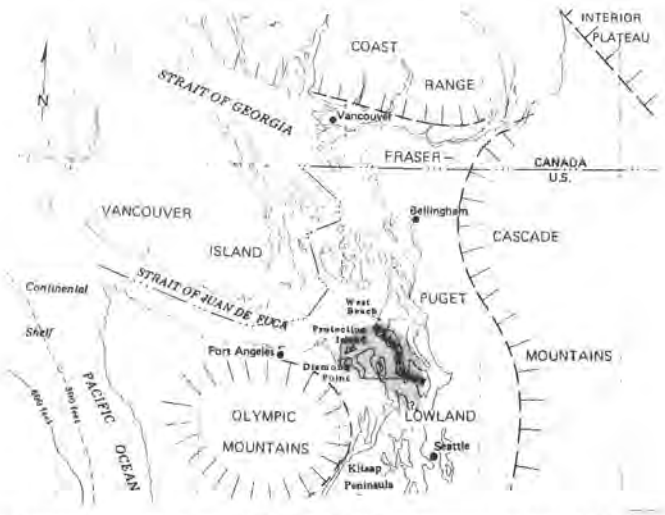
thus is not a true loess according to the strict North American usage of the term. One such place is between Ebeys Landing and Fort Casey where tiny snail shells of fresh water species can be found in the silts. In other areas the silt section may be interrupted by very thin and planar sandy "partings" and(or) isolated ripple marked horizons, indicating at least temporary inundation.

Generally, however, the material appears to be a true loess (that is, wind-deposited silt) throughout the section. The collection of papers published as "Loess, Lithology and Genesis" (Smalley, 1975) mentions at least twelve characteristics of loess deposits. Some of these are:

- an unstratified (massive) character
- a great predominance of silt-size particles
- yellowish or buff color (gray where unweathered)
- occurrence as a uniform blanket, draping older topography
- no compositional or textural relation to underlying formations
- high carbonate content, often secondary
- cohesiveness, tendency to form cliffs
- tendency for vertical jointing
- occurrence of terrestrial gastropods (snails)
- basal "pebble band" common
- high, uniform porosity
- presence of paleosols

Rarely are more than a few of these criteria missing from the sections exposed in this area. Based on field tests, the loess occurrences do not seem to contain significant carbonate, although in one place I have found small (1-inch diameter) carbonate concretions. Possibly the low carbonate content could be due to the relative lack of carbonate source rocks in the Pacific Northwest. So far I have found no land snails. Probably the best confirmation of terrestrial deposition is the presence of a paleosol in places. Generally the fossil soil is at the base of the unit, but near Diamond Point a paleosol containing abundant carbon flecks can be recognized near the middle of a forty-foot-thick section of the massive silt. Jeff Sprague, a Western Washington University graduate student, has been supported by the Division to do detailed studies of Diamond Point and several other sections. So far his findings have supported the concept of deposition by wind.

Distribution – So far the West Beach silt has been recognized as far west as Protection Island and possibly Port Williams on the Olympic Peninsula. The northernmost exposures have been found at West Beach and Blowers Bluff on Whidbey Island. The unit may be exposed as far south as northern Kitsap Peninsula but verification will await further study and the dating of an apparent paleosol here. No exposures have so far been found on the mainland to the east. This may, in part, be due to the relative lack of deep, fresh erosional bluffs such as occur in coastal areas.



General location of West Beach silt occurrences (shaded area)

Soil forming processes would make an exposure of the loess on upland surfaces difficult to differentiate from other silt-rich units.

One might expect wind-deposited dust to blanket extensive areas. Why is the extent of the West Beach silt so localized? Among the possibilities are that it is not really localized, but simply hasn't been recognized elsewhere or that it was deposited in and reworked by water and thus is indistinguishable from any other water-laid silt. Another possibility is that it was eroded from much of its original area of deposition. Such material would erode very easily in today's relatively rainy environment. Undoubtedly, the climate was different from that of the present. Maybe it is just a coincidence that the area where remnants are now found roughly coincides with the "rain shadow" of the Olympic Mountains.

Age – The scarcity of organic material in the basal paleosol of the loess at West Beach has made it difficult to use radiocarbon dating techniques there. However, the unit is well exposed on the north-facing bluffs of Protection Island. Here, a continuous blanket of uniform elevation abruptly drapes down and interfingers with stream and floodplain deposits. Wood from within the base of the loess has been dated at 33,490 ± 550 and 31,500 ± 890 years before present by two different labs. Wood from sediments nearing the end of the period of loess deposition has been dated at 28,200 ± 860 years before present.

Stratigraphic relationships – Puget Sound Quaternary geology is far from a simple "layer cake" of superimposed sediments, and the central Lowland is no exception. Complicating recognition and tracing of the West Beach silt is the variety of its overlying and underlying sediments. Commonly underlying the unit is a glacial drift made up of a rather "poor quality" till, nonsorted sandy gravels, and(or) glaciomarine sediments. This drift unit, where present, is commonly blanketlike rather than exhibiting the abrupt thickening and thinning of the till from the

last ice sheet. In other places, including at West Beach, the loess overlies gray, locally pebbly sand that is as much as 120 feet thick. Features such as the great thickness, vertical and lateral consistency, and lack of wood or peat suggest that these sands were deposited from glacial melt-water streams.

