New Division Releases


Open File Report 89-1: Geologic and Geophysical Mapping of Washington, 1984-1988 and Theses on the Geology of Washington, 1986-1988, compiled by Connie J. Manson. The first part of this work is the cumulated update to the Division of Geology and Earth Resources Information Circular 77, "Index to geologic and geophysical mapping of Washington, 1899-1983." The second part is the cumulated update to the Division's Information Circular 80, "Theses on Washington Geology, 1901-1925." The 26-page report includes 7 plates. The price is $0.93 + .07 (tax) = $1.00.

Geologic Map GM-35: Bluelight 15-minute Quadrangle, Washington; Geologic Map GM-36: Poisal Butte 15-minute Quadrangle, Washington; Geologic Map GM-37: Logy Creek 15-minute Quadrangle, Washington, by R. D. Bentley, N. P. Campbell, and John E. Powell. Each of the three maps has a brief description of geologic units, a diagram of map unit correlation, a cross section, a table of major element geochemical analyses, and a three-color map at 1:48,000 on one sheet. The price is $1.85 + .15 (tax) = $2.00 each.

Geologic Map GM-38: Map of the Saddle Mountains, Washington, by S. P. Reidel. This publication consists of three 3-color maps at 1:48,000, cross sections, and isopach maps of selected Columbia River basalt flows. The plates are accompanied by a 28-page text that includes results of geochemical analyses. The price is $6.03 + .47 (tax) = $6.50.
National Geologic Hazards Program Update

By Raymond Lasansky and Timothy Walsh

During November 1988, the authors of this article attended two meetings sponsored by the U.S. Geological Survey (USGS) and other agencies to review federal and regional geologic hazards programs aimed at reducing losses from geologic hazards. Lasansky participated in the workshop on "Applications of Knowledge Produced in the National Earthquake Hazards Reduction Program: 1977-1987." Walsh attended the "Geohazards 88" symposium.

A panel format was used to review the first decade (1977-1987) of the National Earthquake Hazards Reduction Program (NEHRP). The sponsors were the USGS, the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards, and the National Science Foundation (NSF).

A draft report, augmented with presentations by noted authorities formed the core of the workshop. The following topics were discussed by the panels:

- Update on research application activity throughout the nation.
- Policies and practices of the four principal agencies in NEHRP.
- Improving the collaboration of knowledge producers and knowledge users.
- Background on earthquake insurance.
- Strengthening links in the research applications process of NEHRP.
- Priorities, given a level budget

(Continued on page 32)

Staff Notes

Robert L. "Josh" Logue was promoted January 3 from Geologist 2 to Geologist 3 in the Environmental Geology section. In his new position, Josh will be the lead geologist for Quaternary geology studies in the state geologic map program. He also will head up efforts at slope stability studies in the Puget Sound area.

Stephen P. Palmer was hired February 13 to conduct studies of earthquake hazards in the Puget Sound area. His appointment is made possible by a grant from the National Earthquake Hazards Reduction Program (NEHRP). His duties will focus on the behavior of sediments during earthquake shaking.

Steve earned a B.S. in Geology, and an M.S. and Ph.D. in Engineering Science, all from the University of California, Berkeley. He has worked for Gulf Oil Company, Schlumberger Well Services and Westinghouse Hanford Company. Most recently, he has completed field Bill Lingley's an assessment of the petroleum potential of the Washington outer continental shelf for the Washington Sea Grant Program.

This volcanic pipe in Ferry County is locally known as Corkscrew Mountain. Its peculiar twisted structure gives rise to its name—it looks like a corkscrew.
Status of Radon Efforts in Washington: December 1988

More than 19,000 homes have been tested so far by individual Washington homeowners and public agencies. Testing statewide is broken down something like this:

- In 3 percent of the homes, values of more than 4 picocuries/liter (pCi/L) of air were recorded.
- Test results average less than 1 pCi/L.
- The highest test result was 201 pCi/L.

Testing in Spokane County:

- In 50 percent of the homes tested, values of more than 4 pCi/L were recorded.
- Test results average 8 pCi/L.
- The highest test result was 92 pCi/L.

The federal government has recorded a guideline of 4 pCi/L (annual average measurement) for homes.

The Task Force has started a public information campaign. The radon sperm bureau is in great demand. The Office of Radiation Protection of the Department of Social and Health Services has available radon test kits (call 1-800-323-9727). [Source: Washington State Radon Task Force, December 21, 1988]

Geology of Industrial Minerals Forum Booked for Portland

The Forum on the Geology of Industrial Minerals, an annual gathering at different sites throughout the United States, will be held in the Northwest for the first time. The 25th Forum is scheduled for the Portland Center Red Lion Inn April 30 through May 2, 1989.

Topics to be addressed during the day and a half of paper presentations will include Oregon peridot, emery, talc, limestone, and bentonite; Washington olivine; Idaho garnet and perlite; Northwest diatomite, zeolite, and pozolana; playa resources; and state and provincial summaries, including Oregon, Washington, Idaho, Montana, and British Columbia.

Following the sessions in Portland, a three-day field trip by bus has been planned to showcase the industrial resources of Oregon. Overnight stops are planned at Baker, Ontario, and Bend.

Additional information on the Forum may be obtained from Ron Geitgey, Oregon Department of Geology and Mineral Industries, 910 State Office Building, 1400 S.W. 5th Ave., Portland, OR 97201, phone (503) 229-9580.

WASHINGTON'S MINERAL INDUSTRY - 1988

By Nancy L. Joseph

INTRODUCTION

According to information obtained by the Division of Geology and Earth Resources, three precious metal and one base metal mine were in operation in Washington in 1988. Seventeen companies mined and produced industrial minerals, which included limestone, dolomite, silica, olivine, clay, and diatomite (Table 1). Two companies produced Portland cement, and 10 plants produced lime, calcium chloride, precipitated calcium carbonate, or ground limestone.

Recent information indicates that nonsulfide mineral production in Washington in 1988 was valued at more than $400 million. The production of magnesium metal from dolomite, precious metal mining, and sand and gravel quarrying accounted for the bulk of this figure. The production of Portland cement decreased significantly in 1988 due in part to the closure of the Columbia Northwest Cement Corp. plant in Whatcom County.

Precious metals, which now account for one-quarter of the total value of mineral production, are becoming increasingly important to Washington's mineral industry. The high levels of production from the Canyon mine and the Republic Unit, coupled with projected production at two new mines in 1990 and the increased precious metal exploration in the state should lead to significant increases in precious metal production in the future.

Total revenue from prospecting, mining, and quarrying, including sand and gravel production, on state lands was $399,695 for the fiscal year ending June 30, 1988. This figure includes payments on approximately 300 mineral leases and contracts. Revenues from prospecting increased, while revenues from sand and gravel operations decreased approximately 16 percent. (The sand and gravel industry is not discussed in this article.)

Information in this report is summarized from questionnaires and information provided by the companies. Questionnaires were sent by the Division to companies and individuals active in mineral exploration and development in the state, as well as from published information. The questionnaire is limited in scope, and, therefore, details of activities on individual properties are not always available. All questionnaires were returned, and some information requested, particularly regarding expenditures and production, is deemed confidential by many of those questioned and is not reported.

Therefore, while this summary is a reliable indication of the mineral activity in Washington, it is incomplete and general in nature.

The locations of properties mentioned in this article are shown in Figures 1a and 1b, which cover western and eastern Washington, respectively.

METALS

Development

Gold and silver, with a combined value of more than $50 million, were produced in 1988 from the three active precious metal mines in Washington in 1988. Record amounts of more than 225,000 ounces of gold and more than 540,000 ounces of silver were produced from mines in Chelan County and Ferry County (Fig. 2, Table 2). This represents a modest increase in gold production and approximately 50 percent increase in silver production over the 1987 figures.

Lead and zinc were mined at one mine in Stevens County. This low-tonnage operation was the sole base metal producer reporting to the Division in 1988.

Chelan County

The Canyon mine, a joint venture between Asasena Minerals (U.S.) Inc. and Breakwater Resources Ltd., is the largest gold mine in the state and the second largest underground gold mine in the country. In 1988, 45,665 ounces of gold and approximately 250,000 ounces of silver with an average gold grade of 0.31 oz/ton was produced from the mine in 1988. The increase in gold production over the 1987 record was attributed to increased head grades and higher productivity.

Asasena Inc., which owned 92 percent of the stock in Asasena Minerals Inc., was bought out by Gulf Canada Resources Ltd. in April 1988. The new owners of the company, who reportedly acquired Asasena to obtain their overseas properties, have decided to put their interest in Asasena Minerals up for sale (Northern Miner, December 19, 1988).

Reserves at the Canyon mine at the end of 1987 were 4.5 million tons grading 0.26 oz/ton gold (Breakwater Resources Ltd., annual report, 1987). Underground exploration, drilling, and development continue at the mine. Drilling has delineated an ad-

Meetings

Pacific Northwest Chapter,
Friends of Mineralogy

Annual spring symposium, "Minerals of the Inland Northwest"
May 26-28, 1989
Holiday Inn
Coeur d'Alene, Idaho

Darro Slurman, associate curator of the Royal Ontario Museum, will be the principal speaker. This topic will be minerals of the Yukon Territory and the Yukon iron deposit. Other speakers will include Joe Nagel, curator of the University of British Columbia Geology Museum, and Mel Dyck of Laramie, WY.
For further information, write:
Lanny Beattie
Mineral News
P. O. Box 2043
Coeur d'Alene, Idaho 83814

1989 Workshop on Earthquake Hazards in the Puget Sound/Portland area

March 28-29, 1989
Portland Marriott
Portland, OR

Sponsored by the Oregon Department of Geology and Industries, the Oregon Department of Emergency Management, the Washington Department of Natural Resources, the Washington Department of Community Development, the Federal Emergency Management Agency, and the U.S. Geological Survey.

For additional information, contact:
Timothy Walsh (206) 459-6372
Ian Madin (503) 229-5580
Linda Noon (206) 481-4694

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WASHINGTON STATE AGENCY REPORTS


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October, 1988 though January, 1989

THESIS


U.S. GEOLOGICAL SURVEY

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Figure 1b: Location of selected mines (metallic and industrial minerals) and prospects in eastern Washington. Location numbers are keyed to Table 1.
Table 1. Mineral exploration and development in Washington, 1988. Locations given where available. See Figures 1a and 1b for property locations.

<table>
<thead>
<tr>
<th>Owner/Operator</th>
<th>Property</th>
<th>Location</th>
<th>Commodity Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altheim Placers, Inc.</td>
<td>Leased property to Asamena Minerals</td>
<td>Wenatchee Heights</td>
<td>Au,Ag</td>
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<td>Asamena Minerals Inc.</td>
<td>U.S. Inc. Exploration/ Breakwater Resources Ltd.</td>
<td>Beaverhead Co</td>
<td>Au,Ag Surface drilling</td>
</tr>
<tr>
<td>Asamena Minerals Inc.</td>
<td>Cannon mine</td>
<td>T.22N., R.20E.</td>
<td>Au,Ag Mining, surface drilling, exploration and drilling</td>
</tr>
<tr>
<td>Montes de Oro Inc.</td>
<td>Au Mine development</td>
<td>secs. 1-3</td>
<td>Au</td>
</tr>
<tr>
<td>Raven Hill</td>
<td>Au Geologic exploration, bulk sampling</td>
<td>secs. 21</td>
<td>T.29N., R.18E.</td>
</tr>
<tr>
<td>Sunshine Valley Minerals Inc.</td>
<td>Au Exploration, processing, tailings</td>
<td>secs. 4</td>
<td>T.30N., R.17E.</td>
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<tr>
<td>Welcome Nugget Mines</td>
<td>Au Dredging</td>
<td>upper Wenatchee River</td>
<td></td>
</tr>
<tr>
<td>Welcome Nugget Mines</td>
<td>Au Dry test pits</td>
<td>secs. 30</td>
<td>T.28N., R.18E.</td>
</tr>
<tr>
<td>Ideal Basic Inc.</td>
<td>Au Clay mining</td>
<td>secs. 22-23</td>
<td>T.31N., R.18W.</td>
</tr>
<tr>
<td>Asamena Inc.</td>
<td>Au Drilling, geological, geophysical exploration</td>
<td>secs. 10</td>
<td>T.39N., R.32E.</td>
</tr>
<tr>
<td>Chengold, Inc.</td>
<td>Au Reclaiming, leasehold site</td>
<td>secs. 27-28</td>
<td>T.37N., R.32E.</td>
</tr>
<tr>
<td>Crown Resources Corp.</td>
<td>Drilling</td>
<td>South Penn</td>
<td>T.36N., R.32E.</td>
</tr>
<tr>
<td>Crown Resources Corp.</td>
<td>Drilling</td>
<td>Queen Elizabeth</td>
<td>T.38N., R.32E.</td>
</tr>
<tr>
<td>Crown Resources Corp.</td>
<td>Exploration, mining, surface drilling</td>
<td>Seattle mine</td>
<td>T.37N., R.32E.</td>
</tr>
<tr>
<td>Crown Resources Corp.</td>
<td>Exploration drilling</td>
<td>secs. 33-34</td>
<td>T.37N., R.32E.</td>
</tr>
</tbody>
</table>

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into account the completeness of cleanup and the costs of defending actions.

The program must provide for the schedule adjustments needed to deal with unforeseen events or problems. USDOE must work with federal and regulatory agencies to prepare and implement detailed work plans. These plans must be consistent with national priorities and deadlines. USDOE should have the flexibility to adjust schedules and reallocate resources, so long as such action will not extend cleanup work beyond the deadline. USDOE should keep Congress fully apprised of its progress and any major changes in work schedules and plans.

B. Funding

The program must be able to assure adequate and long-term funding for waste cleanup and disposal. An effective cleanup program will require a Congressional commitment to substantially increase funding levels for cleanup. A trust fund to finance cleanup and disposal work should be considered. Direct appropriations to the fund should be sufficient to ensure the cleanup of existing wastes by the deadlines set by Congress. The proper handling, storage, and disposal of wastes generated in the future should be on a "pay-as-you-go" basis. Agencies responsible for the wastes should be required to make annual payments to the trust fund. Payments to the fund must be sufficient to cover USDOE cleanup costs. The payments must also cover costs incurred by the U.S. Environmental Protection Agency (EPA) and the affected states and Indian tribes. The distribution of trust funds must be based on national cleanup priorities and on work schedules for completing cleanup activities by the established deadlines.

C. Compliance with Federal, State Regulations

For over 40 years, waste handling, storage and disposal has been largely exempt from any independent oversight. In a number of instances, poor waste management and disposal practices have knowingly been tolerated. These practices have contributed significantly to the waste cleanup and contamination problems. USDOE has acknowledged these past practices. It has stated that it will comply with state and federal regulations in the future. But, the situation remains uncertain.

The federal government has attempted to block the application and enforcement of state Resource Conservation and Recovery Act (RCRA) programs at Colorado's Rocky Mountain Arsenal and USDOE facilities. These actions make state regulatory authority questionable. USDOE also continues to challenge EPA's authority to enforce federal regulations and standards. These challenges raise grave doubt that the federal government will effectively regulate itself.

The program must set up a clear regulatory framework for the cleanup. State and federal regulatory programs are key to an effective and credible cleanup process. These regulatory programs provide the independent authority needed to ensure that waste problems are fully evaluated and that corrective actions are both timely and appropriate.

The program must direct that all cleanup and disposal work strictly comply with applicable federal and state laws and regulations. EPA must have the clear authority to issue orders and enforce compliance with approved cleanup plans and schedules.

The role of state regulators must also be reaffirmed. This is especially true where a state has authority to implement federal laws such as RCRA. The implementation of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) at USDOE facilities should not supplant or reduce the implementation of RCRA for active hazardous and mixed waste sites. Likewise, the program must uphold a state's delegation of authority to implement and enforce other federal environmental regulations.

Finally, state and federal regulatory programs are critical parts of the cleanup process. The program must ensure that both EPA and the states have adequate funding for regulatory functions.

D. Public Confidence

The magnitude, history and nature of the nuclear weapons waste problem make public confidence and acceptance crucial to cleanup success. The public must be fully aware of the problem. People must be convinced that cleanup solutions will ensure a safe and healthy environment.

To win public confidence, the decision-making and review processes must be open to the public. The public must have the opportunity to understand the issues. They must have the chance to influence decisions relating to cleanup, transportation and disposal of wastes. In short, affected states and Indian tribes should play a key role in public involvement and education programs. The cleanup program must provide for fund and state and tribal activities such as:

1. Technical review of cleanup plans and methods
2. Transportation and emergency response
3. Environmental monitoring of waste sites and cleanup activities
4. Public information and involvement programs.

E. Development of Cleanup Technology

The density of environmental constraints coupled with the variety of waste forms, types and volumes found at USDOE sites present formidable challenges to an effective cleanup program. We need to ensure the safety, most thorough and cost efficient cleanup and disposal effort possible. We must not limit our options solely to technology currently available. The program must provide for the continuing research and development of advanced cleanup and disposal technologies.

IV. Conclusion

For decades, radioactive and hazardous chemical wastes have been allowed to accumulate at USDOE defense facilities across the nation, including Washington's Hanford Reservation. Today, as the result of increasing past disposal practices and failing temporary storage facilities, these wastes pose a serious threat to the public safety and the environment.

While USDOE has begun to acknowledge and correct the problems caused by the wastes, the future is uncertain.

The cleanup and disposal of wastes will cost billions of dollars and require decades to complete. Yet, no firm schedule exists and funding lags far behind requirements for an effective cleanup effort.

If we are to provide a safe and healthy environment for the citizens of the Northwest and the nation, decisive action is essential. It is time for the federal government to fulfill its obligation to ensure the safe and permanent disposal of these wastes. I urge Congress to act quickly in establishing an effective and credible cleanup program for USDOE facilities.

$2.9 billion between now and mid-1991 to clean up Hanford waste. Future funding must be appropriated by Congress.
Defense Waste Cleanup: A Proposal for a National Solution

Governor Booth Gardner and Governor Neil Goldschmidt
State of Washington
State of Oregon
November 30, 1988

I. Introduction

Over the past 45 years, the United States has developed, produced, and tested nuclear weapons at sites in thirteen states. During this period, massive quantities of radioactive and hazardous wastes have been allowed to accumulate at these sites, including Washington's Hanford Reservation. Some past disposal practices were inadequate. Aging 'temporary' storage facilities have failed. As a result, these wastes threaten the environment and the public health and safety.

As the Governors of Oregon and Washington, we have pledged forces to save our heritage. We are pursuing the retrieval, safe cleanup and permanent disposal of Hanford's radioactive and chemical wastes. Our goal is to achieve cleanup within a time frame.

The defense waste problem is more than an important Northern problem. It is a national problem. It involves U.S. Department of Energy (USDOE) defense facilities in twelve other states. We strongly believe that the long-term answer to Hanford's problems ultimately lies in a national effort to clean up all USDOE defense facilities.

Accordingly, we are calling for prompt and decisive action by Congress to enact legislation which will create an effective, long-term cleanup program. It must cover the cleanup and permanent disposal of radioactive and chemical wastes at Hanford and other USDOE defense facilities.

II. The Need for a National Cleanup Program

Recent reports by USDOE and the General Accounting Office (GAO) document serious waste and contamination problems at virtually every USDOE defense facility. Cases of serious soil and groundwater contamination are common. In some cases, groundwater contamination is thousands of times above federal clean-up standards. At two installations, soil contamination levels exceed 1000 times the levels that of background levels have been reported. Further, the full extent of contamination at some USDOE facilities remains unknown. New problems continue to come to light today.

In July 1988, USDOE told Congress that defense waste cleanup cost as much as $110 billion over the next 50 years. The GAO feels the total cost may be as high as $130 billion. Despite these cost estimates, only about $797 million was appropriated in FY 1989. And, the major portion of these funds is for continued management of waste in temporary storage—and not for cleanup and permanent disposal.

USDOE has made progress in starting cleanup at a number of facilities, including Hanford. But, it remains uncertain whether this work will be completed before serious and permanent harm is done. There is no firm federal commitment to the cleanup. Schedules have slipped repeatedly. USDOE has no milestones or deadlines for completing cleanup work. Funding is far less than needed. Application and enforcement of federal and state laws and regulations are uncertain. The role of affected states and tribes is not clear. Public confidence in the ability to handle these wastes safely has seriously eroded.

The longer cleanup is delayed, the more costly and dangerous it will be. Hundreds of millions of dollars will continue to be spent on temporary storage. Aging storage facilities will continue to fail. Waste forms now stable may not remain so. New waste will continue to spill through the environment, contaminating more soil and water.

The time has come for the federal government to solve the waste problem at Hanford and the other USDOE sites. It is time for a firm and substantive federal commitment. These wastes have been produced as part of the nation's defense programs. Their cleanup and disposal are a national obligation.

The magnitude of waste cleanup and disposal problems dictates the need for a national effort to clean up all USDOE sites. A credible cleanup program must ensure that radioactive and chemical wastes are kept away from people for as long as the wastes are dangerous. The program must include:

1. A detailed schedule;
2. Sufficient funding;
3. An effective regulatory structure;
4. The means to build and maintain public confidence; and
5. The development of advanced technologies to ensure safe, thorough and cost effective waste cleanup and disposal.

III. Key Elements of a National Program

Congress must take action now to ensure the safe and expeditious cleanup of radioactive hazardous and mixed wastes at all USDOE facilities. The program must address these points:

A. Schedule for Cleanup

The program must include a firm commitment to complete the cleanup and dispose of waste within a reasonable and specific period of time. At Hanford, USDOE proposed the cleanup of radioactive wastes at Hanford, the Savannah River Site and the Idaho National Engineering Laboratory within 30 years. Now USDOE hints it will take 50 to 60 years to complete the cleanup.

Without a firm schedule, there is no assurance that the cleanup work will be completed in a timely manner—if at all. Without a schedule, there is no means by which to set priorities, measure performance, determine funding needs or allocate resources.

The program must set milestones and deadlines to complete the cleanup. Federal environmental laws provide a precedent for setting a compliance deadline. We feel that a commitment to clean up all USDOE facilities within 30 years is both essential and achievable.

