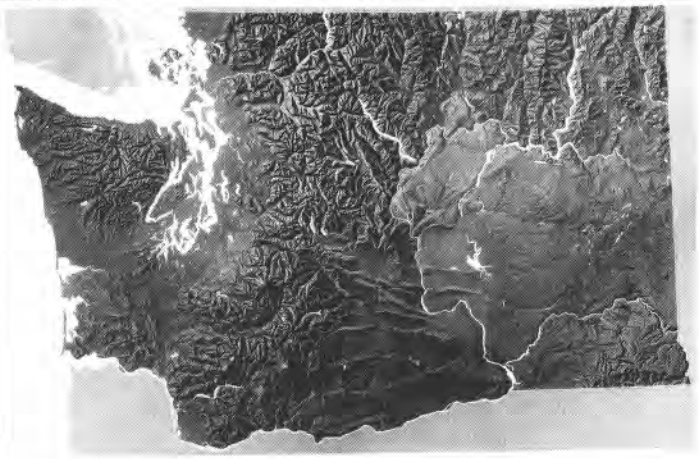

WASHINGTON GEOLOGIC NEWSLETTER

Volume 16, Number 3 July 1988

Washington State Department of Natural Resources

Division of Geology and Earth Resources

This cave-in occurred in 1979 over shallow mine workings at the Wonder mine near Ravensdale. (See article, p. 3.)

Washington Division of Geology and Earth Resources

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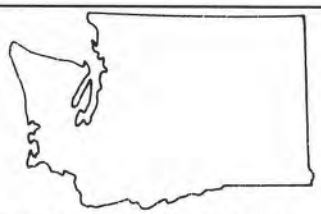

WASHINGTON GEOLOGIC NEWSLETTER

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Seabed Mining Jurisdiction Question

by

Raymond Lasmanis, State Geologist

Before any serious attempts to explore for and develop seabed resources in the federal Exclusive Economic Zone (EEZ) are undertaken, a long-standing jurisdictional controversy between the federal Minerals Management Service (MMS, Department of the Interior) and Department of Commerce has to be resolved.

The Commerce Department claims jurisdiction for leasing outside the continental shelf under the Deep Seabed Hard Mineral Resources Act of 1980. MMS has received jurisdiction for seabed mining in the EEZ from the Outer Continental Shelf Lands Act of 1953.

To resolve the question, Rep. Mike Lowry has introduced H.R. 1260, the National Seabed Hard Minerals Act. A similar bill was to be introduced in the Senate by Sen. Daniel Inouye of Hawaii. A substitute form of H.R. 1260, under consideration, would give the National Oceanic and Atmospheric Administration (NOAA) sole authority over seabed mining regulation. The bill would authorize $28 million to the U.S. Geological Survey and NOAA for geological and biological research.

Consultation with coastal states is a major feature of the House bill. Revenue sharing would provide for 50 percent of the royalties to go to the affected states.

(See related article, page 5.)

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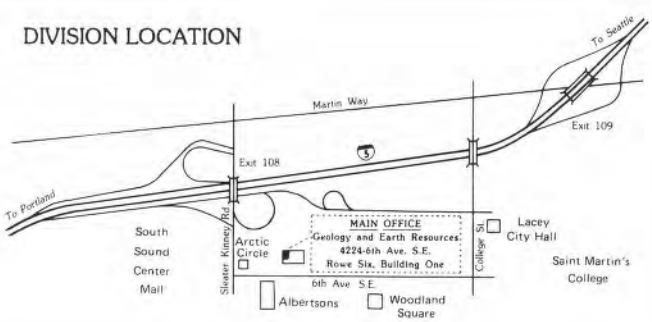

Coal Mine Subsidence in Washington

by

Timothy J. Walsh, Geologist

In 1977, Congress enacted Public Law 95-87, the Surface Mining Control and Reclamation Act (SMCRA), which provided, among other things, for the closure of abandoned, underground mine openings, reclamation of coal mine-induced subsidence, and the amelioration of mine related hazards. Funds for this work are provided by a tax on active coal mines at a rate ranging from 10 to 35 cents/ton, depending on coal rank. The act established an agency, the Office of Surface Mining Reclamation and Enforcement (OSMRE), to administer the provisions of SMCRA.

In Washington, mine reclamation is approached by OSMRE in two ways:

(1) Emergencies, which are defined as recent, sudden events, are reclaimed on a first priority basis. These are most commonly subsidences but have included gas flows caused by a drop in hydrostatic pressure in a mine void during dry weather.

(2) Existing mine hazards were inventoried, and priorities for reclamation were established on a nationwide basis. These include sudden subsidences that have been fenced and are thus not in need of rapid reclamation.

Funds for reclamation are allocated to those states with a federally approved surface mine regulatory program. States without such programs, such as Washington, receive funding at the discretion of the Secretary of the Interior to be expended directly by OSMRE. At present, OSMRE's reclamation expenditures in Washington are on the order of $750,000 annually. Reclamation of existing high priority sites has been accomplished principally in the Roslyn-Cle Elum area, in the Newcastle coal field, and in the Wilkeson-Carbonado area. Emergency reclamation has been necessary about twice a year, chiefly for subsidence. Subsidence reclamation is summarized in Table 1.

Table 1. Mine-subsidence reclamation projects, 1977-1987, performed by OSMRE since enactment of SMCRA. Location:the abbreviated location SW/4 28 (22-7) , for example, indicates southwest quarter of section 28 in T. 22 N., R. 7 E. Failure types: 1, failure of fill in a shaft, slope, or rock tunnel; 2, cave-in due to roof fall; 3, sag due to roof fall; 4, hydrocompaction of spoil

Project name	Mine name	Location	Date	Failure type
Engel	Wonder	SW/4 28(22-7)	2-79	2
Bevan	Burnett	S/2 16(19-6)	6-79	2
Campbell	Burnett	S/2 16(19-6)	5-81	1
Burdic	Wonder	SW/4 28(22-7)	9-81	1 or 2
Lake Whatcom	Rocky Ridge	SW/4 31(38-4)	11-82	2
Noorani	Denny-Renton	SW/4 17(23-5)	11-82	1
Gatto	Burnett	S/2 16(19-6)	2-82	1
May Creek	May Valley	SE/4 2(23-6)	6-82	2?
Beacon Hill	Beacon Hill	NE/4 14(23-4)	1-84	2
New #12	New #12	S/2 12(21-6)	1-84	1
Diamond	Diamond	SW/4 13(23-4)	7-84	1?
Davis	Davis	NW/4 14(21-7)	6-85	1
Denny-Renton	Renton	NW/4 20(23-5)	3-86	3?
Scott	unknown	NW/4 28(19-6)	5-87	1
Grgurich	#2	NE/4 14(21-6)	5-87	4
Koch	Rocky Ridge	SW/4 31(38-4)	9-87	4
Waterhouse	Waterhouse	NE/4 28(24-5)	2-88	1

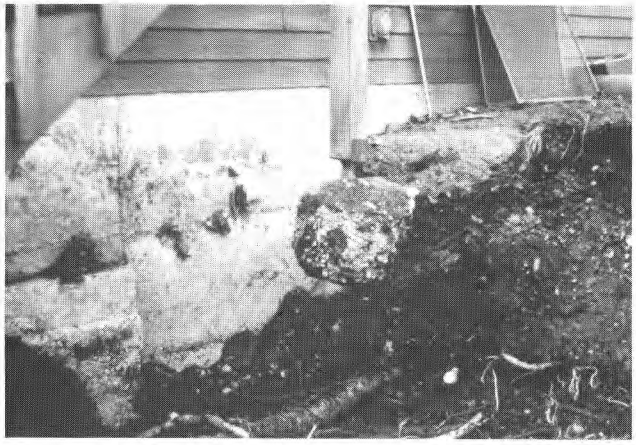

Figure 1. Collapse of an abandoned Waterhouse slope near Bellevue, February 1988. Note dangling support of stairway.

Emergency reclamation typically is accomplished within a few weeks, but funding is available only for reclaiming actual subsidence, not for repairing structural damage caused by subsidence. For this reason, prompt attention must be given to suspected coal mine subsidence before it causes damage, and contractors should consider the likelihood of future subsidence when building in areas of historic coal mining.

Local planning can help ease the potential impact of subsidence; planners are aware of mine-related hazards and can recommend construction techniques for areas affected by coal mines. King County, which has large areas underlain by abandoned coal mines, requires developers of lands designated as Coal Mine Hazard Areas to perform geotechnical studies in order to obtain building permits. King County Code 21.54.190 specifies that these studies must identify and quantify:

" 1. existing underground voids resulting from previous mining activity;
2. location and definition of all surface openings resulting from previous mining activity;
3. location of all concentrations of lethal or noxious gases and groundwater within abandoned mine workings; and
4. location, depth, and characteristics of all mine tailings on the surface of the site."

Any building permit issued requires, among other things, that all openings be sealed and all voids beneath building sites that present significant risk to human health, safety, and welfare be filled or otherwise remedied.

