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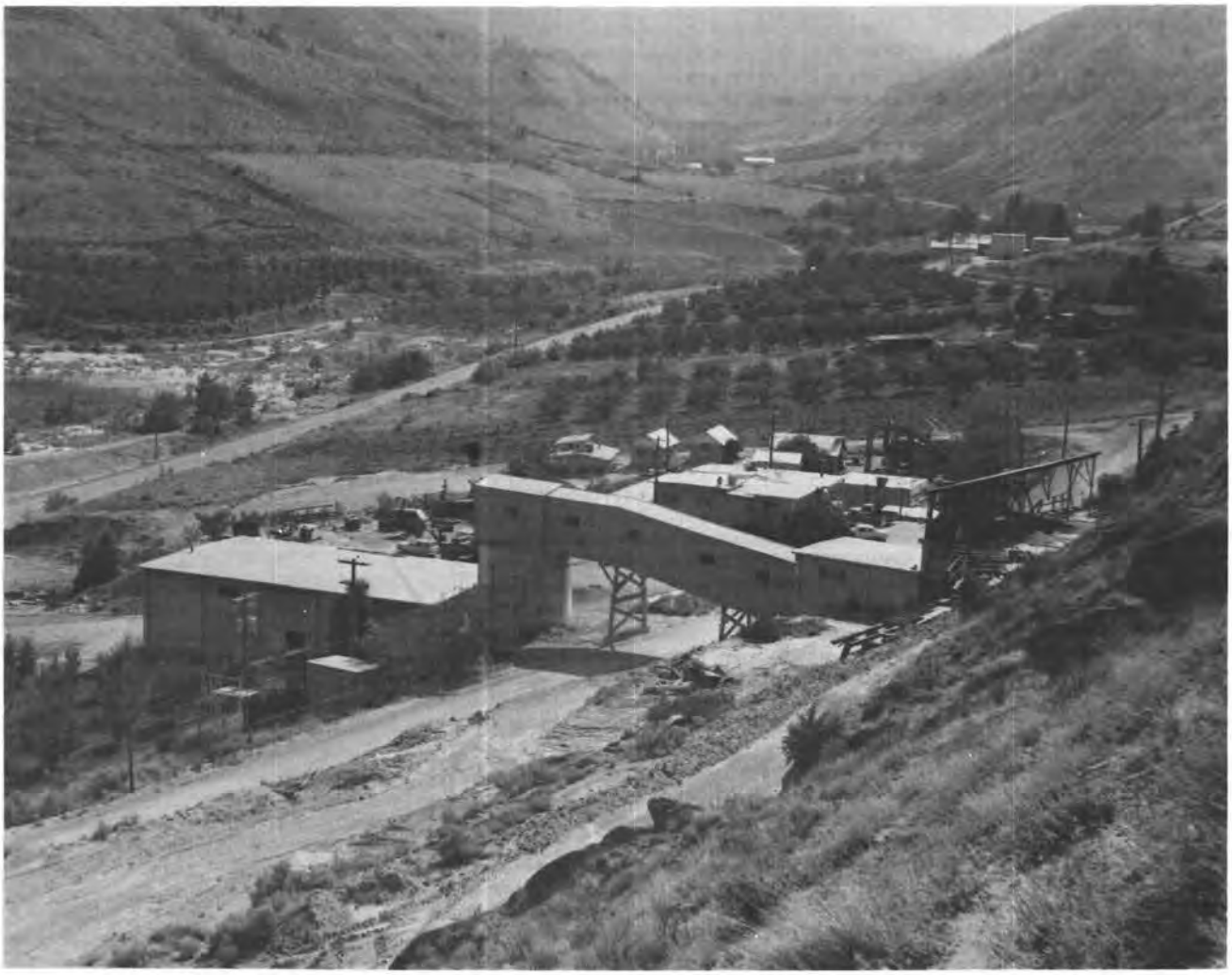

Lovitt mine, near Wenatchee, Chelan County, Washington, 1977. Photo by Jack Jansons

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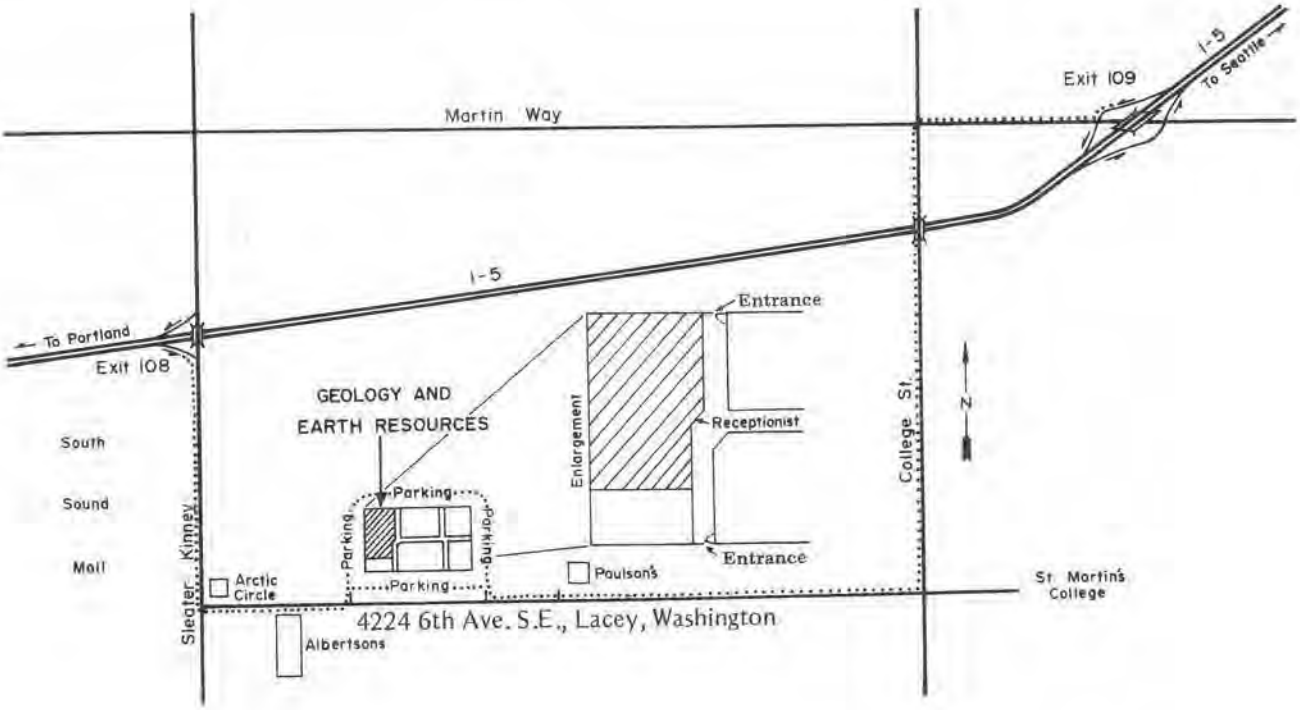


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The Washington Geologic Newsletter, a quarterly report of geologic articles, is published by the Division of Geology and Earth Resources, Department of Natural Resources. The newsletter is free upon request.

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

# THE WENATCHEE GOLD RUSH

by Bonnie Bunning*

## INTRODUCTION

On March 4, 1983, when Breakwater Resources Ltd. and Asamera Minerals, Inc., made their exciting gold find public, companies and individuals from Canada and the United States flocked to the area to lease private and state lands and to stake thousands of mining claims in the Wenatchee National Forest. The possibility of "getting a piece of the trend" led hopefuls to acquire lands from Wenatchee Lake to the basalt-covered mountains 20 miles southeast of Wenatchee, virtually blanketing the Chiwaukum graben and its hypothetical extension. Between March 7 and June 22, Chelan County recorded 3,733 claims and the Recorder's office is still crowded with people looking for available land. More than 50 percent of the claims are staked in the Wenatchee area; the remainder is distributed in neighboring mining districts. In April, the Department of Natural Resources logged over 150 mineral prospecting permit applications. At least half were obviously related to the Wenatchee find, while the remaining 50 percent boosted activity dramatically in the adjacent Peshastin, Swauk, Entiat, and Leavenworth mining districts.