B. Funding

The program must also include a national priority system. That system must ensure that the waste that poses the greatest public and environmental risks are handled first. It must ensure the prompt identification of immediate threats. It must also ensure the cleanup and disposal of any other wastes before the public is put at risk. The system must consider people at risk, environmental factors, and the nature and volumes of wastes. It must also take

An agreement between the federal government and the State of Washington signed 2/27/89 states that Washington will receive

Table 1. Mineral exploration and development in Washington, 1988, continued.

<table>
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<th>Loc.</th>
<th>County</th>
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<th>Property</th>
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<td>Ferry</td>
<td>Cyrus Minerals Co.</td>
<td>Lane Ranch Creek/3D claims</td>
<td>secs. 11-12, T.48N., R.35E.</td>
<td>Exploration, drilling</td>
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<td>15</td>
<td>Ferry</td>
<td>W. A. Dengerstrom, etc./Inland Gold and Silver Corp./ Pegasi Gold Corp.</td>
<td>Leland Property</td>
<td>T.37N., R.33E.</td>
<td>Exploration, drilling</td>
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<td>Ferry</td>
<td>Echo Bay Mines Ltd./Crowne Resource Corp./ Gold Texas Resources Ltd.</td>
<td>Kettle</td>
<td>sec. 19, T.36N., R.33E.</td>
<td>Drilling, underground drilling; announced production plans</td>
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<td>Ferry</td>
<td>Echo Bay Mines Ltd./Crowne Resource Corp./ Gold Texas Resources Ltd.</td>
<td>Overlook, key</td>
<td>sec. 18, T.37N., R.34E.</td>
<td>Drilling, CIS completed; announced plans to put into production</td>
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<td>Ferry</td>
<td>Hecla Mining Co.</td>
<td>Republic Unit, Golden Promise, Golden Eagle area</td>
<td>T.31N., R.32E.</td>
<td>Mining, surface and underground drilling</td>
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<td>Morning Star Mines, Inc.</td>
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<td>Rehabilitation of mine</td>
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<td>Ferry</td>
<td>Newmont Exploration Ltd.</td>
<td>RNC claims</td>
<td>secs. 29-30, T.36N., R.34E.; west of Garfield</td>
<td>Exploration, claim staking</td>
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<td>Ferry</td>
<td>Tanqueray Mines</td>
<td>Kal-ley mine</td>
<td>sec. 3, T.31N., R.33E.</td>
<td>Surface drilling, underground development and sampling</td>
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<td>Lone Star</td>
<td>sec. 2, T.42N., R.35E.</td>
<td>Surface core drilling</td>
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<td>United States Borax &amp; Chemical Corp.</td>
<td>Wheaton Ranch</td>
<td>sec. 3, T.39N., R.32E.</td>
<td>Drilled two core holes</td>
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<td>Empire Creek</td>
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<td>26</td>
<td>United States Borax Leader Chemical Corp./Vulcan Mountain, Inc./Sundance Mining and Development Corp.</td>
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<td>Au,Ag,Cu</td>
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<td>Working heap; property optioned to U.S. Borax</td>
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<td>Republic district</td>
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<td>Reconnaissance</td>
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<td>Au</td>
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</table>

4. Structure of the Yakima Fold Belt, Central Washington: Stephen Reidel and Newell P. Campbell, Leaders
5. Cambrian of Northern Idaho and Northwestern Montana: John Buhl, Leader
6. Geology, Alteration, and Mineralogy of the Alkaline Geos Stock, Northern Idaho: D. Kate Schick, Leader
7. The Moenoc Clarkia Fossil Beds of Northern Idaho: Jack Smiley, Leader
8. Transect through the Baker-Walla Walla-Spokane Terrane: A Forearc to Island Arc Transition in Northeastern Oregon? M. Alan Kays and Ellen M. Bishop, Leaders

Concurrent with Meeting
9. The Northern Columbia Plateau from the Air: Dale F. Straul and Eugene F. River, Leaders
10. Geologic Factors Influencing Residential Radon: Raymond Tolerance and Jan E. Fish, Leaders

Post-Meeting
12. The Deer Trail Group: Is It of the Belt Super-group?: Fred C. Miller and James W. Whipple, Leaders
15. Elements of the Cascades 'Collisional' Orogen: A Transect from the Methow Basin to the San Juan Islands, Washington: Michael F. McGregor, Robert B. Miller, Mark T. Brandt, and Ralph Haugen, Presiding
17. Sources for the Columbia River Basalt Group: Peter R. Hooper and Stephen Retall, Leaders
18. Lake Missoula Floods and Channeled Scablands Part I: Evidence for the Late Wisconsin Ice Dam and Floods in the Purcell Trench: Roy M. Breckenridge, Leader

EXHIBITS
Exhibits will be displayed in the main hall of the Convention Center, adjacent to the poster sessions and meeting rooms. The cost of booths will be $100 for educational and non-profit institutions and $250 for commercial exhibitors.

SPECIAL EVENTS
Don't miss Bloomberg, the largest timed road race in America, with more than 59,000 participants! The 12-kilometer (7.46-mile) race starts at 9 a.m. on Sunday, May 7. All official participants who cross the finish line are awarded T-shirts, and special prizes will be awarded to runners from 5K, 10K, and 15K categories.

A dinner/dance/scenic cruise on beautiful Lake Coeur d'Alene in northern Idaho is planned for Tuesday night. May 9. Bus transportation will be provided.

INFORMATION
For registration information, contact Margie Wallace, Conference Coordinator, Regional University Conference, M.S. 11, Eastern Washington University, Cheney, WA 99004, (509) 359-2406.

For program information, contact John P. Buchanan, Program Chair, Department of Geology, M.S. 70, Eastern Washington University, Cheney, WA 99004, (509) 359-7493.

For exhibit information, contact Russell Boge, Exhibits Coordinator, Department of Geology, M.S. 70, Eastern Washington University, Cheney, WA 99004, (509) 359-7497.
Geological Society of America Sectional Meetings

The Cordilleran and Rocky Mountain Sections of the Geological Society of America will hold their annual meetings from May 8 to 11, 1989, in conjunction with the Rocky Mountain and Pacific Sections of the Paleontological Society, the Pacific Northwest Section of the National Association of Geology Teachers, and the Association for Women Geoscientists. The meetings, scheduled for the Spokane, Washington, Convention Center, are cosponsored by the Department of Geology of Eastern Washington University and the Department of Geology and Geographical Engineering, University of Idaho. The meeting is also hosted by the Spokane office of the Geologic Division, U.S. Geological Survey; the Western Field Operations Center, U.S. Bureau of Mines; the Northwest Mining Association; the Division of Geology and Earth Resources, Washington Department of Natural Resources; and the Idaho Geological Survey.

PROGRAM

Nearly 650 papers covering a wide spectrum of the geology of western North America will be presented in symposia, technical sessions, and poster sessions. Twenty-five field trips will be led into the diverse geologic landscape of the Northern Rocky Mountains, Okanogan Highlands, Blue Mountains, Cascade Mountains, Columbia Basin, and Snake River Plain.

Symposia
1. Geophysical Framework of the Cordillera: Christopher J. Potter and Walter D. Mooney, Presiding
2. Evolution of the Proterozoic Rocks of the Northern Cordillera: Part I: Sedimentation and Tectonics; James W. Whipple, Presiding; Part II: Economic Geology; John C. Bally, Presiding
3. Synoptic Paleozoic Biogeography of Selected Tectonic Fragments, Western North America; J. Thomas Dubois, Jr., Presiding
4. Upper Paleozoic Biostatigraphic and Stratigraphic Relations of the Northern Rocky Mountains; Bruce R. Wardlaw and Ernest H. Gilmore, Presiding
5. Upper Paleozoic Orogenies of Western North America; Linda B. McColm and Nancy L. Joseph, Presiding
6. Late Paleozoic and Early Mesozoic Paleogeographic Relations: Klamath Mountains, Sierra Nevada, and Related Rocks; M. Meghan Miller and David S. Harwood, Presiding
7. Western Edge of the North American Continent: Mesozoic Tectonic Evolution; Karen Lund and Mel A. Kusse, Presiding

Table 1. Mineral exploration and development in Washington, 1988, continued.

<table>
<thead>
<tr>
<th>Loc.</th>
<th>County</th>
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<td>Red Limestone</td>
<td>sec. 35</td>
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<td>Smith Canyon</td>
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<td>Sunshine Valley Minerals, Inc.</td>
<td>Billy Goat claims</td>
<td>sec. 15</td>
<td>AuCu</td>
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<th>Loc. no.</th>
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</table>

**Table 1. Mineral exploration and development in Washington, 1988, continued.**

The Northwest Mining Association, generally headed by an operator or an explorationist, has gone to a consultant as its new president. T. M. Li of Denver took over January 1. Li, vice president and general manager for B ore Doebear-Riverside, Inc., considered one of the top consulting mining engineers in the U.S., took over from Bill Booth of Hecla Mining Company of Coeur d'Alene, Idaho. Mark Anderson, general manager of ASAMER of Washtahoe, was elected vice president of the Spokane-based organization of 2,200 members from the mining industry throughout North America. Other new officers are David A. Holmes, exploration manager for Meridian Minerals Co. in Englewood, Colo., second vice president, and David M. Menard, vice president of Washington Trust Bank in Spokane, treasurer. John L. Niell, a Spokane attorney, was re-elected secretary. Bill Mote of Spokane, the association's executive director, is a standing vice president.

**Denver Consultant Elected in NW Mining Change**

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![Temperature-depth curve for 1988 geothermal gradient test holes.](image)

Drilling operations at the Quartz Creek (DNR 88.7) site, one of eight geothermal gradient test holes drilled by the Division in 1988.

**Table 1. Mineral exploration and development in Washington, 1988.**

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<td>secs. 12-13, T.30N., R.41E.</td>
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<td>77</td>
<td></td>
<td>Stevens</td>
<td>Western Land and Resources</td>
<td>McNally-Freedom claims</td>
<td>T.40N., R.37E.</td>
<td>Au, Ag</td>
</tr>
<tr>
<td>78</td>
<td></td>
<td>Stevens</td>
<td>Bose Cascade Corp.</td>
<td>Corporate lands</td>
<td>T.40N., R.37E.</td>
<td>Au, Ag</td>
</tr>
<tr>
<td>79</td>
<td></td>
<td>Stevens</td>
<td>Meridian Minerals Co.</td>
<td>T.40N., R.37E.</td>
<td></td>
<td>Limestone Exploration</td>
</tr>
<tr>
<td>80</td>
<td></td>
<td>Stevens</td>
<td>United States Borax &amp; Chemical Corp.</td>
<td>T.40N., R.37E.</td>
<td></td>
<td>Au</td>
</tr>
<tr>
<td>81</td>
<td></td>
<td>Stevens</td>
<td>Union Pacific Resources Co.</td>
<td>T.40N., R.37E.</td>
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**Final Interior Rules Making Increases Mining Law Fees in 1989**

The Bureau of Land Management (BLM) has issued final rules that would facilitate greater cost recovery under its mining law administration program by revising certain existing fees and establishing new fees. The rules became effective Jan. 1, 1989.

According to BLM Director Robert F. Burford, the fee changes are being implemented under Title V of the Independent Offices Appropriation Act of 1952. Title V provides that federal agencies should recover costs of program administration for services that provide special benefits to identifiable nonfederal recipients above and beyond those accruing to the public at large.

"In Fiscal Year 1987, we recorded more than $171,000 in new mining claims and processed about 650,000 filings of affidavits for assessment work," Burford said. "We also recorded and processed many other mining claim-related documents. This rulemaking allows us to recover more of the costs of administering this program."

In Oregon and Washington, there were 11,700 new mining claims recorded in FY 1987. More than 32,300 affidavits were filed for assessment work.

Burford indicated that the increased fees would generate nearly $45 million in additional annual revenues that, when combined with current revenues from existing fees, would raise available approximately $5.2 million to be appropriated to BLM for the mining law program.

Burford emphasized that BLM has been sensitive to the impact this rulemaking might have on the min-

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Table 1. Mineral exploration and development in Washington, 1988, continued.

<table>
<thead>
<tr>
<th>Loc. No.</th>
<th>County</th>
<th>Owner/Operator</th>
<th>Property</th>
<th>Location</th>
<th>Commodity</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>80</td>
<td>Whatcom</td>
<td>Seattle-St. Louis Mining Co.</td>
<td>Minnesota mine</td>
<td>sec. 2,</td>
<td>Au, Ag</td>
<td>Exploration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>73N., R.16E.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>81</td>
<td>Whatcom</td>
<td>Steelhead Resources Ltd.</td>
<td>Excelsior mine</td>
<td>sec. 5-6</td>
<td>Au, Ag</td>
<td>Announced reserves</td>
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<td>73N., R.11E.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>Whatcom</td>
<td>Western Gold Mining, Inc.</td>
<td>New Light mine</td>
<td>sec. 27,</td>
<td>Au, Ag</td>
<td>Surface and underground sampling</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>73N., R.17E.</td>
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<td></td>
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<td>Coke Mines Inc.</td>
<td></td>
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<td>metals</td>
<td>Property exams</td>
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<td>American Copper and Nickel Co.</td>
<td></td>
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<td></td>
<td></td>
<td>W. O. Regan and Assoc.</td>
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<tr>
<td></td>
<td></td>
<td>Newman Exploration, Ltd.</td>
<td></td>
<td></td>
<td>metals</td>
<td>Exploration</td>
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<td></td>
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<td>Norante Exploration, Inc.</td>
<td></td>
<td></td>
<td>Au</td>
<td>Reconnaissance</td>
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<td>Pegasus Gold Corp.</td>
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<td></td>
<td>Au</td>
<td>Property evaluation</td>
</tr>
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<td></td>
<td></td>
<td>Phelps Dodge Corp.</td>
<td></td>
<td></td>
<td></td>
<td>Exploration</td>
</tr>
</tbody>
</table>

Differential 250,000 tons of reserves with an average grade of 0.335 oz/t gold in the B-north zone, below the 200-foot level, and 75,000 tons of reserves averaging 0.310 oz/t gold from an extension of the zone to the west. Exploration drilling in the B-4 zone has indicated anomalous mineralization to both the east and the west (Asamena Minerals, Inc., second quarter report, 1988).

Mining methods employed at the underground trackless mine include mining by sublevel blast hole stoping, with backfilling of each sublevel as soon as the ore is removed. A 15 foot x 15 foot decline from the surface at a 15 percent slope provides access to the mine, ore is hauled in two skips in an 18-foot-diameter vertical shaft (Angal, 1988). The mine employs 205 people; their "operating cost is $172 per ounce of gold.

Ferry County

Hecla Mining Co. continued high levels of production at the Republic Unit in Republic. The company produced 80,000 ounces of gold and nearly 290,000 ounces of silver from the Golden Promise veins, with an average gold grade of 0.96 oz/ton. Production was 14 percent more than in 1987. The underground mine produces gold for $135 per ounce (including all costs), which makes it one of the lowest cost gold producers in the nation.

During the first quarter of 1988 the company announced that the Golden Promise area contained 1.2 million tons of reserves and mineralized rock averaging 0.5 oz/ton gold. These reserves should extend the life of the mine for at least 7 years. The company has continued the exploration drilling program in the mine to further increase reserves.

Seven veins have been discovered in the Golden Promise area where production began in 1986. The northeast-striking, southeast-dipping banded chalcedony epithermal veins are in the Eocene Sanpoil Volcanics near the contact with the Rattlesnake Mountain Formation. The veins are a few feet to 20 feet thick and have a vertical range of at least 800 feet. Gold occurs as electrum, native gold, sulsfoalts, and...
tate, which leases the Glacier coal field from the land owner, the Glacier Land Co. Representatives of the Flitchauf estate have elected to keep details of the past summer's exploratory drilling proprietary at this time.

References Cited

Geologic Hazards Program—Continued

It was the consensus of the participants that during the next decade the NEHRP effort should shift resources from pure research to applied research, data translation, and application of knowledge by state and local governments. It was also recommended that an oversight commission be established to advise the four federal agencies that are responsible for carrying out NEHRP under the auspices of the Earthquake Hazards Reduction Act. A more effective hazards reduction program should result. The report will be released by the USGS as Open-File Report 88-13B.

A portion of the NEHRP review workshop was devoted to receiving information about the International Decade for Natural Hazard Reduction. The initial proposal at the United Nations was sponsored by 94 countries. As it was not supported by the U.S., the proposal failed. A substitute U.S. program under the auspices of UNESCO was adopted, its committee consisting of 24 nations, each having one representative and the U.S. having two members. The committee met in Geneva, Switzerland, in July, then in New York during the final meetings during January and March 1989 will be held in Morocco and Japan, respectively. The first U.S. meeting of the corresponding U.S. Decade for Natural Disaster Reduction took place in mid-October. It was agreed that the program decade would start January 1, 1990, that the national effort would be headed by a U.S. committee with an academic chairperson; and that the National Academy of Sciences (NAS) would act in an advisory capacity and direct the new administration team. It is expected that the NEHRP advisory committee will be a federal secretariat with representation from USGS, National Oceanic and Atmospheric Administration and the U.S. Forest Service. Funding will be provided by the USGS and NAS.

A consortium of state and local governments, academic institutions, professional associations, and others will implement the program objectives. Rapid onset hazards highlighted for study and information transfer are earthquakes, volcanic eruptions, tsunamis, landslides, wind storms, and wildfires; also to be considered is drought. Several national demonstration projects have been suggested, including one for the Pacific Northwest. More is to come on this subject during 1989 as concepts are formalized by the U.S. Committee for Natural Hazard Reduction.

The Geohazards '88 symposium was held at the western Regional headquarters of the USGS in Menlo Park, Calif., and was a collaboration of knowledge producers and knowledge users. Attendance was about evenly divided between geologists, seismologists, and hydrologists on the one hand, and urban planners, emergency management specialists, and elected officials on the other. The conference consisted of four sessions highlighting current USGS research on the identification and mitigation of geologic hazards, particularly in western states. USGS and California Division of Mines and Geology (CDMG) seismologists described their efforts at predicting the probabilities and effects of earthquakes along the San Andreas Fault, principally in the Los Angeles and San Francisco areas. USGS geologists discussed landslide hazards and volcanic hazards. The discussion of landslides focused on efforts to describe, catalog, and predict landslides in the San Francisco Bay region. Volcanic hazards in the Cascade Range were described, and attempts to predict future volcanic activities in eastern California were discussed. USGS hydrologists discussed water pollution both in San Francisco Bay and in the San Joaquin Valley. Most of the talks were also presented as poster sessions.

Following the formal sessions there was a lively panel discussion of the pitfalls of disseminating scientific information about geologic hazards to local officials charged with implementing appropriate measures. Of particular interest was the effect of a volcanic eruption warning on the affected community. Considerable distrust was generated because the warning appeared in the press before the official announcement. It was alleged that the ensuing hysteria depressed property values in a popular resort area, underscored the need for carefully timed and planned communications.

The Division has available 30 copies of the December 1989 Monthly Bulletin of the State College of Washington, v. 22, no. 7, part 1, which includes the following articles:
McGrew, J. G., Directional properties of worked magnetite alloys.
Cubry, H. E., Some geologic aspects of the magnetic deposits of Washington.
Send your request to Ray LaMarche, State Geologist (see address on p. 2 of this Newsletter).

Figure 2. Estimated gold production in Washington. The production estimate for 1988 reflects record production from the two major gold mines in the state. Production increased dramatically beginning in 1985 as a result of the opening of the Canyon mine and increased production at the Republic Unit.

The discovery of an additional mine of 246,127 oz of gold and 250,000 oz of silver. The discovery was the result of drilling more than 60 drill holes at the property during the last 2 years. Three separate target areas have been identified by the widely spaced drilling along a zone 9,000 feet in length. Reported values from each of the target areas range from 0.05 to 0.2 oz of gold to more than 0.2 oz of gold. Environmental studies are being conducted at the site in anticipation of a possible 6,000-foot exploration adit that is being contemplated by the company. Drilling continued throughout 1988 to further test the property.

Although Place Inc. and Summit Silver Inc. as well as several local residents have signed leases with the joint venture partners in the Wanatchee Heights area. These leases were part of the approximately 1,200 acres of new leases that were acquired during the third quarter, adding to the large land holdings near Wanatchee that have been obtained by the joint venture partners.

Table 2. Properties producing base and precious metals, 1988.

<table>
<thead>
<tr>
<th>Property</th>
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<th>County</th>
<th>Production and development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cannon mine</td>
<td>Asameras Minerals (U.S.) Inc.</td>
<td>Chelan</td>
<td>Processed gold (95 oz of gold and 250,000 oz of silver)</td>
</tr>
<tr>
<td>H and B mine</td>
<td>Blue Silver Mining</td>
<td>Stevens</td>
<td>Mined 6,000 tons of rock containing lead, zinc, silver, and gold</td>
</tr>
<tr>
<td>Republic Unit</td>
<td>Hecla Mining Co.</td>
<td>Ferry</td>
<td>Processed 70,000 oz of gold and nearly 250,000 oz of silver</td>
</tr>
<tr>
<td>Gold Duke</td>
<td>Vulcan Mountain Co.</td>
<td>Ferry</td>
<td>Processed gold and lead ore for part of the year</td>
</tr>
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Exploration

Sixty-two companies reported exploring for metals in Washington in 1988, and with few exceptions, they were exploring for precious metals. Exploration dollars spent for metals in the state increased significantly. A value estimated from the voluntary reports to the questionnaires sent to operators of mineral properties in Washington indicates that a minimum of $13 million was spent for metal exploration in 1988 as compared to a minimum of $5.3 million reported in 1986. These figures can only be used for comparison because not all expenditures for exploration and development are reported on the returned questionnaires.

Chelan County

Asameras Minerals (U.S.) Inc. and Blue Silver Resources Ltd. announced the discovery of gold mineralization at the Wanatchee Gold property in the Wanatchee Heights area, a few miles south of the Cannon mine. The discovery was the result of drilling more than 60 drill holes at the property during the last 2 years. Three separate target areas have been identified by the widely spaced drilling along a zone 9,000 feet in length. Reported values from each of the target areas range from 0.05 to 0.2 oz of gold to more than 0.2 oz of gold. Environmental studies are being conducted at the site in anticipation of a possible 6,000-foot exploration adit that is being contemplated by the company. Drilling continued throughout 1988 to further test the property.