While this ordinance and a similar ordinance in Pierce County currently provide a measure of protection for homeowners, construction prior to its enactment is not covered. Many homes have already been built over or immediately adjacent to abandoned coal mines in Bellingham, Renton, Newcastle, Issaquah, and rural King County. Most of these structures will not experience any problems because subsidence has already gone to completion or because mine workings are too deep for subsidence to propagate to the surface. However, once the land surface is modified, it becomes more difficult to assess the subsidence potential.

A housing development that was built a few miles south of Bellevue in the mid-1970s contained an abandoned prospect (Table 1, Waterhouse prospect). Meager historic records indicated the presence of the prospect, but fill and grading concealed the exact location of the hole. Because the prospect was only poorly documented, its original extent, the amount and integrity of its fill, and the degree of hazard (if any) that it posed were unknown. In February 1988, the plug of fill in the mine entry failed, leaving a portion of a house foundation unsupported (Fig. 1). The hole grew for several days, eventually reaching a diameter of approximately of 30 feet and damaging the house's foundation and plumbing. While the prospect itself will be reclaimed by OSM, the homeowner will have to bear the burden of the damage to the house, and, at least temporarily, local property values are likely to suffer, even for properties not at risk.

The Division of Geology and Earth Resources (DGER) maintains a large collection of mine maps and other historical information that can be used to locate areas affected or potentially affected by coal mining. Inventories of known and suspected mine hazards are available for inspection at DGER's library and the index to DGER's mine map collection is available for a $1.00 postage and handling charge (DGER Open File Report 83-8 by Schasse and others).

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Washington Offshore Mineral Resources

by

Raymond Lasmanis, State Geologist

(Testimony presented to the Washington State Legislature, Joint Select Committee on Marine and Ocean Resources, March 29, 1988)

INTRODUCTION

The oceans of the world contain vast quantities of minerals. These commodities occur in sea water, in deep ocean-bottom rift systems, as unconsolidated placer deposits on the sea bed, and as deposits in bedrock under the ocean.

On a world scale, sea water is a large source of chemical commodities, such as bromine. There is also significant production of gold, diamonds, tin, rare earth minerals, zircon, chromite, and titanium-bearing iron minerals from marine placer deposits. Sand and gravel are being mined from deep water off the shores of Great Britain and Japan. In several nations bedrock deposits of coal, base metals, and tin are extracted by underground mining below the sea from shafts located on islands and the mainland. Salt and sulfur are exploited from subsea bedrock domes by wells. However, there has not yet been any mining of phosphorite, manganese, or polymetallic sulfides from the ocean floor.

In the United States, mineral production has taken place and is presently occurring along the intertidal zone and in shallow state waters. Table 1 below provides an overview.

Table 1. Commodities extracted or mined from marine waters

Commodity	Source	Location
Salt	Sea water	California, Gulf coast
Magnesium	Sea water	Gulf coast
Bromine	Sea water	Gulf coast
Sand and gravel	Unconsolidated	New York, New Jersey
Oyster shells	Unconsolidated	Gulf coast
Gold	Placer	Oregon, Alaska
Chromite	Placer	Oregon
Titanium	Placer	Florida
Zircon	Placer	Florida
Barite	Bedrock	Alaska
Salt	Bedrock	Gulf coast
Sulfur	Bedrock	Gulf coast

In the United States the value of sand and gravel recovered from offshore deposits exceeds that of all other mined marine minerals.

OFFSHORE MINERALS OF WASHINGTON

There has been no mineral production offshore of Washington in either state or federal waters. However, titaniferous sands and gravel resources have been identified offshore. The polymetallic sulfides found on Juan de Fuca Ridge occur more than 200 nautical miles seaward from the Washington coastline and therefore are beyond the federally declared Exclusive Economic Zone.

Titaniferous iron-bearing black sands have been outlined by drilling, surface sampling, and geophysics along the intertidal zone and as much as 2 miles offshore in the following areas: Baker Bay at the mouth of the Columbia River, on accreted lands (Benson Beach) and offshore of Fort Canby on Cape Disappointment, and at Leadbetter Point, all in Pacific County. Such black sands have also been explored off Brown Point in North Bay of Grays Harbor. Titaniferous sands at Moclips and Copalis have been characterized (Table 2) and contain minor amounts of gold.

In Washington, as elsewhere, by far the most valuable offshore resource is gravel. Large deposits are found from Cape Flattery to Grays Harbor. The deposits have been confirmed by bottom sampling (Fig. 1); studies show that they are associated with ancient shorelines at depths of 20 to 280 meters (1 meter = 3.28 feet). These gravel deposits exist in federal waters beyond the 3-mile limit and are clustered around the entrance to Juan de Fuca Strait and the outfalls of the Hoh, Quinault, and Chehalis Rivers. These sea-floor gravels have remained unburied on the seabed since they were deposited 15,000 years ago. At that time the sea level was 200 meters lower than at present (Fig. 2).

The U.S. Geological Survey has conservatively estimated that if gravel off Washington is present as a layer 1 meter thick, offshore resources contain 1,505 million cubic meters of material (1 cubic meter = 1.31 cubic yards). Gravel at depths of less than 50

Table 2. Percentages of magnetite plus ilmenite and zircon concentrates in the heavy minerals (from Venkatarathnam and McManus, 1973)

Station Number	Latitude	Longitude	% magnetite plus ilmenite	% zircon concentrate	% of total heavies
OC14-IA	46°50.7'N	124°07.6'W	2.7	0.4	1.9
-2B	46°51.0'N	124°09.0'W	4.3	2.0	5.3
-4A	46°52.2'N	124°13.0'W	1.7	0.8	17.8
-7B	46°53.4'N	124°17.9'W	5.8	0.0	18.2
-12B	46°58.4'N	124°14.0'W	18.4	1.9	14.1
-15B	47°00.5'N	124°11.0'W	2.9	0.2	2.3
-17	47°01.1'N	124°14.0'W	10.5	1.5	16.0
-18B	47°01.3'N	124°15.5'W	11.2	1.3	32.9
-22A	47°03.9'N	124°26.2'W	17.8	0.5	28.3
-29A	47°10.5'N	124°13.1'W	10.0	0.4	1.3
-31A	47°11.2'N	124°16.2'W	8.9	0.1	6.4
-34B	47°12.4'N	124°22.3'W	0.4	0.8	13.0
-35A	47°13.0'N	124°26.0'W	18.5	0.1	18.4
-42A	47°19.1'N	124°19.5'W	1.1	0.6	9.0
-43B	47°19.6'N	124°18.6'W	10.2	0.5	1.8
-56A	47°29.2'N	124°21.7'W	5.1	1.6	0.6
-60A	47°30.2'N	124°28.2'W	9.2	0.2	3.1
-63A	47°33.0'N	124°37.3'W	10.9	0.3	19.6
-65A	47°35.3'N	124°31.3'W	11.3	0.4	15.6
-70A	47°39.3'N	124°24.3'W	4.8	7.1	1.0
-75A	47°41.3'N	124°33.8'W	10.8	0.5	15.8
-76B	47°42.0'N	124°37.6'W	13.8	1.9	13.4
-77A	47°42.8'N	124°41.3'W	13.0	0.3	15.3
-84B	47°47.6'N	124°31.8'W	10.7	0.6	0.4
-91B	47°51.6'N	124°45.3'W	13.7	0.9	14.7
-104B	48°00.8'N	124°50.3'W	13.4	0.5	8.4
-111A	48°05.6'N	124°43.9'W	6.0	0.5	0.8
-132A	48°19.8'N	124°49.7'W	11.2	0.2	3.2
-141A	48°24.3'N	124°45.5'W	8.1	0.0	2.0
-165B	48°06.4'N	124°42.4'W	7.3	2.2	1.1
CC-158	Columbia River Estuary		33.3	0.0	14.4
BB-333-178	46°12.0'N	124°11.2'W	10.0	0.0	5.1
BB-333-208	46°19.2'N	124°07.4'W	18.2	0.0	3.5
BB-333-335	46°33.2'N	124°09.2'W	17.5	0.0	8.1

meters can be reached for mining by a suction dredge; at least 144 million cubic yards of gravel in deposits with a 1-meter thickness exists at this depth or shallower (Table 3).

