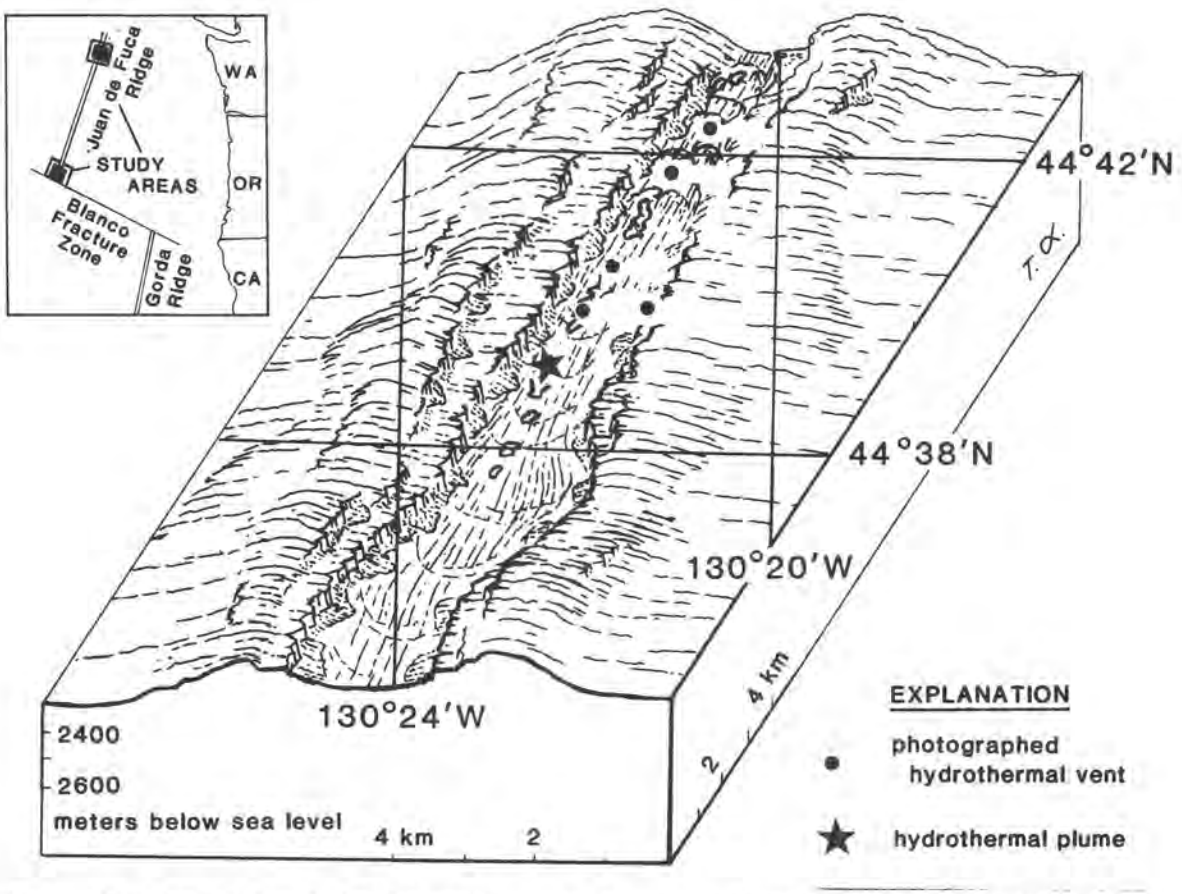
OCTOBER 1983 VOLUME 11 NUMBER 4

WASHINGTON GEOLOGIC NEWSLETTER

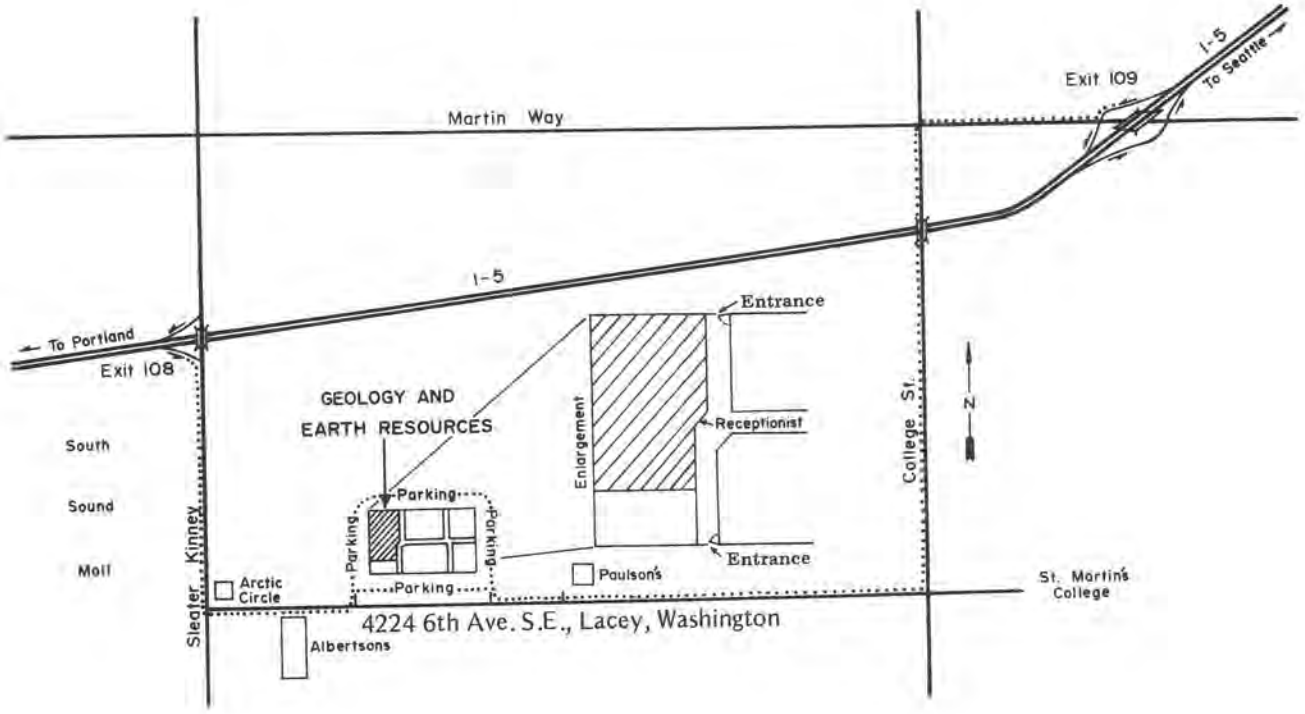


The southern Juan de Fuca Ridge, showing the central depression, hydrothermal vents, and probable hydrothermal plume indicated by water sampling. The USGS study area is shown on the southern extension of the Juan de Fuca Ridge on the inset regional map; the study of the joint Energy, Mines and Resources Canada/U.S. National Oceanographic and Atmospheric Agency 1983 cruise is shown on the northern extension. From *Oceanus* – Koski and others, 1983; map by T. R. Alpha. See page 1 for accompanying article.

BRIAN J. BOYLE
COMMISSIONER OF PUBLIC LANDS
STATE OF WASHINGTON

ART STEARNS, Supervisor
DEPARTMENT OF NATURAL RESOURCES

RAYMOND LASMANIS, State Geologist
DIVISION OF GEOLOGY AND EARTH RESOURCES



MAILING ADDRESS:

Department of Natural Resources
Division of Geology and Earth Resources
Olympia, WA 98504
(206) 459-6372

Field office address:

Department of Natural Resources
Division of Geology and Earth Resources
Spokane County Agricultural Center
N. 222 Havana
Spokane, WA 99202
(509) 458-2038

Laura Bray, Editor

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.

Readers, please respond to questionnaire on back cover sheet.

OFFSHORE METAL DEPOSITS – WASHINGTON AND OREGON

by Ray Lasmanis*

Mineral explorationists have theorized for decades that certain lead, zinc, and copper deposits can form on the ocean floor in a volcanic environment. These concepts have led to the discovery of major ore deposits. However, debates have persisted on the genesis of massive sulfide deposits. A majority of geologists believe that such sulfides were deposited contemporaneously (syngenetic) with the enclosing sediments or volcanics. Others reason that hydrothermal solutions laden with metals invade the host rock millions of years later.

Credence was given to the syngenetic theory when numerous reports began to flow in from scientific deep-water expeditions studying moderately fast-spreading centers on the Pacific Ocean floor. Along with tectonic activity and volcanism, the oceanic ridges contain hydrothermal vents depositing massive sulfides rich in iron, zinc, lead, and copper. Common minerals are pyrite, marcasite, galena, sphalerite, wurtzite, chalcopyrite, and cubanite. By 1978, recent sulfide deposits had been identified off the coasts of Mexico, Galapagos, and Chile. The specific sites are:

Name	Latitude	Longitude
Guaymas Basin	27°N.	111°W.
East Pacific Rise	21°N.	109°W.
East Pacific Rise	13°N.	104°W.