## THE WENATCHEE GOLD DISTRICT

### History

In 1885, the Golden King and MacBeth claims in Squilchuck Canyon were staked on gold-bearing quartz veins and silicified sandstone outcrops known as "reefs" to the early miners. A small amount of gold was recovered with a stamp mill in 1894, but recovery of the microfine gold was poor and the mine didn't produce again until 1910. Minor production is recorded for that year and again in the late 1930's and mid-1940's. Lovitt Mining Co. optioned the property in 1949, and within a month had begun producing ore from the Lovitt mine. Selective mining methods are credited with Lovitt's success in producing more than 1 million ounces of gold from the D "reef" between 1949 and 1967. For a long time the ore was shipped directly to the Tacoma smelter where a substantial credit for the siliceous ores (used as flux in the smelter) helped make the mine profitable. In 1961, Day Mines, Inc., and Lovitt Mining Co. became partners in the renamed L-D mine and began construction of a cyanide mill on the site.

While the L-D mine was producing gold, exploration to extend the ore body continued. Between 1950 and 1953, Anaconda Copper Co. explored the B "reef." Lovitt and Day Mines continued that work during the mid-1960's with financial assistance from the federal government. Underground and surface work successfully outlined new ore bodies in the B "reef" area, but the depth and grade made the target sub-economic. From 1975 to 1978, Cyprus Mines Corp. explored all the known "reefs" on the 5-mile-long trend, and successfully discovered the B West "reef" zone, which, along with the B "reef" is reported to contain 1.5 million tons of 0.16 oz/ton gold, proven and probable reserves.

In 1981, Goldbelt Mines, Inc. (formerly known as 20th Century Energy Corporation and Gambier Exploration Ltd.) joined with Asamera Minerals, Inc., to lease the land package formerly held by Cyprus. In order for Goldbelt to maintain its equity in the project through the summer of 1982, financing was required. This was provided by Breakwater Resources Ltd., giving Breakwater eventual control of Goldbelt. By the fall of 1982, Breakwater was a full participating partner with Asamera.

### Geology

Poorly consolidated Eocene shale, conglomerate, and arkosic sandstone of fluvial origin are the dominant rock types in the Wenatchee district (fig. 1). Organic material is abundant in thin horizons within the sequence, and 1 to 2 percent pyrite is common. Sandstone in the mine area has traditionally been assigned to the Swauk Formation, but recent mappers disagree over the name and age of the rocks. Tabor and others (1982) assign

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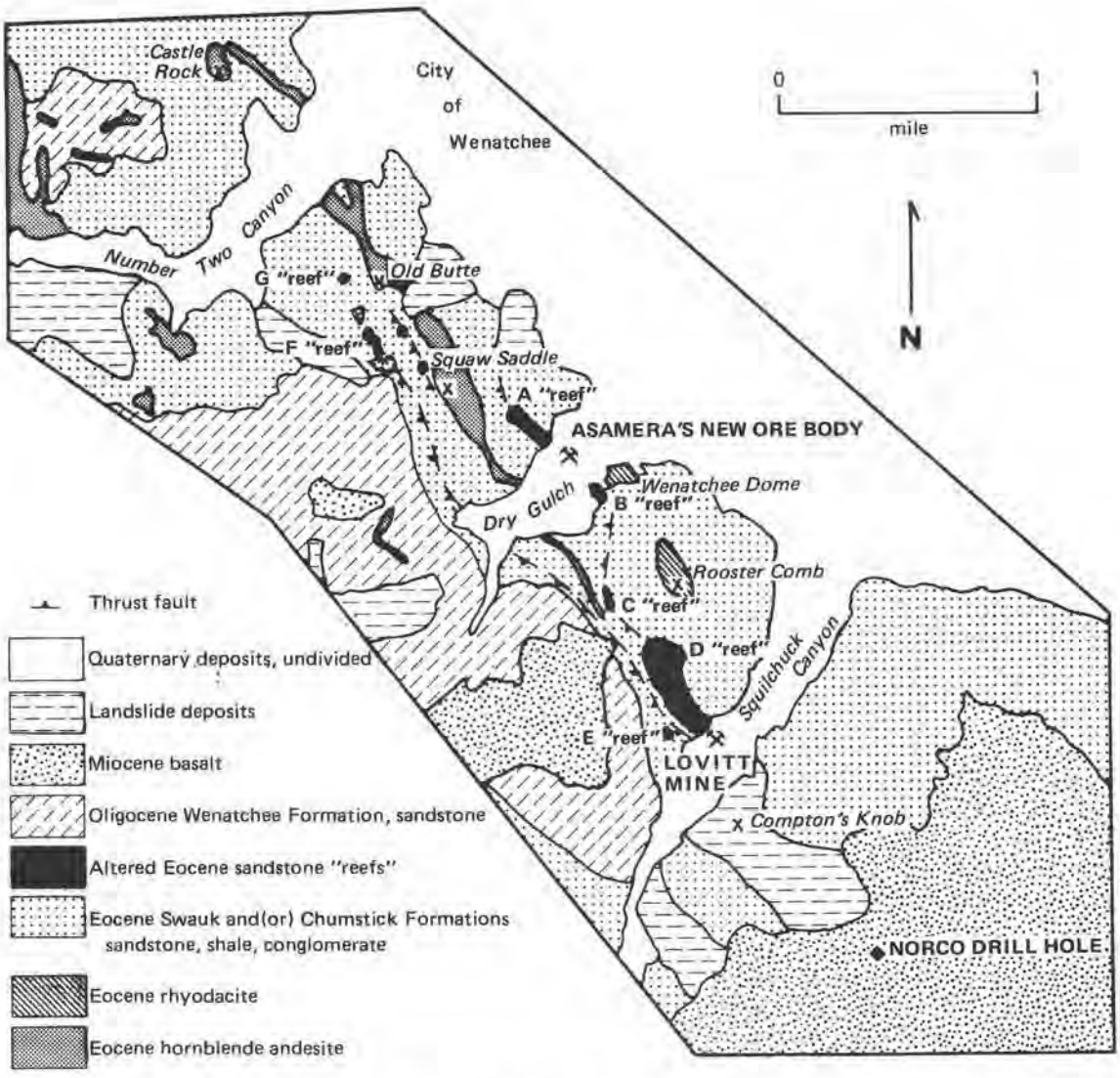


FIGURE 1. — Geologic map of the Wenatchee gold district. Geology from Gresens (1983), Tabor and others (1982), and Patton and Cheney (1971).

them to the Chumstick Formation of middle to late Eocene age. In contrast, Gresens (1983) placed the rocks in the Swauk(?) Formation of early Eocene age. On his geologic map, the two units are shown to be in fault contact in the mine area. The controversy is important to gold exploration insofar as the latter interpretation allows the possibility that the Chumstick Formation sandstone was deposited after the Swauk Formation was mineralized. On figure 1 of this report the Swauk(?) and(or) Chumstick rocks are shown with the same symbol.

Between 43 and 51 m.y.b.p. (million years before present), the mine area rocks were intruded at shallow depths by flow-banded rhyodacite porphyry and perlite. During a second period of volcanism about 30 m.y.b.p., the Eocene sandstone was intruded by hornblende andesite. Both intrusive units lie near silicified portions of sandstone along imbricate thrust faults. Because of its higher silica content and proximity to ore, the rhyodacite is presumed to be the source of alteration and mineralization.

The Swauk/Chumstick sandstones were continuously folded during graben development and are unconformably overlain by Oligocene sandstone of the Wenatchee Formation. One deposit of clean silica sand in the Wenatchee Formation is presently being mined at the head of Dry Gulch. Columbia River basalt of Miocene age covers the southeast extension of the graben, beginning less than a mile south of the L-D mine. According to Patton and Cheney (1971), an oil and gas well drilled in the area in 1934 (see "Norco drill hole" on fig. 1) penetrated basalt and encountered perlitic rhyolite between 715 and 815 feet, strongly suggesting that the graben and favorable rock types continue to the southeast below basalt cover.

## Mineralized Trend

At least 10 areas of silicified sandstone occur along a northwest trend. The southernmost occurrence along the trend was found below basalt cover in the Norco test well. Shaly fault gouge from the drill cuttings assayed 0.697 oz/ton silver with no gold, while rhyolite cuttings from several intervals below a depth of 900 feet assayed 0.016 oz/ton to 0.048 oz/ton gold. Compton's Knob is the only known outcrop of silicified sandstone south of Squilchuck Canyon, but no gold has been found there in exploratory drilling. Most production to date has been from the D "reef" (Golden King - Lovitt - L-D mine) with only 5,200 tons of 0.33 oz/ton gold mined from the B "reef." Years of exploration have developed significant reserves in the B and B West zones. In the past, minor gold values were drilled at E "reef," but underground exploration at the A, C, F, and G, "reefs" has found no gold.

