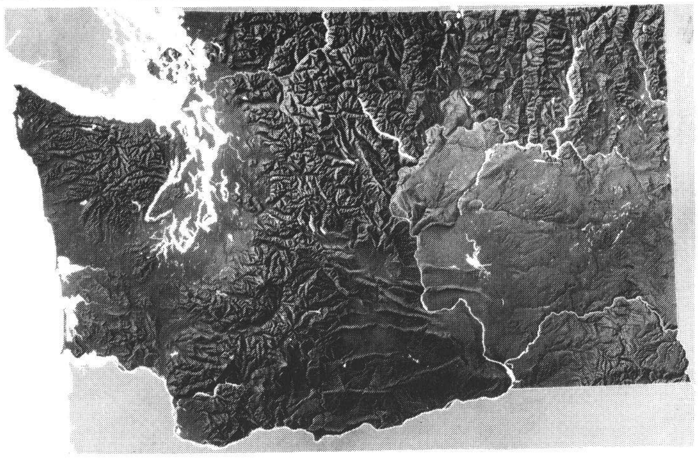

WASHINGTON GEOLOGIC NEWSLETTER

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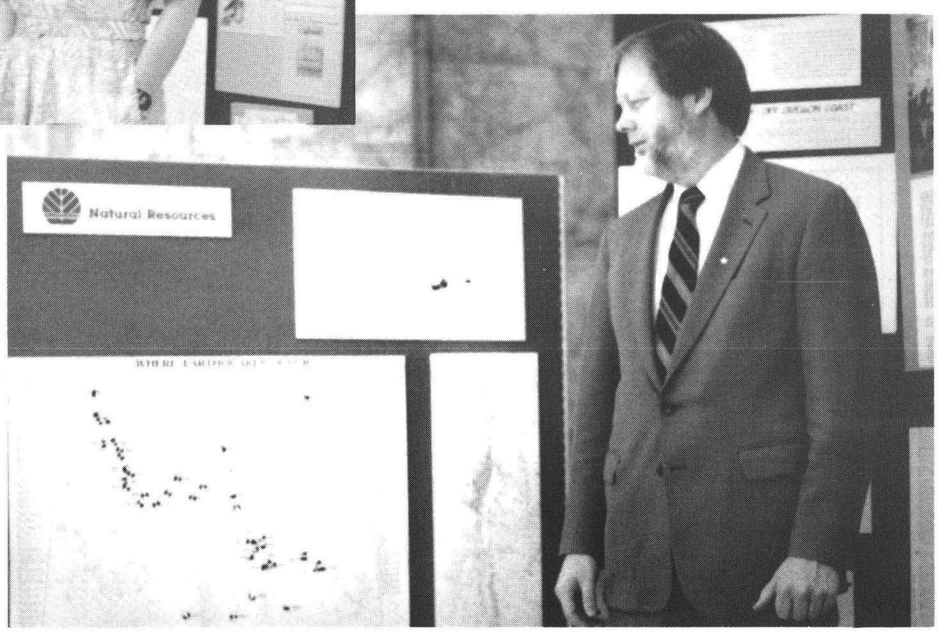

Harry Halverson (above, left), a founder of Kinemetrics, Inc., manufacturer of seismological instruments, Linda Noson (above, right), Federal Emergency Management Agency, and Rep. Dick Nelson (right) with displays at the State Capitol rotunda during Earthquake Awareness Week.

IN THIS ISSUE

WASHINGTON GEOLOGIC NEWSLETTER

The Washington Geologic Newsletter is published quarterly by the Division of Geology and Earth Resources, Department of Natural Resources. The newsletter is free upon request. The Division also publishes bulletins, information circulars, reports of investigations, and geologic maps. A list of these publications will be sent upon request.

Definition of Asbestos

By Raymond Lasmanis

During 1986, the Occupational Safety and Health Administration (OSHA) joined other federal agencies in adopting a generic definition of asbestos as "chrysotile, amosite, crocidolite, tremolite asbestos, anthophyllite asbestos, and actinolite asbestos". No standards were established to distinguish common rock-forming minerals tremolite, anthophyllite, and actinolite and when they can be called asbestos; this distinction is important in order to protect human health. Because nearly all metamorphic and many igneous rocks contain one of the above minerals in non-asbestos form to some degree, both OSHA regulators and the mineral industry need tight mineralogical definitions to provide clarity and consistency.

An advisory committee to OSHA attempted to draft guidelines that would provide consensus. The committee consisted of Malcolm Ross, U.S. Geological Survey; Robert Clifton and William Campbell, formerly with the U.S. Bureau of Mines; Ann G. Wylie, University of Maryland; and Catherine Skinner, Yale University. Their recommendations were not implemented.

Currently, the American Association of State Geologists is reviewing a definition of asbestos that follows closely the recommendations of the above committee. It is hoped that technically correct national guidelines will be implemented.

A mineralogical definition follows:

A. Asbestos - A collective mineralogic term that describes certain silicates belonging to the serpentine and amphibole mineral groups, which have crystallized in the asbestiform habit causing them to be easily separated into long, thin, flexible, strong fibers when crushed or processed. Included in the definition are chrysotile, crocidolite, asbestiform grunerite (amosite), asbestiform anthophyllite, asbestiform tremolite, and asbestiform actinolite.