Galapagos Rift	01°N.	86°W.
East Pacific Rise	20°S.	104°W.

It followed that the spreading centers off the coasts of California, Oregon, and Washington should be investigated. Reconnaissance surveys by the U.S. Geological Survey using submersibles and deep-water cameras during 1980-1982 confirmed that the spreading centers known as the Juan de Fuca Ridge and Gorda Ridge contain identical conditions as those along the East Pacific Rise. Metal deposition is currently taking place on the ocean floor off the Oregon and Washington coasts.

Gorda Ridge is situated off the coasts of California and Oregon 125 to 250 miles from shore. The Juan de Fuca Ridge lies off the coast of Oregon and Washington 200 to 325 miles from shore.

As the ocean floor spreads, long parallel faults form the walls of graben structures along the crests of oceanic ridges. It is within these grabens that hydrothermal vents are aligned along faults and are depositing metallic minerals. Not only is this an opportunity to study the formation of metal deposits but also to study a unique ecosystem that is dependent on hydrothermal heat for survival. Giant tube worms are one of the unusual life forms. Many of these animals get fossilized by sulfides.

Some of the hydrothermal vents have been nicknamed "black smokers" as they belch out dark clouds rich in sulfur, zinc, iron, copper, lead, silver, and cadmium. At the Juan de Fuca Ridge, associated minerals are silica and barite. Typical assays from latitude 44°40' N. and longitude 130°22' W. are shown below:

TABLE 1. – *Results of bulk chemical analysis for two samples (by atomic absorption spectroscopy)*

Element	Sample 1	Sample 2
Zinc (percent of weight)	54.0	59.2
Iron (percent of weight)	8.0	1.8
Copper (percent of weight)	0.32	0.07
Lead (percent of weight)	0.25	0.06
Silver (parts per million)*	290	230
Cadmium (parts per million)	490	1,060

Sample 1: Dark-gray massive zinc sulfide with minor pyrite.
Sample 2: Light-gray spongy zinc sulfide.
* 34.28 parts per million = 1 troy ounce per ton.
From Koski, R. A., and others, p. 46.

Metal sulfide deposits off our coast could have economic implications. Certainly, the deposits are rich concentrations of metals needing further exploration to determine their thickness and extent. To achieve this

* State Geologist, Washington Division of Geology and Earth Resources.

objective, the U.S. Dept. of Interior Minerals Management Service is formulating plans to lease Gorda Ridge for polymetallic sulfide exploration. They hope to hold the lease sale between April and June 1984.