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<td>Ferry</td>
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</tr>
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</table>
At the old Lovett mine, 2 miles south of the Cannon mine, a surface and underground drilling program was conducted by the joint venture partners to evaluate the Wenatchee D reef as an open-pit heap-leach target (Asamera Minerals, Inc., first quarter report, 1988).

Montana de Oro, Inc. removed overburden, opened old mine adits, and drove 300 feet of new drift at their property in the Blewett Mining District. The property consists of quartz-carbonate-talc-sulfide veins in serpentinitized ultrabasic rock.

Raven Hill Mining conducted geological exploration and sampling at their lode and placer deposits in the Chisaukum graben.

Sunshine Valley Minerals, Inc. continued separation of slime and sand at the How Sound tailing piles from the old Holden mine. The U.S. Forest Service is planning to reclaim the tailings pile because of the possible threat of sedimentation to Lake Chelan during a major flood.

Welcome Nugget Mines continues to explore their placer claims on the upper Wenatchee and Little Wenatchee Rivers.

Ferry County

Ferry County was the area in which a large part of the state’s exploration activity took place in 1988. Most of the exploration was centered around the

Nearly 1 million ounces of gold were produced from the Lovett mine (Golden King mine) between 1949 and 1967. The Cannon mine is located to the northwest of the Lovett mine, on the opposite side of the ridge. The view is to the northwest from Wenatchee Heights; Rooster Comb is to the right. (Photo by Roger Gill, Asamera Minerals [U.S.] Inc. Exploration.)

Aerial view of the Cannon mine surface facilities from the south. The trackless underground mine has been in operation since mid-1985 and has produced more than 400,000 ounces of gold. The city of Wenatchee is in the background in the upper right. (Photo courtesy of Asamera Minerals, Inc.)

Coal activity in Washington—1988

By Henry W. Schasse

Coal exploration activity in Washington continued at a low level because the coal market remains soft. Only one company explored for coal (in Whatcom County) during 1988.

The two Washington coal mines that operated during 1987 continued to produce coal during 1988. The Centralia Mine, operated by Washington Irrigation and Development Company (WIDCO), located 5 miles northeast of Centralia, Lewis County, in the Centralia-Chehalis Coal District, continued to be the state’s largest coal producer. Pacific Coast Coal Co. (PCCC) continued to increase its production at its 2-year-old John Henry No. 1 Mine, located approximately 2 miles northeast of Black Diamond, King County, in the Green River Coal District.

WIDCO produced 5,034,935 clean short tons of subbituminous coal during 1988; this is approximately 639,000 tons more than it produced in 1987. The Centralia mine has produced an average of 4.1 million tons per year since it began production in 1973. The mine supplies the steam power plant located approximately a mile from the mine. Coal mined at Centralia comes largely from five coal seams that are stratigraphically near the middle of the Stockmunkch Formation, an upper member of the Eocene Puget Group. Coal production for 1988 was principally from two of those seams, the Smith and Big Dirty coal seams.

PCCC completed its second full year of production at its John Henry No. 1 mine, producing 110,157 short tons of bituminous coal. This represents an increase of 61,000 tons over its 1987 production. A large share of its 1988 production went to WIDCO to blend with coal mined at Centralia in order to maintain sulfur dioxide emissions within state and federal environmental limits at the Centralia steam plant. PCCC also supplied coal to state institutions at Monroe and Shelton and to the U.S. Navy submarine facility at Bangor for their heating plants. In addition, some coal was sold to the Ideal Cement Company.

PCCC mined the Franklin Nos. 7, 8, 9, and 10 coal seams during 1988. (Figure 1). These coal seams, which have a high volatile B bituminous rank, occur stratigraphically near the base of the Eocene Puget Group sediments in the Green River Coal District (Schasse, 1987). PCCC continues to truck its coal to a wash plant operated by Palmer Coking Coal Co. at Black Diamond. Its plans for a new beneficiated coal plant at the mine remain on hold until it has acquired sufficient long-term contracts from industrial customers to justify the necessary capital outlay. The John Henry No. 1 mine has a design capacity of 250,000 tons per year. It currently mines its coal at an overall recovery of 75 percent.

Crevat Coal Company of Cadiz, Ohio, drilled 10 to 20 shallow exploratory holes on the No. 1 (Discovery) coal seam in the Glacier coal field in north-central Whatcom County from June through August 1988 (Schasse, 1988). On the basis of reportedly disappointing results from their drilling, Crevat Coal Co. elected to drop its lease with the A. Finchau es-

Figure 1. View east toward the west highwall in Pit No. 1 of John Henry No. 1 open-pit coal mine, 2 miles northeast of Black Diamond, August 1988. The highwall exposes the Franklin nos. 7, 8, and 9 coal seams in a faulted antitcline; these are highlighted by several thin, light-colored, volcanic ash beds.
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Rector, R. J., 1958, Some tectonic and paleontologic observations on the Quinault Formation: University of Washington, Department of Geology, Scientific Paper 40, 38 p.


Snowley, P. D., 1977, Tertiary geologic framework, neotectonics, and petroleum potential of the Oregon-Republic graben. The number of claims located in the county has more than doubled in the past 2 years; the present total is approximately 3,000 claims (Doug Sauer, Ferry County Planning Department, 1999). Most of these claims are located in the northern part of the county, north of the Clatsop River. A majority of the 20 companies that reported working in the area explored for gold in epithermal veins in the Eocene Sapelo formation and for replacement deposits in Paleozoic sedimentary rocks (Fig. 3).

Echo Bay Mines Ltd. announced in November that they will put two underground mines into production in early 1990. The Kettle and the Overlook mines are a joint venture with Crown Resource Corp. and Gold Texas Resources Ltd., each of whom own 15 percent. More than $13 million have been spent on the two properties to date, and an additional $47 million will be spent to mine the properties in the next year (Echo Bay Mine Ltd., third quarter report, 1988).

Reserves for the two properties have been estimated at 3.5 million tons of ore averaging 0.189 oz/ton gold; however, the deposits have not yet been fully delineated. Consultants to Echo Bay estimate that the two mines will produce 729,000 ounces of gold. Production is expected to be $110,000 ounces of gold per year for the first 5 years, with annual production of 85,000 ounces thereafter at a cost of $250 per ounce. Employment is projected to be between 105 and 130 workers.

The Kettle mine is located a mile west of Curlew. The 3,500-foot-south decline began in 1987 has been completed, and underground drilling was undertaken in 1988 to further define the high-grade and low-grade epithermal vein systems. Echo Bay estimates that the mine will produce 300 to 500 tons per day. The ore will be processed at the Kettle mill located at the Overlook mine deposit 8 miles northeast of Republic.

The Overlook mine will be under a groundwater at which production is estimated to be 1,000 to 1,500 tons per day. The mine, beneath Cooke Mountain, will be accessed by a 2,700-foot adit. An underground shaft will access the upper part of the deposit, provide ventilation, and serve as an escape way. The deposit is a magnetite replacement deposit containing iron oxides and a stockwork of pyrite and molybdenite in the overlying clastic sedimentary rocks, all of which are intruded by an Eocene dike. The Overlook mine deposit has the highest grade of the three deposits tested by Echo Bay near Cooke Mountain; the other two deposits are the Key East and Key West deposits (Fig. 4).

The Kettle and Overlook mines will be processed at the Kettle mill (Fig. 4). The conventional mill will be designed to process 1,500 to 2,000 tons per day and will use tank flotation. Tailings will be pumped to tailings embankments adjacent to the mill site.

Heck Mining Co. has expanded their exploration program in the Republic area, where the company has a land position consisting of more than 5 square miles. Drilling has been concentrated in the

Figure 3. Areas of active exploration in southwestern Ferry County, G (3840 N. 9532 S. 3541 E). Most of the exploration activity was for gold and silver in Eocene volcanic rocks (Eva), Paleozoic and Cretaceous metasedimentary and metavolcanic rocks (MVPM), and serpentinites (Q, Quaternary sediments; E, Eocene volcanic rocks and sediments; T, Tertiary and Mesozoic tectonic rocks; m, metasedimentary rocks. From Keith Doolin, DOCER, unpublished mapping).

be pumped to tailings embankments adjacent to the mill site.
new areas of high-grade mineralization at depth (Mining Record, Nov. 30, 1988). Chemung, Inc. claimed a small heap-leach operation at the deposit that they had acquired in 1987.

Crown Resource Corp., in joint venture with Sutton Resources, Inc. and Texas Star Resources Ltd., completed more than 164 surface core holes in 1984. The mine, which produced limited tonnage in 1985, contains narrow high-grade veins in sediments and tuffaceous rocks of the lower Sanpoil Volcanics.

Crown Resource Corp., in joint venture with Gold Texas Resources Ltd., conducted reconnaissance drilling, geological mapping, and geochemical sampling at their Queen Elizabeth property. Epithermal gold-bearing quartz veins in the Sanpoil Volcanics are the exploration target.

North of the Kettle mine, Aserco Inc. drilled 1,500 feet of core and conducted soil and airborne surveys at their Curlew project. To the north on an adjacent property, United States Borax & Chemical Corp., drilled two holes at their Wheaton Ranch property. Both prospects are in the Sanpoil Volcanics.

Morning Star Mines, Inc., worked to rehabilitate the Morning Star mine and began bulk sampling in the area of previous mining. The gold and copper mine has been idle since World War II.

N. A. Degertem, Inc., in joint venture with Island Gold and Silver Corp. and Pegasus Gold Corp., continued exploration drilling in the Orelle property, directly west of the Overlook and Key properties of Echo Bay. Geologic mapping and magnetic surveys were conducted, and drilling was undertaken to test mineral anomalies. The 8-square-mile property consists of mining claims and private land.

United States Borax & Chemical Corp. drilled more than 2,000 feet of core and conducted soil and airborne surveys at their Tamarack property. The mine is a former copper and gold producer. The deposit, which straddles the international border, is reported to be in metamorphosed rocks of probable volcanic origin at the contact with a serpentine body. According to the Inventory of Washington Mines (Hunting, 1956, p. 59), the deposit was last mined in 1917, and 250,000 tons of rock averaging 1.94 percent copper, 0.047 oz./ton gold, and 0.2 oz./ton silver were recovered. The company has also optioned the Empire Creek property, 12 miles north of Republic, from Kettle River Resources.

Cyprus Minerals Co. drilled in the Lone Ranch Creek area, east of Danville. Other claims were also added to their holdings in the high-grade metamorphic rocks.

Newmont Exploration Ltd. explored for precious metals in the county. The company located a claim block on the South Fork of O'Brien Creek.

Formations: Similarly, marginal faulting along dikes could facilitate migration between the Montesano reservoir sequences and underlying source rocks. A gas seep is present on the margin of a structural high as a diapir by Raw and Grocock (1974), which is located onshore near Cape Elizabeth. Domes and stratigraphic truncations across areas of discrete intrusions are potential petroleum traps.

We speculate that a single, hypothetical Ozette or other oil pool contain 10 million barrels of recoverable oil. However, raised reserves for the Ozette and Hoh would be only a small fraction of this volume owing to discontinuous reservoir strata and the difficulty of defining traps with seismic data.

We speculate reserves for a single, hypothetical Montesano oil pool, assuming that the reservoir has the average porosity and thickness of those penetrated to date, are 20 million barrels. A 300 feet by 300 feet by 300 feet reservoir, with 50 percent full to spill, could contain 250 million barrels of recoverable oil.

The entire shell may have potential to contain gas and/or oil accumulations within the Ozette, Hoh, and Montesano sections. Areas directly adjacent are closer to the Montesano provenance and, consequently, are considered as more prospective with regard to mainland resources development than areas farther west. Furthermore, the coastal area is adjacent to the zone of common seeps and shows. The potential of the continental slope and Pacific abyssal plain is considered poor.

REFERENCES CITED


(4) Porosity of the Montesano Formation sandstone member ranges from 25 to 32% (Fig. 2a), and sandstone unit thickness averages 40 feet. The Montesano sandstone member (Ocean City sand and equivalents) was drilled in the Ocean City area and in the P-0155 well. Similar sandstone units occur on the east side of Aberdeen and directly north of Point Grouville. We regard these sandstones as the primary exploration target on the Washington continental margin.

(5) The Quinault and Quillayute Formations and equivalent strata are probably not buried to sufficient depths to be considered as conventional petroleum plays.

(6) Significant oil and gas shows were tested in the Ocean City, Hoh River, and Forks areas, and oil shows were logged in the P-0155 offshore wildcat. Numerous coastal outcrops of very dark gray mudstone and alluvite present west of the estuary. Two tests of the P-015A yielded 10 and 26 thousand cubic feet of gas per day from a zone in the Hoh river estuary (The Shell Oil Co., 1966), and several gas seeps have been located offshore.

(7) Rocks from the continental margin and western Olympic Peninsula analyzed to date have fair potential to generate natural gas (Rivervolden and others, 1988b). Although some rocks in the Quinault melange near Forks have two rare biomarkers also found in oil samples from the Hoh River (Rivervolden and others, 1988b), no oil-prone source rocks have been identified in the study area.

(8) Geochronologic analysis, thermal alteration indices, vitrinite reflectance, and 3He determinations indicate that the sediments penetrated offshore are generally immature for petroleum generation (Brown and Rice, 1982). The Quinault and Quillayute Formations are probably not buried to sufficient depths to be considered conventional petroleum plays.

(9) Rocks from the continental margin and western Olympic Peninsula analyzed to date have fair potential to generate natural gas (Rivervolden and others, 1988b). Although some rocks in the Quinault melange near Forks have two rare biomarkers also found in oil samples from the Hoh River (Rivervolden and others, 1988b), no oil-prone source rocks have been identified in the study area.

(10) Structures dissected (or formed) by strike-slip faults could facilitate migration between the Montesano reservoir sequences and underlying source rocks. These structures may also control deposition and/or diagenesis of sandstone sequence within the Montesano and Quinault.

Johnson. Explores conducted geological and geochemical exploration seeking gold in an alluvial placer on the Irish claim group.

Other companies exploring in the county include Antilles Resources Ltd., who explored for gold in the Bolle Cascade Corp. engaged in reconnaissance exploration for gold on company lands in the county. Union Pacific Resources Co. explored for uranium.

King County

Weyerhaeuser Co. completed a third season of reconnaissance drilling and mapping at their White River property. The company is seeking gold and copper in quartz-albite-altered Mocene volcanic rock. Mineralization is structurally, temporally, and genetically related to the margin of a Mocene caldera (McCulla, 1986).

Cannon Minerals explored for gold-bearing veins in intrusive rock at El Watlah property near North Bend. Precious metals in Mocene volcanic rocks with quartz-albite alteration were targeted by the company at their White River property. Mark Wagner continued exploration on claims near Covey Basin near Skykomish.

Okanogan County

Exploration has increased in Okanogan County as those seeking precious metals have "moved west" from the Republic graben area into areas with similar geology.

Crown Resource Corp. joint venture with Gold Texas Resources Ltd. announced the discovery of significant mineralization at their Buckhorn project in the Myers Creek Mining District in the north eastern part of the county. The company drilled 13 reverse-circulation holes into the gold-bearing skarn for a total of 5,200 feet. Crown Resources reported significant mineralization in four of the five tests areas, including one 75-foot-thick zone that contained 0.17 ounces of gold.

The Crown Resource Corp. and Gold Texas Resources Ltd. joint venture drilled 5 reverse-circulation holes totaling more than 3,200 feet at the Ida mine. The venture also entered into a lease agreement with Sundance Mining and Development Corp. Geological and geophysical exploration was undertaken in the search for gold-bearing epithermal veins in Eocene volcanic rocks in the Torrora Creek graben.

Washington Mining Inc. joint venture with Crown Resource Corp. drilled 3,000 feet and conducted geological mapping and soil and rock sampling at the Boardie mine. The property, which was last mined in 1944 (Moon, 1980), is located in the Torrora Creek graben and is in Eocene volcanic rocks.

Several companies explored for precious metals west of the Okanogan River. Newhawk Gold Mines Ltd. in joint venture with Relants Resources, Ltd., and Nol David Resources Corp. did limited trenching, drilling, and geochemical sampling at their Smith Canyon property. Newhawk Gold reported that although the work was few, it is the first steps in a program that is intended to encourage, the property was returned to the Relants Resources/Nord Resources joint venture (Newhawk Gold Mines Ltd. 1987).

ECM Inc. conducted geological, geochemical, and geophysical exploration at the Alder mine. The gold-silver-copper property 5 miles southwest of Twisp is in the Lower Cretaceous Buck Mountain Formation.

Quintana Minerals Corp. continued exploration at their American Flax property near Mazama.

L. F. Baum and Associates continued exploration at the Turtle Lake property that included reverse-circulation drilling and geological and geochemical work. The company is seeking precious metals and copper in a sedimentary-rock-hosted deposit.

Say Energy Inc. and OWIC Inc., who hold large claim blocks in the southeast part of the county, explored their claims for gold, silver, and copper.

Other groups exploring in Okanogan County include Dallton ExcaVators, who drilled at their Rose property. Sunshine Valley Minerals, Inc., continued precious metal exploration on their Billy Goat claims; activities included work on roads and geological and geochemical exploration.

Pend Oreille County

Resource Finance Corp. (RFC) has entered into an option purchase agreement with Pintlar Corp., a wholly owned subsidiary of Gulf Resources and Chemical Corp., to acquire the assets of the Pend Oreille mine. The new Canadian company can exercise the option to purchase the underground mine for $12.5 million. Prior to beginning underground development, desilting of the mine will be required, and the mine will be re-opened. The mine is a small producer and is in a high grade lode.

Raven Hill Mining explored for base and precious metals on their Peacock claims group near Cools Mountain.

Pierce County

Mark Wagner explored for gold and copper mineralization in the Mocene Carbon River stock north of Mount Rainier.

Spokane County

Union Pacific Resources Co. explored for uranium in the county. Exploration included geological mapping and sampling.
Stonohim County
Several companies and individuals explored for precious metals in the Sullivan River drainage, including Island Arc Mining Corp. and Jeanne Ring. Reclamation placer mining has been popular in the county.

Stevens County
Boise Cascade Corp., in joint venture with Pathfinder Gold Co., continued to explore for gold and silver in the Sullivan Creek Project. Drilling continued at the epithermal vein deposit in the Sampol Volcanics near the contact with the Klondike Mountain Formation.

These joint venture partners have also been exploring the McNally-Freedom claims held by Western Land and Resources, where geologic mapping, soil geochemistry, and a geophysical survey were conducted.

Boise Cascade Corp. also continued exploration at their Filinannar Creek property. The prospect contains gold-bearing massive sulfide veins in the Jurassic Rossland Volcanic Group. The company also continues to explore for metals on other corporate lands in the county.

Van horn and Watson Mining Co. conducted geologic mapping and core drilling at their Copper penny property. Mapping and sampling were accomplished at their Gold Nugget property. Both of the prospects, which are under lease to Elaine Exploration Co., are in the Rossland Volcanic Group.

Chevelah Eagle Mining Co. continued exploration for base metals and silver on their claim near Chevelah Mountain.

United Copper Mines engaged in minor work on their claim in the Chevelah Mining District. Lead-zinc mineralization in the area is dominated by the Chevelah Mine, which is reported to contain lead-silver-silver in the Maline Formation in the Northport Mining District.

At the H and B mine Blue Silver Mining removed 25,000 tons of ore and mined 6,000 tons of material. The precious and base metal veins at the property are in Precambrian mafic sediments, and some diorite bodies were mined.

The capital assets of the Deer Trail mine, owned by Cortez International Ltd., were liquidated to satisfy debts owed by the company. The Deer Trail mine was in operation from 1908 to 1984. The company holds state mineral leases in the area to explore for the potential of the Tuk magnetite deposit.

Union Pacific Resources Co. explored for uranium in the county.

Whitcomb County
Steelhead Gold, a wholly owned subsidiary of Steelhead Resources Ltd., continued to explore the Excelsior mine east of Glacier. The company announced reserves of 4.1 million tons grading 0.042

c/ton gold and 2.6 oz/ton silver after an extensive drilling program in 1987. Sampling done in 1988 examined possible extensions of the mineralization towards the southwest. The deposit, which was previously drilled by United States Borax & Chemical Corp., is hosted by volcanic and sedimentary rocks of the Jurassic Wells Formation.

The Slate Creek Mining District, Western Gold Mining, Inc., did surface and underground sampling at the New Light mine. Seattle-St Louis Mining Co. continued small exploration on the quartz vein at the Minnesota mine.

Statewide

INDUSTRIAL MINERALS
Development and Exploration
Seventeen companies produced industrial minerals from 21 sites during 1988 (Table 3). Value-added processing increased the sale of the state's industrial minerals. Northwest Alloys, Inc., mine and plant in Stevens County was the highest-value industrial mineral operation in the state because of the value added to dolomite through the production of magnesium metal. Limestone was generally used in the manufacture of portland cement. Silica was produced by four operations for uses that included plate glass, colored glass bottles, and cement. Two companies produced glass cullet, while one company continued to explore the possibility of building a new portland cement plant in Okanogan County. Clay was produced by four companies for use in cement and structural brick. Diatomite was produced by one company, and two companies made products from olivine mined in the state.

Clallam County
Ideal Basic Industries, Inc., produced 100,000 tons of calcium carbonate with their Twin River plant on the central Olympic Peninsula. Calcium carbonate is used in the manufacturing of portland cement. The clay is mined from weathered mudstone in the Twin River Group of Oligocene age.

Grays Harbor County
Wilco Corp. continues to be the sole producer of diatomite in the state. Production in 1988 increased significantly over that in 1987 with the bulk of the production from the pit in section 8. The company has used seismic reflection data acquired by the U.S. Geological Survey (Mann and Snavely, 1984; McCullar and Snavely, 1987, 1988), the Northwest Geophysical Survey (1972), and the University of Washington (Bennett and others, 1969a,b; Bennett and Henry, 1969) to evaluate possible domes on the Washington OCS that may act as oil and/or gas traps. The grid spacing of public-record seismic profiles is greater than the grid spacing of the University of Washington OCS. It is probable that we have not been able to identify many potential traps. Similarly, the wide spacing of seismic profiles prevents accurate mapping of all dimensions of potential traps as well as limiting the ability to demonstrate that the identifiable anticlines have domal configurations. However, we can demonstrate that many folded structures exist in the offshore region, and we anticipate that some of these may act as traps.