Overlying the loess in places are gray sands and sandy gravels, also apparently of melt-water origin. These sandy sediments are indistinguishable in the field from the sandy sediments that in some localities underlie the loess. In places, the streams depositing this upper sand have eroded into or through the loess. In other places, the loess, as well as local nonglacial(?) stream or fresh-water lake sediments, are overlain by these proglacial sands. In one place on West Beach, the loess appears to grade delicately upward into advance (or sub-ice?) stratified and pebbly silt and sand which, in turn, appears conformable with the overlying till. Nearby, where the till cuts through the loess, the loess is shattered into large angular blocks and cut by clastic dikes that extend well into the underlying sands.

Near Cape George, Olympic Peninsula
1. Till (Vashon Drift)
2. Coarse pebbly sand (from Olympic Mountains?)
3. Massive silt (loess) (West Beach silt)
4. Silty sand
5. Stratified silt (lake deposits?)
6. Landslide debris

Source and depositional environment – It is beyond the scope of this brief article to either formally name the West Beach silt or to discuss at length its paleo-climatic implications or possible stratigraphic correlations. (Both will be undertaken in a report to be submitted to an appropriate geological journal.) Nevertheless, some tentative thoughts on possible depositional environments might be of interest to readers.

Assuming that the Protection Island dates are valid and most of the loess was deposited between about 28 and 33 thousand years ago, it could mark the beginning of a change from nonglacial to glacial conditions. Such a climate would produce some of the conditions observed in the field. Present-day coastal bluffs indicate that much of the Fraser Lowland/Straits of Georgia area was occupied by a vast plain of pebbly, silty sand, apparently deposited by melt water from the developing continental ice sheet. This sand plain, apparently deposited by coalescing melt-water streams from Coast Range glaciers, reached as far south as Comox, B.C., about 29,000 years ago (Clague, 1981). Thus, it could have been developing in the northern Georgia Depression at the start of loess deposition in the central Puget Lowland. Such an unvegetated area, subjected to the cold high velocity winds commonly generated by glaciers, could experience severe wind erosion, with deposition of dust blankets far in advance of the braided streams.

This depositional area of the central Puget Lowland was probably in a period of tundra climate, with only local patches of trees and brush. This could explain why wood appears to be so rare in the loess, except where it drapes down into topographic lows and interfingers with stream deposits. Finely divided organic matter such as might develop from decomposing moss, grass, and lichens is common in upland areas of deposition. Thawing conditions where such a subarctic surface is sloping, sometimes create what are known as "bog flows." In at least two widely separated places on Whidbey Island, what may be deposits of such events can be seen. Here, fine highly organic mudflows apparently swept into local stream channels, contorting or incorporating the gravel beds in places. The resulting deposits have a brownish-colored matrix from the fine organic materials, and a distinct upper limit to gravel particle size but they otherwise resemble till. Other indications of colder climate have been observed by palynologists, who, studying undisturbed bog deposits, have identified higher percentages of the pollens of more cold-tolerant plant species during the period of loess deposition.

The advancing continental ice sheet brought its outwash apron southward in front of it. The same braided melt-water streams that probably produced the dust for the loess deposits while in Canada were eroding and(or) burying it by the time they reached the central Puget Lowland.

Thus, this overlying blanket of pebbly sand, although continuous throughout much of the Fraser/Puget Lowland, is thousands of years younger in the south (Clague, 1981). Such deposits are termed "time transgressive" in geology, and often complicate stratigraphic correlation problems. The melt-water streams responsible for these thick sands and gravels in some places deeply eroded the loess blanket and in others removed it completely. The sands and gravels, in turn, were eroded and(or) covered by the concrete-like till or "hardpan" deposited directly from the ice sheet.

CONCLUSION

From the foregoing it is obvious that recognition of the West Beach silt, like most scientific discoveries, may raise as many questions as it solves. Nevertheless, such a "marker bed" can help solve some knotty stratigraphic problems. Geologic mapping has been likened to solving a 3-D puzzle with most of the pieces missing, so we can use any tools we can get. In spite of unresolved scientific questions, the more we know about Quaternary stratigraphy the better it can contribute to applied practical problems such as gravel exploration, ground water and waste disposal questions, landslide distribution, and even regional tectonics.

Since recognition of the West Beach silt as a loess, another, older loess has been recognized in the area. This unit, essentially identical to the West Beach silt, is beyond the range of conventional radiocarbon dating (40,000 years). Thus, stratigraphy and other geologic tools will be needed to recognize it and trace its extent. Together these interesting formations may help solve some perplexing problems in Quaternary geology. They should also be useful in tying together southwest British Columbia, Olympic Peninsula, and southern Puget Sound Pleistocene stratigraphy.

REFERENCES

Clague, J. J., 1981, Late Quaternary geology and geochronology of British Columbia; Part 2 – Summary and discussion of radiocarbon-dated Quaternary history: Geological Survey of Canada Paper 80-35, 41 p.

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

Smalley, I. J., editor, 1975, Loess lithology and genesis: Dowden, Hutchinson and Ross, Inc., Benchmark Papers in Geology 26, 429 p.

Washburn, A. L., 1980, Geocryology, a survey of periglacial processes and environments: John Wiley and Sons, 406 p.

SUMMARY OF U.S. BUREAU OF MINES CURRENT ACTIVITIES IN WASHINGTON, 1982-1983

The U.S. Bureau of Mines (USBM) has projects in progress throughout Washington in four general categories: Cooperative Programs with the Bureau of Indian Affairs, RARE II Further Planning Areas, Wilderness Areas Studies, and Reclamation Research. The work is directed out of the Western Field Operations Center of the USBM, in Spokane. The reclamation projects are conducted out of the Salt Lake City Research Center.