## Alteration

Patton and Cheney (1971) report studies showing at least three distinct episodes of silicification. First, pervasive silica flooded poorly consolidated sandstone. The rocks were then brecciated and recemented with cloudy to cherty quartz and quartz veins. The slow growth of clear, coxcomb quartz of the final stage is believed to postdate gold mineralization. Silicified rocks are light colored, and often stained with iron oxides. Except for minor amounts of calcite, no significant alteration minerals, other than quartz, have been reported.

## Ore Controls

While carbon and pyrite in the host sandstone may have helped to precipitate gold from epithermal solutions, brecciation and shearing related to thrust faults and the intrusion of silica-rich volcanics into the thrust zones are the dominant controls on ore deposition. Weak zones along thrust faults were the preferred sites for rhyodacite intrusion and silica flooding. Pervasive silicification served to cement the loose sandstone host rocks. Subsequent brecciation and faulting of the then-competent host provided open channelways for ore fluid transport and cherty quartz veining. Faulting, intrusion, alteration, and mineralization of the Eocene sediments in the Chiwaukum graben were clearly interdependent, contemporaneous events which combined to control deposition of the gold ore in the Wenatchee district.

## Mineralization

Native gold and electrum are the principal ore minerals in the Wenatchee deposits. Some gold is also included in sulfide grains. Naumanite ($Ag_2Se$) and aguilarite ($Ag_2Se$-$Ag_2S$) have also been reported. Gangue is principally quartz with some calcite. All or part of the pyrite (0 to 3 percent) found in the ore zone may be primary pyrite from the original sandstone. Arsenopyrite has also been reported. Trace element data are scarce on these deposits. An unpublished survey by the Washington Division of Mines and Geology (1964) documented an anomalous mercury halo over the Golden King ore zone.

According to an Asamera geologist, barite has been noted in the L-D mine, but neither barite nor adularia has been identified to date in the Asamera ore bodies.

All productive zones have been in sandstone. One sample of silica-flooded rhyodacite taken by the Washington Division of Geology and Earth Resources in 1983 near B "reef" assayed only 43 ppb (parts per billion) gold.

## Ore Grades

Historically, the Lovitt mine produced ore averaging 0.396 oz/ton gold and 0.6 oz/ton silver. During that time a small amount of ore grading 0.33 oz/ton was mined from the B "reef." The average grade of Cyprus' 1976 discovery (B West zone) is reportedly 0.16 oz/ton gold. Asamera Minerals, Inc., reports ore averaging 0.2 oz/ton gold, and 0.5 oz/ton silver in their B, B West, and B West Extension zones.

## Asamera's New Discovery

### Drilling

In 1982 Asamera Minerals, Inc., began drilling the B and B West zones from newly opened underground workings (fig. 2). Drilling results from the best holes were reported in the September and November 1982 issues of *Northern Miner* (Cotter, 1982a, 1982b). Some of the best intervals from B zone drilling were 240 feet of 0.203 oz/ton gold in hole 7B2; 115 feet of 0.122 oz/ton gold in hole 7C; 240 feet of 0.149 oz/ton gold in hole 9D; 70 feet of 0.163 oz/ton gold in hole 9F; and 200 feet of 0.14 oz/ton gold in hole 9B. The best drilling in the B West zone encountered 13 feet of 0.813 oz/ton gold in hole 12A; 10 feet of 0.538 oz/ton gold in 12C; and 45 feet of 0.127 oz/ton gold in hole 12D. In all, that early drilling confirmed a tonnage of 1½ million tons averaging 0.15 oz/ton gold and 0.5 oz/ton silver. More importantly, Asamera's drilling proved that the two zones were connected and suggested that further drilling be done to the north on the open end of the combined B zones.

Asamera began drilling through valley fill to the north, between the B and A "reef" outcrops, in February of 1983. On March 4, 1983, a spectacular drill intersection of 50 feet averaging 2.98 oz/ton visible free gold was

FIGURE 2. — Flow-banded rhyodacite of the Wenatchee dome (left) lies adjacent to silicified and mineralized sandstone of the B "reef" on the south side of Dry Gulch. Recent drilling by Asamera Minerals, Inc., has discovered new ore shoots under the valley fill in the foreground.

made public and the rush to Wenatchee began. Asamera believes the new find is an extension of the previously defined B and B West combined zones. The best intervals reported in the north extension were 105 feet of 0.305 oz/ton gold in hole 2A (vert); 165 feet of 0.341 oz/ton gold in hole 2B (-60°); 105 feet of 0.118 oz/ton gold in hole 2C (-45°); and 140 feet of 0.136 oz/ton with an interval of 50 feet of 2.98 oz/ton gold in hole 2D (-80°). Ore reserves from all drilling to date are calculated at more than 3 million tons of 0.2 oz/ton gold with about ½ oz/ton silver.

### Mine Plans

Asamera's new discovery will be named the Cannon mine for a prominent member of Asamera's Board of Directors. Preliminary plans are to mine and possibly crush the ore underground. If economics permit, the ore will be milled on site. According to Asamera geologists, ore could be mined and milled for $30 per ton at a rate of 1,000 to 2,000 tons per day and with 96 percent gold recovery. A preferred mining method has yet to be chosen to handle the difficulties of mining large silicified zones in a poorly consolidated host rock. Present drilling is aimed at exploring for suitable shaft and mill sites. On June 16, Asamera called for bids to sink a 1,000-foot shaft, a 2,500-foot-long decline, and 3,000 feet of underground development (Wenatchee World, 1983a). Barring any unforeseen delays, Asamera plans to be in production by late 1984 or early 1985.

## REFERENCES

Bunning, Bonnie, 1981, New developments in minerals and energy in Washington State, 1980: Washington Geologic Newsletter, v. 9, no. 1, p. 1-7.

Bunning, Bonnie, 1983, New developments in minerals and energy in Washington, 1982: Washington Geologic Newsletter, v. 11, no. 1, p. 1-11.

Cotter, Nicholas, 1982a, Asamera drilling confirming potential of Wenatchee mine: Northern Miner, Nov. 11, 1982.

Cotter, Nicholas, 1982b, New scale of magnitude seen for Asamera-operated project: Northern Miner, Sept. 9, 1982.

Gresens, R. L., 1983, Geology of the Wenatchee and Monitor quadrangles, Chelan and Douglas Counties, Washington: Washington Division of Geology and Earth Resources Bulletin 75, 75 p., 3 plates, scale 1:24,000.

Huntting, M. T., 1949, Perlite and other volcanic glass occurrences of Washington: Washington Division of Mines and Geology Report of Investigations 17, p. 29.

Huntting, M. T., 1955, Gold in Washington: Washington Division of Mines and Geology Bulletin 42, 158 p.

International Investor's Viewpoint, 1982, Breakwater Resources: International Investor's Viewpoint, v. 7, no. 2.

Koschmann, A. H.; Bergendahl, M. H., 1968, Principal gold-producing districts of the United States: U.S. Geological Survey Professional Paper 610, p. 254-262.

Lovitt, E. H.; McDowall, V., 1954, The Gold King mine: Western Miner and Oil Review, v. 27, no. 3, March 1954, p. 37-39

Lovitt, E. H.; Skerl, A. C., 1958, Geology of the Lovitt gold mine, Wenatchee, Washington: Mining Engineering, v. 10, no. 9, p. 963-966.

McLaren, D. R.; Weissenborn, A. E.; Weis, P. L.; Kirkemo, Harold, 1966, Gold. *In* U.S. Geological Survey; and others, 1966, Mineral and water resources of Washington: Washington Division of Mines and Geology Reprint 9, p. 82-92.

Morrow, E. H., 1983, Asamera's new gold find in Wenatchee: American Institute of Mining, Metallurgical, and Petroleum Engineers Columbia Section meeting, May 16, 1983, Spokane [oral presentation].

Northern Miner, 1983, Asamera, Inc. strikes it big at Wenatchee: Northern Miner, v. 69, no. 1.