The Juan de Fuca Ridge, off the Washington coast, has been withdrawn from leasing pending negotiations with the Canadian Government. Meanwhile research by the U.S. Geological Survey will continue into 1984 to document sulfide deposition in the Juan de Fuca Ridge. As recently as May 1983, active hydrothermal vents were discovered at latitude 48°06' N. and longitude 129°00' W. by a joint Energy, Mines and Resources Canada/ U.S. National Oceanographic and Atmospheric Agency cruise.

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Normark, W. R.; Murray, J. W.; Lupton, J. E.; Delaney, J. R.; Johnson, H. P.; Koski, R. A.; Clague, D. A., Morton, J. L.. 1982, Polymetallic sulfide deposits and water-column of active hydrothermal vents on the southern Juan de Fuca Ridge: Marine Technology Society Journal, v. 16, no. 3, p. 46-53.

RARE MINERALS FOUND IN STEVENS COUNTY, WASHINGTON

by Ray Lasmanis*

INTRODUCTION

Mineral samples collected at the Wells Fargo mine, Stevens County by Wayne Moen (now retired from the Division of Geology and Earth Resources) were submitted to Bendix Field Engineering Corp. for routine analysis. This spring John Sholes of Bendix, while working on the National Uranium Resource Evaluation (NURE) project, informed us that the rare minerals gearksutite and robinsonite had been identified in these samples. The mine is already known as a past producer of zinkenite.

LOCATION

The Wells Fargo antimony mine is located on state land in the N½NW¼ sec. 36, T. 31 N., R. 38 E. It is situated at an elevation of 4,000 feet on the east slope of Huckleberry Mountain, Deer Trail mining district, Stevens County. The Red Marble magnesite quarry is located 1 mile to the north. Access is by road from the town of Valley.

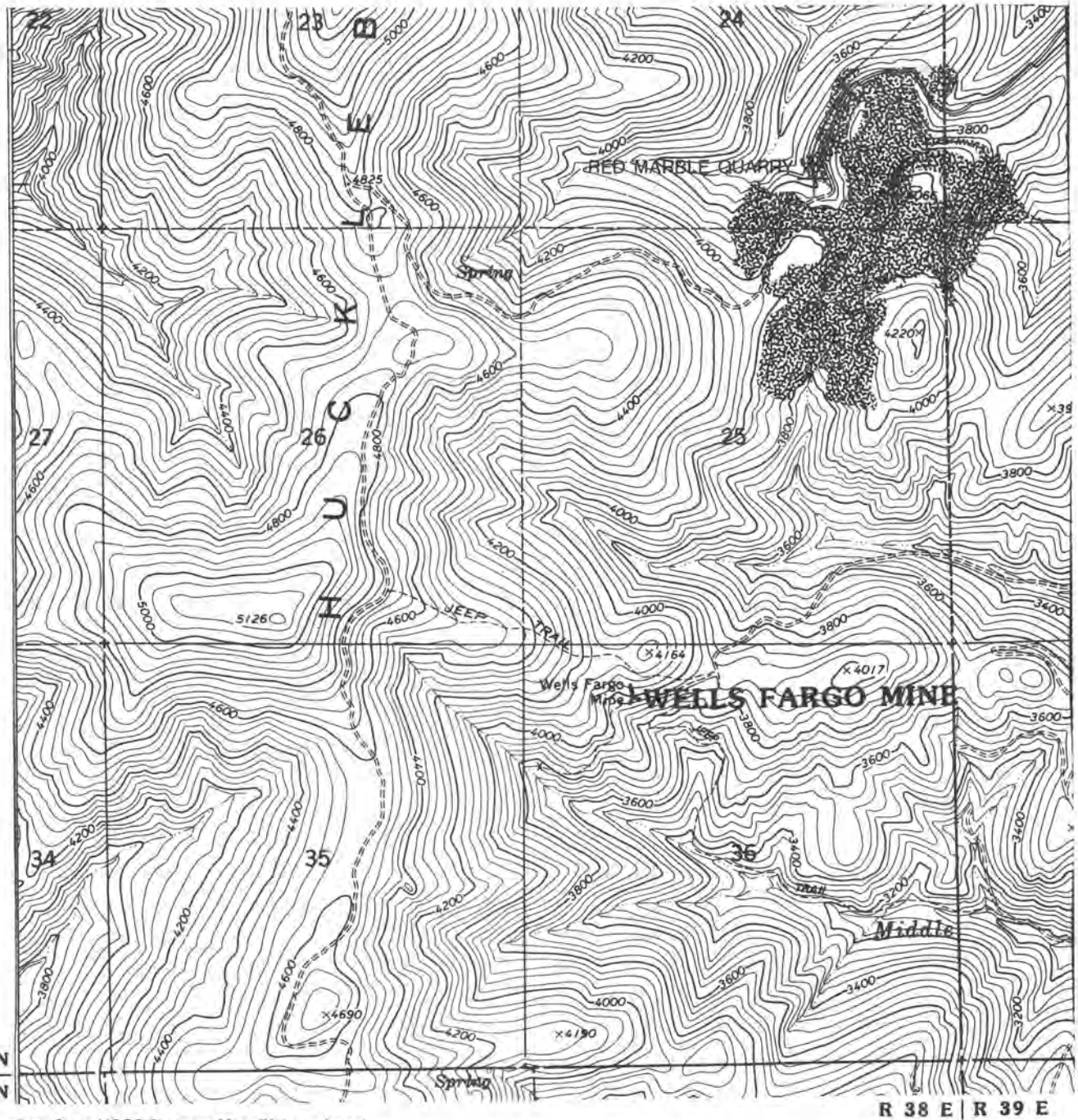
HISTORY

The property was originally located in 1885. The principal development work was done by the Wells Fargo Mining Co. between 1897 and 1917. Two adits were driven into the hill and a raise was brought to the surface. The lower of the two adits was driven on a heading of N. 30° W. The mine has produced small tonnages of antimony, lead, and silver ore.