(Continued on page 15)

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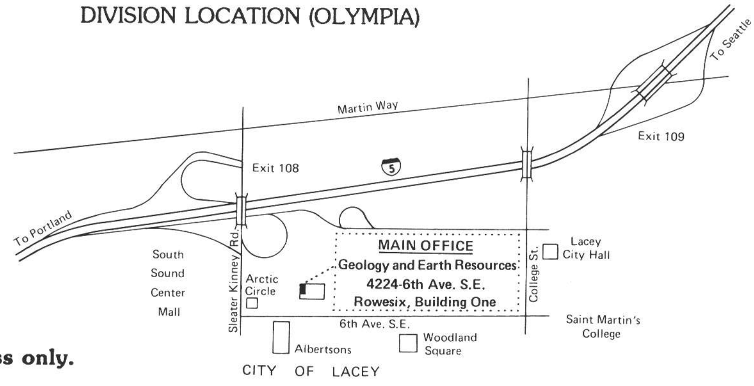

Hanford Defense Waste Program and Its Geologic Setting

By Raymond Lasmanis

On December 22, 1987, President Reagan signed into law major amendments to the Nuclear Waste Policy Act that dropped the Hanford Reservation and Deaf Smith County, Texas, as sites to be characterized for deep geological disposal of the nation's commercial high-level nuclear waste. Congress selected Yucca Mountain, Nevada, as the preferred national site. During 1988, repository-related activities at Hanford were phased out.

This paved the way for Washington State to focus attention on cleaning up Hanford's defense waste, which has accumulated since 1943, when the Hanford Engineering Works was established to carry out objectives of the Manhattan Project – specifically, to produce the world's first nuclear bomb. By the end of 1988, the following amounts of nuclear waste were present at Hanford:

High-level waste	63,000,000 gallons
Transuranic waste	40,000,000 gallons
Low-level waste	140,000,000 gallons
Total	243,000,000 gallons

This waste contains a total of 570 million Curies of radioactivity. In addition, a significant amount of radioactive waste is mixed with hazardous chemical compounds. There is also present a large inventory of non-radioactive chemical wastes at Hanford as noted below:

Inorganic	>220,000 tons
Organic	1,700 tons
Total	>221,700 tons

At Hanford the waste is distributed through approximately 1,400 disposal sites consisting of current double-wall steel tanks, older single-wall tanks, ponds, ditches, French drains, and shallow earth cribs. Nuclear waste was even injected into ground water through a well (216-B-5). Single-shell tanks alone hold 44,000,000 gallons of waste (6.8 million gallons in liquid form) containing 162 million Curies of radioactivity. Of these, 66 tanks are confirmed leakers, with 500,000 gallons having been discharged into the subsurface. As a result, shallow earth materials and ground water under 230 square miles of the Hanford reservation are contaminated. Some of the radioactive contaminants are uranium, plutonium, cesium-137, strontium-90, and iodine-129.

Production of the waste will continue into the future, and additional waste will be generated because of decontamination and decommissioning of eight production reactors, two chemical processing facilities, and 50 test, development, and auxiliary facilities.

It is the subsurface geology overprinted by the hydrologic regime that controls the location and travel of contaminants once they escape containment. Detailed knowledge of geohydrology under each of the clean-up sites would also constrain the type of strategy that would be most effective in preventing further contamination and potential spread to the biosphere. In addition to the physical characteristics of the geologic units and hydrology, the geochemical interaction of contaminants with water and subsurface sedimentary units is an important factor in limiting the spread of certain elements such as plutonium. Figure 1 is a simplified map of the geohydrologic setting at the Hanford site.

In the broadest sense, the geology of the Hanford site can be characterized by two types of units. The whole region is underlain by flows of the Columbia River Basalt Group, which have been folded into anticlines and synclines. Overlying the basalts are semiconsolidated and unconsolidated terrestrial sediments dating from 8.5 million years before the present to modern sand dunes covering parts of the surface. The sedimentary units have been classified into three formations. The Ringold Formation is the oldest; it is overlain by the Hanford formation, and the section is capped by fairly young sediments of the Holocene epoch. (See Fig. 2.) In terms of the depositional environment, fluvial slackwater deposits and ancient soils of the Ringold Formation grade upward in the section to younger fanglomerates that are overlain by the Pasco gravels laid down by the catastrophic glacial Lake Missoula floodwaters. Slackwater deposits, sands, gravels, and thin ash beds characterize Holocene deposits.

The physiography of the basalt surface, the nature of the sediments overlying the basalts, and the Columbia and Yakima Rivers all influence the hydrologic regime at Hanford. Below the water table, which is from 140 to 230 feet below the surface, all void space is filled with water. That part of the section, down nearly to the basalt surface, is known as the unconfined aquifer. Natural ground water recharges the unconfined aquifer around anticlinal basalt hills and mountains such as Rattlesnake Hills, Yakima Ridge, Gable Butte, and Gable Mountain. Natural recharge also occurs from the Yakima River (Fig. 1).