Patton, T. C.; Cheney, E. S., 1971, L-D gold mine, Wenatchee, Washington — New structural interpretation and its utilization in future exploration: Society of Mining Engineers of AIME Transactions, v. 250, no. 1, p. 6-11.

Rea, Dave, 1983, Reports of school gold leave officials cold: Wenatchee World, May 10, 1983.

Tabor, R. W.; Waitt, R. B.; Frizzell, V. A.; 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.

U.S. Bureau of Mines, unpublished data.

Washington Division of Mines and Geology, 1964, [Golden King mine file]: Washington Division of Geology and Earth Resources unpublished material.

Wenatchee World, 1983a, Asamera Mining to call for bids for gold-mining shaft, tunnels: Wenatchee World, June 16, 1983.

Wenatchee World, 1983b, Drilling shows expanded ore zone: Wenatchee World, March 18, 1983.

## SUMMARY OF U.S. GEOLOGICAL SURVEY CURRENT ACTIVITIES IN WASHINGTON DURING 1983

These U.S. Geological Survey projects are 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.** — Approximately 2,000 samples from metamorphic and plutonic units of the Glacier Peak Wilderness Area will be petrographically studied, along with geochronologic, Sr isotopic, and major- and minor-element analytical studies of additional samples. A detailed geologic map of the study area and related mineral resource potential and geophysical maps and reports will be prepared. [Project chief: A. B. Ford.]

**Glacier View/Tatoosh.** — Final reports and maps concerning the mineral resource potential of the Long Swamp RARE II area will be completed and submitted for publication. [Project chief: R. C. Evarts.]

**Mount St. Helens basement rocks.** — Hydrothermal alteration in Oligocene-Miocene volcanic and intrusive rocks underlying Mount St. Helens, mainly to the east and south of the active volcano, will be examined in detail. Petrographic studies will be conducted on samples collected in 1982 from Miocene intrusive rocks. [Project chief: R. P. Ashley.]

**Geochemical exploration of western region wilderness.** — Final geochemical and mineral resource potential maps and reports for wilderness areas in Washington will be prepared and submitted for review and publication in 1983. [Project chief: R. E. Learned.]

**Basin-Range stratiform metals studies.** — The geologic setting of metalliferous Paleozoic shales in the northwestern U.S. will continue to be studied. [Project chief: F. G. Poole.]

**Frontier Tertiary and Mesozoic hydrocarbon basins of the western United States.** – A report on the petroleum geology of Paleogene rocks of the Pacific Northwest will be completed in 1983, along with a report on the origin of natural gas in Oregon. [Project chief: T. D. Fouch.]

**Origin of oil in continental basins.** – The source rock potential of Paleogene nonmarine rocks in central Washington will be studied, along with their relationship to thermal maturity. [Project chief: D. E. Anders.]

**Geologic framework and resources assessment of Oregon-Washington continental margins.** – A 24-channel seismic-reflection survey of the Outer Continental Shelf and Slope off northern Oregon and southern Washington is planned to determine the nature and location of the transition zone between the subducted abyssal sediments on the Oregon slope and the obducted abyssal sediments on the Washington slope. The seismic profiles and velocity data from sonobuoys may provide information relative to geologic controls for this change in tectonic style. A structure map of the continental margin of northwest Washington and land-sea geologic cross sections across the northern and southern Oregon continental margins will be completed. [Project chief: P. D. Snavely.]

**Oceanic volcanism.** – Field and laboratory studies of the Juan de Fuca Ridge basalt will continue. [Project chief: D. A. Clague.]

**Juan de Fuca Ridge – Structure and metallogenic processes.** – A photographic and sampling cruise to the Juan de Fuca Ridge hydrothermal area is planned in 1983. Analyses of samples (sulfide mineral, basalt, and hydrothermal water) collected during the 1981 cruise will be analyzed. A structural study of the Juan de Fuca Ridge crest, using multichannel seismic profiles, will be completed. [Project chief: W. R. Normark.]

**Volcanogenic manganese deposits.** – The study of stratiform manganese deposits in Washington will continue in 1983. Samples collected in the 1982 field season will be analyzed. [Project chief: R. A. Koski.]

**Quaternary dating and neotectonics.** – Reports will be prepared on the glacial chronology of the Chehalis River valley of western Washington. [Project chief: K. L. Pierce.]

**Mount St. Helens pyroclastic flows and structural deformation.** – A geologic map of 1980 pyroclastic-flow deposits will be completed in 1983. Preparation of reports on the proximal "inflated" pyroclastic-flow deposits of 1980, on surge and ash-cloud deposits related to the 1980 pyroclastic flows, and on 1980 phreatic-pit deposits will be in progress. [Project chief: P. D. Rowley.]

**Tephrochronology, western United States.** – Chemical correlation of volcanic ash in California, Nevada, Oregon, and Washington will continue in 1983, along with monitoring the stratigraphy, erosion, transport, and redeposition of ash from Mount St. Helens 1980-82 eruptions. [Project chief: A. M. Sarna-Wojcicki.]

**Sandpoint 2-degree quadrangle, Washington and Idaho.** – Geologic maps of the Bonners Ferry and Copeland 15-minute quadrangles, Idaho, the Monumental Mountains 15-minute quadrangle, Washington, and the Chewelah 1-degree quadrangle will be prepared and submitted for open-file release in 1983. Geochemical studies of collected samples and evaluation of resulting data will continue. [Project chief: F. K. Miller.]

**Seismo-tectonic analysis of Puget Sound Province.** – Compilation of a 1:100,000-scale surficial geologic map and maps showing depth to bedrock, thickness of postglacial alluvium and fill, and depth to poorly consolidated Quaternary materials will be completed in 1983. A summary report on the subsurface geology and geotechnical properties of geologic units underlying the city of Seattle will also be prepared. [Project chief: J. C. Yount.]

**Okanogan geologic map, Washington.** – Fieldwork in the Bossburg 7½-minute and the Brewster 15-minute quadrangles will be completed in 1983. K-Ar and fission-track geochronologic studies of plutonic and volcanic rocks will continue. Reports on the alkalic complexes in north-central Washington and on tectonic transport in the Okanogan and Kettle gneiss domes will be prepared. [Project chief: K. F. Fox.]

**Geologic map of the Colville Indian Reservation.** – Geologic mapping of the Colville Indian Reservation will be completed in 1983. Specialized studies of Pleistocene deposits in the western half of the Reservation and petrographic and chemical studies will continue. Geologic maps of the Seventeen-mile Mountain, Nespelem, Keller, and Twin Lakes 15-minute quadrangles will be compiled. [Project chief: C. D. Rinehart.]

**West Wenatchee 1-degree quadrangle, Washington.** – A geologic map of the Skykomish River 1-degree quadrangle will be prepared for formal publication in 1983. Isotope, fission track, chemical, and petrographic studies will continue. Fieldwork will be completed in the Snoqualmie Pass 1-degree quadrangle and a geologic map will be prepared for open-file release. [Project chief: R. W. Tabor.]

**Geology of the Doe Mountain quadrangle, Washington.** – During 1983, modal analyses and petrographic studies will be conducted on samples collected in 1982, and a geologic map of the Mazama 15-minute quadrangle will be prepared. Compilation of a 1:100,000-scale geologic map of the Robinson Mountain quadrangle will begin. Mapping in the eastern half of the Concrete 2-degree quadrangle will continue. [Project chief: V. R. Todd.]

**Olympic Peninsula offshore-onshore geologic transect.** – Detailed geologic studies in selected areas within and adjacent to the Olympic transect will be completed in 1983. The structural and stratigraphic framework of

this area will be reinterpreted in the light of this mapping and recently completed detailed geologic mapping in the Cape Flattery area and geophysical studies on the adjacent continental shelf. A field trip guidebook on the Tertiary geology along the northwest flank of the Olympic Mountains was prepared for the Annual Meeting of the Geological Association of Canada in May 1983. [Project chief: P. D. Snavely.]

**Volcanic hazards.** — Reports on the pre-1980 pyroclastic flows and lahars from Mount St. Helens and on the volcanic activity of the last 1,500 years at Mount St. Helens will be completed in 1983. Field investigations of volcanic deposits and eruptive activity at Mount Rainier will continue. [Project chief: D. R. Mullineaux.]