Mineral Land Assessment of Indian Lands—Through contracts with the Bureau of Indian Affairs, the USBM has undertaken to conduct studies to assess the mineral potential of certain lands. Phase I consists of literature studies, Phase II consists of field examinations, and Phase III, if warranted, would consist of physical exploration, such as trenching or drilling. The resulting reports are not available to the public from the USBM but can be obtained from the respective tribes (see table 1) [Section Supervisor: Robert G. Ingersoll.]

TABLE 1.– *Status of mineral potential studies on Indian lands*

	Phase I Reports Completed (literature studies)
BIA-5	Colville Reservation
BIA-10	Spokane Reservation
BIA-36	Yakima Reservation
BIA-62	Western Washington Reservations: Chehalis, Hoh, Lower Elwha, Lummi, Makah, Muckleshoot, Nisqually, Nooksack Tribe, Ozette, Port Gamble, Port Madison, Puyallup, Quileute, Quinault, Shoalwater Bay, Skokomish, Squaxin Island, Swinomish, and Tulalip
	Phase II Reports Completed (field examination)
BIA-10-11	Spokane Reservation
	Phase III Field Work for FY 1983
Spokane Reservation (Tungsten and gold colluvium placer)	
	Proposed Field Work Beyond FY 1983 (Phase II)
Yakima (Pumicite, diatomite, geothermal potential)	

RARE II Further Planning Areas – Mineral land assessment programs will continue through fiscal year 1983. Reports will be completed for Glacier Peak (55,220 acres), Glacier View (3,010 acres), and Indian Heaven (27,590 acres). Other areas evaluated by the USBM between 1979 and 1982 are listed in table 2. For location of RARE II Further Planning Areas see figure 1. [Acting Section Chief: Lawrence Y. Marks.]

Wilderness Areas Studies – Mineral assessments of Wilderness Areas in the state have been completed. For a summary see table 3. [Section Supervisor: Ernest Tuchek.]

In a related project, the USBM has undertaken to document the amount of federal land remaining in the state that is available for mineral exploration and development. In the process, the Bureau will evaluate the mineral potential of areas that are withdrawn or restricted. A preliminary report was completed for the state in late fiscal year 1982. A final report should become available in fiscal year 1983. [Section Supervisor: D'Arcy P. Banister.]

Reclamation Research – The Salt Lake City Research Center is currently working on the development, improvement, and demonstration of methods for the surface restoration of mill tailings and mine spoils. Field test plots have been established in copper tailings at the Holden mine, Lake Chelan, and on clay-pit wastes in the Spokane area [Research Supervisor: M. B. Shirts.]

FIGURE 1. — Location map — RARE II Further Planning areas.

TABLE 2. – *RARE II Further planning areas in Washington*

Area	Number	National Forest	Size (acres)	BuMines field work	Status *
Eagle Rock	6054	Snoqualmie	33,100	1979-81	Draft report
Glacier Peak	L6031	Snoqualmie	55,220	1979-81	Draft report
Glacier View	A6061	Gifford-Pinchot	3,010	1982	MLA 16-83
Goat Rocks	C6036	Gifford-Pinchot	1,170	1979	MLA 5-81**
Goat Rocks	A6036	Gifford-Pinchot	4,270	1979	MLA 5-81
Goat Rocks	D6036	Wenatchee	19,200	1979	MLA 5-81
Indian Heaven	6076	Gifford-Pinchot	27,590	1982	MLA 31-83
Long Swamp	A6024	Okanogan	10,200	1980	MLA 12-82
Mount Margaret	A6071	Gifford-Pinchot	21,004	1979	Cancelled
Tatoosh	B6063	Gifford-Pinchot	3,470	Cancelled	Cancelled
Wonder Mountain	6086	Olympic	9,468	1981	MLA 105-82
Total acres			187,702		

* February 1, 1983

** MLA series are Bureau of Mines open-file reports.

TABLE 3. – *Wilderness area studies*

Area	National Forest	Acres	Publication
Alpine Lakes	Snoqualmie	303,508	USGS O.F. 73-93; 75-3
Glacier Peak	Snoqualmie	464,741	USBM O.F. 89-82
Goat Rocks	Gifford Pinchot	82,680	USBM O.F. 103-82
Mount Adams	Gifford Pinchot	42,411	USBM O.F. 14-83
Pasayten	Okanogan	505,524	USGS Bull. 1325
Wenaha-Tucannon	Umatilla	180,000	USBM O.F. 20-83

GOVERNOR APPOINTS STATE GEOLOGIST TO MOUNT ST. HELENS SCIENTIFIC ADVISORY BOARD

Ray Lasmanis, State Geologist and Manager of the Division of Geology and Earth Resources, has been appointed by Governor John Spellman to serve a 4-year term on the newly created Mount St. Helens Scientific Advisory Board. The committee was formed to develop recommendations and advice on measures needed to protect and manage the natural and scientific values of the Mount St. Helens Monument. The first meeting will be held at 9 a.m., May 2, 1983, at the Gifford Pinchot National Forest, Forest Supervisor's office, 500 W. 12th St., Vancouver, WA 98660 (phone 206-696-7570). It will be open to the public. Persons who wish to attend should notify Committee Chairman Robert D. Tokarczyk, Gifford Pinchot Forest Supervisor. Written statements may be filed with the committee at the above address before or after the meeting. The other board members are:

Glenn Cooper, Deputy Station Director, PNW Forest and Range Experiment Station

Jack Winjum, Western Forestry Research Center, Weyerhaeuser Co.