Results of Previous Offshore Drilling
For the offshore exploratory wells have been drilled offshore of Washington. The State of Washington leased oil and gas rights in its territorial waters during the period from 1960 to 1964. The Union Oil Company drilled the first deep offshore exploratory well, the Tideland No. 2, in 1962, but no commercial oil reservoir rocks were encountered. In 1964, an offshore oil and gas lease sale was conducted by the Department of the Interior on the Washington and Oregon OCS. Webster Three Washington OCS exploratory wells (the Shell P-0150/150A and P-0155, and the Pan American P-0141) were drilled on leases purchased during this sale at prices ranging from $3 to $310 per acre (Webster, 1985). Small flows of gas were tested in the P-0150A and tracts of oil were logged in the P-0155. Montesano Formation sandstone reservoirs were not present in two of the OCS wells. In the P-0155, a thick Montesano sandstone was present, the seal was inadequate. All four offshore exploratory wells were abandoned as dry holes. These results, however, do not condemn the area, as major oil and gas producing areas worldwide have had more than 25 dry holes drilled prior to the initial discovery.

OIL AND GAS POTENTIAL OF THE WASHINGTON OFFSHORE

Petroleum exploration is an intermittent process that is controlled by data availability, technical knowledge, results of previous exploration, and economic factors. Offshore exploration ceased in the late 1960s because of the lack of encouraging results from the four offshore wells. Since that time, petroleum exploration data have improved significantly in both quality and quantity, and technical knowledge has increased substantially. Increased exploration interest in the Washington continental margin is foreseen because of these factors, and because most areas favorable for easy discovery of large oil or gas accumulations worldwide have been thoroughly assessed by drilling.

The combination of possible traps, numerous oil shows, and an exceptional quality (if unpredictably distributed) Montesano sandstone reservoir suggests potential for discovery of oil and gas accumulation on the Washington continental shelf. The motivating force for future exploration of offshore Washington would be the possibility of a large field (200 million barrels of oil or equivalent gas). Giant fields contain more than 70 percent of the world's recoverable oil. We regard the potential for discovery of a giant field on the Washington continental margin as 2% on a worldwide scale of 10. However, the best remaining unexplored basins, such as the Arctic National Wildlife Refuge, are 7% or 8% on this same scale, while most unexplored basins worldwide are rated 5% or less.

On the continental shelf, the potential for petroleum generation and for the occurrence of Montesano sandstone reservoirs is greatest near the coastline. The region within 12 miles of the coast and north of 47° latitude the MMS highlighted area in Fig. 1) encompasses approximately 75 percent of the area on the Washington OCS which we regard as favorable for significant petroleum accumulations. We regard the potential for petroleum accumulations seaward of the 12 mile limit on the Washington continental slope and Pacific Ocean abyssal plain, as poor.

TECHNICAL SUMMARY

This section provides technical details that support some conclusions given in the preceding summary.


2. (a) 50 Ma: Subsidence in the area of the present Olympic Mountains and partial topographic isolation of this area by development of thrusting (or constructional-marine?) highlands north of the Crescent thrust, south and east of the Snelling Fault Zone, on the east side of Willapa Bay. These highlands were composed of lower Eocene Crescent Formation basalts.
and claystones suitable for sealing underlying sandstone reservoir horizons. Minor shows recorded in the thick Montesano sandstone unit encountered in the Ocean City area indicate that gas, and possibly oil, have migrated into this sandstone at some time in the past. However, our work suggests that the overlying limestone seal was breached by erosion approximately 5 million years ago, and consequently, oil and gas that may have accumulated in the sandstone escaped.

**UNIVERSITY OF WASHINGTON SEISMIC PROFILE 10-14**

**Figure 3.** A seismic reflection profile acquired in 1967 approximately 10 miles offshore from the mouth of the Queets River during Cruise 10 of the University of Washington RV Oceanic. The ocean surface is at 0.0 seconds two-way travel time (TWT), and the sea floor is at approximately 0.075 seconds TWT, which corresponds to a water depth of 190 feet. The series of laterally continuous black and white horizons recorded below the sea floor corresponds to reflections from discrete sedimentary strata and are termed events. This profile shows steeply dipping strata on the flanks of an anticline that have been truncated by erosion along event A. Nearly horizontal strata have been deposited above horizon At these strata have been replaced by a fault, indicated by the heavy vertical line near the center of the profile. This fault disrupts the sea-floor topography, indicating that fault movement is recent. The horizontal events recorded below 0.125 seconds TWT are multiple echoes of the strata lying between the sea floor and event A. The events reflecting from the strata on the flanks of the anticline continue through this spurious "sea-floor multiple". This seismic reflection profile images sedimentary strata approximately 500 feet below the sea floor; other seismic profiles presented in Palmer and Lingley (1989) image strata to approximately 10,000 feet below the sea floor.

**Traps**

Anticlinal folds in stratified rocks having potential to trap petroleum are generally located using seismic reflection surveying. This geophysical technique involves reflecting sound waves off buried strata in the same fashion that sonar locates submarines. The reflection data are used to map the geometry and approximate depth of anticlinal folds (Fig. 3). The seismic reflection data are generally acquired along shotlines laid out as an intersecting grid.

**Table 3. Properties producing industrial minerals, 1988.**

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Property</th>
<th>Owner and/or Operator</th>
<th>County</th>
<th>Production and development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>Twin River quarry</td>
<td>Ideal Basic Industries, Inc.</td>
<td>Clallam</td>
<td>Mined 100,000 tons</td>
</tr>
<tr>
<td>Clay</td>
<td>Mica mine, plant</td>
<td>Intercity Industries Inc.</td>
<td>Spokane</td>
<td>Mining</td>
</tr>
<tr>
<td>Clay</td>
<td>Elk pit</td>
<td>Mutual Materials Co.</td>
<td>King</td>
<td>Mined 28,500 tons</td>
</tr>
<tr>
<td>Clay</td>
<td>Sec. 31 pit</td>
<td>Mutual Materials Co.</td>
<td>King</td>
<td>Mined 85,000 tons</td>
</tr>
<tr>
<td>Clay</td>
<td>Harris/Blum</td>
<td>North American Refractories Co.</td>
<td>King</td>
<td>Hauled from stock pile</td>
</tr>
<tr>
<td>Diatomite</td>
<td>Sec. 7 and 8 pits</td>
<td>Witco Corp.</td>
<td>Grant</td>
<td>Mined 350,000 tons</td>
</tr>
<tr>
<td>Diatomite</td>
<td>Sec. 17 pit</td>
<td>Witco Corp.</td>
<td>Grant</td>
<td>Mined 30,000 tons</td>
</tr>
<tr>
<td>Dolomite</td>
<td>Crystal City mine</td>
<td>Blue Silver Mining</td>
<td>Lincoln</td>
<td>Mined 30,000 tons</td>
</tr>
<tr>
<td>Dolomite</td>
<td>Several quarries</td>
<td>Nanome Aggregates, Inc.</td>
<td>Stevens</td>
<td>Mining from several pits</td>
</tr>
<tr>
<td>Dolomite</td>
<td>Addy Diatomite quarry</td>
<td>Northwest Alloys, Inc.</td>
<td>Stevens</td>
<td>Mined 760,000 tons</td>
</tr>
<tr>
<td>Limestone</td>
<td>Bear Mountain mt</td>
<td>Clauson Lime Co.</td>
<td>Whatcom</td>
<td>Mining</td>
</tr>
<tr>
<td>Limestone</td>
<td>Wascooda quarry</td>
<td>Columbia River Carbonates</td>
<td>Okanogan</td>
<td>Mined 35,000 tons</td>
</tr>
<tr>
<td>Limestone</td>
<td>Champan Place</td>
<td>Lehigh Portland Cement Co.</td>
<td>Pend Oreille</td>
<td>Mined 241,860 tons</td>
</tr>
<tr>
<td>Limestone</td>
<td>Westport Limestone</td>
<td>Northwest Limestone Co.</td>
<td>Stevens</td>
<td>Mined 45,000 tons</td>
</tr>
<tr>
<td>Limestone</td>
<td>Teneset Limestone quarry</td>
<td>Pacific Calcium, Inc.</td>
<td>Okanogan</td>
<td>Mining and milling</td>
</tr>
<tr>
<td>Olivine</td>
<td>Alpena Olivine</td>
<td>Applied Industrial Materials Corp.</td>
<td>Skagit</td>
<td>Crushing and screening</td>
</tr>
<tr>
<td>Olivine</td>
<td>Swan Larsen olive</td>
<td>Olivine Corp.</td>
<td>Whatcom</td>
<td>Mining</td>
</tr>
<tr>
<td>Silica</td>
<td>Superior quarry</td>
<td>Ash Grove Cement West, Inc.</td>
<td>King</td>
<td>Mined 45,000 tons</td>
</tr>
<tr>
<td>Silica</td>
<td>Rivesdale pit</td>
<td>L-Bar Products, Inc.</td>
<td>King</td>
<td>Mined</td>
</tr>
<tr>
<td>Silica</td>
<td>Lane Mountain Silica</td>
<td>Lane Mountain Silica Co.</td>
<td>Stevens</td>
<td>Mined 300,000 tons</td>
</tr>
<tr>
<td>Silica</td>
<td>Blue Creek mine</td>
<td>Northwest Alloys, Inc.</td>
<td>Stevens</td>
<td>Mined 20,000 tons</td>
</tr>
</tbody>
</table>

Pony sought permits for a new diatomite pit in the Frenchman Hills. The diatomite is mined from lake bed deposits interstratified with flows of the Columbia River Basalt Group.

Basic Resources Corp. conducted geological mapping, sampling, and drilling at their Rock Top claim group. The deposit contains non-swelling bentonite that is present in sedimentary layers between flows of Columbia River basalt. The clay is reported to be suitable for many uses, including absorbants, oil and gas drilling muds, and filters.

**King County**

L-Bar Products, Inc., continued mining silica at their Rivesdale pit. The sand is mined, washed, screened, and dried to produce silica for making colored bottles and cement. The sand is milled from the Eocene Puget Group.

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Ash Grove Cement West, Inc. mined, crushed, screened, and stockpiled 45,000 tons of silica at their Superior quarry. The mine, which began operation in 1987, supplies silica primarily for the production of portland cement; however, other uses include aggregate, decorative stone, sandblast sand, and roofing granules. The low-alkaline, microcrystalline quartz deposit consists of altered and stilified Miocene volcanic rock.

Mutual Materials Co. was the largest clay producer in the state. The company mined shale from two pits in the county.

**Lincoln County**

Dolomite was mined by Blue Silver Mining from the Crystallite Crystalline. The white rock is reported to contain 31.5 percent CaO and 21 percent MgO.

**Okanogan County**

Ciment Quebec Inc. has proposed building the dry-process, state-of-the-art $80 million Interstate Portland Cement, Inc. plant near Ellensburg. The company has signed an option for the high-calcium Reed Limestone property on the west side of the Okanogan River with CM Silver Mines Inc., which owns the property and subsidiary of Lucky Three Mining Co. The company plans to mine the limestone from "White Rock, North Fork" by conveyer to the Portland cement plant on the east side of the river. The project is on standby while a new permitting and financing strategy is developed by the company.

Columbia River Carbonates, a limited partnership of Bleek Management, Inc. and Geister Carbonates Inc. mined and crushed 35,000 tons of high-calcium-carbonate rock at their Wasona quarry. The white marble is sent by rail to the Columbia River Carbonates plant at Woodland, near Vancouver, where it is ground to fine and ultrfine powder and slurry.

Pacific Calcium, Inc. continues to mine limestone and dolomite from the Tonsalist Limestone quarry. The carbonate is crushed in Tonasket and sold for poultry feed and soil amendment and as a lawn-care product.

**Pend Oreille County**

Lehigh Portland Cement Co. produced 241,860 tons of limestone from their Chimpain Place. The limestone is mined from the Cambrian-Ordovician Metalline Formation for use in the production of portland cement. Lehigh is the only company in the state to produce Portland cement from limestone that is mined in Washington.

United Catalysts Inc., in joint venture with First Miss Gold Inc., continued exploration at their Totem site property in the northeastern part of the county. Drilling and bulk sampling was done at the property in a shear zone in the Late Proterozoic Monk Formation.

**Skagit County**

Applied Industrial Materials Corp. (AIMCOR) crushed and screened olivine purchased from an outside source. The company produces olivine flour for use as low-turn and blast sands.

AIMCOR was honored by the Pacific Northwest Region of the U.S. Forest Service for "exceptional environmental stewardship" of public lands exhibited in their reclamation project at the Twin Sisters quarry in the Mt. Baker-Snoqualmie National Forest (Joseph, 1988).

**Spokane County**

Interspace Industries Inc. continued production of clay from the Mica and Potratz pits near Mica. Structural bricks produced at the plant, including popular light-colored bricks, are sold nationwide.

**Siskiyou County**

Northwest Alloys Inc., a wholly owned subsidiary of Aluminum Co. of America, mined 720,000 tons of dolomite from the Addy Dolomite quarry. Northwest Alloys mine and plant at Addy is now the highest value mineral operation in the state because of its high volume of production and the value added to the dolomite by the production of magnesia metal at the plant. The company is one of only three producers of magnesia metal in the United States and can produce 15 to 20 percent of the world plant capacity for the metal. The company employed more than 450 workers in 1986 and continues as the largest employer in Siskiyou County (TEAM WASHINGTON, 1986).

In April, Northwest Alloys resumed the production of 75 percent ferrosilicon at their Addy plant. Ferrosilicon is used in the siliconic process (whereby magnetite in calcined dolomite is reduced by silicon) employed to produce the magnesia plant. The company had been purchasing ferrosilicon since the furnaces were shut down in 1985, but the company resumed production because of the increase in price due to increased demand from the steel industry (Gronley, 1988). Mining of silica resumed at the Blue Creek quarry near Addy in order to supply the ferrosilicon plant. The quarry produced 20,000 tons of quartzite from the Addy Quartzite.

L-Bar Products Inc. continued to produce ferrosilicon from magnesia sludge from the Northern Alloys plant. The fertilizer is marketed as "Ag Mag K."

Hampbell Brothers Inc. operated two industrial mineral properties in the county. Lane Mountain Silica Co., the largest silica producer in the state, produced 230,000 tons of high-purity silica from a

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**Figure 2.** Plots of porosity and permeability data obtained from analysis of cores from various outcrop wells. (a) Data from the Hob and Ochre rocks show that most samples have permeabilities less than 50 md and porosities less than 25%. For commercial offshore production, permeability must exceed 50 md and porosity must exceed 25%. (b) Porosity-permeability data for the sandstone member of the Montesano Formation, a 600-ft-thick massive sandstone drilled in the Ocean City area. Permeabilities of this sandstone generally range from 300 to 2,500 md and porosities range from 25 to 32%. These porosities and permeabilities compare favorably with those of sandstone reservoirs in many of the world's major oil fields; this thick sandstone presents an attractive petroleum exploration target.
The geologic history relevant to petroleum accumulation in coastal Washington began with deposition of the area's oldest unaltered sedimentary rocks, the Ozette (petroleum and others, 1985) and the Hoh rock assemblage (Rau, 1973). The Ozette and Hoh sequences are composed mainly of sandstones, siltstones, and claystones, deposited in deep water on the Pacific Ocean floor between approximately 50 and 15 million years ago (Skarnely, 1987). These rocks have been remobilized to clay-rich sediments to provide the basin and accreted to the North American continent as the Pacific Ocean floor was subducted beneath the continental margin processes. During the intense faulting and folding an architectonic mixture of Hoh and Ozette rock types known as melange. Melange is generally not prospective for oil and gas accumulations. Between about 12 and 2 million years ago, accreted Hoh and Ozette sequences were covered by the Montesano and Quinault Formations, which are also composed of sandstones, claystones, and siltstones. During and after deposition, the Montesano and Quinault Formations were folded, but much less severely than the underlying Ozette and Hoh melanges. This period of deformation created numerous faults and anticlines in the Montesano and Quinault stratigraphic intervals. A small number of these anticlines are probably domes and consequently could serve as potential traps for the accumulation of oil and gas.

Source Rocks, Maturation, and Migration

Despite the lack of oil or gas production in Washington, the western Olympic Peninsula is a remarkably petroleum-productive area. Oil and gas seep to the surface at several locations on the western Olympic Peninsula, and numerous exploratory wells drilled onshore and offshore have discovered oil and gas fields. Very dark gray clay layers in Ozette and Hoh sequences exposed along sea cliffs in Olympic National Park and along the beaches of the coast of the Olympic Peninsula. Early inhabitants of the peninsula referred to these clay layers as "smoke mud." The Montesano clay, off the beach at Ocean Shores (near Ocean City), sold small amounts of oil to a Tacoma refinery between 1958 and 1962 (McFarland, 1963). A nearby well, the State No. 4, produced a small quantity of gas that was sold to the Ocean Shores real estate development. These observations suggest that petroleum has been generated and migrated to the surface along the coastal zone adjacent to the Sate 132 area.

Paradoxically, laboratory studies by the U.S. Geological Survey (Skarnely and Kvenvolden, 1988) and our own work have failed to delineate specific source rock horizons that generated these oil seeps and seeps.

Reservoir Rocks and Seals

Reservoirs for oil, gas, and underground drinking water commonly consist of small gaps or voids (pores) between grains of sand in sandstone. The storage capacity of a sandstone reservoir is determined by the percentage of the rock that is composed of sandstone. A significant volume of sandstone unless fluid can flow from pores rich to the well bore. Pore space and porosity in offshore reservoirs must be especially high in these sediments to produce petroleum at volumes and rates sufficient to recoup the expenses of building a production platform and transportation facilities. On the continental shelf, the decreasing grain size, sandstone generally are considered as potentially commercial reservoirs, whereas few siltstones or claystones produce oil or gas at commercial rates.

Porosity and permeability data obtained from exploratory wells on the Olympic Peninsula indicate that the Hoh and Ozette reservoirs are locally insufficient to support commercial offshore production rates (Fig. 2). Most of the pores in these rocks have been filled with mineral cements, thus reducing both the storage capacity and permeability (Collway, 1974). Furthermore, intense folding, faulting, and fracturing of the Hoh and Ozette sequences that occurred during accretion may limit the lateral extent of individual Hoh or Ozette sandstone reservoirs (Rau, 1975, 1979; Skarnely and others, 1986).

The porosity and permeability of sandstone sequences within the Montesano and Quinault Formations compare favorably to those of producing reservoirs in some of the world's largest oil fields (Fig. 2). Wells drilled in the Ocean City area encountered a continuously porous sandstone unit in the Montesano Formation that is more than 600 feet thick (Bergen and Bird, 1972) and in which nearly one-third of the total sandstone volume is composed of void space (porosity equals 33%). This exceptional sandstone has been drilled only in the ocean City area (Bergen and Bird, 1972) and in one offshore well, the P-015 (The Shell Oil Co., 1967). Our work suggests that equivalents of this sandstone may be locally present elsewhere on the continental margin, but production of the distribution of these sandstones, which is critical to successful exploration, will be difficult. Nonetheless, these Montesano sandstone reservoirs present an attractive petroleum exploration target.

Seals are generally composed of impermeable claystone or siltstone layers that inhibit migration of oil and/or gas from the reservoir. Oil and gas seeps occur where seals are not present or are breached by faulting or erosion, and as a result the petroleum migrates to the surface. In some places faults may seal traps. Most sedimentary sequences in the western Olympic Peninsula contain impermeable siltstones.

The Pegasus Gold Corporation of Spokane is the first recipient of the Northern Rocky Mountain Exce.

Hecia Mining Company's economic rebound in the last five or six years is attributed to diversification of its interests.

Arthur Brown of Coeur d'Alene, Idaho, Hecia's president, credits its ability to develop policies and market mechanisms as other major reasons for a 'substantial increase' in profits in recent years.

The company's Lucky Friday mine, an 80-year-old silver producer at Wallace, Idaho, no longer is Hecia's flagship operation, Brown said during the Northwest Mining Association's 94th annual convention in Spokane.

Other factors in Hecia's healthier fiscal position, according to Brown:

- Exploration in the Northwest Territories of Canada for beryllium, a metal lighter than aluminum;
- Exploration for gold in British Columbia and Nova Scotia;
- A search for industrial metals in six southwest states;
- Ownership of gold property, the old Ketch Hill mine near Republic, which Hecia acquired eight years or so ago and where additional one has been discovered;
- A 25 percent reduction in costs at the Lucky Friday mine.

Hecia reduced its costs for mining silver by $2 an ounce, to about $5, according to Brown. He also said the industry cost for mining gold is about $250 per ounce, but that Hecia has its cost down to about $150 an ounce.

Lower operating costs at the Lucky Friday mine, according to Brown, resulted from increased mechanization and the development of improved methods for hard-rock underground mining. Another item in lowering costs, said Brown, is an agreement with the mine's labor force from $40 to 175 by mid-1989. In exchange, Brown said, Hecia has provided employees with a profit-sharing arrangement.

Gold is Hecia's major income item, according to Brown, followed by industrial metals, then silver. He said the price of silver in recent years has been a "wild roller coaster. If we were involved only in silver, our company would be hurting. We had to diversify."


Petroleum Geology of the Washington Continental Margin

By Stephen P. Palmer and William S. Lingley, Jr.

(Modified from Palmer and Lingley, 1989)

INTRODUCTION

The western Olympic Peninsula and adjacent offshore areas of Washington have a history of oil and gas exploration dating from 1901, when a wildcat well was drilled near Copalis Beach. Subsequently, 116 wildcats have been drilled in this general region including several wells on the beach and four in deepwater offshore. Many of these wells had significant shows of oil and/or gas, but profitable production has not been established (McFarland, 1983). The most recent phase of exploration in the area ceased in 1982 when the Sunburst No. 1 well in Jefferson County was abandoned.