PAST OFFSHORE MINERAL ACTIVITY IN WASHINGTON

The only mineral-related activity conducted in state waters has been the search for and development of titanium- and iron-rich black sands. The minerals that are present in such black sands are magnetite, hematite, and ilmenite. Exploration has

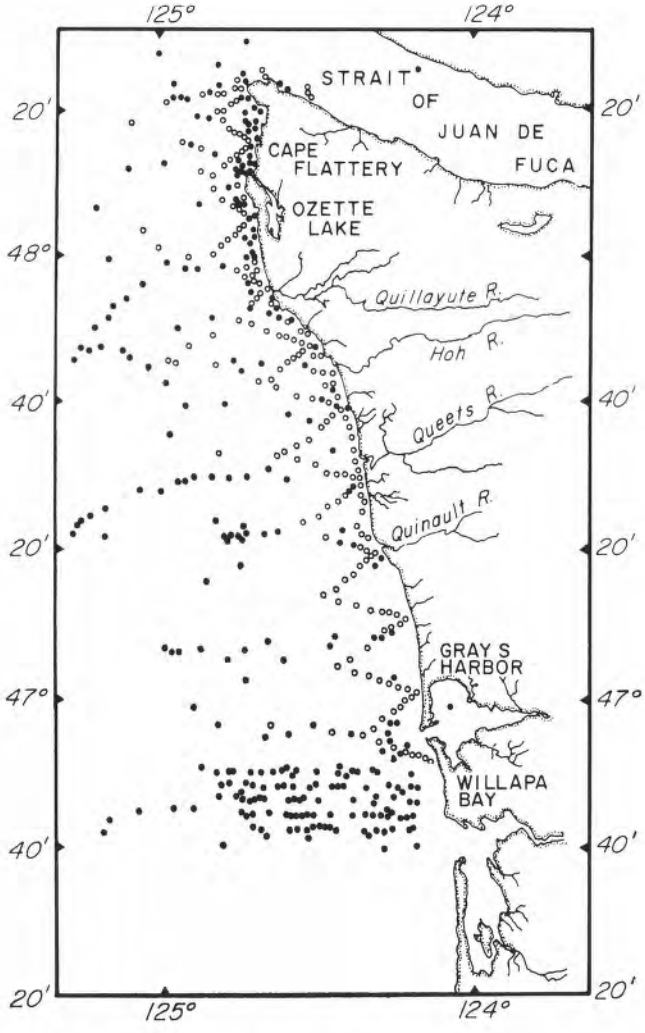

Figure 1. Offshore sampling stations (from Venkatarathnam and McManus, 1973). All samples were analyzed for grain size. The samples designated by open circles were separated for heavy minerals.

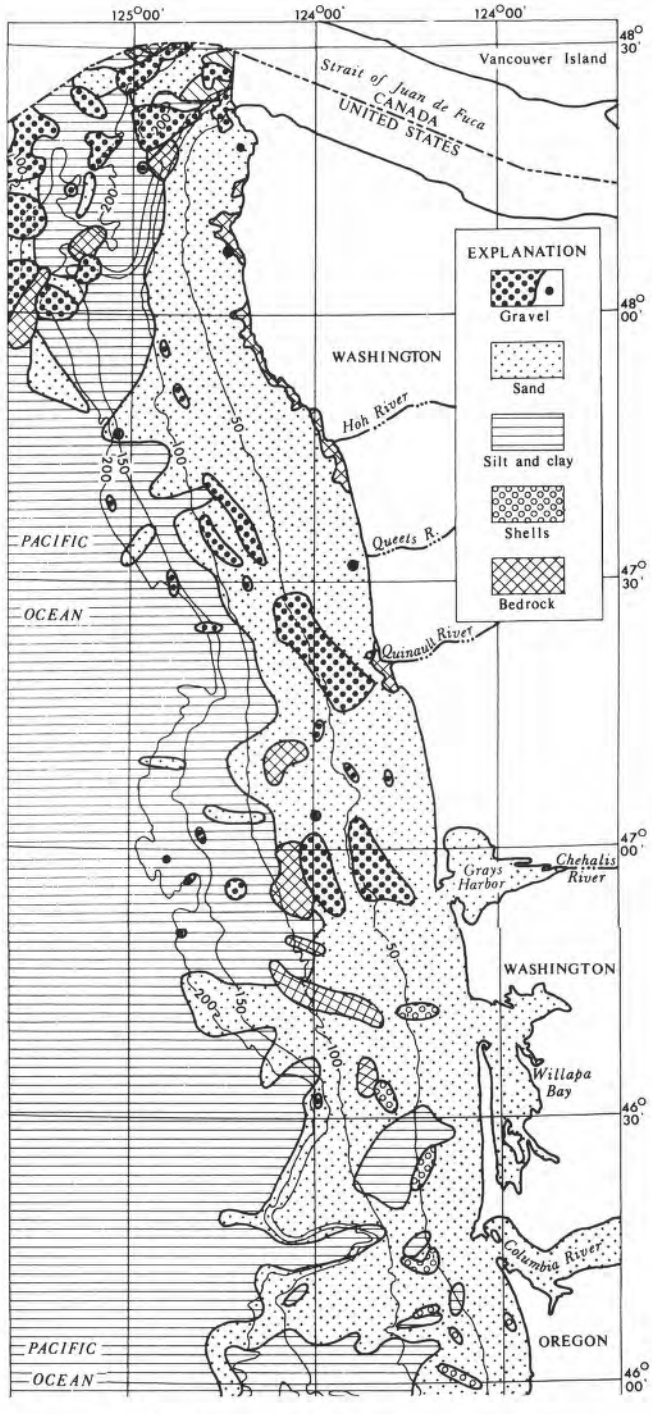

Figure 2. Areal extent of Washington sand and gravel deposits (from Moore and Luken, 1979). Submarine contours in meters.

Table 3. Offshore gravel resources of Washington (from Moore and Luken, 1979)

Center of deposit N lat	W long	Area (square kilometers)	Volume (million cubic meters) 1-meter thickness	5-meter thickness	Average water depth (meters)
48°28'	124°56'	58	58	290	150
48°27'	124°47'	22	22	110	280
48°24'	125°08'	32	32	160	170
48°23'	124°46'	24	24	120	70
48°21'	124°55'	85	85	425	200
48°19'	125°20'	128	128	640	140
48°19'	125°05'	36	36	180	170
48°19'	124°42'	1	1	5	20
48°17'	125°58'	4	4	20	210
48°14'	125°10'	5	5	25	210
48°14'	125°31'	13	13	65	160
48°11'	125°19'	94	94	470	170
48°07'	125°44'	2	2	10	20
48°05'	125°07'	23	23	115	170
48°03'	125°27'	313	313	1565	170
48°01'	125°13'	47	47	235	170
47°56'	124°55'	5	5	25	90
47°51'	124°52'	8	8	40	90
47°47'	125°02'	2	2	10	170
47°39'	125°03'	5	5	25	170
47°37'	124°42'	59	59	295	70
47°34'	124°46'	37	37	185	90
47°32'	124°24'	2	2	10	20
47°30'	124°41'	4	4	20	80
47°30'	124°53'	9	9	45	170
47°25'	124°47'	8	8	40	170
47°22'	124°21'	1	1	5	20
47°22'	124°28'	209	209	1045	40
47°14'	124°28'	7	7	35	60
47°09'	124°24'	8	8	40	50
47°08'	124°18'	5	5	25	30
47°04'	124°30'	2	2	10	70
47°02'	124°48'	4	4	20	140
46°59'	124°54'	1	1	5	160
46°57'	124°50'	3	3	15	170
46°57'	124°29'	90	90	450	70
46°57'	124°20'	127	127	635	40
46°56'	124°43'	16	16	80	130
46°51'	124°52'	2	2	10	200
46°32'	124°30'	4	4	20	170

been concentrated around Cape Disappointment at the mouth of the Columbia River and in Grays Harbor.

A succession of companies has explored in these areas since 1949. The titanium division of National Lead Co. explored in Grays Harbor in 1949. Exploration activity was extended to the mouth of the Columbia River by 1959 with Nareco, Inc. leasing the Baker Bay tidelands from the Department of Natural Resources (DNR). The most serious attempt to produce titanium and iron products was by Washington Mineral Products, Inc. from leased seabed lands in the Cape Disappointment area. After pilot plant operations, the company constructed a concentrating plant at Kalama during January 1967. The operation failed to produce a saleable product and closed. Beach Mining, Inc. acquired most of these leases and filed for mining contracts with DNR on the seabed 1 to 2 miles offshore of Benson Beach (Fig. 3). These leases covered a major elliptical magnetic anomaly. After several baseline studies and the release of an Environmental Impact Statement prepared under the direction of Fisheries and Game Departments, DNR issued mining permit No. 11202 on November 1, 1982. The operator was unable to make the lease payments, and the offshore leases were cancelled on July 18, 1985.

The most recent exploration effort was by Columbia Ocean Minerals, Inc. In 1986 they drilled four vibracore holes from a barge to test the magnetic anomaly west of Benson Beach and Ilwaco. Results apparently were unfavorable.

It should be noted that the mouth of the Columbia River is repeatedly dredged to keep shipping channels open. Any potential mining operations would use similar techniques and equipment to recover minerals from the ocean floor.

CONCLUSIONS

For offshore Washington there is no potential for bedrock mineral deposits, and it is not likely that commercial placer deposits of tin, chrome, gold, or diamonds will be found there.

Domestic onshore titanium resources seem to be sufficient to keep foreign imports below 10 percent of national consumption. Washington black sands have characteristics that make them difficult and expensive to treat metallurgically. Therefore, it is unlikely the sands will be commercially developed in state waters within the next 20 years.

Gravel deposits have the best potential for development by the year 2000. In 1978, the national per-capita consumption was 9,140 pounds of stone and 8,580 pounds (6.7 cubic yards) of sand and gravel. Figures are higher for large metropolitan areas such as Seattle, Portland, and San Francisco. The U.S. Bureau of Mines has estimated that for 1987 every person in Washington state "consumed" 9.34 cubic yards of sand and gravel.