James F. Hays, Earth Sciences Division Director, National Science Foundation

Clifford A. Hopson, Dept. of Geological Sciences, University of California

Dallas Peck, Director, U.S. Geological Survey

Robert Jantzen, Fish and Wildlife Service Director, U.S. Dept. of the Interior

Frank Lockard, Director, Washington Dept. of Game

UNIVERSITY OF WASHINGTON CONDUCTS TESTS ON OLIVINE AS HEAT-STORAGE REFRACTORY

Tests conducted at the University of Washington Department of Mining, Metallurgical and Ceramic Engineering showed that olivine produced by Olivine Corp. of Bellingham has superior qualities as a heat-storage medium. The Washington olivine bricks were significantly denser than those now being used for off-peak thermal power heat-storage units, resulting in greater heat-storage capacity. Research was conducted by Mel Eng, ceramic engineer, under the direction of Dr. O. J. Whittemore.

DIVISION TO PUBLISH DATA ON THE MOUNT TOLMAN COPPER-MOLY DEPOSIT IN AGREEMENT WITH COLVILLE CONFEDERATED TRIBES

The Colville Indian Reservation has great mineral potential, including the Mount Tolman copper-molybdenum deposit. Exploration of tribal lands has been ongoing through their own exploration department. The U.S. Geological Survey is conducting geological mapping of the entire Reservation. Recently, the Division of Geology and Earth Resources, Department of Natural Resources, has reached agreement with the Colville Confederated Tribes to publish data on the Mount Tolman project. The report should be available for release by late 1983, when the collation of material and the editing and publishing process are completed.

GEOLOGIC RESEARCH PROJECTS

Geologic research activities conducted by colleges and universities on the geology of Washington State during 1982 are listed below:

CLARK COLLEGE

Faculty Research Projects

Movement history of the Straight Creek fault (Robert B. Miller with Joseph A. Vance and Peter Misch).

Structural, metamorphic, and plutonic history of the southern margin of the Skagit crystalline core of the north Cascades (Robert B. Miller).

Structure and metamorphism of the Gabriel Peak Orthogneiss and the movement history of the Ross Lake fault zone (Robert B. Miller).

Structure and metamorphism of the northeastern portion of the Ingalls complex (Robert B. Miller).

Tectonic evolution of the Rimrock Lake pre-Tertiary inlier, southern Washington Cascades (Robert B. Miller).

CENTRAL WASHINGTON UNIVERSITY

Faculty Research Projects

Computer automation systems for geochemical instrumentation (James Hinthorne).

Electron and ion microprobe study of trace elements in borosilicate and aluminum silicate minerals (James Hinthorne).

Geologic quadrangle mapping of the Yakima fold belt (Robert Bentley).

Mineralogy of lahars in the Ellensburg group (James Hinthorne).

Paleobotany of the Swauk Formation and other Tertiary units of central Washington (Edward Klucking).

Paleomagnetic studies in the Columbia River basalts (Robert Bentley).

Stratigraphy and structural evolution of the Columbia River basalts and Ellensburg group in Washington and Oregon (Robert Bentley).

EASTERN WASHINGTON UNIVERSITY

Faculty Research Projects

Compilation of computer data base of whole-rock chemical analyses of igneous rocks from Washington (Felix E. Mutschler).

Geochemistry of granitic rocks of northeastern Washington (Mohammed Ikramuddin).

Geochemistry of platinum-group elements (Mohammed Ikramuddin).

Geochemistry of the Sanpoil Volcanics and its relationship to gold-silver mineralization (Mohammed Ikramuddin).

Geologic map of the Inchelium quadrangle, Washington (James R. Snook).

Hydrogeochemical methods of exploration for gold and silver (Mohammed Ikramuddin).

Magnetic stratigraphy of Fargher Lake, Clark County, Washington (William K. Steele).

Major and trace element chemistry of "porphyry" molybdenum, tin-tungsten systems (Felix E. Mutschler).

Paleomagnetism of intrusive igneous rocks of northeastern Washington (William K. Steele).

Permian bryozoans of the carbonate units of the Mission Argillite, northeastern Washington (Ernest H. Gilmour).

Quaternary geology of the northeastern Columbia Plateau (Eugene P. Kiver and Dale F. Stradling).

Quaternary map of northeastern Washington east of the Okanogan River (Eugene P. Kiver and Dale F. Stradling).

Use of remanent magnetization in correlating eastern Washington tephra deposits (William K. Steele).

Use of thallium as a potential guide to mineral deposits (Mohammed Ikramuddin).

Student Research Projects

A lineament evaluation and structural study of northeastern Washington using ERTS and SLAR imagery (Sean C. Donovan).

Carbonate petrology and microfacies of the Carboniferous rocks near Springdale, Washington (Mehemed S. Gheddida).

Economic geology of the Sherman molybdenum prospect, Okanogan County, Washington (Grant Newport).

Geochemistry and petrology of the Sanpoil Volcanics and associated granitic rocks of a part of the Colville Indian Reservation, Washington (Sharon J. M. Digby).