**Tephra hazards from Cascade Range volcanoes.** — A report on the stratigraphy and age of pre-1980 Mount St. Helens tephras will be completed and submitted for review in 1983. [Project chief: D. R. Mullineaux.]

**Ground failure hazards in the Columbia River valley, Oregon and Washington.** — A detailed map and analysis of the Savage Island landslide, in the White Bluffs of the Columbia River valley, Washington, and an evaluation of other selected landslides in the bluffs, including an enumeration and discussion of the geotechnical properties of bluff materials, will be completed in 1983. Ground failures and ground-failure hazards in the Columbia River valley between Richland and Wallula Gap, Washington, will be mapped and evaluated in order to extend a strip map north of Richland that has been completed. A study of prominent landslides in the Columbia River valley downstream from Wallula Gap, in the general vicinity of Arlington, Oregon, and Roosevelt, Washington, and collection of block samples of the sedimentary interbeds in the Yakima basalt that are largely responsible for the instability will be underway. [Project chief: W. H. Hays.]

**Radar analysis — Mount St. Helens.** — Analysis of 1980 and 1981 radar observations covering Mount St. Helens will be completed. A report on the radar characteristics of the Mount St. Helens eruptions sequence, including an analysis of the utility of the radar systems that made the Mount St. Helens observations, will be prepared. [Project chief: H. H. Kieffer.]

**Mid-Tertiary chronostratigraphic framework, Pacific Northwest.** — Reports on transect studies in Washington will be completed. Mid-Miocene mollusks from Knappton, Washington, and from Tillamook, Oregon, will be described and the Miocene of Washington, Oregon, and California will be correlated. [Project chief: K. A. McDougall.]

**Genesis of basalt.** — Preparation of reports on the petrochemical and geologic constraints on the origin of Columbia River basalt magmas will be in progress. [Project chief: T. L. Wright.]

**Experimental petrology of basalt.** — Reports on the occurrence of immiscible sulfide liquids in nature and in melting experiments on Columbia River basalts will be prepared. [Project chief R. T. Helz.]

**Active and fossil geothermal systems.** — Fumarolic alteration products of Mount St. Helens and other Cascade volcanoes will continue to be studied. [Project chief: D. E. White.]

**Hydrothermal alteration in the Cascades.** — Fumarolic incrustations from Mount Hood, Mount St. Helens, and other Cascade volcanoes will be studied. [Project chief: M. H. Beeson.]

**Mount Adams RARE II area, Washington.** — Final reports and maps on the geology and mineral resource potential of the study area will be completed in 1983 and submitted for review and publication. [Project chief: E. W. Hildreth.]

**Recent volcanic processes.** — Satellite studies of the May 1980 mushroom cloud and associated fallout at Mount St. Helens, Washington, will be completed in 1983. [Project chief: J. G. Moore.]

**Mount St. Helens volcano monitoring.** — Major effort in 1983 will be directed towards refining techniques to predict volcanic eruptions. The trilateration, tilt-level, and geochemical measurements will be repeated at Mount St. Helens, Mount Rainier, and Mount Baker. [Project chief: D. W. Peterson.]

**Cascade volcanoes observations.** — During 1983, a coordinated multidisciplinary study will be conducted at Mount St. Helens to determine the subsurface structure and the petrologic processes in the magma supply system. This effort will include isotopic studies of the gases, petrologic studies of eruptive products, magnetic/electromagnetic, and deformation studies, and, in cooperation with the University of Washington, passive and active seismic experiments. Detailed study of the stratigraphic framework of the May 18, 1980, eruptive products and the characteristics of pyroclastic flow and related deposits will continue. A paleomagnetic study to determine the geomagnetic secular variation in the Cascades was started at Mount St. Helens late in 1982; this study will be expanded to other Cascade Range volcanoes in 1983. [Project chief: D. W. Peterson.]

**Geophysics of the Cascade Range.** — Interpretation of gravity and magnetic data for Mount St. Helens and Mount Adams will be completed in 1983. [Project chief: D. L. Williams.]

**Magnetotelluric sounding for geothermal resource assessment.** — Field investigations in the Cascades to define the nature of geothermal anomalies will continue in 1983. Magnetotelluric soundings obtained from Mount St. Helens will be interpreted. A report on interpretation of magnetotelluric data for geothermal exploration, based upon surveys in the Cascades will be prepared. [Project chief: W. D. Stanley.]

**Element availability — Soils.** — A report on the

effects of ash fall on soil chemistry in eastern Washington 2 years after the May 1980 eruption of Mount St. Helens will be prepared. [Project chief: R.C. Severson.]

**Lacustrine geochemical records of climate change.** – Sediments will be collected in 1983 from self-monitoring traps located in lakes of Washington. Geochemical analyses will be made of these sediments, and reports will be prepared on the results of these analyses. A continuous core will be obtained from a lake in Washington. [Project chief: W. E. Dean.]

**Geomagnetic-telluric array investigations of geoelectrical structure in the crust and upper mantle.** – The geoelectrical structure of the Cascade Range, with emphasis on local structures identified in regional studies, will continue in 1983. [Project chief: J. N. Towle.]

**Deep electromagnetic soundings in northwestern United States.** – Data gathered during 1982 will be reduced and analyzed in 1983. A report on the geoelectrical structure of the continental margin of the northwestern United States will be prepared. [Project chief: J.N. Towle.]

**Colville Indian Reservation geophysical studies.** – Interpretive reports on the regional magnetic and gravity data acquired for the study area that relate the geophysical signatures to known and possible mineral potential, as well as relationships between the geophysical data and lithologic units, will be prepared in 1983. [Project chief: V. J. Flanigan.]

**Infrared aerial surveillance of volcanoes of Cascade Range.** – Processing of aerial infrared surveys of the Cascade volcanoes and investigations of the ground radiometry of thermal features will continue, along with updating data on the thermal energy yield of Mount St. Helens eruptions. Reports will be prepared on the results of these studies. [Project chief: J. D. Friedman.]

**Volcano hazards paleomagnetism.** – Paleomagnetic measurements will be made on samples collected in 1982; additional samples will be collected in support of the geologic mapping and geothermal and hazard assessment that is continuing in the Cascade Range. [Project chief: D. E. Champion.]

**Geothermal tectonic seismic studies.** – During 1983, a model of the subduction of the Juan de Fuca plate beneath the North American plate will be developed. Previous research has raised the possibility of a subduction-style earthquake on the megathrust, which would probably significantly increase the earthquake hazards in western Washington. The seismic quiescence in western Washington will continue to be studied by examining teleseismic P-wave delay changes with time and the focal mechanisms of older, larger Puget Sound earthquakes. [Project chief: C. S. Weaver.]

**Pressurized fractures in hot rocks.** – The study of volcanic rift zones, using data from Kilauea, Hawaii, and Mount St. Helens, Washington, will be completed in 1983. A report on deformation in volcanic rift zones will be prepared. The study of fracture and heat formation in hydrothermal environments will continue. Analysis of volcanic tremors induced by magma and water in large vertical fractures will also be completed. [Project chief: D. D. Pollard.]

### Recent Geologic Division Reports

Reports on Washington geology released since last year's summary of USGS activities are listed below [some open-file reports that we have in our Division library were listed in previous newsletters and are not repeated here]:


Beck, M. E.; Faxon, M. F.; Fox, K. F., Jr., 1982, Post early Eocene tectonic rotation of northeastern Washington and the emplacement history of "Quesnellia" [abstract]: Geological Society of America Abstracts with Programs, v. 14, no. 7, p. 441.

Brown, E. H.; O'Neil, J. R., 1982, Oxygen-isotope geothermometry and stability of lawsonite and pumpellyite in the Shuksan metamorphic suite, north Cascades, Washington: Contributions to Mineralogy and Petrology, v. 80, no. 3, p. 240-244.

Casadevall, T.; Ewart, J.; Harris, D.; Rose, W., 1982, Gas emissions and the prediction of eruptive behavior at Mount St. Helens, Washington [abstract]: Eos (American Geophysical Union Transactions), v. 63, no. 8, p. 174.

Casadevall, T.; Ewart, J.; Symonds, R., 1982, Gas emissions and 1981-1982 activity at Mount St. Helens, Washington [abstract]: Eos (American Geophysical Union Transactions), v. 63, no. 45, p. 1143.