Washington is blessed with abundant gravel deposits because much of the area was glaciated. However, high quality gravel resources in the Seattle/Tacoma area are rapidly being depleted. The largest sand and gravel operation in the state, on tidewater, at Steilacoom, is nearing 100 years of production. Urban development in that area and elsewhere in King and Pierce counties is severely restricting access to or removing potential resources from production. Crushed rock, which is more expensive, can replace gravel to some extent in paving by using asphalt instead of concrete.

As noted, land sources of gravel within reasonable distances of metropolitan markets will continue to be depleted. In my opinion, shortages will be felt by the year 2000. At that time Washington's offshore gravel deposits will be attractive for exploration.

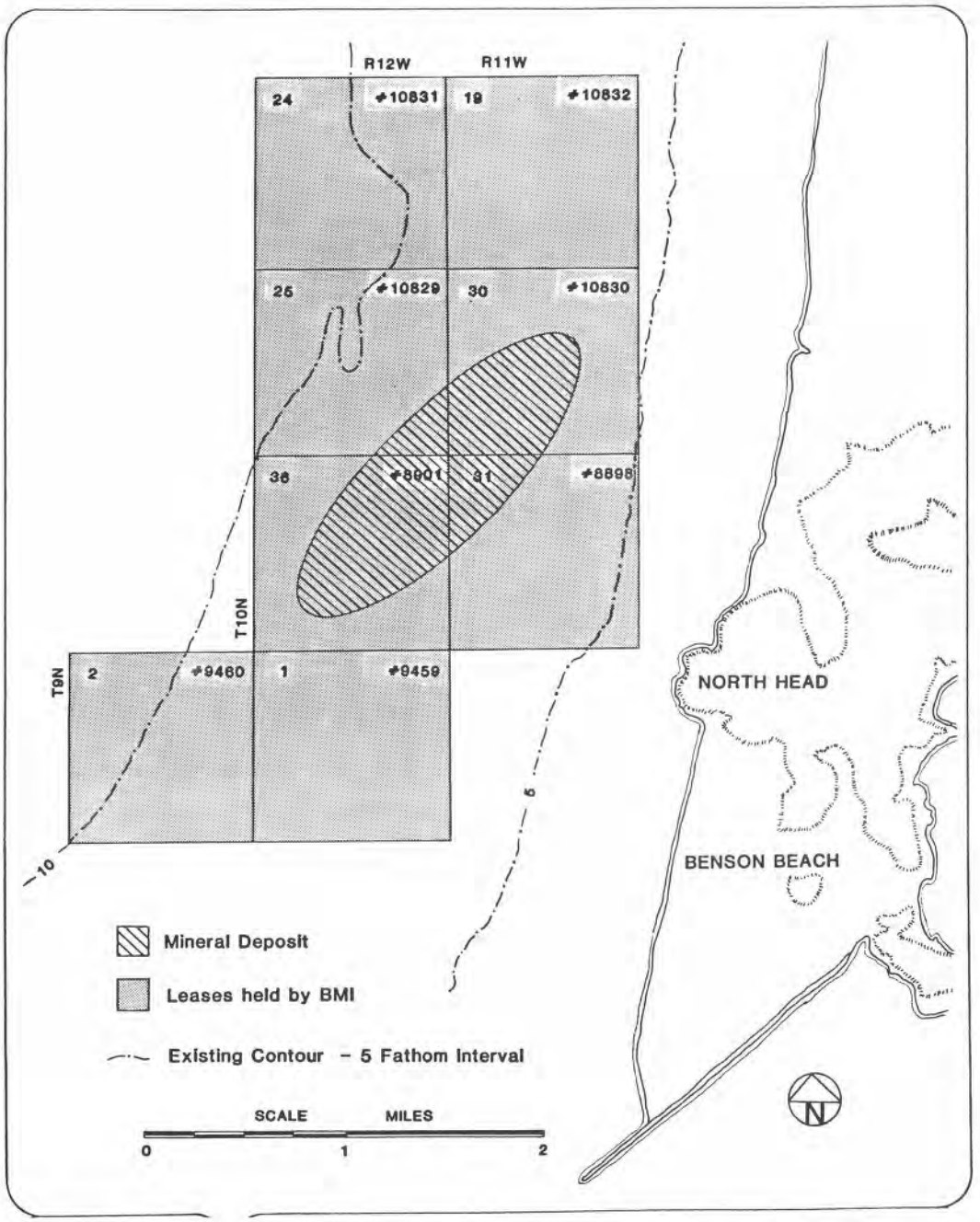

Figure 3. Beach Mining Inc. black-sand leases (expired) in Pacific County (from Dearborn Assoc., Inc., 1980).

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Geothermal Gradient Test Planned for 1988

by

Brent Barnett, Geologist

Since the mid-1970s the Washington Division of Geology and Earth Resources has engaged in geothermal resource research and assessment throughout the state. Funding for the program has come largely from U.S. Department of Energy and National Science Foundation contracts and grants, coupled with subordinate State contributions.

A major portion of these investigations has been the drilling of shallow (500 to 1,200 ft) geothermal gradient test holes in Washington's Cascade Mountains. Early drilling projects (1975-1983) were aimed at assessing potential resource targets distributed more or less throughout the range, such as known hot springs, sites surrounding Quaternary stratovolcanoes, and fields of Pleistocene-to-Holocene fissure-type volcanoes. More recently, efforts have focused on the southern Washington Cascades, with emphasis on the drilling of favorable structural trends, many of which host Pliocene-to-Holocene intrusive and volcanic rocks, and on evaluating other broad areas of recent volcanism that remain unstudied.

The geothermal gradient drilling planned for 1988 is the sixth project of its kind since 1975. As many as six holes will be drilled this summer in the Gifford Pinchot National Forest, in a corridor extending roughly south from Mount Rainier to the Columbia River. Brent Barnett will be supervising the drilling project. In addition to down-hole gradient measuring, the program will entail outcrop sampling for age-dating and geochemical analyses of Quaternary volcanic rocks, as well as detailed geologic mapping in the vicinity of the drill sites. Mike Korosec, the geothermal program manager, will be conducting the Quaternary volcanic rocks study and assisting Barnett with the mapping. The work will allow further refinement of the heat-flow characteristics of the Cascade volcanic arc and improve interpretations of Quaternary volcanism in southern Washington.

Coal Exploration in Whatcom County

by Henry Schasse, Geologist

Cravat Coal Company of Cadiz, Ohio, has filed a notice of intent with the U.S. Department of Energy, Office of Surface Mining, to pursue coal exploration activities this summer in the Glacier coal field in Whatcom County. The property, owned by the Glacier Land Company, is located approximately 4 miles south of the town of Glacier and northwest of Mount Baker in sections 19, 20, 29, and 30, T.39N., R.7E. (Fig. 1). The company plans to explore the property using air-rotary and air-core drilling techniques.

At various times interest in the Glacier seams has been rekindled, but most plans have been abortive. Work has been mostly centered around the discovery tunnel (Fig. 2) near the south edge of the field. The property was last explored in 1976 by Gates and Fox, an affiliate of Canadian-American Exploration Company (Can Am). Can Am did not initiate mining as a result of their exploration. To date, exploration has not unravelled the complex geology of the Glacier area to provide a meaningful estimate of reserves or mining conditions.

Figure 2. Original adit, Discovery seam, Glacier coal field. (Photo by Ellis Vonheeder, DNR)

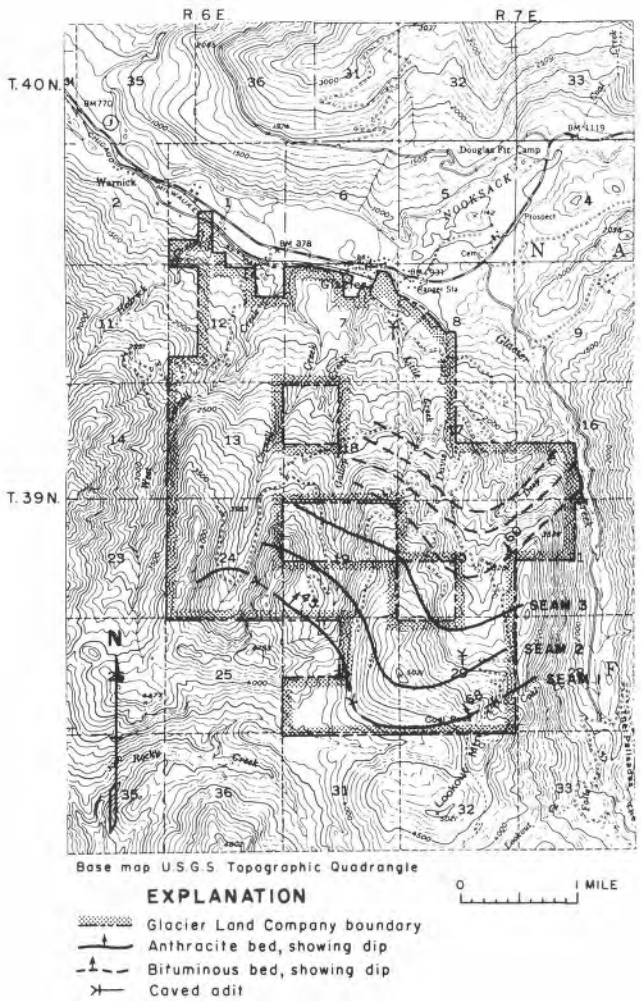

Figure 1. Glacier coal field (from Moen, 1969).