Geochemistry and petrography of veins and wall rocks associated with gold-silver mineralization in the Republic district, Ferry County, Washington (Walter M. Martin).

Geochemistry of alaskite and quartz monzonite of Mount Spokane, northeastern Washington, and its relation to uranium mineralization (Roy Bongiovanni).

Geochemistry of metapelites and calc-silicate hornfelses associated with uranium mineralization at the Midnite mine, northeastern Washington (Gin Chou).

Geology of part of the Inchelium quadrangle, Washington (Dick Winters).

Geology of the Heidegger Hill and Monumental Mountain area, northeastern Washington (John Janzen).

Geology of the Orient project uranium deposits, Washington (Mark Wicklund).

Geology of the southeastern portion of the Inchelium quadrangle, Washington (Bruce Smith).

Geomorphology and hydrology of the Latah Creek drainage, Spokane County (Robert Chiang).

Induced polarization-direct current resistivity methods in exploration for pre-Miocene paleo-drainage channels in eastern Washington (John S. McBeth).

Stratigraphy and structural analysis of the Gold Hill area, Inchelium quadrangle, Stevens County, Washington (Howard Orlean).

Structure and depositional environment of the Manastash Formation, Kittitas County, Washington (Dennis G. Lewellen).

Structure of the Deer Trail anticlinorium (David W. Henderson).

Reconnaissance trace element geochemistry of the Loon Lake batholith, northeastern Washington (Adolphus A. Afemari).

Vertical geochemical variations in granodiorites associated with porphyry molybdenum-copper deposits at Mount Tolman, Ferry County, Washington (Danelle D. Elder).

FORT STEILACOOM COMMUNITY COLLEGE

Eocene-Oligocene relationships in southeastern Adna quadrangle (Theresa Hensen and Shawn Jones).

Research on geologically sensitive coastal area, Puget Sound and Pacific Ocean beaches (Joanne Shelley).

GREEN RIVER COMMUNITY COLLEGE

Faculty Research Project

Bedrock geology and Quaternary history of the Enumclaw area (Robert H. Filson).

PACIFIC LUTHERAN UNIVERSITY

Faculty Research Projects

Geology of the Indian Creek gneiss and related rocks, Rimrock Lake area, Yakima County (Brian Lowes).

Origin of vivianite in Pleistocene sediments of the Olympic coastal strip (Steven Benham).

Pleistocene stratigraphy of the Olympic coastal strip (Steven Benham).

TACOMA COMMUNITY COLLEGE

Faculty Research Project

Guide to the roadside geology of Mount Rainier National Park, Washington (Jack H. Hyde).

UNIVERSITY OF WASHINGTON

Faculty Research Projects (partial listing)

Approach of North America to the Juan de Fuca segment of the East Pacific Rise (Robert Bostrom).

Geologic evolution of the southern San Juan Islands (Darrel S. Cowan).

Geologic maps of Mount Baker and Mount Shuksan 15-minute quadrangles (Peter Misch).

Geology of eastern Washington (Eric Cheney).

Geology of the metamorphic core complexes of northeast Washington (Eric Cheney).

Imbricate zone below Shuksan thrust sheet in type area and other north Cascades projects (Peter Misch).

Major faults in the northern Puget Lowland (Eric Cheney).

Student Research Projects (partial listing)

Epithermal mineralization along the Bodie Mountain detachment fault, Okanogan County, Washington (Brian Butler).

Geology and geochronology of the Republic district, Ferry County, Washington (Linda Oliver).

Geology of roof pendants in the Stevens Pass area (John Berti).

Geology of the Big Jim intrusive, Chiwaukum Mountains (Peter Kelemen).

Petrogenesis of high-pressure metamorphosed metalliferous metasediment, Shuksan/Easton Schist (Claudia Owen).

Structural evolution of the northern parts of the Kettle and Okanogan domes of northeast Washington. (Kristin Orr).

WASHINGTON STATE UNIVERSITY

Faculty Research Projects

Bonneville and Missoula flood gravels in the lower Snake River (G. D. Webster).

Geologic mapping of the Clarkston 15-minute quadrangle (G. D. Webster and P. R. Hooper).

Minor and trace element chemistry of Big Seam (coal), Centralia, Washington (F. F. Foit, Jr.).

Stratigraphy, sedimentology, and tectonic setting of Eocene nonmarine strata in western Washington (S. Y. Johnson).

Synthesis of the structure, strain, and metamorphism in the Kootenay Arc, northeast Washington (A. J. Watkinson).

The Lewiston structure and Lewiston Basin, Columbia River basalt (P. R. Hooper).

Student Research Projects

Bonneville flood deposits along the Snake River near Lewiston, Idaho (Eric Swanson).

Evolution of the Chiwaukum graben, central Washington (Eric Johnson).

Geology of the Swauk Formation in the Lion Gulch area, central Cascades, Washington (Steve Taylor).

Ground-water geochemistry of Columbia Plateau basalts (Ali Ghenaw).

Petrology and geologic structure of a portion of the Seventeen Mile Mountain quadrangle, Ferry County, Washington (Wade Holder).

Petrochemistry of the Keller Butte pluton and associated plutons, Colville batholith, Washington (Diane Carlson).

Sedimentation, stratigraphy, and structure of the Swauk Formation in the Swauk Creek area, central Cascades, Washington (Greg Fraser).

Stratigraphy and sedimentology of the Swauk Formation, Tronsen Ridge, Washington (James Roberts).