Casadevall, T. J.; Rose, W., Jr.; Greenland, P.; Ewart, J.; Wunderman, R., 1981, Gas emissions from Mount St. Helens, Washington – Constraints on a model for behavior of magma in the near-surface environment [abstract]: Eos (American Geophysical Union Transactions), v. 62, no. 45, p. 1088.

Cashman, K. V.; Taggart, J. E., 1982, Petrology of the 1981-1982 eruptive products from Mount St. Helens, Washington [abstract]: Eos (American Geophysical Union Transactions), v. 63, no. 45, p. 1143-1144.

Cater, F. W., 1983, 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.

Chadwick, W. W., Jr.; Swanson, D. A.; Iwatsubo, E. Y.; Helike, C. C., 1982, Deformation of the crater floor at Mount St. Helens [abstract]: Eos (American Geophysical Union Transactions), v. 63, no. 45, p. 1140.

Church, S. E., 1982, Lead isotope data from the Columbia River Basalt Group – Evidence for a layered upper mantle [abstract]: Geological Society of America Abstracts with Programs, v. 14, no. 7, p. 463.

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 Wonder Mountain Roadless area, Washington: U.S. Geological Survey Open-File Report 82-1066, 85 p.

Church, S. E.; Mosier, E. L.; Frisken, J. G.; Arbogast, B. F.; McDougal, C. M.; Evans, J. G., 1982, Analytical results for stream sediments and panned concentrates from stream sediments collected from the Glacier Peak Wilderness and adjacent areas, Washington: U.S. Geological Survey Open-File Report 82-780, 227 p.

Dzurisin, Daniel, 1982, Value of remote tilt monitoring to eruption prediction at Mount St. Helens, Washington [abstract]: Eos (American Geophysical Union Transactions), v. 63, no. 45, p. 1140.

Dzurisin, Daniel; Johnson, D. J.; Westphal, J. A., 1981, Ground tilts during two recent eruptions of Mount St. Helens, Washington [abstract]: Eos (American Geophysical Union Transactions), v. 62, no. 45, p. 1089.

Friedman, J. D., 1982, Energy of domal evolution at Mount St. Helens, June 1980 through May 18, 1982 [abstract]: Geological Society of American Abstracts with Programs, v. 14, no. 7, p. 492.

Grant, A. R., 1982, Summary of economic geology data for the Glacier Peak Wilderness, Chelan, Snohomish, and Skagit Counties, Washington: U.S. Geological Survey Open-File Report 82-408, 37 p.

Grant, W. C.; Weaver, C. S.; Hollweg, J. E., 1981, The February 14, 1981, Elk Lake, Washington, earthquake and its aftershock sequence [abstract]: Eos (American Geophysical Union Transactions), v. 62, no. 45, p. 966.

Hinkley, Todd; Smith, K. S., 1982, Leachate chemistry of the tephra from the May 18, 1980 eruption of Mount St. Helens [abstract]: Eos (American Geophysical Union Transactions), v. 63, no. 45, p. 1143.

Johnson, D. J., 1982, Gravity changes in the crater of Mount St. Helens, Washington, April-September, 1982 [abstract]: Eos (American Geophysical Union Transactions), v. 63, no. 45, p. 1140.

Johnston, M. J. S.; Dvorak, J., 1981, Implications of tilt and magnetometer measurements at Mount St. Helens, Washington, 1980-1981 [abstract]: Eos (American Geophysical Union Transactions), v. 62, no. 45, p. 1089.

Kennedy, G. L.; and others, 1982, Aminostratigraphy and faunal correlations of late Quaternary marine terraces, Pacific coast, USA: Nature, v. 299, no. 5883, p. 545-547.

Keuler, R. F., 1982, Map showing some potential effects of petroleum spills on shorelines of the Port Townsend quadrangle, central Puget Sound region, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-1238, 1 sheet, scale 1:100,000.

Kieffer, H. H., 1981, Radar observations at Mount St. Helens [abstract]: Eos (American Geophysical Union Transactions), v. 62, no. 45, p. 1089.

Luedke, 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.

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

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.

Michaelson, C. A.; Weaver, C. S., 1981, Teleseismic P-wave residual studies in Washington and northern Oregon [abstract]: Eos (American Geophysical Union Transactions), v. 62, no. 45, p. 1089.

Moore, J. G.; Rice, C. J., 1981, Chronology and character of Mount St. Helens explosive eruptive phase of May 18, 1980 [abstract]: Eos (American Geophysical Union Transactions), v. 62, no. 45, p. 1081-1082.

Muffler, L. J. P.; and others, 1982, Geothermal systems of the Cascade Range: Pacific Geothermal Conference, University of Auckland Geothermal Institute, Auckland, New Zealand, Nov. 8-12, 1982, proceedings, p. 337-343.

Newhall, C. G., 1982, A prehistoric debris avalanche from Mount St. Helens [abstract]: Eos (American Geophysical Union Transactions), v. 63, no. 45, p. 1141.

Ort, K. M.; Tabor, R. W.; Frizzell, V. A., Jr., 1982, Chemical analyses of selected Tertiary and Quaternary volcanic rocks, Cascade Range, Washington: U.S. Geological Survey Open-File Report 83-1, 14 p.

Peterson, D. W., 1981, An overview of activity at Mount St. Helens, Washington, since May 1980 [abstract]: Eos (American Geophysical Union Transactions), v. 62, no. 45, p. 1088.

Rapp, J. B.; Kvenvolden, K. A.; Clifton, H. E., 1982, Aliphatic hydrocarbons in surface sediments of Willapa Bay and Grays Harbor, Washington: U.S. Geological Survey Open-File Report 82-609, 14 p.

Sato, Motoaki; McGee, K. A., 1981, Continuous monitoring of hydrogen on the south flank of Mount St. Helens. *In* Lipman, P. W.; Mullineaux, D. R., editors, 1981, The 1981 eruptions of Mount St. Helens, Washington. U.S. Geological Survey Professional Paper 1250, p. 209-219.

Smith, D. B.; Zielinski, R. A.; Taylor, H. E., 1982, Leaching characteristics of ash from the May 18, 1980, eruption of Mount St. Helens volcano, Washington [abstract]: Geological Society of America Abstracts with Programs, v. 14, no. 7, p. 619.

Swanson, D. A.; Chadwick, W. W., Jr.; Iwatsubo, E. Y.; Helicke, H. H., 1982, Endogenous growth of the Mount St. Helens dacite dome [abstract]: Eos (American Geophysical Union Transactions), v. 63, no. 45, p. 1140.

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.

Weaver, C. S.; Smith, S. W., 1981, The St. Helens seismic zone – A major crustal fault zone in western Washington [abstract]: Eos (American Geophysical Union Transactions), v. 62, no. 45, p. 966.

Weaver, C. S.; Zollweg, J. E., 1982, Deep earthquakes and possible magmatic gas transport at Mount St. Helens, Washington [abstract]: Eos (American Geophysical Union Transactions), v. 63, no. 45, p. 1140.

## 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.

Gresens, Randall L., 1983, Geology of the Wenatchee and Monitor quadrangles, Chelan and Douglas Counties, Washington: Washington Division of Geology and Earth Resources Bulletin 75, 75 p., 3 plates, scale 1:24,000. Price $5.00*

The first mining claims were staked for gold in the Wenatchee area in 1885. Prospectors flocked into the region and, as a result, the City of Wenatchee was incorporated in 1892. The lure of gold has again attracted the attention of the public and exploration companies. A staking and leasing rush of major proportions is taking place during 1983.

The Geology and Earth Resources Division of the Department of Natural Resources is fortunate to be able to publish this timely report by the late Randall L. Gresens, a professor at the University of Washington. The author was employed by the division to complete the geologic mapping of the Wenatchee and Monitor quadrangles, in the summers of 1975-1982, and to write a bulletin to accompany the maps. The Division was in possession of his manuscript, completed field maps, and cross sections at the time of his tragic accident in the summer of 1982.

Randy's report presents new hypotheses regarding the age and origin of hydrothermal alteration, as well as associated ore minerals at the L-D gold mine (also known as the Lovitt, Gold King, and Golden King). The report expands and elaborates on the geologic units, especially sedimentary formations of the Wenatchee area. His attention to detail and lucid style of writing make this report extremely useful to present and future workers in the area.