The Glacier property is unique in Washington in that it contains anthracite. The coal occurs as lenses mainly in three beds ranging in average thickness from 6 to 10 feet. At least four other coal beds lie above the highest of these three beds but these are much thinner and contain coal of lower rank. The Glacier coal seams occur near the base of the Chuckanut Formation in sandstone and shale that rest on the Yellow Aster Complex and the Darrington Phyllite (Brown and others, 1987).

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A high-altitude 1:63,360-scale photographic stereogram of the John Day Dam in Klickitat County. When a stereoscope is used with this photo pair, the scene will appear to be three dimensional, as if the viewer were flying overhead.

Resources for Earth Scientists

John Brown, a geologist, finds Department of Natural Resources (DNR) aerial photos very useful in identifying land forms such as landslides, stream drainage patterns, and geologic structures. "Air photos are more current than any map I know of," John says, "and I can get them easily. I certainly get my money's worth out of them."

DNR produces maps and air photos to assist in the management of 5 million acres of state land scattered throughout Washington. Revenue generated from activities on this land, such as timber harvesting, agricultural leasing, and gravel extraction, is used to support trust beneficiaries: public schools, universities, institutions, and local governments.

DNR is a revenue-generating agency. It makes all these photos and maps available to the public. Through its sales efforts, the Photo and Map Sales Office in Olympia supports the Department's extensive aerial photography program.

Aerial photography is available for most of the state, although, generally, national forests and parks are not covered. Projects have been flown almost every year since 1957.

Aerial photo prints come in various scales and in color or in black and white, depending on the county. The different scales available include 1:12,000 (1" = 1,000'), 1:24,000 (1"=2000'), and 1:63,360 (1" = 1 mile). Standard print size is 9" x 9".

All DNR aerial photography is flown in "flight lines", which results in continuous strips of photographs covering north-south slices of the state's terrain. Consecutive photos in a flight line overlap by about 60 percent. This permits an individual to use a stereoscope to see a three-dimensional image of topographic features in a pair of overlapping photographs. (See example, this page).

Orthophotography is also available. The photograph of the hydroelectric station at the John Day Dam is an example of this type of photography. Orthophotos are prepared from high-resolution black-and-white photographs that have been corrected to eliminate distortion caused by terrain relief. They are true to scale and have been modified to include section lines and some geographic names.

Orthophoto maps are available for eastern Washington at a scale of 1:24,000 (1" = 2,000'). Each map covers an entire township. For western Washington, two scales are available: a 1:24,000-scale township format (photo in upper right column) and a 1:12,000 (1" = 1,000') scale that covers a quarter township per map.

The Photo and Map Sales Office also sells DNR 1:100,000-scale Public Lands maps, DNR township topographic maps at scales of 1"=1,000' and 1"=2,000', and other miscellaneous types of maps. This office is also a dealer for U.S. Geological Survey topographic maps.

Detail from an orthophoto that includes the area of John Day hydroelectric facility also shown in the stereo pair. This orthophoto is at a scale of 1:24,000 and was made from photography flown in 1986. The 20 is the section number. North is at the top.

John Day Dam as it appears in a 1:12,000 black-and-white aerial photo. North is at the top of the photo.

Black-and-white aerial photos cost $7.00 each plus tax. The price is $17 plus tax for the first color photo; additional photos on the same roll are $7 each. (Please contact the sales office for more information on color photo pricing.) Orthophotos cost $5.00 each plus tax. Maps can be ordered by mail; specify section, range, and township numbers. A free index is available to assist in locating the area of interest. The Photo and Map Sales office is open between 8:00 and 4:30 on weekdays. The address and phone number are:

Department of Natural Resources
Photo and Map Sales
1065 South Capitol Way
Olympia, WA 98504
Phone: (206) 753-5338

(From text provided by Resource Mapping staff, Photo and Map Sales office)

Mineral Industry News Notes

by

Nancy L. Joseph, Geologist

METALS

Chelan County

Asamera Minerals Inc. and **Breakwater Resources Ltd.**, owners of the Cannon mine, announced in March the discovery of gold mineralization on lands held by the joint venture near Wenatchee. The discovery, in an area 2 miles southeast of the Cannon Mine, is the result of several years of exploration. Breakwater Resources reports that 42 of 60 holes drilled along a strike length of 9,000 feet intersected gold and silver mineralization in silicified feldspathic sediments. The Asamera-Breakwater joint venture plans a 6,000-foot exploration adit on the property to facilitate underground drilling and bulk metallurgical sampling. The estimated cost of the project, scheduled for completion in mid-1989, is $3 million.

During the first quarter of 1988 the Cannon mine milled 125,120 tons of ore having an average grade of 0.325 ounces of gold per ton to produce 37,285 ounces of gold and 56,972 ounces of silver. The Cannon mine is presently the largest gold mine in the state and the second largest underground gold mine in the country.

Althouse Placers, Inc. has signed an option agreement with Asamera Minerals Inc. for three other properties in the Wenatchee area, one of which is near the Asamera-Breakwater discovery.

Ferry County

The Republic Unit of **Hecla Mining Company** in Republic produced 16,000 ounces of gold during the first quarter of 1988. Recent exploratory work by Hecla resulted in expansion of known reserves by 1.2 million tons of mineralized rock averaging 0.5 ounce of gold per ton.

Tanqueray Resources Ltd. has acquired an option to earn a 60 percent working interest in the Valley mine, north of Republic, through a work commitment of more than $500,000 over the next 14 months and other considerations. The company's first-quarter report states that of ten drill holes completed during 1988, eight intersected the principal vein, but commercial grades were not reported. Additional surface drilling has been completed, and results are being evaluated. The mine has been idle since late 1987.

Crown Resource Corp. and **Sutton Resources Inc.** announced an expansion of the joint venture to include **Texas Star Resources** in detailed exploration of the Seattle/Flag Hill property. Under the terms of the agreement, Texas Star Resources can earn a 50 percent share in the property by expenditure of $2 million over the next 5 years.

Echo Bay Mines has applied for a wastewater treatment permit for its properties north and east of Republic. This request is one step in the process of obtaining a permit to mine, should the company decide to proceed at these properties. Crown Resources Corp. and Gold Texas Resources, Ltd., each sold 5 percent of their interest in the Key and Kettle properties to their joint venture partner, Echo Bay. Echo Bay now controls 70 percent of these properties.

INDUSTRIAL MINERALS

Okanogan County

Interstate Portland Cement Inc., a sister company of Ciment Quebec Inc., announced that it is contemplating a new portland cement plant in the Okanogan Valley near Oroville. The company has estimated that limestone from White Rock Mountain contains more than 50 years of reserves. The property was acquired from CM Silver Mines, Inc., a wholly owned subsidiary of Lucky Three Mining. Plans discussed by the company include a 5.5-mile-long overland conveyor belt to transport the limestone from the quarry to the cement plant. The company estimates that operation would create 200 new permanent jobs. Presently, only the Lehigh Portland Cement Co. near Metaline Falls is producing portland cement from rock mined in Washington. Much of our cement is imported from Japan. A go-no go decision for the new operation will be made by September 1988.

Stevens County

Northwest Alloys Inc. in Addy has reactivated their furnace to produce 75 percent ferrosilicon. The company had shut down their 27-megawatt furnace approximately 30 months ago after ferrosilicon became widely available at a low price. The Addy Quartzite, mined near the plant, provides silica for the product. The company uses the ferrosilicon in the production of magnesium metal from dolomite at the Stevens County facility.

AIMCOR Honored by U.S. Forest Service

by

Nancy L. Joseph, Geologist

Applied Industrial Minerals Corp. (AIMCOR) has been honored as the Mineral Operator of the Year (1987) by the Pacific Northwest Region of the U.S. Forest Service. The company was cited for "exceptional environmental stewardship" exhibited at their AIMCOR Olivine property in the Mt. Baker-Snoqualmie National Forest, near Hamilton.

The deposit consists of olivine-rich sands that are mined, crushed, and screened to produce olivine for foundry and blast sands. Between 1959 and 1986, the Twin Sisters quarry had been operated by IMC Olivine, a division of International Minerals and Chemical Corp. In late 1986 the Industry Group of IMC was sold to the newly formed AIMCOR.

Prior to 1984, a washing process was used to screen the olivine, and rejected fines were contained in tailings ponds. This fine sand is highly erodible. Because of the steep surrounding topography, runoff is naturally funneled to the tailings pond area and can carry the fines into the South Fork of the Nooksack River approximately 1/4 mile away. The river is a major anadromous fishery for spring Chinook salmon, a valued but depleted species. A dry screening is now being used, and newly produced fines are no longer placed in a tailings pond. The environmental impact of the operation has been dramatically reduced.