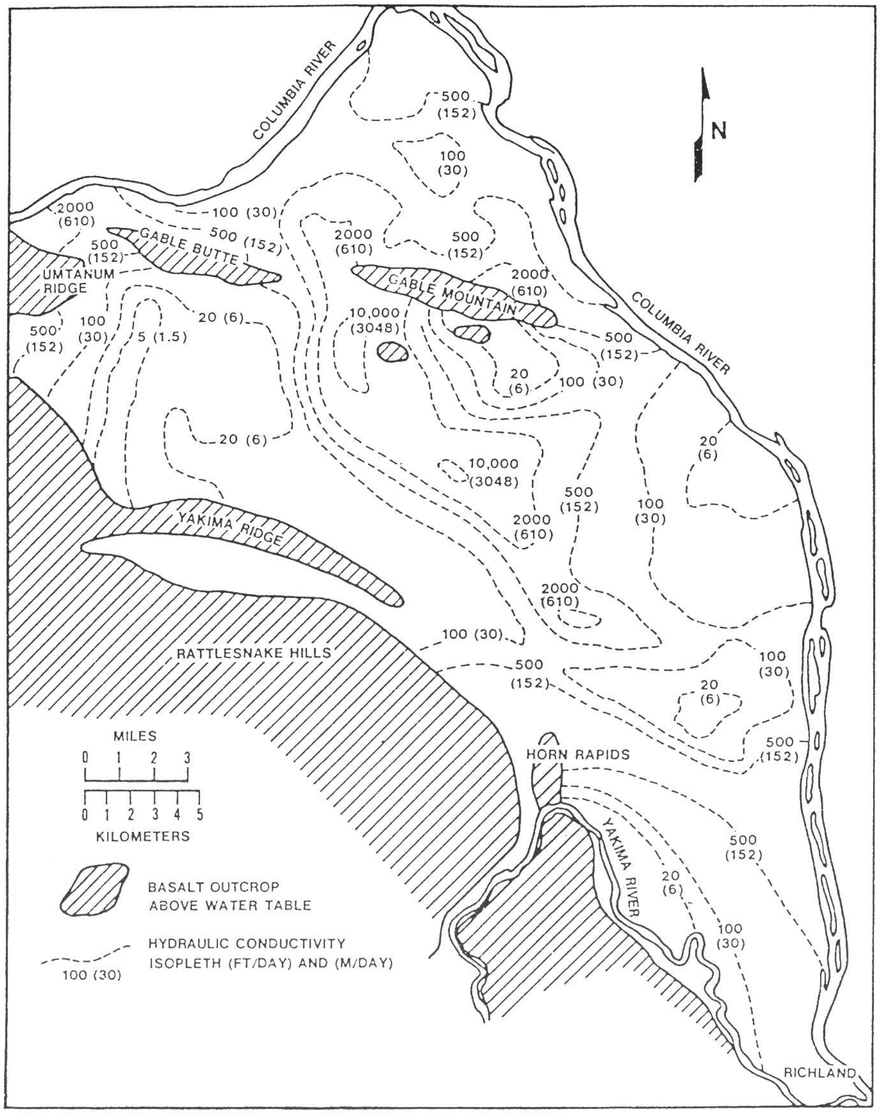

Figure 1. Geohydrologic setting of the Hanford site. (From Atlantic Richfield Hanford Co., 1976)

The general direction of ground-water flow is to the southeast; ground water discharges into the Columbia River.

One example of a contaminated area is near the old injection well 216-B-5, where isotopes of plutonium-239, -240, cesium-137 and other isotopes have been introduced into the aquifer of the Ringold Formation, reached the top of the basalt, and spread out laterally following the hydrologic gradient. Both beta-gamma and alpha activity were detected, but over time there has been a decrease in fission products in the ground-water plume due to the short half-life of the isotopes.

Another example is radioactive waste buried in cribs 216-U-1 and 2 where uranium-contaminated ground water was discovered in 1985. The culprit in that case was a caliche layer diverting contaminants, especially mobile cesium-137, to nearby boreholes which then piped the water deeper into the unconfined aquifer.

Above the water table is the unsaturated vadose zone containing less water and where pore spaces are filled with water vapor and air. At Hanford, sediments from the surface to a depth of 30 feet are extremely dry. Rainfall entering the sediments is returned back into the atmosphere through evaporation and transpiration. Where the waste liquid volume was not large enough to cause waste to penetrate into the water table, the absorbent qualities of Holocene sediments and the vertical movement of moisture toward the surface contained pollutants in the immediate vicinity of each contaminated site.

In order to isolate hazardous and radioactive materials from the geohydrologic environment, various technologies will be employed. These range from stabilization in place to removal and encapsulation, to separation and transhipment to the deep salt bed waste isolation pilot plant facility in New Mexico or the commercial high-level repository site at Yucca Mountain, Nevada.

Period	Epoch	AGE (M.Y.)	STRATIGRAPHY		LITHOLOGIC CHARACTER	THICKNESS (METERS)	HYDROLOGIC CHARACTER	AQUIFER
QUATERNARY	HOLOCENE		ALLUVIUM, COLLUVIUM, AND EOLIAN SEDIMENTS		Sands, silts, gravels and clays modified by wind erosion	dunes to 20	Occur everywhere above the water table	Dry
				Mazama ash	Ash fall; Crater Lake, Oregon	.2-.3		
		0.01		Glacier Peak ash	Ash fall; Glacier Peak, Washington	.05		
	PLEISTOCENE			St. Helens ash	Ash fall; Mt. St. Helens, Washington	.05		
			HANFORD FORMATION (informal)	Touchet silts	Fine-grained facies of the glaciofluvial deposits; bedded in quiet water	0-120	Occur above the water table except between the high terrace plateaus and the Columbia River; has very high transmissivity and storage	In places an unconfined aquifer or dry
				Pasco gravels	Predominantly coarse-grained gravels; cobbles and sands with cut and fill structure			
				paleosols and fanglomerates	Calcareous sand and silt eolian deposits, mainly derived from the Ringold Formation; coarse clastics	0-25	Occur everywhere above the water table	Dry
TERTIARY	PLIOCENE	1.6	RINGOLD FORMATION	Upper	Locally capped by caliche; mostly well-bedded fluvial silts and sands with some gravels	0-125	Sand and gravel beds have very high hydraulic conductivity and storage; some beds of silty clay or clay are essentially impermeable	Unconfined aquifer
				Middle	Sands and gravels; well sorted, compact, but variably cemented	0-120		
	MIOCENE	5.3		Lower	Laterally extensive paleosol underlain by cross-bedded sand, silt and clay	0-18		Aquiclude
				Basal	Coarse sand and cobble gravel fining upward and capped by a paleosol	0-65		Aquifer
		8.5	SADDLE MOUNTAINS BASALT OF THE COLUMBIA RIVER BASALT GROUP					