Bentley, R. D.; Campbell, N. P., 1983, Geologic map of the Ellensburg quadrangle, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-28, scale 1:62,500. Free*

Bentley, R. D.; Campbell, N. P., 1983, Geologic map of the Yakima quadrangle, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-29, scale 1:62,500. Free*

GM-28, Geologic map of the Ellensburg quadrangle, Washington, and GM-29, Geologic map of the Yakima quadrangle, Washington, are the latest in a continuing series of geologic quadrangle maps published by the Division of Geology and Earth Resources and funded by the U.S. Department of Energy. The purpose of this map series is to improve the geologic coverage in areas of the Columbia Basin and to publish the results. The interpretation of the complex geologic stratigraphy and structure are particularly important for the evaluation of the Hanford Reservation as a potential site for the long-term storage of nuclear waste.

Each map is printed in three colors – the base in brown, geology in black, and structure in red. They include geologic cross sections; and the Yakima quadrangle map includes a 1:24,000 scale inset map for Yakima Ridge, an area of complex geology located just north of the City of Yakima.

R. D. Bentley, Professor of Geology at Central Washington University in Ellensburg mapped the bedrock geology. N. P. Campbell, Professor of Geology at Yakima Valley College in Yakima, mapped the surficial geology.

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## 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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Denver, CO 80225
(303) 234-5888

Prepayment is required. Open-file reports are announced, with price, in the monthly list, "New Publications of the Geological Survey." A free subscription to the list may be obtained on application to: Mailing List Unit, U.S. Geological Survey, 329 National Center, Reston, VA 22092.

Boucher, P. R.; Fretwell, M. O., 1982, Irrigation-water quality in the Sulphur Creek basin, Yakima and Benton Counties, Washington, April 1965 through March 1977: U.S. Geological Survey Open-File Report 81-1008, 68 p., 1 plate.

Cline, D. R.; Jones, M. A.; Dion, N. P.; Whiteman, K. J.; Sapik, D. B., 1982, Preliminary survey of groundwater resources for Island County, Washington: U.S. Geological Survey Open-File Report 82-561, 46 p.

Drost, B. W., 1982, Water resources of the Gig Harbor Peninsula and adjacent areas, Washington: U.S. Geological Survey Open-File Report 81-1021, 148 p., 1 plate.

Evarts, R. C.; Frisken, J. G.; Bishop, K. R., 1983, Geochemical analyses of rock and stream-sediment samples from the Long Swamp roadless area, Okanogan County, Washington: U.S. Geological Survey Open-File Report 83-227, 13 p.

Ford, A. B., 1983, Map of bedrock geologic data sites, Glacier Peak Wilderness study, Chelan, Skagit, and Snohomish Counties, Washington: U.S. Geological Survey Open-File Report 83-454, 1 sheet, scale 1:100,000.

Fox, K. F., Jr., 1983, Northeast-trending subcrustal fault transects western Washington: U.S. Geological Survey Open-File Report 83-398, 12 p.

Fraser, D. C., 1983, Airborne electromagnetic surveys of the Cascade Range, western United States: U.S. Geological Survey Open-File Report 83-92, 64 p., 30 plates.

Lawson, W. A.; Evarts, R. C., compilers, 1983, Map showing the status of mineral resource potential evaluation of wilderness and roadless areas, Washington: U.S. Geological Survey Open-File Report 83-392, 1 sheet, scale 1:1,000,000.

Miles, M. B., 1980, Flood profiles and inundated areas along the upper Cowlitz River, Lewis County, Washington: U.S. Geological Survey Open-File Report 80-225, 18 p.

Nelson, L. M., 1982, Streamflow and sediment transport in the Quillayute River basin, Washington: U.S. Geological Survey Open-File Report 82-627, 29 p.

Sheppard, R. A.; Gude, A. J., 3d, 1982, Mineralogy, chemistry, gas absorption and $NH_4$+-exchange capacity for selected zeolitic tuffs from the western United States: U.S. Geological Survey Open-File Report 82-969, 16 p.

Swanson, D. A.; Wright, T. L., 1983, Semiquantitative spectrographic analyses of stream-sediment samples from the Wenaha Tucannon Wilderness, Washington and Oregon: U.S. Geological Survey Open-File Report 83-297, 5 p.

Swanson, D. A.; Wright, T. L.; Munts, S. R., 1983, Mineral resource potential of the Wenaha Tucannon Wilderness, Washington and Oregon: U.S. Geological Survey Open-File Report 83-374, 9 p.

Turney, G. L.; Klein, J. M., 1982, Surface-water-quality data from selected sites in Washington affected by Mount St. Helens eruptions – March 27-September 30, 1980: U.S. Geological Survey Open-File Report 81-1007, 154 p.

Yount, James C.; Crosson, R.S., editors; Jacobson, Muriel, compiler, 1983, Proceedings of workshop XIV, Earthquake hazards of the Puget Sound region, Washington, convened under auspices of National Earthquake Hazards Reduction Program, 13-15 October 1980, Lake Wilderness, Washington: U.S. Geological Survey Open-File Report 83-19, 306 p.

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## 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.

Beget, J. E., 1981, Postglacial eruption history and volcanic hazards at Glacier Peak, Washington: University of Washington Doctor of Philosophy thesis, 192 p.

Beyer, W. C., 1981, Petrology and genesis of a uranium-bearing system of pegmatite dikes, Nancy Creek area, northeastern Washington: University of Montana Master of Science thesis, 82 p.

Brainard, R. C., 1982, Geology of the Colville area, Washington, township 35 north, east half of range 38 east, west half of range 39 east: Washington State University Master of Science thesis, 60 p.

Dansart, W. J., 1982, A petrographic study of the Josephine breccia in the Metaline district of northeastern Washington, using cathodoluminescence: University of Idaho Master of Science thesis, 72 p.

Duncan, G. W., 1982, Structural geology and stratigraphy of the east half of township 37 north, range 38 east, and the southeastern half of township 37 north, range 39 east, Stevens County, Washington: Washington State University Master of Science thesis, 68 p.

Ellison, P. J., 1982, Mineralization and alteration of a composite stock in the Gold Hill area, Stevens County, Washington: Washington State University Master of Science thesis, 67 p.

Faxon, M. F., 1982, Paleomagnetic direction of Sanpoil Volcanics in the southern Republic graben and along the Spokane River: Western Washington University Master of Science thesis, 106 p.

Gladden, S.C., 1981, Landslide hazardous areas, Bellevue, Washington: San Diego State University Master of Science thesis, 76 p.

Hogge, C. E., 1982, Geology of the Paleozoic black shale sequence, Moberg Hill, Stevens County, Washington: Washington State University Master of Science thesis, 80 p.

Janik, M. G., 1982, Cathodoluminescence of gangue dolomites near lead-zinc occurrences in Stevens County, northeastern Washington: University of Idaho Master of Science thesis, 88 p.

Krapf, R. W., 1978, Characterization of loess deposits and paleosols of the Palouse Formation in Idaho and Washington: University of Idaho Doctor of Philosophy thesis, 134 p.

Krissek, L. A., 1982, Sources, dispersal, and contributions of fine-grained terrigenous sediments on the Oregon and Washington continental slope: Oregon State University Doctor of Philosophy thesis, 226 p.

Laskowski, E. R., 1982, Geology of the black shale belt of the Bruce Creek area, Stevens County, Washington: Washington State University Master of Science thesis, 113 p.

Logan, R. L., 1983, Temporal trends in the geochemistry and petrology of the Mount St. Helens pyroclastic flow deposits: Western Washington University Master of Science thesis, 109 p.

McClain, K. J., 1981, A geophysical study of accretionary processes on the Washington continental margin: University of Washington Doctor of Philosophy thesis, 141 p.

Michaelson, C. A., 1983, Three-dimensional velocity structure of the crust and upper mantle in Washington and northern Oregon: University of Washington Master of Science thesis, 100 p.

Niemi, W. L., 1981, The identification and stratigraphic correlation of basalt aquifers in the southern half of the Quincy Basin, Grant County, Washington, using borehole geophysics: University of Idaho Master of Science thesis, 105 p., 4 plates.

Rohay, A. C., 1982, Crust and mantle structure of the north Cascades Range, Washington: University of Washington Doctor of Philosophy thesis, 163 p.

Snook, J. D., 1981, Geology of the north half of the Arden 7½-minute quadrangle, Stevens County, Washington: University of Idaho Master of Science thesis, 51 p., 2 plates.