Dennis Wheeland, the new plant manager, and AIMCOR were committed to reclamation of the former tailings pond site when they took over the operation. The goals of the reclamation project were to stabilize and reclaim the 13-acre site and to prevent the dispersal of fines. The site was contoured, and water breaks were built to reduce runoff. Old culverts were replaced with boulder-lined channels to channelize runoff and eliminate erosion of the fine sands. Rock was also placed at the toe of the slopes of the tailing ponds to maximize stability. Soil samples were taken to determine the appropriate fertilizer, grass seed mixture, and tree species; this site is dry and the soil is slightly basic, unusual conditions for west of the Cascades. The area was then limed, hydro-seeded, and planted with lodgepole pine, a local native species.

After the first winter and spring of the project, runoff is reportedly remaining in the boulder-lined channels, and erosion of the former tailings ponds is minimal. More lodgepole seedlings will be planted this year. The hydro-seeded grass is flourishing, and AIMCOR, with the aid of the Forest Service, is looking into planting more grasses, including fescue, that might appeal to elk in the area.

Dennis Wheeland, plant manager for AIMCOR (center), accepting U.S. Forest Service award from Jerry Allen, Special Assistant to the Regional Forester, Region 6 (left), and Larry Hudson, District Ranger, Mt. Baker-Snoqualmie National Forest. (Photo courtesy of Bureau of Land Management)

Whale Hunting on the Olympic Peninsula

by

Keith L. Kaler

In early June a party from the Natural History Museum of Los Angeles County, Los Angeles, California, began the tedious process of excavating a skeleton of a primitive toothed cetacean (whale) from a site on the Olympic coast. The party consisted of museum associate Jim Goedert, Bill Buchanan, and museum preparators Fritz Clark and Howell Thomas. The fossil had been found 2 years earlier by Jim and his wife Gail, both of whom have extensively explored the Cenozoic marine sediments of Washington over the last 10 years.

The crew had a week in which to excavate the specimen.The site is exposed only at minus tides. Access is difficult because of rugged topography and slippery rocks. Work could be done only during the 5 to 6 hours between recession of the water from the site and the time when waves again began lapping at the fringes of the work site. During this short period excavation went on uninterrupted. Rain, high wind, and breakdown of equipment were the week's fare.

The fossil consists of a fairly complete skeleton of a cetacean of uncertain identity. The skeleton, when assembled, will be about 10 feet long. It consists of most of the skull, mandibles, cervical and thoracic vertebrae, ribs, and parts of the front appendages (scapula). All the bones are encased in an extremely refractory sandstone concretion. The team used a portable rock saw, electric chisel (with accompanying generator), and hand tools to remove the concretion from the surrounding matrix. As it would have been impractical if not impossible to have removed the entire skeleton in one block, smaller sections were dislodged. These smaller pieces ranged from fist size to blocks weighing several hundred pounds.

The skeletal material will be removed from the matrix and reassembled at the lab in Los Angeles. Because of the durability of the matrix, none of the blocks had to be encased in plaster for strengthening before being transported.

Weldon W. Rau examined samples of the matrix and found the following foraminifers:

Melonis pompilioides (Fichtel and Moll) - common
Gyroidina soldanii d'Orbigny - few
Gutilina G. frankei Cushman and Ozawa - rare
Quinqueloculina sp. - rare
Valvulineria willapaensis Rau - common
Also found were well-preserved fish teeth.

Fritz Clark using a portable electric chisel to undermine a concretionary block that contains vertebrae and ribs.

Jim Goedert (with saw) and **Howell Thomas** working to free the whale's scapula, which is embedded in a concretion lying in the Makah sediments.

According to Rau, this assemblage is best referred to an upper part of the Refugian Stage, which is presently regarded as a lower part of the Oligocene (Walsh and others, 1987, accompanying explanatory sheet). It should be pointed out that the matrix comes from the Jansen Creek member of the Makah Formation (Snavely and others, 1980) and that this member is a lithostromic unit from which Rau and his colleagues have found numerous misplaced assemblages of foraminifers usually of the Refugian Stage. The Jansen Creek member actually lies within rocks of a lower part of the Zemorrian Stage, slightly higher stratigraphically than the uppermost part of the Refugian Stage, which this matrix assemblage represents. Rau (written commun., 1988) also notes, "In regard to the environment of deposition, three of the five (and the most abundant) species listed [above] represent bathyal conditions, and two of these are likely confined to lower bathyal depths. Thus the assemblage most likely lived at depths no less than 1,000 meters and possibly as great as 2,000 meters."

Though it has not yet been described, this cetacean is potentially an important find. Cetacean evolution began in the middle Eocene, roughly 50 million years ago. These first whales, of the suborder Archaeoceti, became extinct at the end of the Eocene. At some time in the early to middle Oligocene, the modern cetacean suborders evolved: the Odontocetes (toothed whale) and the Mysticetes (baleen whales). Whether these arose from the archeocetes remains controversial (Barnes, 1984). The key to the early evolution of these suborders and the resolution of this controversy may lie in fossils of late Eocene or earliest Oligocene age. Fossils of early Oligocene Cetacea are rare; most Oligocene representatives are of middle or later age. Thus, with a proved early Oligocene age for the matrix fauna, any cetacean found in these Makah sediments has a good chance of being new and important. This Washington specimen, one of the earliest found in the entire Pacific basin, may well help clarify the origins and evolution of living whales.

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Walsh, T. J.; Korosec, M. A.; Phillips, W. M.; Logan, R. L.; Schasse, H. W., 1987, Geologic map of Washington—Southwest Quadrant: Washington Division of Geology and Earth Resources Geologic Map GM-34, 28 p., 1 plate, scale 1:250,000 and an accompanying explanatory sheet.

Interior Proposes Rulemaking to Increase Mining Law Fees

The Department of the Interior's Bureau of Land Management (BLM) has proposed rules in the Federal Register that would increase three mining claim fees and establish four new fees.

BLM Director Robert F. Burford characterized the proposed fee changes as a much needed action to help BLM recover an allowable share of the costs of carrying out the agency's mining law administration program under the Mining Law of 1987, as amended. The proposed fees would not recover all costs associated with the mining program, but would put the program on an equitable basis, establishing reasonable fees for services provided by the federal government.

Burford said that the increased fees would generate about $5.7 million in additional revenues, which when combined with current revenues from existing fees would make available approximately $6.4 million to be appropriated to BLM for the mining law program.

"The fee changes would be relatively small overall," Burford added, "and informal consultations with industry members, small and large, lead us to believe that this action should not cause economic hardship. These modifications are also consistent with existing county government recording fees."

Under the mining law, a U.S. citizen is entitled to locate a claim on federal land that is not otherwise withdrawn from mineral entry. The claimant may then explore for minerals and develop any valuable deposits that are discovered. In order to obtain these benefits, a claimant must properly maintain the claim by, among other things, complying with the Federal Land Policy and Management Act of 1976, which requires recordation of each claim initially, followed by an annual filing of an affidavit that the required amount of assessment work has been done, or a notice that the owner intends to hold the claim. Any active disturbing in excess of 5 acres requires submission and approval of a mining plan, which is subjected to environmental analysis.

	Existing fees	Proposed fees
Mining claim recordation		
New claims	$5	$10
Annual filings of affidavits for assessment work	--	5
Transfers of interest	--	5
Amendments	--	5
Mineral patents		
New application	25	250
Each additional claim in application	--	50
Deferments of assessment work	10	50

Comments on the proposed rulemaking should be submitted not later than August 22, 1988, to Director (140), Bureau of Land Management, Room 5555, Main Interior Building, 1800 C Street N.W., Washington, D.C. 20240.

Staff Notes

Brent Barnett has rejoined the Olympia office staff. Brent served as Project Geologist for the State of Washington during the 1985 geothermal drilling program. Since earning his B.S. degree from Ohio State University in 1979, he has worked throughout the Northwest in minerals exploration and hydrogeology. Brent received his M.S. degree in geology from Eastern Washington University in 1985. He will again be overseeing geothermal drilling.

William Phillips is one of the junior authors of "Residual Bouguer gravity anomaly map of the Cascade Range, California, Oregon, Washington, and British Columbia (D. L. Williams, senior author, U.S. Geological Survey Geophysical Investigations Map GP-973, 1988)

William Lingley, **William Phillips**, **Weldon Rau**, and **Timothy Walsh** assisted with the field trips in conjunction with the Northwest Petroleum Association Meeting in May.

Seismograph in Division Office

Kinemetrics Systems of Pasadena, CA, has donated a short-period seismograph to the Division. The company has been supportive of seismology and seismic research for two decades. According to A. M. Serici, President of Kinemetrics, the donation, "while primarily intended to provide useful technical instrumental data to better understand local earthquakes and geological conditions, may also promote increasing legislative and public awareness of the pressing need for improved earthquake hazard research and mitigation in the Pacific Northwest area."

The Division plans to make a permanent display for public education, complete with sample seismograms of various types of ground motion. At the present time, placement of the seismometer in the office setting is being tested.

The seismograph will supplement the work of the University of Washington's Geophysics Program, which is the current center for earthquake information. Questions about earthquakes are best referred to members of the program at Mail Stop AK-50, University of Washington, Seattle, WA 98195, or by phone to (206) 543-8020.