The Minerals Management Service (MMS), Department of the Interior, has begun preparation for an auction of oil and gas leases on the Washington and Oregon continental shelf (OCS), designated Sale 132. Sale 132 would be scheduled during 1992 if industry interest, as indicated in a formal notification process, is sufficient to assure that the auction will be successful and if environmental issues are satisfactorily resolved. The location of the Washington portion of proposed Sale 132 is shown on Figure 1. State territorial waters, encompassing the area within 3 miles of the coast, are not included in the sale.

The purpose of this study was to provide a geological and geophysical assessment of the petroleum potential of the Washington OCS for the benefit of the public. The area of our assessment includes State territorial waters and all federal waters north of Oregon from the 3-mile limit westward to the boundary of Sale 132. A secondary objective of this project was to collect and archive geological and geophysical data in the public domain that are relevant to petroleum assessment in the Washington OCS. These data, which will be available to the public through the Division of Geology and Earth Resources, are also useful for regional geological studies and hazard assessment.

PETROLEUM GEOLOGY OF THE WASHINGTON CONTINENTAL MARGIN

Petroleum assessments are based on the study of sedimentary rocks that have potential to generate and store commercial quantities of oil and/or gas. Sedimentary rocks buried in the Earth's crust commonly contain fossil wood, leaves, algae, other organic debris that are source materials for gas and oil. Heating source rocks to near the boiling point of water activates chemical reactions that convert the organic debris to petroleum (thermal maturation).* Low-density petroleum produced by these reactions migrates toward the surface from its source through water-filled pores and faults. Stratified sedimentary rocks are commonly folded and/or faulted into domes (anticlinal structures in which strata dip away from the fold culmination in every direction) which can stop or trap the upward-migrating petroleum. Pore spaces that have the capacity to store large volumes of oil and gas (reservoir rocks) must be present within the trap. In addition, these reservoir rocks must be overlain by impermeable rocks (seals) that inhibit continued upward migration of the petroleum. Oil and gas fields are large traps which reflect the rare situation in which all of the conditions described above occur in proper sequence that is, deposition of source, reservoir, and sealing rocks, followed by development of a trap, and then maturation and migration of the petroleum into the trap. A petroleum assessment is simply a quantitative analysis of each of these factors based on geologic study of an area.

* This article is a summary of an assessment of the oil and gas potential of the Washington outer continental shelf conducted by the Division of Geology and Earth Resources and the Washington Sea Grant Program (Palmer and Lingley, 1989). This study and the publication of the complete report were supported by an appropriation from the Washington State Legislature, under ES88 No. 5533, Laws of 1987, to the Washington Sea Grant Program at the University of Washington. Additional support was provided by grant NA86AA-D-50044 from the National Oceanic and Atmospheric Administration to the Washington Sea Grant Program, projects R/MS:33 and A/PC:5. The writers express their appreciation to Parke Swanley of the U.S. Geological Survey and to W. W. Bau of Washington Division of Geology and Earth Resources for numerous contributions to this report and for reviewing the text. We thank Trish Peetson and Glenn Letherer of the Ocean Resources Assessment Project, Washington Sea Grant Program, for their kind assistance.

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Figure 1. Location of oil and gas seeps and some significant wells on the western Olympic Peninsula and adjacent offshore regions, the area of the proposed OCS Lease Sale 132, and the area highlighted by the Minerals Management Service (MMS).
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INTRODUCTION

The western Olympic Peninsula and adjacent offshore areas of Washington have a history of oil and gas exploration dating from 1901, when a wildcat well was drilled near Copalis Beach. Subsequently, 116 wildcats have been drilled in this general region including several wells on the beach and four in deep-water offshore. Many of these wells had significant shows of oil and/or gas, but profitable production has not been established (McFarland, 1983). The most recent phase of exploration in the area ceased when the Sunburst No. 1 well in Jefferson County was abandoned during 1982.

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Figure 1. Location of oil and gas seeps and some significant wells on the western Olympic Peninsula and adjacent offshore regions, the area of the proposed OCS Lease Sale 132, and the area highlighted by the Minerals Management Service (MMS).
The geologic history relevant to petroleum accumulation in coastal Washington began with deposition of the area's oldest unaltered sedimentary rocks, the Ozette Sandstone (Pc), at about 200 million years ago. The Ozette Sandstone is the oldest formation in the region and the base of the sedimentary sequence that eventually led to the formation of the Olympic Mountains.

The Ozette and Hoh sequences are composed mainly of sandstones, siltstones, and shales that were deposited in deep water on the Pacific Ocean floor between approximately 50 and 15 million years ago (Snavely, 1985). These sediments were subsequently eroded and transported to the shallow shelf, where they were deposited to form a thick sequence of sandstones, siltstones, and shales. This sequence is known as the Ozette-Hoh Sequence.

The Ozette-Hoh Sequence is divided into two main units: the Ozette Sandstone and the Hoh Formation. The Ozette Sandstone is composed of fine-grained sandstones and siltstones that were deposited in a shallow marine environment. The Hoh Formation is composed of fine-grained silts and clays that were deposited in a deeper marine environment.

The Ozette-Hoh Sequence is an important reservoir for oil and gas in the western Olympic Peninsula. The sedimentary rocks in this sequence contain significant amounts of hydrocarbons, which have been trapped in reservoir rocks that are competent to contain oil and gas.

The Ozette-Hoh Sequence has been studied extensively for its potential for oil and gas accumulation. The sequence is divided into several formations, each with different characteristics that affect its potential as a reservoir.

The Ozette Sandstone is the oldest formation in the area and is composed of fine-grained sandstones and siltstones. These sediments were deposited in a shallow marine environment and contain significant amounts of hydrocarbons. The Hoh Formation is composed of fine-grained silts and clays that were deposited in a deeper marine environment. These sediments contain lesser amounts of hydrocarbons compared to the Ozette Sandstone.

The Ozette-Hoh Sequence has been the subject of extensive geophysical and geotechnical studies to determine its potential for oil and gas accumulation. These studies have shown that the sequence contains significant amounts of hydrocarbons, which have been trapped in reservoir rocks that are competent to contain oil and gas.
Ash Grove Cement West, Inc. mined, crushed, screened, and stockpiled 45,000 tons of silica at their Superior quarry. The mine, which began operation in 1987, supplies silica primarily for the production of portland cement; however, other uses include aggregate, decorative stone, sandblast sand, and roofing granules. The low-alumina, microcrystalline quartz deposit consists of altered and silicified Miocene volcanic rock.

Mutual Materials Co. was the largest clay producer in the state. The company mined shale from two pits in the county.

**Lincoln County**

Dolomite was mined by Blue Silver Mining from the Crystalline Crust mine. The white rock is reported to contain 31.5 percent CaO and 21 percent MgO.

**Okanogan County**

Ciment Quebec Inc. has proposed building the dry-process, state-of-the-art $80 million Interstate Portland Cement, Inc. plant near Ellensburg. The company has signed an option for the high-calcium Reed Limestone property on the west side of the Okanogan River with CN Silver Mines, Inc., a wholly owned subsidiary of Lucky Three Mining Co. The company plans to move the limestone from "White Rock, Northmont" by conveyor to the portland cement plant on the east side of the river. The project is on standby while a new permitting and financing strategy is developed by the company.

Columbia River Carbonates, a limited partnership of Bleak Management, Inc. and Geislar Carbonates Inc. mined and crushed 35,000 tons of high-calcium-carbonate rock at their Wasonoma quarry. The white marble is sent by rail to the Columbia River Carbonates plant at Woodland, near Vancouver, where it is ground to fine and ultrina powder and slurry.

Pacific Calcium Inc. continues to mine limestone and dolomite from the Tonasket Limestone quarry. The carbonate is crushed in Tonasket and sold for poultry feed and soil amendment and as a lawn-care product.

**Pend Oreille County**

Lehigh Portland Cement Co. produced 241,860 tons of limestone from the Cinnamah Phase. The limestone is mined from the Cambrian-Ordovician Maitland Formation for use in the production of portland cement. Lehigh is the only company in the state to produce portland cement from limestone that is mined in Washington.

United Catalysts Inc., in joint venture with First Miss Gold Inc., continued exploration at their Totem Sile property in the northeasternmost part of the county. Drilling and bulk sampling were done at the property in a shear zone in the Late Proterozoic Monk Formation.

**Skagit County**

Applied Industrial Materials Corp. (AIMCOR) crushed and screened olivine purchased from an outside source. The company produces olivine flour for use as foundry and blast sands.

AIMCOR was honored by the Pacific Northwest Region of the U.S. Forest Service for "exceptional environmental stewardship" of public lands exhibited in their reclamation project at the Twin Sisters quarry in the Mt. Baker-Snoqualmie National Forest (Joseph, 1988).

**Spokane County**

Interpace Industries Inc. continued production of clay from the Mica and Potratz pits near Mica. Structural bricks produced at the plant, including popular light-colored bricks, are sold nationwide.

**Stevens County**

Northwest Alloys Inc., a wholly owned subsidiary of Aluminum Co. of America, mined 760,000 tons of dolomite from the Addy Dolomite quarry. North-west Alloys mine and plant at Addy is now the highest value mineral operation in the state because of its high volume of production and the value added to the dolomite by the production of magnesium metal at the plant. The company is one of only three producers of magnesium metal in the United States and can produce 15 to 20 percent of the world plant capacity for the metal. The company employed more than 500 workers in 1986 and continues as the largest employer in Stevens County (TEAM WASHINGTON, 1986).

In April, Northwest Alloys resumed the production of 75 percent ferroSilicon at their Addy plant. FerroSilicon is used in the silicothermic process (whereby magnesia in calcined dolomite is reduced by silicon) employed at the magnesium plant. The company had been purchasing ferroSilicon since the furnaces were shut down in 1985, but the company resumed production because of the increase in price due to increased demand from the steel industry (Clevy, 1988). Mining of silica resumed at the Blue Creek quarry near Addy in order to supply the ferroSilicon plant. The quarry produced 20,000 tons of quartzite from the Addy Quarzite.

L-Bar Products Inc. continued to produce ferroSilicon from magnesia sludge from the Northwest Alloys plant. The fertilizer is marketed as "Ag Mag R.C."

Hemphill Brothers Inc. operated two industrial mineral properties in the county. Lane Mountain Silica Co., the largest silica producer in the state, produced 230,000 tons of high-purity silica from a

![Figure 2](https://example.com/figure2.png)

**Figure 2.** Plots of porosity and permeability data obtained from analysis of cores from numerous sandstone wells. (a) Data from the Hoh and Quette rocks show that most samples have permeabilities less than 50 md; porosities less than 25%. For commercial offshore production, permeability must exceed 50 md to permit adequate flow rates. The high clay content of Hoh and Quette sandstones reduces the effective porosity below the measured porosity values shown in this figure. (b) Porosity-permeability data for the sandstone member of the Montesano Formation, a 600-fthick massive sandstone drilled in the Ocean City core area. Porosities of this sandstone generally range from 26 to 2.50 per cent, and permeabilities range from 2.5 to 32%. These porosities and permeabilities compare favorably with those of sandstone reservoirs in many of the world’s major field; this thick sandstone presents an attractive petroleum exploration target.
and claystones suitable for sealing underlying sandstone reservoir horizons. Minor shows recorded in the thick Montesano sandstone unit encountered in the Ocean City area indicate that gas, and possibly oil, have migrated into this sandstone at some time in the past. However, our work suggests that the overlying shale zone was breached by erosion approximately 5 million years ago, and, consequently, oil and gas that may have accumulated in the sandstone escaped.

**Traps**

Anticlinal folds in stratified rocks having potential to trap petroleum are generally located using seismic reflection surveying. This geophysical technique involves reflecting sound waves off buried strata in the same fashion that sonar locates submarines. The reflection data is used to map the geometry and approximate depth of anticlinal folds (Fig. 3). The seismic reflection data are generally acquired along shotlines laid out as an intersecting grid.

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**Figure 3.** A seismic reflection profile acquired in 1967 approximately 10 miles offshore from the mouth of the Queets River during Cruise 10 of the University of Washington RV Oceanographer. The ocean surface is at 0.0 seconds two-way travel time (TWT), and the sea floor is at approximately 0.075 seconds TWT, which corresponds to a water depth of 190 feet. The series of laterally continuous black and white horizons recorded below the sea floor corresponds to reflections from discrete sedimentary strata and are termed events. This profile shows steeply dipping strata on the flanks of an anticline that have been transected by erosion along event A. Nearby horizontal sediments have been deposited above horizon B; these strata have been displaced by a fault, indicated by the heavy vertical line near the center of the profile. This fault disrupts the sea-floor topography, indicating that fault movement is recent. The horizontal events recorded below 0.125 seconds TWT are multiple echoes of the strata lying between the sea floor and event A. The events reflecting from the strata on the flanks of the anticline continue through this spurious "sea-floor multiple." This seismic reflection profile images sedimentary strata approximately 500 feet below the sea floor; other seismic profiles presented in Palmer and Lingley (1989) image strata to approximately 10,000 feet below the sea floor.

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**Table 3.** Properties producing industrial minerals, 1988.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Property</th>
<th>Owner and/or Operator</th>
<th>County</th>
<th>Production and development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>Twin River quarry</td>
<td>Ideal Basic Industries, Inc.</td>
<td>Clallam</td>
<td>Mined 100,000 tons</td>
</tr>
<tr>
<td>Clay</td>
<td>Mica mine, plant and Potter's pit</td>
<td>Interpace Industries Inc.</td>
<td>Spokane</td>
<td>Mining</td>
</tr>
<tr>
<td>Clay</td>
<td>Elk pit</td>
<td>Mutual Materials Co.</td>
<td>King</td>
<td>Mined 28,500 tons</td>
</tr>
<tr>
<td>Clay</td>
<td>Sec. 31 pit</td>
<td>Mutual Materials Co.</td>
<td>King</td>
<td>Mined 85,000 tons</td>
</tr>
<tr>
<td>Clay</td>
<td>Harris/Blum</td>
<td>North American Refractories Co.</td>
<td>King</td>
<td>Hauled from stockpile</td>
</tr>
<tr>
<td>Diatomite</td>
<td>Sec. 7 and 8 pits</td>
<td>Witco Corp.</td>
<td>Grant</td>
<td>Mined 350,000 tons</td>
</tr>
<tr>
<td>Diatomite</td>
<td>Sec. 17 pit</td>
<td>Witco Corp.</td>
<td>Grant</td>
<td>Mined 30,000 tons</td>
</tr>
<tr>
<td>Dolomite</td>
<td>Crystal City mine</td>
<td>Blue Silver Mining</td>
<td>Lincoln</td>
<td>Mined 30,000 tons</td>
</tr>
<tr>
<td>Dolomite</td>
<td>Several quarries</td>
<td>Nanone Aggregates, Inc.</td>
<td>Stevens</td>
<td>Mined from several pits</td>
</tr>
<tr>
<td>Dolomite</td>
<td>Addy Dolomite quarry</td>
<td>Northwest Alloys, Inc.</td>
<td>Stevens</td>
<td>Mined 760,000 tons</td>
</tr>
<tr>
<td>Limestone</td>
<td>Bear Mountain pit</td>
<td>Clauson Lime Co.</td>
<td>Whatcom</td>
<td>Mining</td>
</tr>
<tr>
<td>Limestone</td>
<td>Wauconda quarry</td>
<td>Columbia River Carbonates</td>
<td>Okanogan</td>
<td>Mined 35,000 tons</td>
</tr>
<tr>
<td>Limestone</td>
<td>Champan Place</td>
<td>Lehigh Portland Cement Co.</td>
<td>Pend Oreille</td>
<td>Mined 241,860 tons</td>
</tr>
<tr>
<td>Limestone</td>
<td>Northport Limestone</td>
<td>Northport Limestone Co. (Hespahill Brothers, Inc.)</td>
<td>Stevens</td>
<td>Mined 45,000 tons</td>
</tr>
<tr>
<td>Limestone</td>
<td>Tenaker Limestone quarry</td>
<td>Pacific Calcium, Inc.</td>
<td>Okanogan</td>
<td>Mining and milling</td>
</tr>
<tr>
<td>Olivine</td>
<td>Almior Olivine</td>
<td>Applied Industrial Materials Corp.</td>
<td>Skagit</td>
<td>Crushing and screening</td>
</tr>
<tr>
<td>Olivine</td>
<td>Swan Larsen quarry</td>
<td>Olivine Corp.</td>
<td>Whatcom</td>
<td>Mining</td>
</tr>
<tr>
<td>Silica</td>
<td>Superfort quarry</td>
<td>Ash Grove Cement West, Inc.</td>
<td>King</td>
<td>Mined 45,000 tons</td>
</tr>
<tr>
<td>Silica</td>
<td>Ravensdale pit</td>
<td>L-Bar Products, Inc.</td>
<td>King</td>
<td>Mining</td>
</tr>
<tr>
<td>Silica</td>
<td>Lane Mountain Silica</td>
<td>Lane Mountain Silica Co. (Hespahill Brothers, Inc.)</td>
<td>Stevens</td>
<td>Mined 300,000 tons</td>
</tr>
<tr>
<td>Silica</td>
<td>Blue Creek mine</td>
<td>Northwest Alloys, Inc.</td>
<td>Stevens</td>
<td>Mined 20,000 tons</td>
</tr>
</tbody>
</table>

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King County

L-Bar Products, Inc., continued mining silica at their Ravensdale pit. The sand is mined, washed, screened, and dried to produce silica for making colored bottles and cement. The sand is mined from the Eocene Puget Group.

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Snookomish County
Several companies and individuals explored for precious metals in the Sultan River drainage, including Island Arc Mining Corp. and Jeanne Ring. Recreational placer mining has been popular in the county.

Stevens County
Boise Cascade Corp., in joint venture with Pathfinder Gold Co., continued to explore for gold and silver in the Okanogan area. Drilling continued at this epithermal vein deposit in the Sampull Volcanics near the contact with the Klondike Mountain Formation.

These joint venture partners have also been exploring the McNally-Freedom claims held by Western Land and Resources, where geologic mapping, soil geochemistry, and a geophysical survey were conducted.

Boise Cascade Corp. also continued exploration at their Fiilfilline Creek property. The prospect contains gold-bearing massive sulfide veins in the Jurassic Rosland Volcanic Group. The company also continues to explore for metals on other corporate lands in the county.

Vanhorn and Watson Mining Co. conducted geological mapping and core drilling at their Copper Penny property. Mapping and sampling were accomplished at their Gold Nugget property. Both of the prospects, which are under lease to Walaine Exploration Co., are in the Rosland Volcanic Group.

Cheeveh Eagle Mining Co. continued exploration for base metals and silver on their claims near Cheelah Mountain.

United Copper Mines engaged in minor work on their claims in the Cheelah Mining District. Lead-zinc exploration continued at their lead-zinc-silver properties in the Metaleine Formation in the Northport Mining District.

At the H and B mine Blue Silver Mining removed 25,000 tons of ore and mined 6,000 tons of material. The precious and base metal veins at the property are in Precambrian metasedimentary rocks.

The capital assets of the Deer Trail mine, owned by Cortez International Ltd., were liquidated to satisfy debts owed by the company. The Deer Trail mine was in operation from 1961 to 1984. The company holds state mineral leases in the area to explore the potential of the Turk magnetite deposit.

Union Pacific Resources Co. explored for uranium in the county.

Whatcom County
Steelhead Gold, a wholly owned subsidiary of Steelhead Resources Ltd., continued to explore the Excelsior mine east of Glacier. The company announced reserves of 4.1 million tons grading 0.042

c/ton gold and 2.6 oz/ton silver after an extensive drilling program in 1987. Sampling done in 1988 examined possible extensions of the mineralization to the west of the deposit. The deposit, which was previously drilled by United States Borax & Chemical Corp., is hosted by volcanic and sedimentary rocks of the Jurassic Wells Formation.

In the Slate Creek Mining District, Western Gold Mining Inc., did surface and underground sampling at the New Light mine. Seattle-St. Louis Mining Co. continued core exploration on the quartz vein at the Minnesota mine.

Statewide

INDUSTRIAL MINERALS
Development and Exploration
Seventeen companies produced industrial minerals from 21 sites during 1988 (Table 3). Value-adding processing increased the value of the state's industrial minerals. Northwest Alloys, Inc., mine and plant in Stevens County was the highest-value industrial mineral operation in the state because of the value added to dolomite through the production of magnesium metal. Limestone was generally used in the manufacture of portland cement. Silica was produced by two companies for use in cement and structural bricks. Dimontite was produced by one company, and two companies made products from olivine mined in the state.

Clallam County
Ideal Basic Industries, Inc., produced 100,000 tons of clay and 44,400 tons of whiting. The company expanded to their Seattle plant, where it is used in the manufacturing of portland cement. The clay is mined from weathered mudstone in the Twin River Group of Oligocene age.

Grant County
Wilco Corp. continues to be the sole producer of diatomite in the state. Production in 1988 increased significantly over that in 1987 with the bulk of the production from the pit in section 8. The company has used seismic reflection data acquired by the U.S. Geological Survey (Mann and Steavy, 1984; McClein and Steavy, 1987, 1988), the Sound Imaging Corporation (Hillberry, 1979), and the University of Washington (Bennett and others, 1969a,b; Bennett and Henry, 1969) to evaluate possible domes on the Washington OCS that may act as oil and/or gas traps. The grid spacing of public-record seismic profiles is greater than the resolution needed to define the trap. Therefore, it is probable that we have been unable to identify many potential traps. Similarly, the wide spacing of seismic profiles prevents accurate mapping of all dimensions of potential traps as well as limiting the ability to demonstrate that the identifiable anticlines have domal configurations. However, we can demonstrate that many folded structures exist in the offshore region, and we anticipate that some of these may act as traps.

Results of Previous Offshore Drilling
For several exploration wells have been drilled offshore of Washington. The State of Washington leased oil and gas rights in its territorial waters during the period from 1960 to 1964. The Union Oil Company drilled the first deep offshore exploratory well, the Tidelands State No. 2, in 1962, but no commercial reservoir rocks were encountered. In 1964, an offshore oil and gas lease sale was conducted by the Department of the Interior on the Washington and Oregon OCS. Webster Three Washington OCS exploratory wells (the Shell P-0150/150A and P-0155, and the Pan American P-0141) were drilled on leases purchased during this sale at prices ranging from $5 to $310 per acre (Webster, 1985). Small flows of gas were tested in the P-0150A and traces of oil were logged in both wells. The P-0155 Montesano Formation sandstone reservoirs were not present in two of the OCS wells. In the P-0155, a thick Montesano sandstone was present, the seal was inadequate. All four offshore exploratory wells were abandoned as dry holes. These results, however, do not condemn the area, many major oil and gas producing areas worldwide have had more than 25 dry holes drilled prior to the initial discovery.