In the 1960's, the state lease was held by M. L. Carr, F. V. Carr, Clarence R. Carr, and J. Merv Carr, all of Valley, Washington. A sublease was granted to Fargo Mining Corp., which started a 2-year underground development program in 1968. The lower adit was extended to 540 feet intersecting the downdip extension of the vein system. It was in the course of this development program that a massive lense of zinkenite was discovered. It was the first documented occurrence of the mineral in the state.

Since 1981, part of the mine area has been under a state Mineral Prospecting Lease (No. 64348) issued to

* State Geologist, Washington Division of Geology and Earth Resources.

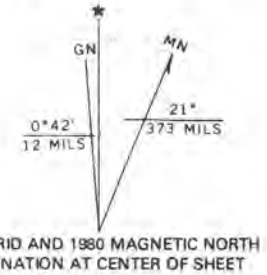


Base from USGS Stensgar Mtn. 7½' quadrangle

LOCATION MAP
WELLS FARGO MINE

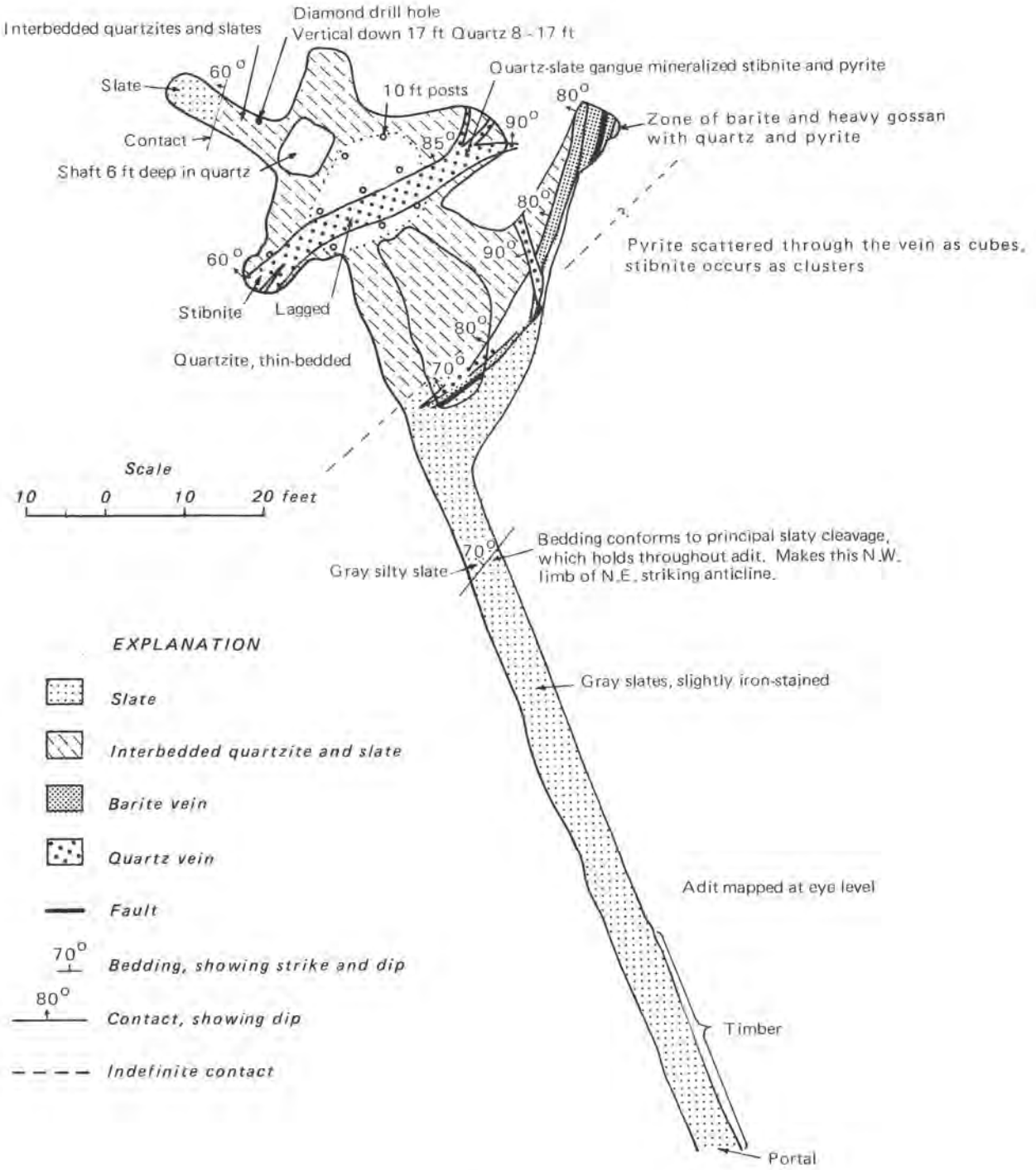
Scale 1:24,000

0 ½ 1 mile



UTM GRID AND 1980 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

WELLS FARGO MINE



Mapped by C. Phillips Purdy, Jr.

Geologic plan of the upper adit at the Wells Fargo mine (after Purdy, 1947).

Entrance to lower adit of Wells Fargo mine — October 1969

Jerry L. and Connie Lee Schlehuber of Davenport. They have applied to have the lease converted to a mining contract. The W½NW¼ is under lease (No. 64920) to Joy Mining Co. of Spokane. They are conducting geochemical and geophysical surveys and plan to clean out the lower adit.