Structural morphology and associated strain in parts of the Kootenay Arc, northeastern Washington (Mike Ellis).

Structure, stratigraphy, and sedimentation of the Swauk Formation, Mount Lilian area, central Washington Cascades (Darrell Peoples).

Trace element analysis of a Washington coal seam (Sara Kohn).

WESTERN WASHINGTON UNIVERSITY

Faculty Research Projects

Biogeochemistry of PAH aerosols in glacial systems of the Cascades Range (R. S. Babcock with H. W. Wilson).

Geology of the Excelsior mine area, Whatcom County (A. Wodzicki).

Granite intrusion and ore deposition in the Index mining district (A. Wodzicki).

Intraspecific and interspecific variation in species of "Pseudorthoceras" (Cephalopoda, Nautiloidea) from the Middle Pennsylvanian of the Mid-continent – Statistical analysis of fossil orthoconic nautiloids as a new approach to the taxonomy of the order Orthocerida (S. M. Aronoff).

Paleomagnetic secular variations in Mount St. Helens area (R. F. Burmester).

Paleomagnetic study of Teanaway basalts (R. F. Burmester).

Paleomagnetism and Eocene intrusions in Lake Chelan area (R. F. Burmester).

Paleomagnetism and tectonics of Cretaceous batholiths in the north Cascades (M. E. Beck).

Paleomagnetism and tectonics of Cretaceous rocks in the Methow graben (M. E. Beck).

Paleomagnetism and tectonics of early Tertiary volcanic rocks of northeast Washington (M. E. Beck with C. A. Suczek and D. Engebretson).

Petrology and geochemistry of pre-Tertiary igneous and metaigneous rocks in the north Cascades Range (R. S. Babcock with Peter Misch).

Petrology and geochemistry of Tertiary intrusive rocks in the northern Cascades (R. S. Babcock).

Petrology and geochemistry of the Boulder batholith (R. S. Babcock with A. Wodzicki and E. Krogstad).

Quaternary sediments in Hecate Strait, British Columbia – Study of high-latitude carbonate sediments and of the petrology of associated terrigenous sediments (C. A. Suczek).

Stability of gold-thioarsenate complexes under hydrothermal conditions and the deposition of gold in contemporary geothermal systems (R. S. Babcock).

Study of hydrothermal alteration near Gamma Hot Springs, Glacier Peak (A. Wodzicki).

Study of volcanogenic massive sulfide deposit at Fifteen-Mile Creek area, Stevens County (A. Wodzicki).

Tertiary tectonics of western Washington – Combined sedimentation/sedimentary petrology (C. A. Suczek) and paleomagnetics (M. E. Beck and D. C. Engebretson) on Tertiary marine sedimentary units.

Student Research Projects

Age investigation of pre-Salmon Springs Drift glacial deposits in the southern Puget Lowland (John Roland).

Depositional framework and regional extent of the West Beach silt and its significance in pre-late Wisconsin stratigraphy of the Puget Lowland (Jeff Sprague).

Economic geology of the Fifteen-Mile Creek area, Stevens County, northeast Washington – A volcanogenic massive sulfide deposit? (Bert Hyde).

Geology and genesis of Excelsior mine, Whatcom County (Russ Franklin).

Geology of the Canyon Creek area (Chilliwack and Nooksack Groups) (Jeff Jones).

Geology of the Park Butte – Loomis Mountain area (David Blackwell).

Hydrothermal alteration and geothermal potential of the Gamma Ridge rocks, Glacier Peak (Rick Waldron).

Net shore-drift, Mason County (Dana Blankenship).

Net shore-drift, Pierce County (Brad Harp).

Net shore-drift, Thurston County (David Hatfield).

Paleolimnological study of Lake Whatcom (Allen Moore).

Paleomagnetic study of unnamed Eocene basalts and sediments of Summit Creek, east of Mount Rainier (David Abbott).

Paleomagnetism of Cretaceous plutons, north Cascades (William Harrison).

Paleomagnetism of the Mount Rainier area (Paul Furlong).

Paleomagnetism of the Republic graben (Michael Faxon).

Paleomagnetism, tectonic evolution, and magnetostratigraphy of the Lincoln Creek Formation of Grays Harbor basin, Washington (John Karachewski).

Petrology of tectonic blocks and geology along the Shuksan thrust, Mount Shuksan area, north Cascades (Peter Leiggi).

Petrology of xenoliths in pumice and dome rock from the 1980-81 eruptions of Mount St. Helens (Christina Heliker).

Petrology, stratigraphy, and basin tectonics of the Montesano Formation, southwest Washington (Phil Bigelow).

Quaternary chronology of the Palouse loess near Washtucna (Lucy Foley).

Sedimentary petrology and depositional environment of the Hoko River Formation, Olympic Peninsula (Leif Christenson).

Sedimentary petrology of the early Miocene Clallam Formation, Olympic Peninsula (Kurt Anderson).

Structure and petrology of Baker area-Spring Creek (Chuck Ziegler).

Structure and petrology of the Tomyhoi Peak area, north Cascades (James Sevigny).

Temporal trends in geochemistry and petrology of the 1980 Mount St. Helens pyroclastic flow deposits (Josh Logan).

WHITMAN COLLEGE

Quaternary, environmental, and economic geology of the eastern Olympic Peninsula (R. J. Carson).