OIL AND GAS POTENTIAL OF THE WASHINGTON ONSHORE AND OFFSHORE OCS
Petroleum exploration is an intermittent process that is controlled by data availability, technological knowledge, results of previous exploration, and economics. Offshore exploration ceased in the late 1960s because of the lack of encouraging results from the four offshore wells. Since that time, geophysical data have improved significantly in both quality and quantity, and technical knowledge has increased substantially. Increased exploration interest in the Washington continental shelf is foreseeable because of these factors, and because most areas favorable for easy discovery of large oil or gas accumulations worldwide have been thoroughly assessed by drilling.
Johnson, Explorations conducted geological and geochemical exploration seeking gold in an alluvial deposit on the Irish claim group.

Other companies exploring in the county include Antilles Resources Ltd., which explored for gold, and Boise Cascade Corp. engaged in reconnaissance exploration for gold on company lands in the county. Union Pacific Resources Co. explored for uranium.

King County

Weberhauser Co. completed a third season of reconnaissance drilling and mapping at their White River property. The company is seeking gold and copper in quartz-albite-alterated Mocene volcanic rock. Mineralisation is structurally, temporally, and genetically related to the margin of a Miocene caldera (McCulla, 1986).

Cannon Minerals explored for gold-bearing veins in intrusive rocks at El Watlah property near the North Bend. Precious metals in Mocene volcanic rocks with quartz-albite alteration were targeted by the company at their White River property. Mark Wagner continued exploration on claims near Conely Basin near Skykomish.

Okanogan County

Exploration has increased in Okanogan County as those seeking precious metals have "moved west" from the Republic graben area into areas with similar geology.

Several companies explored for precious metals west of the Okanogan River. Newhawk Gold Mines Ltd., in joint venture with Reliant Resources, Ltd., and Need Resources Corp., did limited trenching, drilling, and geochemical sampling at their Smith Canyon property. Newhawk Gold reported that although the indications were not overly encouraging, the property was returned to the Reliant Resources/Nord Resources joint venture (Newhawk Gold Mines Ltd., 1987).

ECM Inc. conducted geological, geochemical, and geophysical exploration at the Alder mine. The gold-silver-copper property 5 miles southwest of Twin Pines is the Lower Cretaceous Buck Mountain Formation.

Quintana Minerals Corp. continued exploration at their American Flag property near Mazama.

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Pend Oreille County

Resource Finance Corp. (RFC) has entered into an option purchase agreement with Pinnlar Corp., a wholly owned subsidiary of Gulf Resources and Chemical Corp., to acquire the assets of the Pend Oreille mine. The new Canadian company can exercise the option on the core of the underground mine for $1.25 million. Prior to beginning underground development, dewatering of the mine will be required. The pre-feasibility study began at the mine in 1985.

Bunton Mining Corp. joint venture with Crown Resources Ltd. drilled 3,000 feet and conducted geological mapping and soil and rock sampling at the Bodie mine. The property, which was last mined in 1944 (Moen, 1980), is located in the Toroda Creek graben and is in Eocene volcanic rocks.

Several companies explored for precious metals west of the Okanogan River. Newhawk Gold Mines Ltd., in joint venture with Reliant Resources, Ltd., and Need Resources Corp., did limited trenching, drilling, and geochemical sampling at their Smith Canyon property. Newhawk Gold reported that although the indications were not overly encouraging, the property was returned to the Reliant Resources/Nord Resources joint venture (Newhawk Gold Mines Ltd., 1987).

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Crowne Resource Corp., in joint venture with Sutron Resources, Inc. and Texas Star Resources Ltd., completed more than 15,000 feet of core holes and 3,000 feet underground long holes for a total of more than 2,700 feet at the Seattle mine. The mine, which produced limited tonnage in 1984, contains narrow high-grade veins in sediments and tuffaceous rocks of the lower Sanpoil Volcanics.

Crowne Resource Corp., in joint venture with Gold Resources Ltd., continued reconnaissance drilling, geological mapping, and geochemical sampling at their Queen Elizabeth property. Epithelial gold-bearing quartz veins in the Sanpoil Volcanics are the exploration target.

North of the Kettle mine, Asarco Inc. drilled 1,500 feet of core and conducted mineralogical work and geophysical surveys at their Curlew project. To the north on an adjacent property, United States Borax & Chemical Corp. drilled two holes at their Wheaton Ranch property. Both prospects are in the Sanpoil Volcanics.

Morning Star Mines, Inc., worked to rehabilitate the Morning Star mine and began bulk sampling in the area of previous mining. The gold and copper mines have been active since World War II.

N. A. Degestrom, Inc., in joint venture with Island Gold and Silver Corp. and Pegasus Gold Corp., continued exploration on their Island property, directly west of the Overlook and Key properties of Echo Bay. Geologic mapping and magnetic surveys were conducted, and drilling was undertaken to test magnetite anomalies. The 8-square-mile property consists of mining claims and private land.

United States Borax & Chemical Corp. drilled more than 2,000 feet of core and 3,000 feet of underground long holes, 1,500 feet of core and conducted mineralogical work and geophysical surveys at the Kettle mine. The mine was active in mid-1987.

Crowne Resource Corp., in joint venture with Sutron Resources Ltd. and Texas Star Resources Corp., conducted delineation drilling at the South Penn property. Twenty-one reverse-circulation and three core holes for a total of 5,700 feet were drilled at the epithermal gold and silver deposit in the Sanpoil Volcanics. The drill program has enlarged the area of previously defined mineralization and discovered new areas of high-grade mineralization at depth (Mining Record, Nov. 30, 1988). Chemgox, Inc. claimed a small heap-leach operation at the deposit that they developed in 1987.

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The topic for the 5th annual symposium of the Northwest Petroleum Association, to be held May 30, 1989, will be the hydrocarbon potential of the Columbia Basin, Oregon, and Washington. Emphasis will be on the potential for producing offensive and oleaginous products with studies underlying the Columbia River, Columbia Basin, and the Columbia River. Technical presentations and two days of field trips are scheduled. For more information, contact Phil Bogan, 1426 NW Harrison Bldg., Bend, OR 97701; (503) 382-0650.

Republic grain. The number of claims located in the county has more than doubled in the past 2 years; the present total is approximately 3,000 claims (Doug Dauer, Ferry County Planning Dept., 1989). Most of these claims are located in the northern part of the county, north of the Cowlitz River. A number of the companies that reported working in the area explored for gold in epithermal veins in the Eocene Soper Formation and for replacement deposits in Paleozoic sedimentary rocks (Fig. 3).

Echo Bay Mines Ltd. announced in November that they will put two underground mines into production in early 1990. The Kettle and the Overlook mines are a joint venture with Crown Resource Corp. and Gold Texas Resources Ltd., each of whom own 15 percent. More than $13 million has been spent on the two properties to date, and an additional $47 million will be spent to put the mines into production (Echo Bay Mines Ltd., third quarter report, 1988).

Reserves for the two properties have been estimated at 3.5 million tons of ore averaging 0.189 oz/ton gold; however, the deposits have not yet been fully delineated. Consultants to Echo Bay estimate that the two mines will produce 729,000 ounces of gold. Production is expected to be 110,000 ounces of gold per year the first 2 years, with annual production of 85,000 ounces thereafter in a cost of 300 per ounce. Employment is projected to be between 10 and 150 workers.

The kettle mine is located a mile west of Curlew. The 3,500-foot spiral decline began in 1987 has been completed, and underground drilling was undertaken in 1988 to further define the banded and brecciated epithermal lithocap and breccias veins. Echo Bay estimated that production from the mine will be 300 to 500 tons per day. The one will be processed from the Kettle mine, the Overlook deposit 8 miles northeast of Republic.

The Overlook mine will be an underground mine at which production is estimated to be 1,000 to 1,500 tons per day. The mine, beneath Cooke Mountain, will be accessed by a 2,700-foot adit. An underground deposit of the uppermost part of the deposit, provide ventilation, and serve as an escape way. The deposit is a magnetic replacement deposit, and its structural and stratigraphic setting is a small, flat-lying deposit in the overlying clastic sedimentary rocks, all of which are intruded by an Eocene dike. The Overlook deposit has the highest grade ore of the three deposits tested by Echo Bay near Cooke Mountain; the other two deposits are the Key East and Key West deposits (Fig. 4).

One ore from the Kettle and Overlook mines will be processed at the Key mill (Fig. 4). The conventional mill will be designed to process 1,500 to 2,000 tons per day and will use tank flotation. Tailings will be pumped to tailings embankments adjacent to the mill site.

Heck Mining Co. has expanded their exploration program in the Republic area, where the company has a land position consisting of more than 8 square miles. Drilling has been concentrated in the

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At the old Lovitt mine, 2 miles south of the Cannon mine, a surface and underground drilling program was conducted by the joint venture partners to evaluate the Wenatchee D reef as an open-pit heap-leach target (Asamera Minerals, Inc., first quarter report, 1988).

Montana de Oro, Inc. removed overburden, opened old mine adits, and drove 300 ft of new drifts at their property in the Blewett Mining District. The property consists of quartz-calite-talc-sulfide veins in serpentinized ultrabasic rock.

Raven Hill Mining conducted geological exploration and sampling at their lode and placer deposits in the Chisaukum graben.

Sunshine Valley Minerals, Inc. continued separation of slime and sand at the How-Sound tailing piles from the old Holden mine. The U.S. Forest Service is planning to reclaim the tailing pile because of the possible threat of sedimentation to Lake Chelan during a major flood.

Welcome Nugget Mines continues to explore their placer claims on the upper Wenatchee and Little Wenatchee Rivers.

Ferry County
Ferry County was the area in which a large part of the state's exploration activity took place in 1988. Most of the exploration was centered around the

Nearly 1 million ounces of gold were produced from the Lovitt mine (Golden King mine) between 1949 and 1967. The Cannon mine is located to the northwest of the Lovitt mine, on the opposite side of the ridges. The view is to the northwest from Wenatchee Heights; Rooster Comb is to the right. (Photo by Roger Gill, Asamera Minerals [U.S.] Inc. Exploration.)

Aerial view of the Cannon mine surface facilities from the south. The trackless underground mine has been in operation since mid-1985, and has produced more than 400,000 ounces of gold. The city of Wenatchee is in the background in the upper right. (Photo courtesy of Asamera Minerals, Inc.)

COAL ACTIVITY IN WASHINGTON—1988
By Henry W. Schasse

Coal exploration activity in Washington continued at a low level because the coal market remains soft. Only one company explored for coal (in Whatcom County) during 1988.

The two Washington coal mines that operated during 1987 continued to produce coal during 1988. The Centralia Mine, operated by Washington Irrigation and Development Company (WIDCO), located 5 miles northeast of Centralia, Lewis County, in the Centralia-Chehalis Coal District, continued to be the state's largest coal producer. Pacific Coast Coal Co. (PCCC) continued to increase its production at its 2-year-old John Henry No. 1 Mine, located approximately 2 miles northeast of Black Diamond, King County, in the Green River Coal District. WIDCO produced 5,034,935 clean short tons of subbituminous coal during 1988; this is approximately 639,000 tons more than it produced during 1987. The Centralia mine has produced an average of 4.1 million tons per year since it began production in 1971. The mine supplies the steam power plant located approximately a mile from the mine. Coal mined at Centralia comes largely from five coal seams that are stratigraphically near the middle of the Skookumchuck Formation, an upper member of the Eocene Puget Group. Coal production for 1988 was principally from two of those seams, the Smith and Big Dirty coal seams.

PCCC completed its second full year of production at its John Henry No. 1 mine, producing 110,157 short tons of bituminous coal. This represents an increase of 61,000 tons over its 1987 production. A large share of its 1988 production went to WIDCO to blend with coal mined at Centralia in order to maintain sulfur dioxide emissions within state and federal environmental limits at the Centralia steam plant. PCCC also supplied coal to state institutions at Monroe and Shelton and to the U.S. Navy submarine facility at Bangor for their heating plants. In addition, some coal was sold to the Ideal Cement Company.

PCCC mined the Franklin Nos. 7, 8, 9, and 10 coal seams during 1988. (Figure 1). These coal seams, which have a high volatile B bituminous rank, occur stratigraphically near the base of the Eocene Puget Group sediments in the Green River Coal District (Schasse, 1987). PCCC continues to truck its coal to a wash plant operated by Palmer Coking Coal Co. at Black Diamond. Its plans for a new beneficiation plant at the mine remain on hold until it has acquired sufficient long-term contracts from industrial customers to justify the necessary capital outlay. The John Henry No. 1 mine has a design capacity of 250,000 tons per year. It currently mines its coal at an overall recovery of 75 percent.

Crvat Coal Company of Cadr, Ohio, drilled 10 to 20 shallow exploratory holes on the No. 1 (Discovery) coal seam in the Glacier coal field in north-central Whatcom County from June through August 1988 (Schasse, 1988). On the basis of reportedly disappointing results from their drilling, Crvat Coal Co. elected to drop its lease with the A. Firchau es-

Figure 1. View east toward the west ridge in Pit No. 1 of John Henry No. 1 open-pit coal mine, 2 miles northeast of Black Diamond, August 1988. The highwall exposes the Franklin nos. 7, 8, and 9 coal seams in a faulted antitcline; these are highlighted by several thin, light-colored, volcanic ash beds.

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tate, which leases the Glacier coal field from the land owner, the Glacier Land Co. Representatives of the Flitchau estate have elected to keep details of the past summer's exploratory drilling proprietary at this time.

References Cited

Geologic Hazards Program—Continued

It was the consensus of the participants that during the next decade the NEHRP effort should shift resources from pure research to applied research, data translation, and application of knowledge by state and local governments. It was also recommended that an oversight commission be established to advise the four federal agencies that are responsible for carrying out NEHRP under the auspices of the Earthquake Hazards Reduction Act. A more effective hazards reduction program should result. The report will be released by the USGS as Open-File Report 88-13B.

A portion of the NEHRP review workshop was devoted to receipt of information about the International Decade for Natural Hazard Reduction. The initial proposal at the United Nations was sponsored by 94 countries. As it was not supported by the U.S., the proposal failed. A substitute U.S. program under the auspices of UNESCO was adopted, its committee consisting of 26 nations, each having one representative and the U.S. having two members. The meeting held in Geneva, Switzerland, in July, then in Nice, France. The final meetings during January and March 1989 will be held in Morocco and Japan, respectively. The first U.S. meeting of the corresponding U.S. Decade for Natural Disaster Reduction took place in mid-October. It was agreed that the program decade would start January 1, 1990; that the national effort would be handled by a U.S. committee with an academic chairperson; and that the National Academy of Sciences (NAS) would act in an advisory capacity and direct the new administration team by February 1, 1989. Serving on the U.S. committee will be a federal secretariat with representation from USGS, National Oceanic Atmospheric Administration and the U.S. Forest Service. Funding will be provided by the USGS and NAS.

A consortium of state and local governments, academic institutions, professional associations, and others will implement the program objectives. Rapid onset hazards highlighted for study and information transfer are earthquakes, volcanic eruptions, tsunamis, landslides, wind storms, and wildfires; also to be considered is drought. Several national demonstration projects have been suggested, including one for the Pacific Northwest. More is to come on this subject during 1989 as concepts are formalized by the U.S. Committee for Natural Hazard Reduction.

The Geohazards '88 symposium was held at the western Regional headquarters of the USGS in Menlo Park, Calif., and was a collaboration of knowledge producers and knowledge users. Attendance was about equally divided between geologists, seismologists, and hydrologists on the one hand, and urban planners, emergency management specialists, and elected officials on the other. The conference consisted of four sessions highlighting current USGS research on the identification and mitigation of geologic hazards, particularly in western states. USGS and California Division of Mines and Geology (CDMG) seismologists described their efforts at predicting the probabilities and effects of earthquakes along the San Andreas Fault, principally in the Los Angeles and San Francisco areas. USGS geologists discussed landslide hazards and volcanic hazards. The discussion of landslides focused on efforts to describe, catalog, and predict landslides in the San Francisco Bay region. Volcanic hazards in the Cascade Range were described, and attempts to project future volcanic activities in eastern California were discussed. USGS hydrologists discussed water pollution both in San Francisco Bay and in the San Joaquin Valley. Most of the talks were also presented as poster sessions.

Following the formal sessions there was a lively panel discussion of the pitfalls of disseminating scientific information about geologic hazards to local officials charged with implementing appropriate measures. Of particular interest was the effect of a volcanic eruption warning on the affected community. Considerable distrust was generated because the warning appeared in the press before the official announcement. It was alleged that the ensuing hysteria depressed property values in a popular resort area, undermining the need for carefully timed and planned communications.

Figure 2. Estimated gold production in Washington. The production estimate for 1988 reflects record production from the two major gold mines in the state. Production increased dramatically beginning in 1985 as a result of the opening of the Canyon mine and increased production at the Republic Unit.

The District has available 30 copies of the December 1989 Monthly Bulletin of the State College of Washington, v. 22, no. 1, which includes the following articles: McGrew, J. G., Directional properties of worked magnetite alloys. Cuber, H. E., Some geologic aspects of the magnetic deposits of Washington. Send your request to Ray Lemaerts, State Geologist (see address on p. 2 of this Newsletter).

Table 2. Properties producing base and precious metals, 1988.

<table>
<thead>
<tr>
<th>Property</th>
<th>Owner and/or operator</th>
<th>County</th>
<th>Production and development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cannon mine</td>
<td>Asamena Minerals (U.S.) Inc.</td>
<td>Chelan</td>
<td>Produced 146.695 oz of gold and 250,000 oz of silver</td>
</tr>
<tr>
<td>H and B mine</td>
<td>Blue Silver Mining Stevens</td>
<td>Ferry</td>
<td>Mined 6,000 tons of rock containing lead, zinc, silver, and gold</td>
</tr>
<tr>
<td>Republic Unit</td>
<td>Necla Mining Co.</td>
<td>Ferry</td>
<td>Produced 70,000 oz of gold and nearly 290,000 oz of silver</td>
</tr>
<tr>
<td>Gold Dike</td>
<td>Vulcan Mountain, Asamena</td>
<td>Flood</td>
<td>Processed gold heap leach operation for part of the year</td>
</tr>
</tbody>
</table>

Exploration

Sixty-two companies reported exploring for metals in Washington in 1988, and with few exceptions, they were exploring for precious metals. Exploration dollars spent for metals in the state increased significantly. A value estimated from the voluntary replies to the questionnaires sent to operators of mineral properties in Washington indicates that a minimum of $13 million was spent for metal exploration in 1988 as compared to a minimum of $3.5 million reported in 1986. These figures can only be used for comparison because not all expenditures for exploration and development are reported on the returns submitted.
Table 1. Mineral exploration and development in Washington, 1988, continued.

<table>
<thead>
<tr>
<th>Loc. County</th>
<th>Owner/Operator</th>
<th>Property</th>
<th>Location</th>
<th>Commodity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 Whatcom</td>
<td>Seattle-St. Louis Mining Co.</td>
<td>Minnesota mine</td>
<td>sec. 2</td>
<td>Au, Ag</td>
<td>Exploration</td>
</tr>
<tr>
<td>81 Whatcom</td>
<td>Steelhead Resources Ltd.</td>
<td>Escalaion mine</td>
<td>sect. 5-6</td>
<td>Au, Ag</td>
<td>Announced reserves</td>
</tr>
<tr>
<td>82 Whatcom</td>
<td>Western Gold Mining, Inc.</td>
<td>New Light mine</td>
<td>sec. 27</td>
<td>Au, Ag</td>
<td>Surface and underground sampling</td>
</tr>
<tr>
<td></td>
<td>Cote Mines Inc.</td>
<td></td>
<td></td>
<td>Au</td>
<td>Property exam</td>
</tr>
<tr>
<td></td>
<td>American Copper and Nickel Company, Inc.</td>
<td></td>
<td></td>
<td>Au</td>
<td>Property exam</td>
</tr>
<tr>
<td></td>
<td>M. D. Regan &amp; Associates</td>
<td></td>
<td></td>
<td>Au</td>
<td>Property exam</td>
</tr>
<tr>
<td></td>
<td>Newman Exploration, Ltd.</td>
<td></td>
<td></td>
<td>Au</td>
<td>Exploration</td>
</tr>
<tr>
<td></td>
<td>Noranda Exploration, Inc.</td>
<td></td>
<td></td>
<td>Au</td>
<td>Reconnaissance</td>
</tr>
<tr>
<td></td>
<td>Pegasus Gold Corp.</td>
<td></td>
<td></td>
<td>Au</td>
<td>Property evaluation</td>
</tr>
<tr>
<td></td>
<td>Phelps Dodge Corp.</td>
<td></td>
<td></td>
<td>Au</td>
<td>Exploration</td>
</tr>
</tbody>
</table>

Additional 250,000 tons of reserves with an average grade of 0.335 oz/t gold in the B-north zone, below the 200-foot level, and 75,000 tons of reserves averaging 0.310 oz/t gold from an extension of the zone to the west. Exploration drilling in the B-4 zone has indicated anomalously mineralization to the east and the west (Asamena Minerals, Inc., second quarter report, 1988).

Mining methods employed at the underground trackless mine include mining by sublevel blast hole stoping, with backfilling of each sublevel as soon as the ore is removed. A 15-foot x 15-foot decline from the surface at a 15 percent slope provides access to the mine, one is hoisted in two skips in an 18-foot-diameter vertical shaft (Angell, 1988). The mine employs 205 people; their "operating cash cost" is $172 per ounce of gold.

Ferry County
Hecla Mining Co. continued high levels of production at the Republic Unit in Republic. The company produced 80,000 ounces of gold and nearly 290,000 ounces of silver from the Golden Promise veins, with an average gold grade of 0.96 oz/t. Production was 14 percent more than in 1987. The underground mine produces gold for $15 per ounce (including all costs), which makes it one of the lowest cost gold producers in the nation.