GEOLOGY

The Wells Fargo mine is situated in a northeast-trending belt of folded metasedimentary rocks of Precambrian (Proterozoic) age. In the mine area the Deer Trail Group is represented by the Buffalo Hump Formation — a thick sequence of gray to black slates and minor interbedded quartzites. Both normal and thrust faults have been documented throughout the belt. Within the mine, quartz, barite, and sulfide veins and stringers are localized in quartzite interbeds. Sheared contacts are common. All structures and contacts strike north to northeast and have steep dips to the northwest.

MINERALOGY

Two veins were mapped by C. Phillips Purdy, Jr., during August 1947. One was a quartz vein containing stibnite and pyrite. The other, a barite vein, was heavily oxidized, containing quartz and pyrite. In 1968, development on the quartz vein uncovered a massive lense of zinkenite 18 inches wide and 18 feet long. Associated with the zinkenite were dolomite, pyrite, jamesonite, and sphalerite. By July 24, 1969, 50 tons of zinkenite was stockpiled at the mine for sale as mineral specimens.

A study of samples from the zinkenite discovery revealed the presence of the rare minerals robinsonite and gearksutite. This is the first known occurrence of these minerals in the state. Gearksutite indicates that the deposit has undergone hydrothermal alteration rich in fluorine.

Robinsonite is a lead, antimony, bismuth sulfide having a formula $Pb_9(Sb,Bi)_{12}S_{27}$. The mineral is triclinic. Gearksutite is an alumino-fluoride of calcium having the formula $CaAl(OH)F_4 \cdot H_2O$. The mineral is probably monoclinic and occurs as earthy masses. The Wells Fargo mine samples were identified by X-ray diffraction at Bendix Field Engineering Corp. in Grand Junction, Colorado. The d-spacings and relative intensities for both minerals as determined by Bendix are listed below:

X-RAY MINERAL IDENTIFICATION

ROBINSONITE		GEARKSUTITE	
d-spacing	I/Io	d-spacing	I/Io
3.93	15	4.56	25
3.74	20	3.50	35
3.63	15	3.15	100
3.44	100	2.72	15
3.33	20	2.66	20
3.00	15	2.46	10
2.79	50	2.27	10
2.15	15	2.06	15
2.06	10	1.93	15
1.99	10	1.82	20
1.83	10		

The Wells Fargo mine will continue to produce rare and unusual minerals. Besides those mentioned in this article, assays and spectrographic analyses indicate that

the deposit contains silver, gold, copper, and arsenic.

Those wishing to visit the mine should contact the lessees to obtain permission.

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Campbell, Ian; Loofbourow, J. S., Jr., 1962, Geology of the magnesite belt of Stevens County, Washington: U.S. Geological Survey Bulletin 1142-F, 53 p.

Evans, J. G., 1982, Preliminary geologic map of the Stensgar Mountain quadrangle, Stevens County, Washington: U.S. Geological Survey Open-File Report 82-492, 1 sheet, scale 1:24,000.

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Spokane Chronicle, 1970, Fargo negotiates over antimony: Spokane Chronicle, February 9, 1970.

Wallace Miner, 1969, Zinkenite, rare lead-antimony mineral is identified in samples from Valley, Washington, mine: Wallace Miner, July 26, 1969.

Weaver, C. E., 1920, Mineral resources of Stevens County: Washington Geological Survey Bulletin 20, 350 p.

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Western Mining News, 1970, Fargo Mining Co. sees bright antimony outlook: Western Mining News, March 6, 1970.

NWMA ANNOUNCES 89th ANNUAL CONVENTION

The Northwest Mining Association will hold its 89th annual convention in Spokane on December 1-3. The convention theme, "Domestic Mining – An Era of Change," was selected to emphasize the tough economic climate facing the mining industry. Base metal prices are at all-time low levels and the iron and steel industry is fighting for survival. More than 75 speakers will present new technology, new operating ideas, and new perspectives on survival in today's economic situation.

The NWMA short course to be held on November 28-30 will present an in-depth study of the exploration, discovery, and development of five important western precious-metal mines.

Registration information for the convention and short course is available from the Northwest Mining Association, 633 Peyton Bldg., Spokane, WA 99201, (509) 624-1158.

DIVISION TO START WORK ON NEW STATE GEOLOGIC MAP

by J. Eric Schuster

The Division of Geology and Earth Resources is beginning the process of generating a new state geologic map. Planning has been ongoing for several months and data collection and compilation will begin later this fall and early winter.

There will be several differences between the 1961 state geologic map and the new one, both as to publication format and the methods used to compile the geologic data. The 1961 state map, as reprinted, was at 1:500,000 scale on a single sheet, with an additional sheet for explanation. The new state map will be done in four quadrants at a scale of 1:250,000. Quadrant boundaries will be 47°15' north latitude and 120°30' west longitude, which puts the common corners of the four quadrants very near the City of Ellensburg. The southwest quadrant will be prepared and printed first, with a projected release date of June 1986. The northeast quadrant will follow, to be released between July and December in 1988. The sequence and schedule for the northwest and southeast quadrants have not been determined, but each can be expected to take 2 years, which would indicate state map completion during 1992.

Map preparation procedures will include initial compilation of geologic data at an intermediate scale and use of geophysical data as a check on geologic interpretations.

We have decided to generate a series of 1:100,000-scale geologic quadrangle maps as intermediate products. We have made this decision because (1) modern 1:100,000-scale base maps now exist for most of the State of Washington, (2) geologic map compilations at this scale will be highly useful to resource managers and explorationists, and (3) the 1:100,000 scale will allow our geologic staff to preserve most of the detail of original maps during the initial map compilation stage. These maps will be released as black and white Division open-file maps and will be available to the public. We expect that initial compilation, field checking, reconnaissance mapping to "plug holes," and release of the 1:100,000 geologic maps for the southwest quadrant will be accomplished by July 1985. The remaining time until release of the 1:250,000-scale colored map for the southwest quadrant will be spent simplifying the 1:100,000 maps, formulating explanatory materials, drafting, editing (internal and external), and printing.