Figure 2. Stratigraphic column for the Hanford site. (Modified from Atlantic Richfield Hanford Co., 1976, and Bjornstad, 1985).

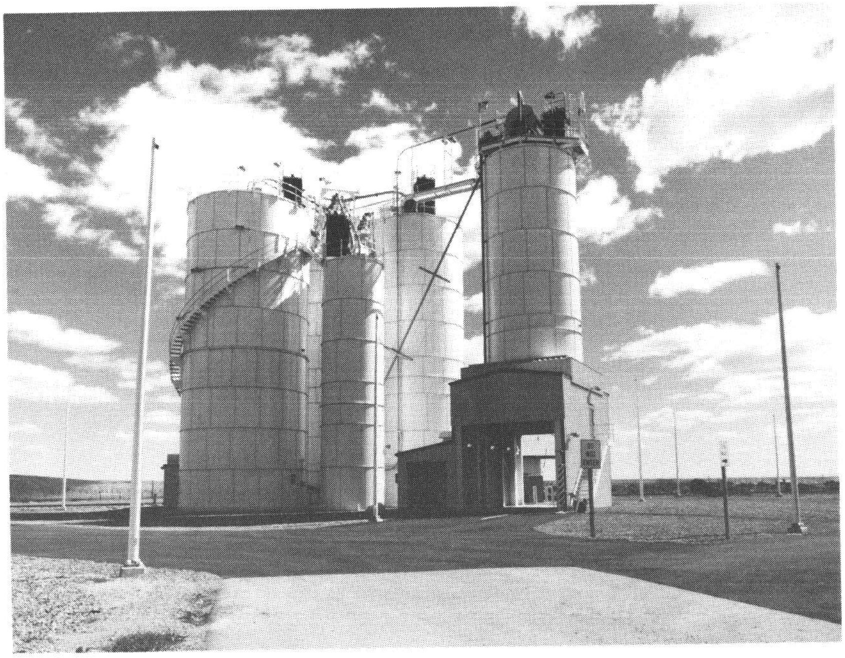

Figure 3. Dry materials for the grout treament of waste are stored in this set of tanks. Photo courtesy of Westinghouse Hanford Co.

Figure 4. Mixing of waste materials and grout for the grout treatment takes place in this facility. Photo courtesy of Westinghouse Hanford Co.

Low-level radioactive tank wastes will be mixed with a cement-like material, called grout, pumped to a concrete vault constructed below ground level, and allowed to cure for 28 days. The result will be a solid block of concrete and grout which will then be covered by a protective barrier. A demonstration Grout Treatment Facility, operated by Westinghouse Hanford Co. for the U.S. Department of Energy (DOE), was dedicated August 20, 1988. The project consists of a dry materials storage facility (Fig. 3), a mixing facility (Fig. 4), and the vault (Fig. 5). This full-scale demonstration project will treat 1 million gallons of phosphate and sulfate waste.

High-level radioactive waste stored in double-shell tanks will be processed into a vitrified material called borosilicate glass. France has been successfully using this technology since 1969. The first U.S. demonstration plant is under construction at the Savannah River facility in South Carolina. See Figure 6 for an example of borosilicate glass from Savannah River Plant pilot project. It is estimated that the Hanford Waste vitrification plant will cost in excess of $1.2 billion. Start-up is scheduled for 1999. The resulting glass canisters will be shipped to Yucca Mountain for placement in the deep geological repository.

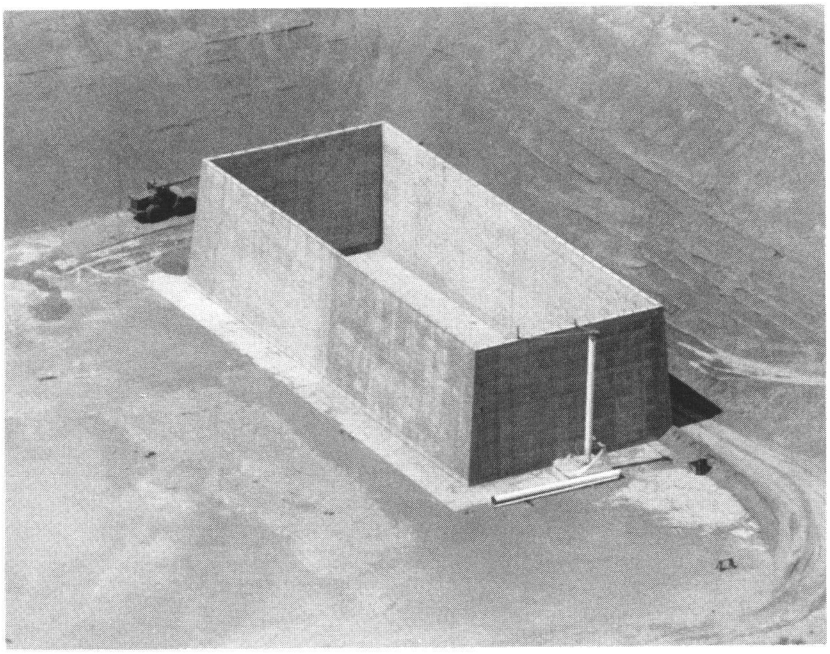

Figure 5. A concrete vault being prepared to receive the grout and waste mixture. The vault's inside dimensions are 125 feet by 50 feet; the vault is 34 feet deep. The entire structure is set below ground level and will be covered when filled. Photo courtesy of Westinghouse Hanford Co.