During the first quarter of 1988 the company announced that the Golden Promise area contained 1.2 million tons of reserves and mineralized rock averaging 0.5 oz/t gold. These reserves should extend the life of the mine for at least 7 years. The company has continued the exploration drilling program in the mine to further increase reserves.

Seven veins have been discovered in the Golden Promise area where production began in 1986. The northeasterly striking, southeast-dipping banded calc-silicate epithermal veins are in the Eocene Sanpoil Volcanics near the contact with the Klondike Mountain Formation. The veins are from 2 feet thick to 20 feet thick and have a vertical range of at least 800 feet. Gold occurs as electrum, native gold, sulfosalts, and tellurides.

Geothermal Drilling by the State of Washington in 1988

By Brent Barnett

From September to early November of 1988, the Washington Division of Geology and Earth Resources successfully completed the drilling of eight geothermal gradient test holes in the Cascade Range of southern Washington. Funding for the project was provided by a grant from the U.S. Department of Energy, with subordinate State matching funds. Drill site selection and project supervision were done by Brent Barnett and Michael Korosec of the Division staff.

The holes are located in the Gifford Pinchot National Forest along a line extending roughly south from Mount Rainier to near the Columbia River (Figure 1). This region was selected because of favorable results from earlier projects (Barnett and Korosec, 1986, Korosec, 1984, Schuster and others, 1978), and it was designed to fill gaps remaining in the area distribution of temperature gradient and heat flow data points. Young volcanic features, prominent faults, and other inferred structures were used as more specific criteria for selecting individual sites. Each of the eight holes was drilled to approximately 152 meters depth.

The results of down-hole temperature measurements from each hole are shown diagrammatically in Figure 2. Preliminary gradient values in °C/km (not corrected for terrain effect) are: Carlton Creek (DNR 88-3), 52; Chambers Creek (DNR 88-3), 58; Table Mountain (DNR 88-4), 56; Pin Creek (DNR 88-6), 50; Quartz Creek (DNR 88-7), 34; Shingle Mountain (DNR 88-8), 34.

Both the Snyder Mountain (DNR 88-2) and Babashio Ridge (DNR 88-5) holes appear to be isothermal down to 152 m, and thermally decoupled from regional crustal heat flow. These preliminary results confirm the existence of a widespread zone of high heat flow and temperature gradients, and have further delineated the extent of this significant geothermal energy target.

References Cited

Barnett, Brent; Korosec, M. A., 1986, Geothermal exploratory drilling by the State of Washington in 1985:

Figure 2. Temperature-depth curves for the 1988 geothermal gradient test holes. Readings were taken at 5-meter intervals in each hole. Large deviations on the curve of DNR 88-5 are due to the exothermic reaction of curing cement which was used in sealing the hole. The gradients of both DNR 88-5 and DNR 88-8 had not yet stabilized by the time of the last logging of the holes.

Final Interior Rulesmaking Increases Mining Law Fees in 1989

The Bureau of Land Management (BLM) has issued final rules that would facilitate greater cost recovery under its mining law administration program by revising certain existing fees and establishing new fees. The rules became effective Jan. 31, 1989.

According to BLM Director Robert F. Burford, the fee changes are being implemented under Title V of the Independent Offices Appropriation Act of 1952. Title V provides that federal agencies should recover costs of program administration for services that provide special benefits to identifiable nonfederal recipients above and beyond those accruing to the public at large.

"In Fiscal Year 1987, we recorded more than 167,000 new mining claims and processed about 654,000 filings of affidavits for assessment work," Burford said. "We also recorded and processed many other mining claim-related documents. This rulemaking allows us to recover more of the costs of administering this program."

In Oregon and Washington, there were 11,700 new mining claims recorded in FY 1987. More than 32,300 affidavits were filed for assessment work.

Burford indicated that the increased fees would generate nearly $4.5 million in additional annual revenues that, when combined with current revenues from existing fees, would make available approximately $5.2 million to be appropriated to BLM for the mining law program.

Burford emphasized that BLM has been sensitive to the impact this rulemaking might have on the

Table 1. Mineral exploration and development in Washington, 1988, continued.

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<tbody>
<tr>
<td>68 Stevens</td>
<td>Leadpoint Consolidated Mines Co.</td>
<td>Leadpoint Consolidated properties</td>
<td>secs. 12-13, T.5R.N., R.41E.</td>
<td>Ag, Pb, Zn</td>
<td>Surface sampling</td>
</tr>
<tr>
<td>69 Stevens</td>
<td>Ramone Aggregates, Inc.</td>
<td>Several quarries</td>
<td>secs. 7-8, 17-18, T.5R.N., R.42E.</td>
<td>Dolomite</td>
<td>Mining and processing</td>
</tr>
<tr>
<td>70 Stevens</td>
<td>Northport Limestone Co. (subsidiary of Hemphill Brothers, Inc.)</td>
<td>Northport Limestone</td>
<td>sec. 8, T.3R.N., R.40E.</td>
<td>Limestone</td>
<td>Mining and screening</td>
</tr>
<tr>
<td>71 Stevens</td>
<td>Northwest Alloys, Inc.</td>
<td>Blue Creek mine</td>
<td>sec. 29, T.3R.N., R.40E.</td>
<td>Silica</td>
<td>Mining</td>
</tr>
<tr>
<td>72 Stevens</td>
<td>Northwest Alloys, Inc.</td>
<td>Ady dolomite quarry</td>
<td>secs. 13-14, T.3R.N., R.39E.</td>
<td>Dolomite</td>
<td>Mining, production of magnesium metal</td>
</tr>
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<td>73 Stevens</td>
<td>Orient Mining Co.</td>
<td>First Thought mine</td>
<td>T.3R.N., R.37E, Au,Ag</td>
<td>Au,Ag</td>
<td>Drilling</td>
</tr>
<tr>
<td>74 Stevens</td>
<td>United Copper Mines</td>
<td>secs. 31-32, T.3R.N., R.41E.</td>
<td>Au,Ag</td>
<td>Assessment work</td>
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<tr>
<td>75 Stevens</td>
<td>Yamhill and Watson Mining Co.</td>
<td>Copper Penny</td>
<td>sec. 29, T.4R.N., R.37E.</td>
<td>Au,Ag</td>
<td>Geological mapping, sampling</td>
</tr>
<tr>
<td>76 Stevens</td>
<td>Yamhill and Watson Mining Co.</td>
<td>Gold Nugget</td>
<td>sec. 29, T.4R.N., R.37E.</td>
<td>Au,Ag</td>
<td>Geological mapping, sampling</td>
</tr>
<tr>
<td>77 Stevens</td>
<td>Western Land and Resources</td>
<td>McNally-Freedom claims</td>
<td>T.4R.N., R.37E.</td>
<td>Au,Ag</td>
<td>Exploration</td>
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<td>78 Stevens</td>
<td>Boise Cascade Corp.</td>
<td>Corporate lands</td>
<td>T.4R.N., R.37E.</td>
<td>Au,Ag</td>
<td>Exploration</td>
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<td>79 Stevens</td>
<td>Meridian Minerals Co.</td>
<td>limestone Exploration</td>
<td>T.4R.N., R.37E.</td>
<td>Au,Ag</td>
<td>Exploration</td>
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<td>80 Stevens</td>
<td>United States Bureau of Mines, Chemical Corp.</td>
<td>Union Pacific Resources Co.</td>
<td>T.4R.N., R.37E.</td>
<td>Au,Ag</td>
<td>Exploration</td>
</tr>
<tr>
<td>81 Whatcom</td>
<td>Clauson Lme Co.</td>
<td>Bear Mountain pit</td>
<td>near Maple Falls</td>
<td>Limestone</td>
<td>Mining</td>
</tr>
<tr>
<td>82 Whatcom</td>
<td>Olmig Corp.</td>
<td>Swen Larsen quarry</td>
<td>sec. 34, T.3R.N., R.46E.</td>
<td>Olivine</td>
<td>Mining</td>
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</table>

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Table 1. Mineral exploration and development in Washington, 1988, continued.

<table>
<thead>
<tr>
<th>Loc. no.</th>
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<td></td>
<td></td>
<td>Okanogan Resources Corp.</td>
<td>Chapmanee</td>
<td>sec. 27</td>
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<td>Pend Oreille Lehigh Portland Cement Co.</td>
<td>Pend Oreille Placer</td>
<td>sec. 15</td>
<td>zinc</td>
<td>Mining</td>
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<td>Pend Oreille RCF Resource Finance Corp./Pintlar Corp.</td>
<td>Pend Oreille mine</td>
<td>sec. 2</td>
<td>Ag, Au</td>
<td>Exploration, mine development</td>
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<td>Pend Oreille Raven Hill Mining</td>
<td>Peacock claims</td>
<td>sec. 25</td>
<td>Ag, Au</td>
<td>Drilling, bulk sampling</td>
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<td>Pend Oreille United Catalyst Inc./First Miss Gold Inc.</td>
<td>Totem Talc</td>
<td>sec. 23</td>
<td>Ag, Au</td>
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<td></td>
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<td>Skagit Applied Industrial Materials Corp.</td>
<td>AJMCOR Olivine</td>
<td>sec. 3-4</td>
<td>Ag, Au</td>
<td>Milling, reclamtion</td>
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<td></td>
<td></td>
<td>Snohomish Island Arc Exploration</td>
<td></td>
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<td></td>
<td>Snohomish Jeanie Ring</td>
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<td>Spokane Interpace Industries Inc.</td>
<td>Spokane Nica mine plant and Potratz pit</td>
<td>sec. 14</td>
<td>Ag, Au</td>
<td>Clay Mining</td>
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<td>Spokane Union Pacific Resources Co.</td>
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</table>

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Denver Consultant Elected in NW Mining Change

The Northwest Mining Association, generally headed by an operator or an explorationist, has gone to a consultant as its new president. T. M. Li of Denver took over January I. He succeeds the mining engineers in the U.S. who have been reelected to the Spokane-based organization of 2,000 members from the mining industry throughout North America.

Other new officers are David A. Holmes, exploration manager for Meridian Minerals Co. in Englewood, Colo., second vice president, and David M. Menard, vice president of Washington Trust Bank in Spokane, treasurer.

T. M. Li, a Spokane attorney, was re-elected secretary, Bill Mote of Spokane, the association's executive director, is a standing vice president.
Geological Society of America Sectional Meetings

The Cordilleran and Rocky Mountain Sections of the Geological Society of America will hold their annual meetings from May 8 to 11, 1988, in conjunction with the Rocky Mountain and Pacific Sections of the Paleontological Society, the Pacific Northwest Section of the National Association of Geology Teachers, and the Association for Women Geoscientists. The meetings will be held in the Spokane, Washington, Convention Center, are cosponsored by the Department of Geology of Eastern Washington University and the Department of Geology and Geophysical Engineering, University of Idaho. The meeting is hosted by the Spokane office of the Geologic Division, U.S. Geologic Survey; the Western Field Operations Center, U.S. Bureau of Mines; the Northwest Mining Association; the Division of Geology and Earth Resources, Washington Department of Natural Resources; and the Idaho Geologic Survey.

Program

Nearly 650 papers cover a wide spectrum of the geology of western North America. The symposia, technical sessions, and poster sessions will be presented on the following topics: Twelve field trips will be led into the diverse geologic landscape of the Northern Rocky Mountains, Okanogan Highlands, Blue Mountains, Cascade Mountains, Columbia Basin, and Snake River Plain.

Symposia

1. Geophysical Framework of the Cordillera: Christopher J. Potter and Walter D. Mooney, Presiding

2. Evolution of the Proterozoic Rocks of the Northwestern Cordillera: Christopher J. Potter and Walter D. Mooney, Presiding

3. Synoptical Paleozoic Biogeography of Selected Tectonic Zones, Western North America: James W. Whipple, Presiding

4. Upper Paleozoic Biostratigraphy and Stratigraphy of the Northern Rocky Mountains: Bruce R. Wardlaw and Ernest H. Gilmore, Presiding

5. Upper Paleozoic Orogeny of Western North America: Linda B. McCollum and Nancy L. Joseph, Presiding

6. Late Paleozoic and Early Mesozoic Paleogeographic Relations: Klamm Mountains, Sierra Nevada, and Related Ranges: Meghan Miller and David S. Harwood, Presiding

7. Western Edge of the North American Continent: Mesozoic Tectonic Evolution: Karen Lund and Mel A. Wight, Presiding


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Table 1: Mineral exploration and development in Washington, 1988, continued.

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<td>39</td>
<td>Lincoln</td>
<td>Blue Silver Mining</td>
<td>Crystal City mine</td>
<td>sec. 24, T.28N., R.36E.</td>
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<td>40</td>
<td>Okanogan</td>
<td>L.F. Baum and Associates</td>
<td>Turtle Lake</td>
<td>sec. 9-10, T.30N., R.26E.</td>
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<td>41</td>
<td>Okanogan</td>
<td>Columbia River Carbonates</td>
<td>Wauconda quarry</td>
<td>sec. 13, T.38N., R.30E.</td>
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<td>42</td>
<td>Okanogan</td>
<td>CM Silver Mines, Inc./Crown Quebec Inc.</td>
<td>Reed Limestone</td>
<td>sec. 35, T.39N., R.26E.</td>
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<td>43</td>
<td>Okanogan</td>
<td>Crown Resource Corp./Gold Texas Resources Ltd.</td>
<td>Burchhorn</td>
<td>sec. 3, T.40N., R.31E.</td>
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<td>44</td>
<td>Okanogan</td>
<td>Crown Resource Corp./Gold Texas Resources Ltd./Sunset Mining and Development Corp.</td>
<td>Jeds mine</td>
<td>sec. 21, T.38N., R.31E.</td>
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<td>45</td>
<td>Okanogan</td>
<td>Dalton Excavating</td>
<td>Roxy</td>
<td>sec. 25, T.39N., R.26E.</td>
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<td>46</td>
<td>Okanogan</td>
<td>ECM Inc.</td>
<td>Alder Mine</td>
<td>secs. 23-26, T.39N., R.26E.</td>
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<td>47</td>
<td>Okanogan</td>
<td>Kerr-McGee Corp.</td>
<td>Smokey Mine</td>
<td>T.40N., R.29S.</td>
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<td>48</td>
<td>Okanogan</td>
<td>Newmark Gold Mines Ltd., Reclain Resources, Ltd./Avid Resources Corp.</td>
<td>Smith Canyon</td>
<td>T.32N., R.21E.</td>
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<td>49</td>
<td>Okanogan</td>
<td>GMC Inc.</td>
<td></td>
<td>secs. 26, T.30N., R.22E.</td>
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<td>50</td>
<td>Okanogan</td>
<td>Pacific Colton, Inc.</td>
<td>Tonasket Lime quarry</td>
<td>sec. 26, T.28N., R.35E.</td>
</tr>
<tr>
<td>52</td>
<td>Okanogan</td>
<td>Sky Energy Inc.</td>
<td>Wasco Resources</td>
<td>sec. 34, T.39N., R.31E.</td>
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<td>53</td>
<td>Okanogan</td>
<td>Westmont Mining Corp.</td>
<td>Bodie</td>
<td>T.39N., R.31E.</td>
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<td>54</td>
<td>Okanogan</td>
<td>Sunshine Valley Minerals, Inc.</td>
<td>Billy Goat claims</td>
<td>sec. 15, T.40N., R.25E.</td>
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<table>
<thead>
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<tr>
<td>26 Ferry</td>
<td>United States Bosnia Leader Chemical Corp./Vulcan Mountain, Inc. Sundance Mining and Development Corp.</td>
<td>Gold Dike/Gold Hill</td>
<td>secs. 7-8</td>
<td>Au,Ag,Cu</td>
<td>Drilling</td>
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<tr>
<td>27 Ferry</td>
<td>Vulcan Mountain, Inc.</td>
<td>Gold Dike mine</td>
<td>secs. 7-8</td>
<td>Au,Ag,Cu</td>
<td>Working heap; property optioned to U.S. Borax</td>
</tr>
<tr>
<td>Ferry</td>
<td>Antilles Resources Ltd.</td>
<td>Republic district</td>
<td>Au</td>
<td>Geologic exploration</td>
<td></td>
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<tr>
<td>Ferry</td>
<td>Boise Cascade</td>
<td>Company lands</td>
<td>Exploration</td>
<td></td>
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<tr>
<td>Ferry</td>
<td>Union Pacific Resources Co.</td>
<td></td>
<td></td>
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<td>Reconnaissance</td>
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</table>

2. Volcanism, Plutonism, and Sedimentation Associated with Cordilleran Complex and Graben Development in the Central Okanogan Highlands, Washington, R. Wade Holder, Grace A. Landreth, Carley Holder, David R. Gaylord, and Kenneth F. Fox, Jr., Leaders
4. Structure of the Yakima Fold Belt, Central Washington, Stephen Redefel and Newell P. Campbell, Leaders
5. Cambrian of Northern Idaho and Northwestern Montana; John Bush, Leader
6. Geology, Alteration, and Mineralogy of the Alkaline Geo Stocks, Northern Idaho; D. Kate Schatz, Leader
7. The Miocene Clarkia Fossil Beds of Northern Idaho, Jack Smalley, Leader
8. Transect through the Baker-Walla Walla-Sixes Terrane; A Forearc to Island Arc Transition in Northeastern Oregon?; M. Allen Kays and Ellen M. Bishop, Leaders

Concurrent with Meeting

9. The Northern Columbia Plateau from the Air; Dale F. Stradling and Eugene F. River, Leaders
10. Geologic Factors Influencing Residential Radon; Raymond Telser and Dan E. Pay, Leaders
11. Geologic Controls of Groundwater Movement in the Spokane Aquifer; George E. Madsen, Leader

Post-Meeting

12. The Deer Trail Group; Is It of the Belt Supergroup?; Fred K. Miller and James W. Whipple, Leaders
14. Mineralization and Tectonics in the Southern Kootenay Arc and Purcell Anticline; Richard Lambert and Troyge Hoy, Leaders
15. Elements of the Cascades "Collisional" Orogen; A Transect from the Methow Basin to the San Juan Islands, Washington; Michael F. McGroder, Robert B. Miller, Mark T. Brandt, and Ralph Haugen, Presenting
16. Geology of Eocene Mineral Deposits, Ferry County, Washington; Richard Thieshauder, Leader
17. Sources for the Columbia River Basalt Group; Peter R. Hooper and Stephen Retzel, Leaders
18. Lake Missoula Floods and Channeled Scablands Part I: Evidence for the Late Wisconsin Ice Dam and Floods in the Purcell Trench; Roy M. Breckenridge, Leader
Part II: Glacial and Multiple Flood History of the Northern Borderlands; Eugene F. River and Dale F. Stradling, Leaders

EXHIBITS

Exhibits will be displayed in the main hall of the Convention Center, adjacent to the poster sessions and meeting rooms. The cost of booths will be $100 for educational and non-profit institutions and $250 for commercial exhibitors.

SPECIAL EVENTS

Don't miss Bloomsday, the largest timed road race in America, with more than 59,000 participants! The 12-kilometer (7.46-mile) race starts at 9 a.m. on Sunday, May 7. All official participants who cross the finish line are awarded T-shirts, and special prizes will be awarded to veterans of the Vietnam War.

Dinner/dance/swanaic cruise on beautiful Lake Coeur d'Alene in northern Idaho is planned for Tuesday night, May 9. Bus transportation will be provided.

INFORMATION

For registration information, contact Margie Wallace, Conference Coordinator, Regional University Conference, M.S. 11, Eastern Washington University, Cheney, WA 99004, (509) 359-2406.

For program information, contact John P. Buchanan, Program Chairman, Department of Geology, M.S. 70, Eastern Washington University, Cheney, WA 99004, (509) 359-7493.

For exhibit information, contact Russ Boggs, Exhibits Coordinator, Department of Geology, M.S. 70, Eastern Washington University, Cheney, WA 99004, (509) 359-7497.
Defense Waste Cleanup: A Proposal for a National Solution

Governor Booth Gardner and Governor Neil Goldschmidt
State of Washington
State of Oregon
November 30, 1988

I. Introduction

Over the past 45 years, the United States has developed, produced, and tested nuclear weapons at sites in thirteen states. During this period, massive quantities of radioactive and hazardous wastes have been allowed to accumulate at these sites, including Washington's Hanford Reservation. Some past disposal practices were inadequate. Aging "temporary" storage facilities have failed. As a result, these wastes now threaten the environment and the public health and safety.

As the Governors of Oregon and Washington, we have pledged forces to solve this threat. We are pursuing the retrieval, safe cleanup and permanent disposal of Hanford's radioactive and chemical wastes. Our goal is to achieve this cleanup within a national effort to clean up all USDOE defense facilities.

The defense waste problem is more than an important Northerner's problem. It is a national problem. It involves U.S. Department of Energy (USDOE) defense facilities in twelve other states. We strongly believe that the long-term answer to Hanford's problems ultimately lies in a national effort to clean up all USDOE defense facilities.

Accordingly, we call for prompt and decisive action by Congress to enact legislation which will create an effective, long-term cleanup program. It must cover the cleanup and permanent disposal of radioactive and chemical wastes at Hanford and other USDOE defense facilities.

II. The Need for a National Cleanup Program

Recent reports by USDOE and the General Accounting Office (GAO) document serious waste and contamination problems at virtually every USDOE defense facility. Cases of radioactive and groundwater contamination are common. In some cases, groundwater contamination is thousands of times above federal standards. At two installations, soil contamination levels hundreds of thousands of times that of background levels have been reported. Further, the full extent of contamination at USDOE facilities remains unknown. New problems continue to come to light.

In July 1988, USDOE told Congress that defense waste cleanup could cost as much as $110 billion over the next 50 years. The GAO feels the cost may be as high as $130 billion. Despite these cost estimates, only about $795 million was appropriated by FY 1989. And, the major portion of these funds is for continued management of waste in temporary storage—and not for cleanup and permanent disposal.

USDOE has made progress in starting cleanup at a number of facilities, including Hanford. But, it remains uncertain whether this work will be completed before serious and permanent harm is done. There is no firm federal commitment to the cleanup. Schedules have slipped repeatedly. USDOE has no milestones or deadlines for completing cleanup work. Funding is too low and too slow. Application and enforcement of federal and state laws and regulations are uncertain. The role of affected states and tribes is not clear. Public confidence in the ability to handle these waste problems seriously has eroded.