Meetings

Pacific Northwest American Geophysical Union
35th Annual Meeting
September 29-30
Royal Roads Military College
Victoria, British Columbia

Abstract deadline: August 28
Information:
John Mothersill
Royal Roads Military College
FMO Victoria, British Columbia
V0S 1B0 Canada
(604) 380-4516

Friends of Mineralogy
14th Annual meeting
September 30-October 2
Topic: Carbonate minerals
The Executive Inn
5700 Pacific Highway East
Tacoma, Washington

Information:
Ed Godsey
450 110th Ave., S.E.
Bellevue, Washington 98007
(206) 746-3306

National Academy of Sciences,
U.S. Geological Survey, and
Association of American State Geologists
(Convenors)
September 26-30, 1988
Sheraton Denver Tech Center
Denver, Colorado
Theme: Integrating technology and geoscience applications

Registration:
Buhler and Abraham, Inc.
8700 First Avenue
Silver Spring, MD 20910

Northwest Mining Association
94th Annual Convention and Trade Show
November 30-December 3, 1988
Sheraton Spokane Hotel, Spokane Riverpark Convention Center
Spokane, Washington

Information:
Northwest Mining Association
414 Peyton Building
Spokane, WA 99201
(509)624-1158

Geological Projects in Washington Supported by the National Science Foundation, 1988

(These projects cover areas in Washington. Some of these projects are also listed under the pertinent university name in the academic projects list below.)

Evolution of the Ross Lake fault—*Robert B. Miller (San Jose State University, California)*

Whole mantle electrical conductivity and the velocity field of the upper core–Constraints from applied mantle filter theory—*Adam Schultz (University of Washington)*

Magnetic phase transitions and thermodynamic behavior of iron-bearing silicate minerals—*Subrata Ghose (University of Washington)*

Investigation of aspherical structure of the core and the core-mantle boundary—*Kenneth Creager (University of Washington)*

Mantle geophysics with high-pressure and high-temperature diamond anvil cell techniques—*Yosiko Sorenson (University of Washington)*

Hydrogen in iron at high pressures—*J. Michael Brown (University of Washington)*

Accurate dating of Quaternary sediments and tephra by thermoluminescence methods—*Glenn W. Berger (Western Washington University)*

Genesis of late Quaternary loess and paleosols on the Columbia Plateau, eastern Washington—*Alan J. Busacca (Washington State University)*

Time scales for advance and retreat of glaciers in response to climate changes—*Charles F. Raymond (University of Washington)*

Large-scale glacial erosion and debris production—*James B. Harsh (Washington State University)*

An electromagnetic study of the lithosphere and asthenosphere beneath the Juan de Fuca plate and the adjacent continent; main phase—*John R. Brooker (University of Washington)*

Experimental field and theoretical investigations of assimilation of peridotite in zoned calc-alkaline plutonic complexes—*Mark S. Ghiorso (University of Washington)*

1988 Geological Projects, Washington Colleges and Universities

The following list is taken from material submitted by the geology departments of the state's colleges and universities. Named in parentheses with the faculty projects are student collaborators. Some projects involve areas outside Washington.

Central Washington University

Faculty Projects

Deep crustal transect, 117th meridian, Oregon and Washington (in cooperation with Cornell University)—*Steven E. Farkas, Don Ringe (Clifton E. Mitchell)*

Study of (1) methods to transfer geologic map information to a Geographic Information System with public-domain software, and (2) computer-assisted petrography for real-time color image analysis—*James R. Hinthorne*

Structural geology at the western margin of the Columbia River basalts—*Robert D. Bentley, John E. Powell (Steven D. Jensvold)*

Student Project

Detailed surficial geology of the Ryegrass waste disposal site, east of Ellensburg—*Susan A. Lovas*

Clark College

Faculty Projects

Geologic evolution and morphology of Mount St. Helens dome–A map series at 1:2000—*Wayne E. Colony (with Robin Holcomb, USGS)*

Geology of the Blanco Fracture Zone using side-looking sonar—*Wayne E. Colony (with John R. Delaney, University of Washington)*

Pacific Lutheran University

Faculty Projects

Geology of the Olympic Peninsula coastal strip, Olympic National Park—*Steve Benham*

Zeolites from Eocene basalts, Olympic and Kitsap Peninsulas—*Steve Benham*

Tacoma Community College

Faculty Project

Roadside geology of Mount Rainier National Park—*Jack H. Hyde*

University of Washington, Geophysics Program

(Abbreviated project titles; see also National Science Foundation list)

Faculty Projects

Agassiz ice cap survey—*Edwin D. Waddington*

Avalanche prediction—*Charles F. Raymond*

Core structure—*Kenneth C. Creager (Dai McClurg)*

DAC geophysics—*Yosiko S. Sorenson*

Deep conductivity—*John. R. Booker (Nong Wu)*

Domain structure—*Ronald T. Merrill*

Earthquake hazards—*Robert S. Crosson (John VanDecar)*

Earthquakes in the Pacific Northwest—*Robert S. Crosson (Jonathan Lees)*

Flows and currents—*J. Dungan Smith (David Mohrig)*

Geothermal seismicity—*Stephen D. Malone, Anthony Qamar (Sally Barker, Robert Leet)*

Glacier comparison—*Charles F. Raymond*

Glacier time scales—*Charles F. Raymond*

Hydrogen in metals—*J. Michael Brown*

Marine sediment transport—*J. Dungan Smith*

Mendocino induction—*John R. Booker (Maryann Helferty)*

Student Projects

Structure, petrology, and associated mineralization of the Similkameen batholith, Okanogan County, Washington—*A. M. Buddington*

Structural and metamorphic history of the Cascade River Schist in the Sibley Creek area, North Cascades—*J. D. Dragovich*

Hydrologic and geologic mechanisms for the generation of channelized debris flows, Boulder Creek drainage basin, North Fork Nooksack River, Washington—*M. E. Gowan*

Hydrothermal alteration associated with the Devils Mountain fault zone, Skagit County, Washington—*D. Graham*

A fluid inclusion study of hydrothermal processes at the Cannon mine, Chelan County, Washington—*M. Klisch*

An investigation of tourmaline as a pathfinder mineral for base metal-bearing breccia pipes and associated porphyry copper-type deposits in the Cascade Range of Washington—*C. Smith*

Washington State University

Faculty Projects

Development of short- and long-term plans for development of conceptual models of ground-water flow within Hanford Reservation post-basalt sedimentary deposits—*David R. Gaylord, with-Kevin Lindsey*

Sedimentology, stratigraphy and geological evolution of Eocene volcaniclastic and siliciclastic deposits in the Republic and Toroda Creek grabens, north-central Washington—*David R. Gaylord (Scott Price)*

Stratigraphic and sedimentary controls on hydraulic conductivity in the Ringold Formation and glaciofluvial strata on the Hanford Reservation, Washington—*David R.Gaylord (Ken Lane)*

Tectonic models of the Kootenay Arc—*A. John Watkinson*

Columbia River basalt research—*Peter R. Hooper*

Geophysical studies of the eastern Columbia Plateau—*Richard L. Thiessen and Kent R. Johnson*

Study of ground-water quality and ground-water contamination in Palouse loess—*C. Kent Keller (Vicki Martinez)*

Occurrence of carbon dioxide and oxygen in unsaturated Palouse loess—*C. Kent Keller*

Western Washington University

Faculty Projects

Geochemistry of plutonic and metamorphic rock units in the North Cascades—*R. S. Babcock*

Geochemistry and tectonic evolution of the Crescent Basalt—*R. S. Babcock*

Geochemistry and petrology of the Fifes Peak Formation—*R. S. Babcock*

Geochemistry and petrology of alkaline intrusives in north-central Washington—*R. S. Babcock*

Thermoluminescence dating of volcanic ash—*G.W. Berger*

Thermoluminescence dating of eolian and waterlaid sediments from North America and New Zealand—*G. W. Berger*

Analysis of metamorphic deformation in the North Cascades—*E. H. Brown*

Paleomagnetism of volcanic rocks from the Olympic Peninsula—*D. C. Engebretson*

Global investigation of asymmetric seafloor spreading—*D. C. Engebretson*

Computer animation of plate tectonic processes—*D. C. Engebretson*

Development of up-to-date global plate reconstruction atlas—*D. C. Engebretson*

Sediment transport in Deer Creek and slope stability along the main channel of Deer Creek, Skagit County, Washington—*H. M. Kelsey*

Petrology, provenance, and depositional environment of sedimentary rocks of the Crescent terrane—*C. A. Suczek*

Petrology of modern sands from western Washington—*C. A. Suczek*

Strain in the crystalline core of the North Cascades; its relation to block rotation and right-lateral movement—*J. L. Talbot*

Student Projects

Structural analysis of eugeosynclinal rocks in Big Sheep Creek area, Northport, Washington—*Frank Shore*

Geochemistry and petrology of plutonic rocks between the Kettle Gneiss Dome and Republic graben, Curlew and Togo Mountain quadrangles, Washington—*Charles Knaack*

Petrochemistry of Eocene hornblende-bearing plutonic rocks of the Colville batholith in the central Okanogan highlands and correlation with graben-filling volcanics—*Grace Holder*

Ground-water infiltration estimation for the Washington State University hazardous waste facility—*Herminio Muniz*

Selected Additions to the Division of Geology and Earth Resources Library

May and June, 1988

These reports are available for reference in the Division library in Olympia. Contact the individual publishers for loan or purchasing information.