Solid transuranic waste stored in steel drums and special boxes under several feet of soil will be repackaged and sent to New Mexico for geologic disposal in salt formations. Radioactive cesium and strontium isotopes chemically separated from single-shell tank waste and placed in capsules will be stored in pools at Hanford and then will eventually be disposed of at the Yucca Mountain geologic repository.

A process for in-situ vitrification of contaminated soils is being developed by Battelle Pacific Northwest Laboratories for the USDOE. A full-scale demonstration project was conducted in June 1987. The objective is to stabilize radioactive and hazardous wastes in place. Graphite electrodes are inserted into the soil to a depth of 6 feet, current is applied, and the soil, silt, sand, and gravel melts to a glassy material resembling obsidian. On the edges of the melted area, sand melts first, leaving the pebbles only partially vitrified (Fig. 7). This approach, to immobilize transuranic elements, is currently under evaluation.

The magnitude of defense waste to be cleaned up and the number of disposal issues at USDOE sites in 13 states demonstrate that this environmental challenge needs a national solution. (See statement

Figure 6. Borosilicate glass from the Savannah River plant pilot project. The disc is 3 inches in diameter.

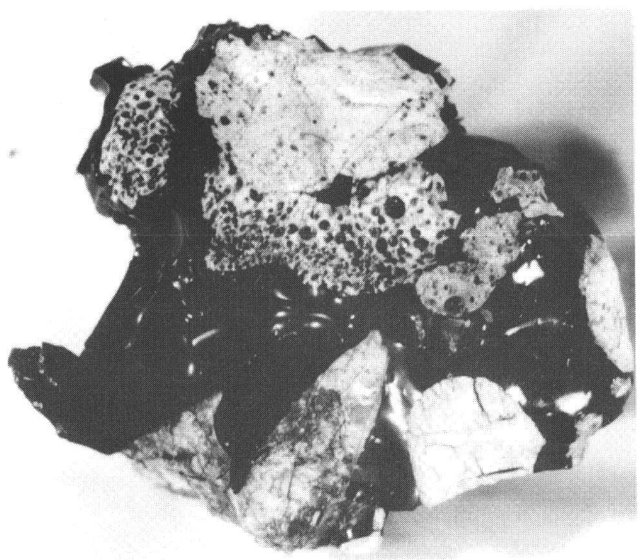

Figure 7. Vitrified sand and gravel. Pebbles in this sample are only partly fused. The sample is about 3 inches across.

by Governors Gardner and Goldschmidt, Washington Geologic Newsletter, Vol. 17, No. 1, p. 38-39). Congress, the USDOE, and individual states recognize that the time has come to move toward environmental cleanup of defense facilities.

The U.S. Department of Energy, which operates the Hanford Site, is planning to begin cleaning up its waste sites and to obtain federal-state permits for treating, storing, and disposing of hazardous wastes. Two regulatory agencies, the U.S. Environmental Protection Agency (EPA) and the Washington Department of Ecology, will oversee USDOE's actions under federal and state waste cleanup and management laws.

After a year of negotiations, on February 17, 1989, it was announced that agreement in principle has been reached as to a draft three-party agreement (USDOE, EPA, Washington Dept. of Ecology). The draft agreement sets up a 30-year program for Hanford cleanup; the estimated cost for the first 5 years is $2.8 billion. During April, public workshops were conducted in several cities to solicit public comment on the agreement. The agreement was signed May 15.

Congress is moving ahead to implement the clean-up program at Hanford. The federal fiscal year (FY) 89 ends September 30, 1989, and has sufficient appropriations to meet program needs. An additional $30 million may be added to the program by Congress. President Bush's FY 90 budget lists $367 million for Hanford cleanup, meeting scheduled program expenditures. The FY 91 proposed budget also seems to be adequate, with the exception of a possible additional $20 million needed to bring the vitrification plant on stream by the 1999 deadline. To implement the provisions of the triparty agreement, funding for FY 91 and 92 will be critical.

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New Post for Bonnie Bunning

Bonnie Bunning, former staff geologist with the Division of Geology and Earth Resources (DGER), has been appointed Assistant Division Manager for Minerals in the Department of Natural Resources (DNR) Lands and Minerals Division in Olympia. She will direct that division's subsurface resources and energy leasing program, hazardous waste management program, and land use coordination with local government program for DNR land holdings outside of urban areas.

After working for six years as an exploration geologist for mining companies, Bonnie came to DGER in 1980 as a Geologist 3 to serve as economic geologist and lead geologist for the division's field office, first in Cheney and later in Spokane. In 1985 she was promoted to Geologist 4, Section Head for the division's Geology and Resources Section in Olympia. During the next three years she performed economic geology duties, participated in the state's Career Executive Program, was Assistant State Geologic Map Program Coordinator, and served as Executive Secretary to the State Board on Geographic Names.