The longer cleanup is delayed, the more costly and dangerous it will be. Hundreds of millions of dollars will continue to be spent on temporary storage. Aging storage facilities will continue to fail. Waste forms now stable may not remain so. Waste will continue to spread through the environment, contaminating more soil and water.

The time has come for the federal government to solve the waste problem at Hanford and the other USDOE sites. It is time for a firm and substantive federal commitment. These wastes have been produced as part of the nation's defense programs. Their cleanup and disposal are a national obligation.

The magnitude of waste cleanup and disposal problems dictates the need for a national effort to clean up all USDOE sites. A credible cleanup effort must ensure that radioactive and chemical wastes are kept away from people for as long as the wastes are dangerous. The program must include:

1. A detailed schedule;
2. Sufficient funding;
3. An effective regulatory structure;
4. The means to build and maintain public confidence; and
5. The development of advanced technologies to ensure safe, thorough and cost effective waste cleanup and disposal.

III. Key Elements of a National Program

Congress must take action now to ensure the safe and expeditious cleanup of radioactive hazardous and mixed wastes at all USDOE facilities. The program must address these points:

A. Schedule for Cleanup

There must be a firm commitment to complete the cleanup and dispose of waste within a reasonable and specific period of time. In 1983, USDOE proposed the cleanup of radioactive wastes at Hanford, the Savannah River plant and the Idaho National Engineering Laboratory within 30 years. Now USDOE hints it will take 50 to 60 years to complete the cleanup.

Without a firm schedule, there is no assurance that the critical cleanup work will be completed in a timely manner—if at all. Without a schedule, there is no means by which to rank priorities, measure performance, determine funding needs or allocate resources.

The program must set milestones and deadlines to complete the cleanup. Federal environmental laws provide a precedent for setting a compliance deadline. We feel that a commitment to clean up all USDOE facilities within 30 years is both essential and achievable.

The program must also include a national priority system. That system must ensure that the wastes that pose the greatest public and environmental risks are handling first. In must ensure the priority of remediation of immediate threats. It must also ensure the cleanup and disposal of any other wastes before the public is put at risk. The system must consider people at risk, environmental factors, and the nature and volume of wastes. It must also take

An agreement between the federal government and the State of Washington signed 2/27/89 states that Washington will receive

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<td>Lone Ranch Creek/DG Claims</td>
<td>secs. 11-12, T.46N., R.35E.</td>
<td>Au, Ag</td>
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<td>N.A. DeGroot, Inc.</td>
<td>Leland Property</td>
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<td>Au</td>
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<td>Echo Bay Mines Ltd.</td>
<td>Kettle sec. 16</td>
<td>T.39N., R.33E.</td>
<td>Au</td>
<td>Drilling, underground drilling</td>
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<td>17</td>
<td>Ferry</td>
<td>Echo Bay Mines Ltd.</td>
<td>Overlook sec. 16</td>
<td>T.21N., R.34E.</td>
<td>Au</td>
<td>Drilling, EIS completed, announced plans to put into production</td>
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<td>18</td>
<td>Ferry</td>
<td>Necla Mining Co., Republic Unit</td>
<td>Golden Eagle, Golden Eagle area</td>
<td>T.21N., R.33E.</td>
<td>Au</td>
<td>Mining, surface and underground drilling</td>
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<td>Johnson</td>
<td>Irish claim group</td>
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<td>Au</td>
<td>Exploration</td>
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<td>Morning Star Mines, Inc.</td>
<td>Morning Star sec. 16</td>
<td>T.40N., R.34E.</td>
<td>Au</td>
<td>Rehabilitation of mine</td>
</tr>
<tr>
<td>21</td>
<td>Ferry</td>
<td>Newport Exploration Ltd.</td>
<td>RHC Claims sec. 29-20</td>
<td>T.28N., R.33E; west of Garlow</td>
<td>Au, Ag</td>
<td>Exploration, claim staking</td>
</tr>
<tr>
<td>22</td>
<td>Ferry</td>
<td>Tannery</td>
<td>Tailgate mine sec. 2</td>
<td>T.28N., R.33E.</td>
<td>Au, Ag</td>
<td>Surface drilling, underground development and sampling</td>
</tr>
<tr>
<td>23</td>
<td>Ferry</td>
<td>United States Borax &amp; Chemical Corp.</td>
<td>Lone Star sec. 2</td>
<td>T.42N., R.33E.</td>
<td>Au</td>
<td>Surface core drilling</td>
</tr>
<tr>
<td>24</td>
<td>Ferry</td>
<td>United States Borax &amp; Chemical Corp.</td>
<td>Wheaton Ranch sec. 2</td>
<td>T.39N., R.33E.</td>
<td>Au, Ag</td>
<td>Drilled two core holes</td>
</tr>
<tr>
<td>25</td>
<td>Ferry</td>
<td>United States Borax &amp; Chemical Corp.</td>
<td>Empire Creek sec. 6</td>
<td>T.39N., R.33E.</td>
<td>Au</td>
<td>Optimized property</td>
</tr>
</tbody>
</table>

Washington Geologic Newsletter, Vol. 17, No. 1

7 Washington Geologic Newsletter, Vol. 17, No. 1
Table 1. Mineral exploration and development in Washington, 1988. Locations given where available. See Figures 1a and 1b for property locations.

<table>
<thead>
<tr>
<th>Loc. County no.</th>
<th>Owner/Operator</th>
<th>Property</th>
<th>Location</th>
<th>Commodity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chelan Placers, Inc.</td>
<td>Wenatchee Heights</td>
<td>Leased property to Assamea Minerals</td>
<td>Au, Ag</td>
<td>Surface drilling</td>
</tr>
<tr>
<td>2</td>
<td>Assamea Minerals (U.S.) Inc./Breakwater Resources Ltd.</td>
<td>Cannon mine</td>
<td>Mining, underground exploration and drilling</td>
<td>Au, Ag</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Montane de Oro, Inc.</td>
<td>Wenatchee Heights</td>
<td>Mine development</td>
<td>Au</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Raven Hill Minerals</td>
<td>Wenatchee Heights</td>
<td>Geologic exploration, bulk sampling</td>
<td>Au</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sunshine Valley Minerals, Inc.</td>
<td>Wenatchee Heights</td>
<td>Exploration, processing, tailings</td>
<td>Au</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Welcome Nugget Mines</td>
<td>Wenatchee Heights</td>
<td>Dredging</td>
<td>Au, Ag</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Welcome Nugget Mines</td>
<td>Wenatchee Heights</td>
<td>Dredging</td>
<td>Au, Ag</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Ideal Basic Inc.</td>
<td>Wenatchee Heights</td>
<td>Clay mining</td>
<td>Au</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Asaro Inc.</td>
<td>Wenatchee Heights</td>
<td>Drilling, geologic, geophysical exploration</td>
<td>Au</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Crown Gold, Inc.</td>
<td>Wenatchee Heights</td>
<td>Drilling</td>
<td>Au</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Crown Resources Corp./Sutton Resources Ltd./Texas Star Resources Corp.</td>
<td>Wenatchee Heights</td>
<td>Drilling</td>
<td>Au</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Crown Resources Corp./Gold Texas Resources Ltd.</td>
<td>Wenatchee Heights</td>
<td>Drilling, geologic mapping</td>
<td>Au</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Crown Resources Corp./Sutton Resources Ltd./Texas Star Resources Corp.</td>
<td>Wenatchee Heights</td>
<td>Exploration, surface, drilling</td>
<td>Au</td>
<td></td>
</tr>
</tbody>
</table>

into account the complexities of cleanup and the costs of defending actions.

The program must provide for the schedule adjustments needed to deal with unforeseen events. USDOE must work with federal and state regulatory agencies to prepare and implement detailed work plans. The plans must be consistent with national priorities and deadlines. USDOE should have the flexibility to adjust schedules and reallocate resources, so long as such action will not extend cleanup work beyond the deadline. USDOE should keep Congress fully apprized of its progress and any major changes in work schedules and plans.

B. Funding

The program must be able to ensure adequate and long-term funding for waste cleanup and disposal. An effective cleanup program will require a Congressional commitment to substantially increase funding levels for cleanup. A trust fund to finance cleanup and disposal work should be considered. Direct appropriations to the fund should be sufficient to ensure the cleanup of existing wastes by the deadlines set by Congress. Proper handling, storage and disposal of wastes generated in the future should be on a "pay-as-you-go" basis. Agencies responsible for the wastes should be required to make annual payments to the trust fund.

Payments to the fund must be sufficient to cover USDOE cleanup costs. The payments must also cover costs incurred by the U.S. Environmental Protection Agency (EPA) and the affected states and Indian tribes. The distribution of trust funds must be based on national cleanup priorities and on work schedules for completing cleanup activities by the established deadline.

C. Compliance with Federal, State Regulations

For the 40 years, waste handling, storage and disposal has largely been exempt from any independent oversight. In a number of instances, poor waste management and disposal activities have knowingly been tolerated. These practices have contributed significantly to the waste cleanup and contamination problems. USDOE has acknowledged these past practices and it has stated that it will comply with state and federal regulations in the future. But, the situation remains uncertain.

The federal government has attempted to block the application and enforcement of state Resource Conservation and Recovery Act (RCRA) programs at Columbia's Rocky Mountains Arsenal and USDOE facilities. These actions make state regulatory authority questionable. USDOE also continues to challenge EPA's authority to enforce federal regulations and standards. These challenges raise grave doubts that the federal government will effectively regulate itself.

The program must set up a clear regulatory framework for the cleanup. State and federal regulatory programs are key to an effective and credible cleanup process. These regulatory programs provide the independent authority needed to ensure that waste problems are fully evaluated and that corrective actions are both timely and appropriate.

The program must direct that all cleanup and disposal work strictly comply with applicable federal and state laws and regulations. EPA must have the clear authority to issue orders and enforce compliance with approved cleanup plans and schedules.

The role of state regulators must also be reaffirmed. This is especially true where a state has authority to implement federal laws such as RCRA. The implementation of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) at USDOE facilities should not supplant or replace the implementation of RCRA for active hazardous and mixed waste sites. Likewise, the program must provide a state's delegated authority to implement and enforce other federal environmental regulations.

Finally, state and federal regulatory programs are critical parts of the cleanup process. The program must ensure that both EPA and the states have adequate funding for regulatory functions.

D. Public Confidence

The magnitude, history and nature of the nuclear weapons waste problem require public confidence and acceptance crucial to cleanup success. The public must be fully aware of the problems. People must be convinced that cleanup solutions will ensure a safe and healthy environment.

To win public confidence, the decision-making and review processes must be open to the public. People must have the opportunity to understand the issues. They must have the chance to influence decisions related to cleanup transportation and disposal sites.

In the short term, affected states and Indian tribes should have a key role in public involvement and education programs. The cleanup program must provide for broad and frequent Indian and tribal activities such as:

1. Technical review of cleanup plans and methods;
2. Transportation of emergency response;
3. Environmental monitoring of waste sites and cleanup activities; and
4. Public information and involvement programs.

E. Development of Cleanup Technology

The density of environmental oversight has coupled with the variety of waste forms, types and volumes found at USDOE facilities presents a formidable challenge to an effective cleanup program. We need to ensure the safest, most thorough and cost-efficient cleanup and disposal effort possible. We must not limit our options solely to technology currently available. The program must provide for the continuing research and development of advanced cleanup and disposal technology.

IV. Conclusion

For decades, radioactive and hazardous chemical wastes have been allowed to accumulate at USDOE defense facilities across the nation, including Washington's Hanford Reservation. Today, as the result of inaction past disposal practices and failing temporary storage facilities, these wastes pose a serious threat to the public safety and the environment.

While USDOE has begun to acknowledge and rectify the problems, the degree of cleanup, the future is uncertain. The cleanup and disposal of wastes will cost billions of dollars and require decades to complete. Yet, no firm schedule exists and funding lags far behind requirements for an effective cleanup effort.

If we are to provide a safe and healthy environment for the citizens of the Northwest and the nation, decisive action is essential. It is time for the federal government to fulfill its obligation to ensure the safe and permanent disposal of these wastes. I urge Congress to act quickly in establishing an effective and credible cleanup program for USDOE facilities.
Selected Additions to the Division of Geology and Earth Resources Library

October, 1988 through January, 1989

THESSES


U.S. GEOLOGICAL SURVEY

Published reports


Open-File Reports


Figure 1b. Location of selected mines (metallic and industrial minerals) and prospects in eastern Washington. Location numbers are keyed to Table 1.
WASHINGTON STATE AGENCY REPORTS


GEOLOGY OF WASHINGTON—General


OTHER REPORTS OF INTEREST


Ludwig, W. J.; Houtz, R. E., 1979, Nespach map of sediments in the Pacific Ocean basin and marginal seas: American Association of Petroleum Geologists, 2 sheets, scale 1:1,000,000.


Note: The DGER library has also received numerous reports from Rockwell San Francisco Operations (pertaining to the geology and hydrology of the Harbor area, from various consulting firms relating to the geology and seismic hazards of western Washington and adjacent areas), and all available U.S. Federal Emergency Management Agency reports in their earthquake hazards reduction series. These items are too voluminous to list here, but are available for examination in the DGER library in Olympia.
Status of Radon Efforts in Washington: December 1988

More than 19,000 homes have been tested so far by individual Washington homeowners and public agencies.

- Testing statewide is broken down something like this:
  - In 3 percent of the homes, values of more than 4 picocuries/liter (pCi/L) of air were recorded.
  - Test results average less than 1 pCi/L.
  - The highest test result was 201 pCi/L.
- Testing in Spokane County:
  - In 50 percent of the homes tested, values of more than 4 pCi/L were recorded.
  - Test results average 8 pCi/L.
  - The highest test result was 92 pCi/L.

The federal government has recommended a guideline of 4 pCi/L (annual average measurement) for homes. The Task Force has started a public information campaign. The radon task force is in great demand. The Office of Radiation Protection of the Department of Social and Health Services has available, free-radon hot line (800-623-9727)). [Source: Washington State Radon Task Force, December 21, 1988.]

Geology of Industrial Minerals Forum Booked for Portland

The Forum on the Geology of Industrial Minerals, an annual gathering at different sites throughout the United States, will be held in the Northwest for the first time. The 25th Forum is scheduled for the Portland Center Red Lion Inn April 30 through May 2, 1989.

Topics to be addressed during the day and a half of paper presentations will include Oregon perlite, gem stone, limestone, and bentonite; Washington olivine; Idaho garnet and perlite; Northwest diatomite, zeolite, and pumice; playa resources; and state and provincial summaries, including Oregon, Washington, Idaho, Montana, and British Columbia.

Following the sessions in Portland, a three-day field trip by bus has been planned to showcase the industrial resources of Oregon. Overnight stops are planned at Baker, Ontario, and Bend.

Additional information on the Forum may be obtained from Ron Gettig, Oregon Department of Geology and Mineral Industries, 910 State Office Building, 1400 S.W. 5th Ave., Portland, OR 97201, phone (503) 229-5580.

Meetings

Pacific Northwest Chapter, Friends of Mineralogy

Annual spring symposium, "Minerals of the Inland Northwest"
May 26-28, 1989
Holiday Inn Coeur d'Alene, Idaho

Darts Steinman, associate curator of the Royal Ontario Museum, will be the principal speaker. This topic will be minerals of the Yukon Territory and the Yukon iron deposit. Other speakers will include Joe Nagel, curator of the University of British Columbia Geology Museum, and Mel Dyck of Laramie, WY.

For further information, write:
Lanny Beem
Mineral News
P. O. Box 2043
Coeur d'Alene, Idaho 83814

1989 Workshop on Earthquake Hazards in the Puget Sound/Portland area

March 28-29, 1989
Portland Marriott
Portland, OR

Sponsored by the Oregon Department of Geology and Industries, the Oregon Department of Emergency Management, the Washington Department of Natural Resources, the Washington Department of Community Development, the Federal Emergency Management Agency, and the U.S. Geological Survey.

For additional information, contact:
Timothy Walsh (206) 459-6372
Jan Madin (503) 229-5580
Linda Noon (206) 481-4694

Washington Geologic Newsletter, Vol. 17, No. 1 42

WASHINGTON'S MINERAL INDUSTRY - 1988

By Nancy L. Joseph

INTRODUCTION

According to information obtained by the Division of Geology and Earth Resources, three precious metal and one base metal mine were in operation in Washington in 1988. Seventeen companies mined and produced industrial minerals, which included limestone, dolomite, silica, olivine, clay, and diatomite (Table 1). Two companies produced Portland cement, and 10 plants produced lime, calcium chloride, precipitated calcium carbonate, or ground limestone.

Furthermore, information indicates that nonfuel mineral production in Washington in 1988 was valued at more than $400 million. The production of magnesium metal from dolomite, precious metal mining, and sand and gravel quarrying accounted for the bulk of this figure. The production of Portland cement decreased significantly in 1988 due in part to the closure of the Columbia Northwest Cement Corp. plant in Whatcom County.

Precious metals, which now account for one-quarter of the total value of mineral production, are becoming increasingly important to Washington's mineral industry. The high levels of production from the Cinnabar mine and the Republic Unit, coupled with projected production at two new mines in 1990 and the increased precious metal exploration in the state should lead to significant increases in precious metal production in the future.

Total revenue from prospecting, mining, and quarrying for sand and gravel production, on state lands was $399,695 for the fiscal year ending June 30, 1988. This figure includes payments on approximately 300 mineral leases and contracts. Revenues from prospecting increased, while revenues from sand and gravel operations decreased approximately 16 percent. (The sand and gravel industry is not discussed in this article.)

Information in this report is summarized from volunteered data, collected in 1988, a questionnaire sent by the Division to companies and individuals active in mineral exploration and development in the state, as well as from published information. The questionnaire is limited in scope, and, therefore, details of activities on individual properties are not always available. All questionnaires were returned, and some information requested, particularly regarding expenditures and production, is deemed confidential by many of those questioned and is not reported.

Therefore, while this summary is a reliable indication of the mineral activity in Washington, it is incomplete and general in nature.

The locations of properties mentioned in this article are shown in Figures 1a and 1b, which cover eastern Washington, respectively.

METALS Development

Gold and silver, with a combined value of more than $400 million, were the only metals produced from the three active precious metal mines in Washington in 1988. Record amounts of more than 225,000 ounces of gold and more than 540,000 ounces of silver were produced from mines in Chelan County and Ferry County (Fig. 2, Table 2). This represents a modest increase in gold production and approximately 50 percent increase in silver production over the 1987 figures.

Lead and zinc were mined at one mine in Stevens County. This low-tonnage operation was the sole base metal producer reporting to the Division in 1988.

Chelan County

The Cinnabar mine, a joint venture between Asafera Minerals (U.S.) Inc. and Breakwater Resources Ltd., is the largest gold mine in the state and the second largest underground gold mine in the country. Approximately 952,675 ounces of gold and approximately 250,000 ounces of silver with an average gold grade of 0.31 oz/ton was produced from the mine in 1988. The increase in gold production over the 1987 record was attributed to increased head grades and higher productivity.

Asafera Inc., which owned 92 percent of the stock in Asafera Minerals Inc., was bought out by Gulf Canada Resources Ltd. in April 1988. The new owners of the company, who reportedly acquired Asafera to obtain their overseas properties, have decided to put their interest in Asafera Minerals up for sale (Northern Miner, December 19, 1988).

Reserves at the Cinnabar mine at the end of 1987 were 4.5 million tons grading 0.39 oz/ton gold (Breakwater Resources Ltd., annual report, 1987). Underground exploration, drilling, and development continue at the mine. Drilling has delineated an ad
National Geologic Hazards
Program Update

By Raymond Lasmaris and Timothy Walsh

During November 1988, the authors of this article attended two meetings sponsored by the U.S. Geological Survey (USGS) and other agencies to review national and regional geologic hazards programs aimed at reducing losses from geologic hazards. Lasmaris participated in the workshop on "Applications of Knowledge Produced in the National Earthquake Hazards Reduction Program: 1977-1987." Walsh attended the "Geohazards 88" symposium.

A panel format was used to review the first decade (1977-1987) of the National Earthquake Hazards Reduction Program (NEHRP). The sponsors were the USGS, the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards, and the National Science Foundation (NSF).

A draft report accompanied presentations by noted authorities formed the core of the workshop.

The following topics were discussed by the panels:
- Update on research application activity throughout the nation
- The future of research applications in the NEHRP: 1987-1997
- Policies and practices of the four principal agencies in NEHRP
- Improving the collaboration of knowledge producers and knowledge users
- Background on earthquake insurance
- Strengthening weak links in the research applications process of NEHRP
- Priorities, given a level budget

(Continued on page 32)
New Division Releases


Open File Report 89-1: Geologic and Geophysical Mapping of Washington, 1984-1988 and Theses on the Geology of Washington, 1986-1988, compiled by Connie J. Manson. The first part of this work is the cumulated update to the Division of Geology and Earth Resources Information Circular 77, "Index to geologic and geophysical mapping of Washington, 1899-1983." The second part is the cumulated update to the Division’s Information Circular 80, "Theses on Washington Geology, 1901-1925." The 26-page report includes 7 plates. The price is $0.93 + .07 (tax) = $1.00.

Geologic Map GM-35: Bluelight 15-minute Quadrangle, Washington; Geologic Map GM-36: Poisel Butte 15-minute Quadrangle, Washington; Geologic Map GM-37: Lory Creek 15-minute Quadrangle, Washington, by R. D. Bentley, N. P. Campbell, and John E. Powell. Each of the three maps has a brief description of geologic units, a diagram of map unit correlation, a cross section, a table of major element geochemical analyses, and a three-color map at 1:48,000 on one sheet. The price is $1.85 + .15 (tax) = $2.00 each.

Geologic Map GM-38: Map of the Saddle Mountains, Washington, by S. P. Reidel. This publication consists of three 3-color maps at 1:48,000, cross sections, and isopach maps of selected Columbia River basalt flows. The plates are accompanied by a 28-page text that includes results of geochemical analyses. The price is $6.03 + .47 (tax) = $6.50.