Individual staff geologists will be responsible for data collection, compiling, field checking, contacting "outside" mappers, reconnaissance mapping, correlation, arranging for peer review, and initial drafting of each

1:100,000-scale quadrangle map. Provisional assignments of Division staff geologists to 1:100,000 sheets for the southwest quadrant have been made, as follows:

Quadrangle	Senior author	Junior author
Copalis Beach, S½	Josh Logan	Tim Walsh
Shelton, S½	Josh Logan	Tim Walsh
Tacoma, S½	Tim Walsh	Bill Phillips
Snoqualmie Pass, S½	Tim Walsh	Bill Phillips
Wenatchee, SW¼	Tim Walsh	Hank Schasse
Westport	Josh Logan	Hank Schasse
Chehalis River	Josh Logan	Hank Schasse
Centralia	Hank Schasse	Tim Walsh
Mount Rainier	Hank Schasse	Bill Phillips
Yakima, W½	Tim Walsh	Hank Schasse
Ilwaco	Tim Walsh	Hank Schasse
Astoria	Tim Walsh	Hank Schasse
Mount St. Helens	Bill Phillips	Mike Korosec
Mount Adams	Mike Korosec	Bill Phillips
Toppenish, W½	Tim Walsh	Mike Korosec
Vancouver	Bill Phillips	Mike Korosec
Hood River	Mike Korosec	Josh Logan
Goldendale, W½	Bill Phillips	Josh Logan

The interested reader who has data to contribute or other input relative to the compilation of any of the above quadrangle maps should feel free to contact the senior author/compiler at the Division office in Olympia (see address on inside of newsletter cover). The reader should also note that we will not re-compile and re-release 1:100,000 quadrangle maps that were recently published by the U.S. Geological Survey or are in preparation now, such as the Snoqualmie Pass and Wenatchee sheets.

We intend to make rather extensive use of available geochemical, age dating, and geophysical data and interpretations as aids in making and checking stratigraphic correlations and structural interpretations. To this end, we are soliciting releasable geophysical data and interpretations which are not now in the public realm. Interested readers should contact Eric Schuster, Assistant State Geologist.

We intend to show on the state geologic map as much offshore structural information as possible. We plan to enter into a cooperative project with the U.S. Geological Survey to compile all existing offshore geophysical, stratigraphic, and structural data and interpretations at a scale of 1:250,000. An upcoming agreement between the Department of the Interior Minerals Management Service and the American Association of State Geologists for coastal state offshore geologic framework studies and resource evaluations is expected to provide funding.

We plan to coordinate and unify the work of staff geologists through the use of several working teams and an in-house state map committee. Teams will operate in the areas of cartography, field mapping, analytical data, structure, Quaternary geology, and nomenclature and correlations. These teams, while coordinating the work of individual compilers, will in turn be working with the state map committee, which has responsibilities not only for overall guidance and planning, but for preparation of the 1:250,000-scale geologic map from the 1:100,000 scale open-file maps. Team members are drawn from the Division staff. The membership of the state map committee consists of the chairpersons of the various teams. Eric Schuster chairs the state map committee.

Funds and human resources for the state geologic map program have come not from increased legislative appropriations but from planned reductions in other Division programs, primarily the coal resource assessment and geothermal resource assessment programs.

Because of limited resources, we realize that the production of a high-quality state geologic map is going to require assistance from our colleagues in universities, federal agencies, and the private sector. We therefore invite contributions of data, suggestions, and volunteer editing or review.

We are also convinced that a state geological survey's most important task is to keep the state geologic map up-to-date. There is also no better way for a state geological survey to exert a positive influence on the state's economic development.

With these convictions in mind, we look forward to broader and closer working relationships with our colleagues and to providing better geologic information to the citizens of Washington.

RECENT REPORTS ADDED TO OUR DIVISION LIBRARY

The following publications have been acquired recently and are now available for reference in our Division library:

Fox, K. F., Jr., 1983, Melanges and their bearing on late Mesozoic and Tertiary subduction and interplate translation at the west edge of the North American Plate: U.S. Geological Survey Professional Paper 1198, 40 p.

Dethier, D. P.; Safioles, S. A., 1983, Map showing potential sources of sand, gravel, and quarry rock, Port Townsend quadrangle, Washington: U.S. Geological Survey Miscellaneous Investigations Series Map I-1198-B, 1 sheet, scale 1:100,000.

Johnson, F. L.; Denton, D. K.; Iverson, S. R.; and others, 1983, Mineral resources of the Glacier Peak RARE II area (no. L6031), Snohomish County, Washington — Summary report: U.S. Bureau of Mines (Spokane) MLA 75-83, 44 p., 2 plates.

DIVISION STAFF MEMBER AWARDED MASTER'S DEGREE

Robert L. (Josh) Logan recently received his Master of Science degree in geology from Western Washington University in Bellingham. His thesis was entitled "Temporal Trends in the Geochemistry and Petrology of the Mount St. Helens Pyroclastic Flow Deposits."

Josh was employed as a geologist by a consulting firm for 4 years before he joined the staff of the Division of Geology and Earth Resources as an environmental geologist on June 2, 1980. He is a co-author of our Information Circular 76, "Mount St. Helens — Annotated Index to Video Archives" [now in press].