In March 1988, she became DNR Management Analyst. In this post she served the department's top management staff as an investigator of important management issues. For example, she chaired the department's Strategic Planning Implementation Task Force and participated in the Management Advisory Group on Training. As Management Analyst she retained her duties as Executive Secretary to the State Board on Geographic Names and will retain those duties in her new post as well. (Modified from: Natural Resources News, v. 9, no. 3, April 1989, p. 1.)

Staff Note

The Washington Sea Grant Program, supported by an appropriation from the Washington State Legislature and additional funding from the National Oceanic and Atmospheric Administration, has recently released a book written by two geologists from the Division of Geology and Earth Resources, **Stephen Palmer** and **William Lingley, Jr**. The book, titled *An Assessment of the Oil and Gas Potential of the Washington Outer Continental Shelf,* is one of a series of Sea Grant publications examining the issues surrounding petroleum resources and offshore exploration. The 83-page book, which has 12 oversize plates, sells for $45 and is available from the Washington Sea Grant Program, University of Washington, Seattle, WA 98195.

Geotechnical Aspects of the Centralia Surface Coal Mine, Centralia, Washington

By Frank V. LaSalata, Senior Geotechnical Engineer
Washington Irrigation and Development Company

The surface coal mine operated by the Washington Irrigation and Development Company (WIDCO) has been in production since 1971. The mine is located near Centralia in southern Thurston and northwestern Lewis counties west of the foothills of the Cascades and east of the Interstate Highway 5 corridor in western Washington (Fig. 1). Current yearly output is approximately 4.5 million clean tons of coal, requiring an annual 42 million prime yard stripping effort. To date the mine has produced approximately 73 million tons of clean coal and excavated approximately 570 million cubic yards of overburden material. The mine's sole customer is the adjacent Centralia Steam Electric plant.

The federal surface-mining permit for the mine encompasses approximately 14,000 acres of rolling terrain. The mine has three active pits, and a fourth pit is currently under development. Each pit is separated from the others by physical features such as faults, valleys, or ridges.

The mine operates a varied complement of stripping machinery. Scrapers, electric powered shovels, hydraulic excavators, bucket wheel excavators, dozers, overburden trucks, and walking draglines make up the fleet of excavation equipment. All prime movers with the exception of the draglines are used to pre-strip, or set up and prepare, the area to a level amenable for dragline operation (Fig. 2). The draglines then expose the coal in a multi-seam design operation (Fig. 3). Material excavated from above the coal seams, called spoil, is placed in the open pit left by the last cut or mined-out area (Fig. 4). In this manner, mining and backfilling operations are carried on concurrently, thereby accomplishing contemporaneous backfilling, reclamation, and revegetation of the mined-out area.

The geology of the mine area is structurally complex. Valleys that run through the property are generally the sites of major fault systems that have displaced the three principal coal seams mined by WIDCO: the Big Dirty, the Little Dirty, and the Smith (Snavely and others, 1958).

These seams are in the Skookumchuck Formation (Snavely and others, 1951). The Skookumchuck includes siltstones and claystones, and fine-grained sandstones. Upwards of 35 percent of the sandstone material passes the No. 200 sieve, whereas siltstones and claystones are composed almost entirely of material at or below this size. The material is also poorly cemented, which permits rapid degradation during periods of high precipitation.

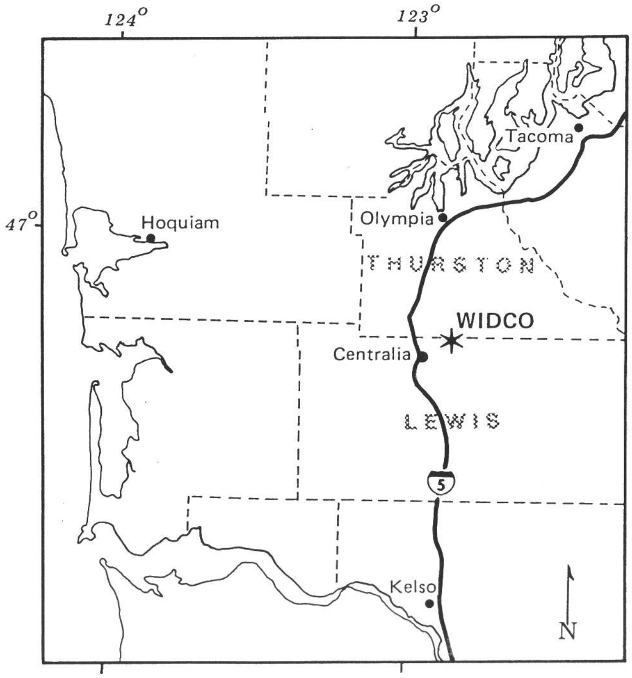

Figure 1. Location of the WIDCO mine.

WIDCO estimates that in-place material swells an average of 28 percent from its original (in-place) state to its excavated volume. Combine this with the fine-grained composition and an average mine-wide rainfall of 49.6 inches per year, and the potential for slope instability becomes a critical factor in mine operations.