RECENTLY RELEASED REPORTS BY THE DIVISION OF GEOLOGY AND EARTH RESOURCES NOW AVAILABLE

Copies of these publications may be obtained by writing to the Department of Natural Resources, Division of Geology and Earth Resources, Olympia, WA 98504. Please add a $1 distribution charge to your total order.

Livingston, V. E., Jr., 1959, reprinted 1983, Fossils in Washington: Washington Division of Geology and Earth Resources Information Circular 33, 34 p. Price 50 cents.

McFarland, C. R., 1983, Oil and gas exploration in Washington, 1900-1982: Washington Division of Geology and Earth Resources Information Circular 75, 119 p. Price $2.50.

Moen, W. S.; Huntting, M. T., 1975, reprinted 1983, Handbook for gold prospectors in Washington: Washington Division of Geology and Earth Resources Information Circular 57, 90 p. Price $2.

THESES ADDED TO OUR DIVISION LIBRARY

We have recently acquired the following theses in our Division library where they are now available for reference work.

Alemi, M. A., 1978, A gravity survey of Coos Bay, Oregon: University of Oregon Master of Science thesis, 71 p.

Bethel, J. P., 1982, An investigation of the primary and secondary mineralogy of a sequence of glacial outwash terraces along the Cowlitz River, Lewis County, Washington: University of Washington Master of Science thesis, 90 p.

Bishop, D. T., 1974, Petrology and geochemistry of the Purcell sills, Boundary County, Idaho and adjacent areas: University of Idaho Doctor of Philosophy thesis, 147 p.

Bolm, J. G., 1975, Structural and petrographic studies in the Shuswap terrane: University of Idaho Doctor of Philosophy thesis, 93 p.

Carsten, F. P., 1982, Petrology of the Upper Cretaceous strata of Orcas Island, San Juan County, Washington: Washington State University Master of Science thesis, 120 p.

Cheshier, R. A., 1982, Geological features of a mineralized shear zone, Kettle Falls, Stevens County, Washington: Washington State University Master of Science thesis, 67 p.

Chrzastowski, M. J., 1982, Net shore-drift of King County, Washington: Western Washington University Master of Science thesis, 153 p.

Cotton, W. P., Jr., 1982, Hydrochemistry of ground water near Pullman, Washington: Washington State University Master of Science thesis, 89 p.

Domack, E. W., 1982, Facies of late Pleistocene glacial marine sediments on Whidbey Island, Washington: Rice University Doctor of Philosophy thesis, 312 p., 11 plates.

Doh, Seong-Jae, 1982, Paleomagnetic record of late Quaternary sediments from Fargher Lake, Washington: Eastern Washington University Master of Science thesis, 25 p.

Foley, L. L., 1982, Quaternary chronology of the Palouse loess near Washtucna, eastern Washington: Western Washington University Master of Science thesis, 137 p.

Frizzell, V. A., Jr., 1979, Petrology and stratigraphy of Paleogene nonmarine sandstones, Cascade Range, Washington: Stanford University Doctor of Philosophy thesis, 151 p.

Furlong, P. O., 1982, Paleomagnetism of the Mount Rainier area, western Washington: Western Washington University Master of Science thesis, 76 p.

Hallet, Bernard, 1975, Nature and effects of chemical processes at the base of temperate glaciers: University of California, Los Angeles Doctor of Philosophy thesis, 95 p.

Hemstrom, M. A., 1979, A recent disturbance history of forest ecosystems at Mount Rainier National Park: Oregon State University Doctor of Philosophy thesis, 67 p.

Humphrey, N. F., 1982, Pore pressures in debris failure initiation: University of Washington Master of Science thesis, 169 p.

Knappe, Roy, Jr., 1974, The micropaleontology of a section of the Tepetate Formation, southern Baja California, and a paleobiogeographic comparison with equivalent Foraminifera along the west coast of the United States: Ohio University Master of Science thesis, 114 p.

Liszak, J. L., 1982, The Chilliwack Group on Black Mountain, Washington: Western Washington University Master of Science thesis, 104 p.

Orazulike, D. M., 1982, Igneous petrology and petrochemical variation in the Coyote Creek pluton, Colville batholith and its relation to mineralization at Squaw Mountain, Colville Indian Reservation, Washington: Washington State University Doctor of Philosophy thesis, 275 p., 1 plate.

Paine, J. G., 1982, Crustal structure of volcanic arcs based on physical properties of andesites, volcaniclastic rocks, and inclusions in the Mount St. Helens lava dome: University of Washington Master of Science thesis, 138 p.

Peters, D. C., 1973, Hypocenter location and crustal structure inversion of seismic array travel-times: University of Washington Doctor of Philosophy thesis, 127 p.

Reinink-Smith, L. M., 1982, The mineralogy, geochemistry, and origin of bentonite partings in the Eocene Skookumchuck Formation, Centralia mine, southwestern Washington: Western Washington University Master of Science thesis, 179 p.

Strickler, D. L., 1982, Paleomagnetism of three late Cretaceous granitic plutons, north Cascades, Washington: Western Washington University Master of Science thesis, 99 p.

Van Deusen, J. E., III, 1978, Mapping geothermal anomalies in the Klamath Falls, Oregon, region using gravity and aeromagnetic data: University of Oregon Master of Science thesis, 117 p., 6 plates.