DIVISION OF GEOLOGY AND EARTH RESOURCES RELEASES OPEN-FILE REPORTS

The following open-file reports may be purchased from the Department of Natural Resources, Division of Geology and Earth Resources, Olympia, WA 98504; they are also available for inspection in our Division library. ***Note the Handling and Distribution charge at the end of the listing.**

Open-File Report 83-4

Dishberger, Debra McLean, 1983, Preparation of residual gravity maps for the southern Cascade Mountains, using Fourier analysis: Washington Division of Geology and Earth Resources Open-File Report 83-4, 3 sheets (blackline), scale 1:250,000, text - 12 p., appendices - 28 p., 3 map sheets. Price $2.50.*

This report describes a Fourier analysis method for separating residual and regional gravity anomalies from a complete Bouguer gravity anomaly field. The technique is applied to gravity data from the southern Cascade Mountains, Washington. Residual gravity anomaly maps are presented for various regional wavelength filters, a power spectrum of the frequency components in the south Cascade gravity data is displayed, and listings of the computer programs used in calculating the filters and power spectrum are given. No attempt is made to interpret the results of this study in terms of geologic structure.

The new residual gravity anomaly maps are designed to be used in conjunction with sheet 2 (southern Cascades) in the following report: Danes, Z. F.; Phillips, W. M., 1983, Complete Bouguer gravity anomaly map, Cascade Mountains, Washington: Washington Division of Geology and Earth Resources Geophysical Map GM-27, 2 plates (price $3.25).

Open-File Report 83-4 is a continuation of gravity work in the Cascade Mountains of Washington supported by the Division of Geology and Earth Resources since 1974 and by the U.S. Department of Energy's state-coupled Geothermal Resource Assessment Program since 1978. The basic purpose of this research has been collection of baseline gravity data for use in geothermal resource evaluation. However, the gravity data and anomaly maps should also be useful in any work, such as petroleum or mineral exploration, requiring definition of major structural features.

The author is a recent graduate of The Evergreen State College where she majored in computer science. Prior to attending Evergreen, Debra Dishberger earned a bachelor's degree in geophysics from Texas A & M University. During the time this report was being written, she was a student intern donating her time and geophysical expertise to the Division. She is currently employed as a geophysicist by Western Geophysical, P. O. Box 2469, Houston, TX 77001.

Open-File Report 83-5

Berri, Dulcy; Korosec, M. A., 1983, Geological and geothermal investigation of the lower Wind River valley, southwest Washington, Cascade Range: Washington Division of Geology and Earth Resources Open-File Report 83-5, 2 plates, scale 1:24,000, 46 p. Price $3.00.*

Hot springs, warm wells, and Quaternary volcanic centers within the vicinity of the lower Wind River valley have long been impressive features suggesting a significant potential for geothermal resources in this portion of the Columbia Gorge area. With funds provided by the U.S. Department of Energy's state-coupled Geothermal Resource Assessment Program, Dulcy Berri was retained to study the area in 1982. Berri, holder of a master's degree in geology from Portland State University, mapped the geology and structure at a scale of 1:24,000. The report presents the resulting map and cross sections, along with a text which includes regional geologic framework, extensive descriptions of geologic units, and structural interpretations. It also incorporates additional information collected for geothermal exploration by Division geologist Michael Korosec. Interpretations and discussions of

findings which bear significantly on future exploration and possible development of the region's geothermal resources complete this report.

Open-File Report 83-6

Schasse, H. W.; Walsh, T. J.; Phillips, W. M., 1983, Guide to Washington coal literature: Washington Division of Geology and Earth Resources Open-File Report 83-6, 5 plates, 61 p. Price $5.00.*

Since coal was discovered in Washington State in 1833, over 400 articles, reports, and maps have appeared in the technical literature describing various elements of Washington coal geology. In addition, a large group of published accounts treats aspects of regional geology, such as structure and stratigraphy, that are vital for planning or conducting coal mining, exploration, and research. This report is designed to serve as a guide to this complex body of literature. A comprehensive coal bibliography and geological and geophysical map indexes for prospective and known coal-bearing areas are included. The map indexes and bibliography are current through 1982.

Open-File Report 83-7

Korosec, M. A.; Phillips, W. M.; Schuster, J. E.; Danes, Z. F.; Biggane, J. H.; Hammond, P. E.; Clayton, G. A., 1983, The 1980-1982 geothermal resource assessment program in Washington; with chapters on thermal springs, gravity investigations, heat-flow drilling, low-temperature resources in eastern Washington, geology of the south Cascades and White Pass areas, and targets for geothermal resource exploration: Washington Division of Geology and Earth Resources Open-File Report 83-7, 299 p. Price $5.00.*

Open-File Report 83-7 is a collection of progress and final reports for projects conducted from 1980 through 1982 as part of the geothermal exploration program. Supported by funds from the state and through a contract from the U.S. Department of Energy's state-coupled Geothermal Resource Assessment Program Division of Geology and Earth Resources staff members and several sub-contracted geologists from universities conducted geological and geophysical surveys aimed at delineating possible geothermal resources within Washington. Each project is discussed in a separate chapter which includes all pertinent information collected to date. A final chapter summarizes the findings of the program with a discussion of what is known and what has yet to be learned for each of the best geothermal target areas.

Open-File Report 83-8

Schasse, H. W.; Koler, M. L.; Herman, N. E., 1983, Directory and user's guide to the Washington State coal mine map collection: Washington Division of Geology and Earth Resources Open-File Report 83-8, 110 p. Free.*

Over the years, 912 coal mine maps have been placed in the Washington State collection. This report presents a comprehensive guide to the collection. A catalog, index maps, cross-reference lists, and a user's guide are provided. The catalog lists the names of mines, operators, map titles, dates, map scales, and brief descriptions of features which are illustrated on the maps. Index maps show the approximate area covered by any given mine. Two cross-reference lists are sorted alphabetically by mine name and operator name. These features will permit users of the directory to quickly identify maps of interest by geographic areas, mine or operator name, map content, and map date.

The work was supported by contributions from Cominco American, Inc.; GCO Minerals Co.; Getty Oil Co.; Hart-Crowser & Associates, Inc.; Longview Fibre Co.; Meridian Land & Minerals Co.; Rocky Mountain Energy; Soil Sampling Service, Inc.; and Weyerhaeuser Co.