Theses

Buchanan, Peter, 1988, Debris avalanche and debris torrent initiation, Whatcom County, Washington, U.S.A.: University of British Columbia Master of Science thesis, 237 p.

Glicken, Harry, 1986, Rockslide-debris avalanche of May 18, 1980, Mount St. Helens volcano, Washington: University of California, Santa Barbara Doctor of Philosophy thesis, 303 p., 5 plates.

Hanson, James Phillip, 1986, Modelling the hydraulics of flows and sediment transport of a Missoula flood in the Pasco Basin, Washington: Kent State University Master of Science thesis, 156 p.

Ott, L. E., 1988, Economic geology of the Wenatchee mining district, Chelan County, Washington: University of Idaho Doctor of Philosophy thesis, 270 p., 2 plates.

Paeth, Robert Carl, 1967, Depositional origin of Mima mounds: Oregon State University Master of Science thesis, 61 p.

Turner, Robert J., 1988, The effects of a mid-foreshore groundwater effluent zone on tidal-cycle sediment distribution: Western Washington University Master of Science thesis, 29 p.

U.S. Geological Survey Open-File Reports

Available for sale from:
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Childers, Dallas; Hammond, S. E.; Johnson, W. P., 1988, Hydrologic data for computation of sediment discharge—Toutle and North Fork Toutle Rivers near Mount St. Helens, Washington, water years 1980-84: U.S. Geological Survey Open-File Report 87-548, 117 p.

Dinehart, R. L., 1986, Sediment data for streams near Mount St. Helens, Washington—V. 2, Water years 1981-83: U.S. Geological Survey Open-File Report 85-632, 10 sheets microfiche [438 p.].

Evans, J. G.; Peterson, J. A., 1988, Geochemical studies in the Stensgar Mountain quadrangle, Stevens County, Washington: U.S. Geological Survey Open-File Report 88-267, 26 p.

Hays, W. W., editor; Kitzmiller, Carla, compiler, 1988, A review of earthquake research applications in the National Earthquake Hazards Reduction Program—1977-1987; Proceedings of Conference XLI: U.S. Geological Survey Open-File Report 88-13-A, 602 p.

Kvenvolden, K. A.; Rapp, J. B.; Hostettler, F. D., 1988, Hydrocarbon geochemistry of petroleum associated with sediment-hosted sulfides from Escanaba Trough, southern Gorda Ridge: U.S. Geological Survey Open-File Report 87-375-C, 18 p.

Lane, R. C., 1988, Selected ground-water information for the Columbia Plateau regional aquifer system, Washington and Oregon, 1982-1985; V. I, Geohydrology: U.S. Geological Survey Open-File Report 88-182, 236 p.

Lane, R. C., 1988, Selected ground-water information for the Columbia Plateau regional aquifer system, Washington and Oregon, 1982-1985; V. II, Water levels: U.S. Geological Survey Open-File Report 88-183, 136 p.

McClellan, P. H.; Snavely, P. D., Jr., 1988, Multichannel seismic-reflection profiles collected in 1980 off of the Washington and northern Oregon coast: U.S. Geological Survey Open-File Report 88-205, 4 p., 1 plate.

Prych, E. A., 1988, Flood-carrying capacities and changes in channels of the lower Puyallup, White, and Carbon Rivers in western Washington: U.S. Geological Survey Water Resources Investigations Report 87-4129, 69 p.

Rinehart, C. D.; Greene, R. C., 1988, Geologic map of the northwestern three-fourths of the Aeneas quadrangle, Okanogan and Ferry Counties, Washington: U.S. Geological Survey Open-File Report 88-281, 18 p., 1 plate.

U.S. Geological Survey Published Reports

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U.S. Geological Survey
Room 678, U.S. Court House
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Crandell, D. R., 1988, Deposits of pre-1980 pyroclastic flows and lahars from Mount St. Helens volcano, Washington: U.S. Geological Survey Professional Paper 1444, 91 p., 1 plate.

Keuler, R. L., 1988, Map showing coastal erosion, sediment supply, and longshore transport in the Port Townsend 30- by 60-minute quadrangle, Puget Sound region, Washington: U.S. Geological Survey Miscellaneous Investigations Series Map I-1198- E, 1 sheet, scale 1:100,000.

Williams, D. L.; Finn, Carol; Couch, R. W.; Danes, Z. F.; Pitts, G. S.; Phillips, W. M.; Riddihough, R. P., 1988, Residual Bouguer gravity anomaly map of the Cascade Range, California, Oregon, Washington, and British Columbia: U.S. Geological Survey Geophysical Investigations Map GP-973, 2 sheets, scale 1:500,000.

Other Reports of Interest

Cross, R. W., 1988, Preliminary intraflow structure and stratigraphy evaluation for borehole DC-24CX: Rockwell Hanford Operations, 30 p.

Deacon, R. J.; Hales, P.; Phillips, W. M.; Walsh, T. J., 1988, Geologic road log from Portland to Ocean Shores: Northwest Petroleum Association, 14 p.

Fragaszy, R. J., editor, 1988, Proceedings of the 24th symposium on engineering geology and soils engineering: Idaho Department of Transportation, 452 p.

Gordy, P. L., 1988, Evaluation of the hydrocarbon potential of the Georgia depression: British Columbia Ministry of Energy, Mines and Petroleum Resources, 1 v., 10 plates.

Northwest Petroleum Association, 1988, Symposium, program and abstracts: Northwest Petroleum Association, 1 v.

Schorn, H. E.; Wehr, W. C., 1986, *Abies milleri*, sp. nov., from the Middle Eocene Klondike Mountain Formation, Republic, Ferry County, Washington: Thomas Burke Memorial Washington State Museum Contribution in Anthropology and Natural History 1, 7 p. [*Abies*, fir]

Smith, J. A., 1987, An expert system model of Mt. St. Helens: U.S. Geological Survey, 23 p.

U.S. Bureau of Mines, 1988, Minerals yearbook 1987; Volume 1, Metals and minerals: U.S. Bureau of Mines, 1,067 p.

University of Washington Quaternary Research Center, 1988, Holocene subduction in the Pacific Northwest: University of Washington Quaternary Research Center, 21 p.

University of Washington Geophysics Program, 1986, Quarterly network report 86-B on seismicity of Washington and northern Oregon: University of Washington Geophysics Program, 25 p.

University of Washington Geophysics Program, 1988, Quarterly network report 88-A on seismicity of Washington and northern Oregon, January 1 through March 31, 1988: University of Washington Geophysics Program, 22 p.

ERRATUM:

On Sheet 2 of the Geologic Map of Washington—Southwest Quadrant (GM-34) in the "List of Named Units", the map symbol for the tuffaceous rocks of Wildcat Creek (alphabetized under Wildcat Creek) should be Φvc instead of Qvc. The unit is Oligocene in age, not Quaternary.

Officials and Scientists Discuss Earthquake Hazards

Geologists have long believed that the seismically active Northwest U.S. could produce a magnitude 7.5 earthquake with the potential for killing thousands and injuring thousands more. Now there is growing evidence to suggest that parts of Oregon, Washington, and British Columbia could be rocked by a so-called great earthquake of magnitude 9 that might cause destruction far beyond today's planning goals for government and industry emergency managers.

While there is by no means consensus supporting the theory that a magnitude 9 could occur in the region, recent scientific research points to the possible occurrence of eight great earthquakes in the Pacific Northwest in the past 5,000 years. Capable of widespread destruction, sudden submergence of coastal areas, and massive water waves (tsunamis), these great earthquakes would be similar to the devastating 1964 Alaska earthquake or the 1985 Mexico earthquake. Some scientists believe that future research will provide other explanations for this geologic evidence that is being used to infer that catastrophic earthquakes have occurred in the Northwest. Until other origins for the features are proven, a great earthquake along the coast of Oregon, Washington, and British Columbia must be considered a possibility.

In mid-April nearly 200 scientists, emergency managers, engineers, and business and community leaders attended a workshop held in Olympia and sponsored by federal and state agencies. The purpose of the meeting was to review earthquake hazards in the Puget Sound and Portland, Oregon, areas. This workshop was part of a 5-year cooperative program funded by the U.S. Geological Survey and the Federal Emergency Management Agency (FEMA) to study the dangers earthquakes pose to people living in the Pacific Northwest. In addition to discussing the likelihood of catastrophic earthquakes, those meeting also reviewed the well-established earthquake history of the area. Historic earthquakes indicate that earthquakes as large as magnitude 7.5 will continue to occur deep beneath Puget Sound and at shallow depths in the North Cascade mountains. Recent earthquake activity in southwest Washington suggests the possibility of earthquakes of magnitudes to 7 in the Southern Cascade mountains, posing hazards to both Washington and the Portland area.

While earthquakes cannot be prevented, the damage they do can be significantly reduced. Information about ways to reduce damage is available from FEMA in Bothell and from local emergency management offices. (The previous issue of this newsletter contains lists of information sources.) Information about the geology of Washington and Oregon can be obtained from the Washington Division of Geology and Earth Resources in Olympia and from the Oregon Department of Geology and Mineral Industries in Portland, respectively.

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