Historically WIDCO experienced at least one massive spoil failure per year between 1971 and 1987. Single slide movements have involved upwards of 4 million cubic yards of material and resulted in costly decreases in productivity and operational flexibility. No slide resulted in a personal injury or fatality, nor has one caused any significant property damage. Generally speaking, the mass slope movements observed at the WIDCO operation are very slow and take a minimum of several hours to a few days to fully develop. This steady creep mode of emplacement allows the operator time to move workers and equipment to safety, as well as to attempt remedial action to minimize the effect of the slide.

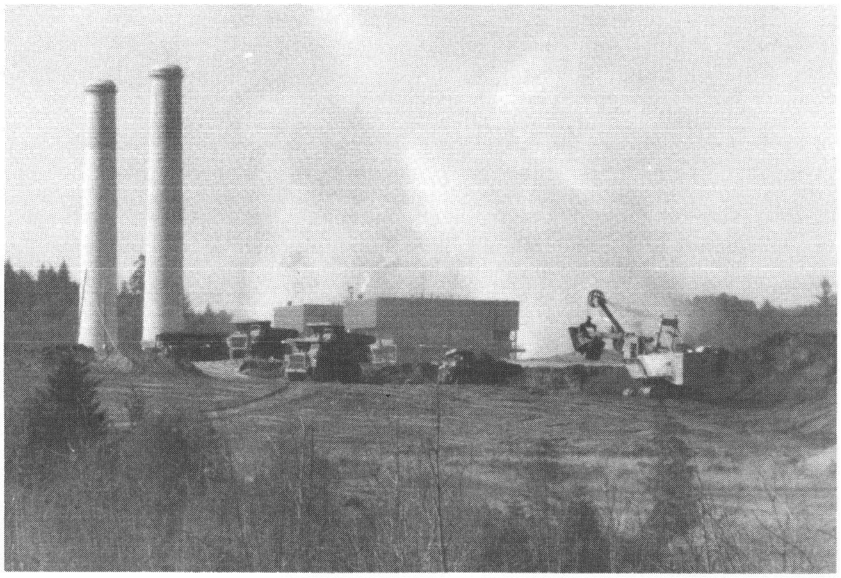

Figure 2. Typical truck and shovel pre-strip operation at WIDCO.

Figure 3. Typical dragline spoil side operation.

The three primary factors that affect slope movements at the Centralia mine are:

(1) Geologic material type,

(2) Geologic structure, and

(3) Climate.

As stated earlier, significant portions of the lithologies in the Skookumchuck Formation are fine-grained materials. The grain-size distribution curves are skewed heavily toward the fine silt- to clay-size particle range. These small particles act as the binder in the in-place materials and allow some of the highwall materials to be excavated to a 1:1 slope (45 degrees). The fine-grained nature of the sediments also results in significantly reduced porosity and permeability in the in-place Skookumchuck material. However, once the sediments are blasted and excavated, the overall volume swells an average of 28 percent. This volume increase translates to a dramatic increase in voids, resulting in a significant increase in porosity and permeability in the spoil. Material commonly is exposed for several days, weeks, or months prior to final placement. This allows time and the elements to degrade the spoil material. In-place Skookumchuck material has been tested by WIDCO and exhibits cohesive strengths of 3,100 to 8,000 pounds per square foot with accompanying internal angles of friction (phi angles) of between 10 and 25 degrees. Skookumchuck spoil, on the other hand, has cohesive strengths of 500 to 2,600 pounds per square foot and phi angles of 0 to 10 degrees (depending on moisture content). This dramatic decrease in strength is the direct result of the fine-grained character of the original rock types coupled with the rapid degradation brought on by excavation, material handling, and moisture.

Figure 4. Typical dragline highwall operation to uncover coal, with coal loading in the foreground.

Geologic structure plays a two-fold role in the geotechnical aspects of the Centralia operation. Faults result in planes of weakness in the parent highwall material and offer fracture paths for water to collect; this results in locally elevated pore pressures.

Numerous faults cross the mine area and have caused displacements from several feet to approximately 1,500 feet. Minor displacements, those on the order of 5 to 100 feet, are mined through and can be incorporated in the active mine plan. Major displacements, those in excess of 100 feet, require either development of a separate pit or cause termination of mining in a given area (depending on whether the throw is up or down across the fault). Fault zones are characteristically several hundred feet wide and involve the entire height of the highwall.

Given the fine-grained nature of the original materials, fault zones are commonly composed of gouge and are essentially zones of highly plastic clay-size materials. Areas adjacent to these gouge zones are normally highly fractured as well, and they function as collection areas in ground-water migration paths. These areas, where saturated, display elevated pore pressures in the highwall. This causes a significant local decrease in overall mass material strength and an increase in the potential for highwall instability. Where these zones parallel the direction of mining, large sections of highwall can slab off once a sufficient amount of the toe (the lower buttress weight) is removed during the normal mining sequence.

Climate also plays a major role in the operation of the Centralia coal mine. Annual rainfall averages just over 4 feet and is generally concentrated between October and June. The rain saturates the spoil, thereby decreasing its strength, and results in pit drainage problems, and, as noted, causes elevated pore pressures in both the highwall and spoils. Spoil slopes that may stand at 2:1 during the summer can become mobile during the winter if not sufficiently prepared and sealed. Drainage is the key to minimizing the amount of water that is allowed to collect and settle into the spoil. A system of ditches directs water to pond systems out of the active mine area, thereby reducing deep infiltration into the spoil.

Since 1987 WIDCO has implemented a rigorous plan of geotechnical analysis and design support. Machine locations are continually surveyed, as are detailed cross sections of the active highwall and spoil slope configurations. Site-specific mine planning designs are then formulated on the basis of survey location data. These designs are analyzed with a specialized computer program that identifies potential slope stability problems. If such problems are identified, the design is modified to achieve an overall stable slope configuration.