The mine maps are housed in storage units in the Division's office facilities in Lacey, Washington, where the maps are available for reference work. These maps provide an invaluable source of information for coal exploration, resource evaluation, and for mine-subsidence hazard evaluation and mitigation.

*** Please add $1 to cover a Handling and Distribution charge for your total publication order.**

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.

Bostick, N. H., 1970, Thermal alteration of clastic organic particles (phytoclasts) as an indicator of contact and burial metamorphism in sedimentary rocks: Stanford University Doctor of Philosophy thesis, 220 p.

Chiang, R. H., 1982, Quantitative geomorphology of the Hangman Creek drainage basin, Washington and Idaho: Eastern Washington University Master of Science thesis, 63 p.

Clayton, G. A., 1983, Geology of the White Pass area, south-central Cascade Range, Washington: Uni-

versity of Washington Master of Science thesis, 212 p., 1 plate.

Henderson, D. W., 1983, Structure of the Deer Trail anticlinorium, Stevens County, Washington: Eastern Washington University Master of Science thesis, 43 p., 2 plates.

Karachewski, J. A., 1983, Paleomagnetism, sedimentary petrology, and paleogeography of the Oligocene Lincoln Creek Formation in Grays Harbor basin, southwestern Washington: Western Washington University Master of Science thesis, 181 p.

Magill, J. R., 1981, Cenozoic tectonic rotations of Oregon and Washington: Stanford University Doctor of Philosophy thesis, 296 p.

Nesbitt, E. A., 1982, Paleoecology and biostratigraphy of Eocene marine assemblages from western North America: University of California at Berkeley Doctor of Philosophy thesis, 215 p.

Stinson, K. J., 1981, Analysis of geomagnetic depth sounding data: University of British Columbia Master of Science thesis, 267 p.

Timmons, D. M., 1982, Stratigraphy, lithofacies and depositional environment of the Cowlitz Formation, T. 4 and 5 N., R. 5 W. northwest Oregon: Portland State University Master of Science thesis, 89 p., 1 plate.

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

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Atwater, B. F., 1983, Guidebook for 1983 Friends of the Pleistocene field trip to the Sanpoil River valley, northeastern Washington: U.S. Geological Survey Open-File Report 83-456, 19 p.

Bliss, J. D., 1983, Washington State - Basic data for thermal springs and wells as recorded in GEOTHERM: U.S. Geological Survey Open-File Report 83-438, 45 p.

Burmester, R. F.; Miller, F. K., 1983, Preliminary geologic map of the Abercrombie Mountain area, Pend Oreille County, Washington: U.S. Geological Survey Open-File Report 83-600, 100 p., 1 plate, scale 1:48,000.

Church, S. E.; Hammond, P. E.; Barnes, D. J., 1983, Mineral resource potential of the Indian Heaven roadless area, Skamania County, Washington: U.S. Geological Survey Open-File Report 83-467, 9 p.

Church, S. E.; Mosier, E. L.; Hammond, P. E.; and others, 1983, Geochemical and statistical analysis of analytical results for stream sediments, panned concentrates from stream sediments, rocks, ores and waters collected from the Indian Heaven roadless area, Skamania County, Washington: U.S. Geological Survey Open-File Report 83-234, 58 p., 1 plate.

Ford, A. B., 1983, Annotated guide to geologic reports and maps of the Glacier Peak wilderness and adjacent areas, northern Cascades, Washington: U.S. Geological Survey Open-File Report 83-97, 34 p.

Gannett, M. W.; Bargar, K. E., 1981, Volcanic stratigraphy and secondary mineralization of U.S.G.S. Pucci geothermal test well, Mount Hood, Oregon: U.S. Geological Survey Open-File Report 81-1330, 27 p.

Jacobson, M. L.; Rodriguez, T. R.; Seiders, W. H., compilers, 1983, Summaries of technical reports, Volume XVI, prepared by participants in National Earthquake Hazards Reduction Program: U.S. Geological Survey Open-File Report 83-525, 410 p.

Luepke, Gretchen, 1982, Heavy mineral data from samples collected in Willapa Bay and vicinity, Washington: U.S. Geological Survey Open-File Report 82-739, 23 p. [one sheet microfiche].

McDougall, Kristin, 1981, Systematic paleontology and distribution of late Eocene benthic foraminifers from northwestern Oregon and southwestern Washington: U.S. Geological Survey Open-File Report 81-109, [7 sheets microfiche].

Miller, F. K., 1983, Preliminary geologic map of the Gypsy Peak area, Pend Oreille County, Washington, and Bonner and Boundary Counties, Idaho: U.S. Geological Survey Open-File Report 83-601, 14 p., 1 plate, scale 1:48,000.

Miller, F. K., 1983, Preliminary geologic map of the Smith Peak area, Bonner and Boundary Counties, Idaho:

U.S. Geological Survey Open-File Report 83-602, 10 p., 1 sheet, scale 1:48,000.

Robison, J. H.; Forcella, L. S.; Gannett, M. W., 1981, Data from geothermal test wells near Mount Hood, Oregon: U.S. Geological Survey Open-File Report 81-1002, 24 p.

Swanson, D. A.; Clayton, G. A., 1983, Generalized geologic map of the Goat Rocks wilderness and roadless areas (6036, Parts A, C, and D), Lewis and Yakima Counties, Washington: U.S. Geological Survey Open-File Report 83-357, 10 p., 1 plate, scale 1:48,000.

Vaccaro, J. J.; Bolke, E. L., 1983, Evaluation of water-quality characteristics of part of the Spokane aquifer, Washington and Idaho, using a solute-transport digital model: U.S. Geological Survey Open-File Report 82-769, 69 p.

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