Stauss, L. D., 1982, Anomalous paleomagnetic directions in Eocene dikes of central Washington: Western Washington University Master of Science thesis, 101 p.

Underwood, J. E., 1981, Evaluation of ground water pollution potential from surface impoundments in northern Idaho and eastern Washington: University of Idaho Master of Science thesis, 180 p.

## 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., 1983, Comparative physiographic diagrams of Mount St. Helens, Washington, and Crater Lake, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1403, 1 sheet, scale 1:62,500.

Barnes, D. J., 1983, Mineral investigation of the Glacier View RARE II area (no. A6061), Pierce County, Washington – Summary report: U.S. Bureau of Mines [Spokane] MLA 16-83, 11 p.

Barnes, D. J., 1983, Mineral investigation of the Indian Heaven RARE II area (no. 6076), Skamania County, Washington – Summary report: U.S. Bureau of Mines [Spokane] MLA 31-83, 12 p., 1 plate.

Donaldson, N. C., 1980, Soil survey of Whitman County, Washington: U.S. Soil Conservation Service, 185 p., 143 plates.

Frank, David, 1983, Origin, distribution, and rapid removal of hydrothermally formed clay at Mount Baker, Washington: U.S. Geological Survey Professional Paper 1022-E, 31 p., 1 plate.

Hubbell, D. W.; Laenen, J. M.; McKenzie, S. W., 1983, Characteristics of Columbia River sediment following the eruption of Mount St. Helens on May 18, 1980: U.S. Geological Survey Circular 850-J, 21 p.

Jacobson, M. L.; Rodriquez, T. R.; Seiders, W. H., compilers, 1983, Summaries of technical reports, volume XV, prepared by participants in National Earthquake Hazards Reduction Program: U.S. Geological Survey Open-File Report 83-90, 518 p.

Johnson, F. L.; Denton, D. K.; McCulloch, R. B.; Stebbins, S. A., 1983, Mineral investigation of the Eagle Rock RARE II area (no. 6054), Snohomish and King Counties, Washington: U.S. Bureau of Mines MLA 54-83, 20 p.

Jordan, Raymond; Kieffer, H. H., 1982, Topographic map of Mount St. Helens, Washington showing changes between April 11 and May 16, 1980: U.S. Geological Survey Miscellaneous Investigations Series Map I-1311, 1 sheet, scale 1:10,000.

Keuler, R. F., 1982, Map showing some potential effects of petroleum spills on shorelines of the Port Townsend quadrangle, central Puget Sound region, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-1238, 1 sheet, scale 1:100,000.

Lenfesty, C. D., 1980, Soil survey of Okanogan County area, Washington: U.S. Soil Conservation Service, 153 p., 105 plates.

Miller, M. S., 1983, Mineral investigation of the Mount Adams Wilderness study area and adjacent Mount Adams RARE II area A6069 (FS), Skamania and Yakima Counties, Washington — Summary report: U.S. Bureau of Mines [Spokane] MLA 14-83, 15 p., 1 plate.

Minard, J. P., 1982, Distribution and description of geologic units in the Mukilteo quadrangle, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-1438, 1 sheet, scale 1:24,000.

Munts, S. R., 1983, Mineral investigation of the Wenaha-Tucannon Wilderness study area (FS), Asotin, Columbia, and Garfield Counties, Washington, Wallowa County, Oregon — Summary report: U.S. Bureau of Mines [Spokane] MLA 20-83, 17 p.

## ROCKHOUND BROCHURE NEWLY PUBLISHED

In cooperation with Bob Pattie, of the Washington State Mineral Council, the Washington Division of Geology and Earth Resources has published a pamphlet entitled "Gems and Minerals of Washington." It features a shaded relief map, divided into eight regions, showing locations of sites where rocks, minerals, fossils, and gems may be found. The purpose of the pamphlet is to create an interest in rockhounding in the state and promote recreation and tourism. A "Regional Site and Rock Club Index" lists the rockhound clubs in the state who can be very helpful in planning a successful rockhounding trip.

The brochure may be obtained without charge by writing to the Department of Natural Resources, Division of Geology and Earth Resources, Olympia, WA 98504.

## STRATIGRAPHIC CORRELATION UPDATE FOR OREGON AND WASHINGTON NOW PUBLISHED

Updated information on stratigraphic correlations for geologic units from the last 66 million years of geologic history in the Pacific Northwest is now available in a new report published by the Oregon Department of Geology and Mineral Industries, in cooperation with the Washington Division of Geology and Earth Resources.

The report, Oil and Gas Investigation 7, "Correlation of Cenozoic Stratigraphic Units of Western Oregon and Washington," has 91 pages of text and is accompanied by a correlation chart. The publication represents the current knowledge of 28 leading stratigraphers on the rock units of 20 local stratigraphic columns. Coordinators for the project were J. M. Armentrout, D. A. Hull, J. D. Beaulieu, and W. W. Rau.

Oil and Gas Investigation 7 is now available at the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, OR, 97201. Purchase price is $8. Orders under $50 require prepayment. The report is also available for inspection in our Washington Division of Geology and Earth Resources library.

## 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.

Biggane, J. H., 1983, Geophysical logs from water wells in the Yakima area, Washington: Washington Division of Geology and Earth Resources Open-File Report 83-2, 53 p. Free.* [Accompanies: 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.]

Manson, Connie J.; Thorsen, G. W., 1983, Landslides of Washington — An annotated bibliography through 1982: Washington Division of Geology and Earth Resources Open-File Report 83-3, 78 p. Price $5.*

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## ACTIVE PERMITS 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. | 340 | Grant | BN 1-9 | 965 FWL and 1,869 FNL* sec. 9 (15-25E) | 2,400 | 20,000 | 12-21-82 | 5-22-81 |
| Voyager Petroleums | 353 | King | Black Diamond No. 4-13 | 514.17 FWL and 704.31 FSL sec. 4 (21-7E) | 818 | 6,500 | 6-22-83 | 5-16-83 |
| AMOCO Prod. Co. | 354 | King | Enumclaw Mill No. 1-34 | 1,430 FNL and 1,370 FWL sec. 34 (20-7E) | 1,447 | 2,500 | | 5-16-83 |
| | | | | **Oil and Gas Stratigraphic Tests** | | | | |
| AMOCO Prod. Co. | 356 | Pierce | Buckley No. 1 | 1,990 FWL and 2,033 FSL sec. 11 (19-6E) | 755 | 1,800 | | 7-26-83 |
| AMOCO Prod. Co. | 357 | Lewis | Storm King Offset No. 1 | 1,758 FSL and 1,261 FWL sec. 29 (14-5E) | 1,915 | 2,000 | | 7-26-83 |
| AMOCO Prod. Co. | 358 | King | Enumclaw Mill Offset No. 1 | 1,831 FEL and 503 FSL sec. 20 (20-7E) | 1,052 | 2,000 | | 7-26-83 |
| AMOCO Prod. Co. | 359 | King | Enumclaw Mill Twin No. 1 | 2,014 FNL and 1,091 FWL sec. 34 (20-7E) | 1,448 | 2,000 | | 7-26-83 |
| AMOCO Prod. Co. | 360 | King | Fall City Twin No. 1 | 1,217 FNL and 925 FEL sec. 7 (24-8E) | 975 | 1,500 | | 7-26-83 |
| AMOCO Prod. Co. | 361 | Pierce | National No. 1 | 968 FSL and 2,228 FEL sec. 28 (15-6E) | 1,610 | 2,000 | | 7-26-83 |
| AMOCO Prod. Co. | 362 | King | Snoqualmie Mill Offset No. 1 | 1,489 FNL and 1,297 FWL sec. 25 (24-7E) | 842 | 1,500 | | 7-26-83 |
| AMOCO Prod. Co. | 363 | King | Snoqualmie Mill Twin No. 1 | 1,779 FWL and 601 FSL sec. 19 (23-8E) | 2,190 | 1,500 | | 7-26-83 |
| AMOCO Prod. Co. | 364 | Lewis | Storm King Twin No. 1 | 2,005 FSL and 2,569 FEL sec. 23 (14-5E) | 1,835 | 1,500 | | 7-26-83 |

* Land description indicates that the location is 965 ft from the west line and 1,869 ft from the north line of sec. 9, township 15 north, range 25 east, Willamette meridian.

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