RECENT U.S. GEOLOGICAL SURVEY OPEN-FILE REPORTS ADDED TO OUR DIVISION LIBRARY

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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Church, S. E.; Frisken, J. G.; Mosier, E. L.; McDanal, S. K., 1982, Analytical results for stream sediments, panned concentrates from stream sediments, and rocks collected from the Wonder Mountain Roadless Area (6086), Washington: U.S. Geological Survey Open-File Report 82-1066, 84 p.

Hill, Gary W.; Phillips, R. L.; Clifton, H. E., 1981, Seismic profiles from Willapa Bay, Washington: U.S. Geological Survey Open-File Report 81-1315, 3 sheets microfiche.

Luepke, Gretchen, 1982, Heavy-mineral variability in beach and dune sands in the vicinity of the mouth of the Columbia River: U.S. Geological Survey Open-File Report 82-1091, 16 p.

Ort, K. M.; Tabor, R. W.; Frizzell, V. A., Jr., 1983, Chemical analyses of selected Tertiary and Quaternary volcanic rocks, Cascade Range, Washington: U.S. Geological Survey Open-File Report 83-1, 14 p.

Snavely, P. D., Jr.; Wagner, H. C., 1983, Geophysical data collected across the continental margin between Washington and Oregon along line 16, USGS R/V S. P. Lee cruise 11-80: U.S. Geological Survey Open-File Report 83-20, 1 sheet.

Tabor, R. W.; Frizzell, V. A., Jr.; Booth, D. B.; Whetten, J. T.; Waitt, R. B., Jr.; Zartman, R. E., 1982, Preliminary geologic map of the Skykomish River 1:100,000 quadrangle, Washington: U.S. Geological Survey Open-File Report 82-747, 31 p., 1 plate, scale 1:100,000.

RECENT GEOLOGIC REPORTS ADDED TO OUR DIVISION LIBRARY

The following reports have recently been acquired by the Division of Geology and Earth Resources and are now available for reference work in the library:

Alpha, T. R; Morley, J. M.; Myers, Bobbie; Leighley, Terry, 1982, Physiographic diagrams of Mount St. Helens, Washington, showing changes in its summit crater, 1981: U.S. Geological Survey Miscellaneous Field Studies Map MF-1420, 1 sheet.

Cater, Fred W., 1982, Intrusive rocks of the Holden and Lucerne quadrangles, Washington — The relation of depth zones, composition, textures, and emplacement of plutons: U.S. Geological Survey Professional Paper 1220, 108 p.

Foxworthy, Bruce L.; Hill, Mary, 1982, Volcanic eruptions of 1980 at Mount St. Helens — The first 100 days: U.S. Geological Survey Professional Paper 1249, 125 p.

Luepke, R. G.; Smith, R. L., 1982, Map showing distribution, composition, and age of late Cenozoic volcanic centers in Oregon and Washington: U.S. Geological Survey Miscellaneous Investigations Series Map I-1091-D, 1 sheet, scale 1:1,000,000.

Tabor, R. W., 1982, Geologic map of the Wonder Mountain roadless area, Mason County, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-1418A, 1 sheet, scale 1:62,500.

Tabor, R. W.; Waitt, R. B., Jr.; Frizzell, V. A., Jr.; Swanson, D. A.; Byerly, G. R.; Bentley, R. D., 1982, Geologic map of the Wenatchee 1:100,000 quadrangle, central Washington: U.S. Geological Survey Miscellaneous Investigations Series Map I-1311, 1 sheet, scale 1:100,000, 26 p.

NEW GEOTHERMAL PUBLICATIONS RELEASED

Geophysical Map 27, Complete Bouguer gravity anomaly map of the Cascade Mountains, Washington, by Z. F. Danes and W. M. Phillips, 2 sheets. Price $3.25.

Open-File Report 83-1, Principal facts and a discussion of terrain correction methods for the complete Bouguer gravity anomaly map of the Cascade Mountains, Washington, by Z. F. Danes and W. M. Phillips, 15 pages, 145 gravity data sheets. Free.

Gravity measurements made at 4,305 stations in the Cascade Mountains, Washington, are presented in Geophysical Map 27 and Open-File Report 83-1. A complete Bougue gravity anomaly map at a scale of 1:250,000 was constructed using the gravity data, and is presented in Geophysical Map 27. The complete Bouguer gravity anomaly map is divided into 2 sheets. Sheet 1 shows complete Bouguer gravity anomalies for the Cascade Mountains north of 47° N. latitude. Sheet 2 covers the remainder of the Cascade Mountains from 47° N. latitude, south to the Oregon border along the Columbia River. The map sheets have a contour interval of 5 mgals. A Bouguer reduction density of 2.67 g/cc was used throughout the Cascade map area. Theoretical gravity is IGF(1967).

Open-File Report 83-1 presents the principal facts for each gravity station within the Cascade Mountains map area. Recorded are longitude, latitude, elevation in feet, and observed gravity in mgals. Computational methods used to reduce the gravity data to the complete Bouguer anomaly form are also described. The principal fact data set is also available on magnetic tape for users wishing to process the data on their own computer systems.

The gravity data were collected as part of the Division of Geology and Earth Resources geothermal research program. Funding for the work was provided by the U.S. Department of Energy.

The senior author, Z. F. Danes, is professor of physics at the University of Puget Sound, Tacoma, Washington. W. M. Phillips is a Division of Geology and Earth Resources geologist.

These reports may be ordered from the Washington Department of Natural Resources, Division of Geology and Earth Resources, Olympia, WA 98504. Please add $1 to your total order for a mailing and distribution charge.

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