In conjunction with the analysis procedure, geologic materials are examined, classified, and analyzed on a regular basis. The physical properties are incorporated into the stability analyses to provide site-specific design support for construction of stable slopes. Since the implementation of this type of planning, spoil slope and highwall instability has been minimized, resulting in increased productivity and overall improved mine efficiency.

The Centralia surface coal mine continues to enhance the geotechnical support aspects of mine operation. In this manner WIDCO can face the challenges of operating in a complex geologic—and geotechnically varied—environment for many years to come.

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In the Legislature

of the

STATE OF WASHINGTON

House of Representatives

HOUSE FLOOR RESOLUTION NO. 89-4675, by Representatives Dick Nelson, Georgette Valle and Roy Ferguson

WHEREAS, Today marks the fortieth anniversary of the destructive April 13, 1949, Olympia area earthquake; and

WHEREAS, This major earthquake registered a magnitude of seven point one on the Richter scale, caused one hundred fifty million dollars in damage (1984 dollars), killed seven people and was felt over a five hundred ninety-four thousand square kilometer area; and

WHEREAS, This quake was not an isolated event, but was instead a recurrent event, reflective of Washington State's everpresent earthquake threat; and

WHEREAS, Governor Gardner has recently recognized this fortieth anniversary with a proclamation establishing the week of April 9 through April 15 as Washington State Earthquake Awareness Week; and

WHEREAS, At this moment, outside of the House Chamber, a group of concerned citizens and earthquake professionals have recognized this fortieth anniversary by acknowledging the state's susceptibility to major earthquakes and offering an earthquake awareness exhibit for all interested individuals; and

WHEREAS, These concerned citizens and earthquake professionals, who have taken an active role in increasing earthquake awareness in Washington State are Ms. Linda Noson from the Federal Emergency Management Agency; Ms. Carol Martens from the Department of Community Development, Division of Emergency Management; Mr. Harry Halverson retired from Kinemetrics, Inc.; and Mr. Tim Walsh from the Department of Natural Resources, Division of Geology;

NOW, THEREFORE, BE IT RESOLVED, That the Washington State House of Representatives, on this fortieth anniversary recognize that disastrous event, acknowledge Washington's earthquake threat and encourage all Washingtonians, citizens and legislators alike, to increase their earthquake awareness; and

BE IT FURTHER RESOLVED, That the House of Representatives recognize and honor Ms. Linda Noson, Ms. Carol Martens, Mr. Harry Halverson and Mr. Tim Walsh as leaders of earthquake awareness; and

BE IT FURTHER RESOLVED, That copies of this Resolution be transmitted by the Chief Clerk of the House of Representatives to the aforementioned individuals and to the Department of Community Development, Division of Emergency Management.

ADOPTED April 13, 1989.

I hereby certify this to be a true and correct copy of Resolution adopted by the House of Representatives April 13, 1989.

ss/ Alan Thompson, Chief Clerk,
House of Representatives

1989 Earthquake Workshop

By Josh Logan and Steve Palmer

The third annual "Puget Sound/Portland Area Workshop on Earthquake Hazards and Risks" was presented March 28-30 in Portland, OR. The purpose of the meeting, which was funded by the National Earthquake Hazards Reduction Program (NEHRP), was to increase public awareness of earthquake hazards in the Pacific Northwest and to provide a forum for earthquake research and mitigation activities, giving technical and non-technical professionals an opportunity to interact. Representatives from such diverse fields as geology, seismology, engineering, planning, emergency management, politics, insurance, and fire and police protection participated. The Washington Department of Natural Resources' Division of Geology and Earth Resources (DGER) co-sponsored the event with the Washington Department of Community Development, the Oregon Department of Geology and Mineral Industries (DOGAMI), the Oregon Department of Emergency Management, the Federal Emergency Management Agency (FEMA), and the U.S. Geological Survey (USGS). Ian Madin from DOGAMI chaired the workshop planning committee.

This year's workshop consisted of two days of meetings followed by a day-long field trip to Netarts Bay. In one of the welcoming talks, Walt Hays, deputy for research applications in the Office of Earthquakes, Volcanoes, and Engineering of the USGS, summarized the progress of the NEHRP since its inception and outlined future directions for the program. He stressed the need to accelerate progress in research, development of professional practices, and implementation of mitigation measures. He described the enormity of tasks, such as gaining better knowledge of seismogenic zones; retrofitting existing buildings; eliminating unsafe school buildings; improving siting, design, and construction techniques; improving professional skills; increasing the state of earthquake preparedness; and producing more "champions" of earthquake hazard mitigation.

Two concurrent sessions were held on the workshop's first day, a geosciences session and a professional skill enhancement session. The purposes of the professional skill enhancement session were to explain the basic technical issues regarding earthquakes in the Pacific Northwest and to present methods of using technical information to reduce or respond to earthquake hazards. Talks presented during the morning part of this session reviewed the causes and effects of earthquakes. Tony Qamar and Ruth Ludwin of the University of Washington, and Linda Noson, FEMA, discussed the fundamentals of earthquakes, and answered such questions as "What is an earthquake, and how are they measured?" and "Where will earthquakes occur in the Pacific Northwest?". Steve Palmer, DGER, reviewed the impacts of earthquakes on the land and water, including liquefaction and ground settlement, seismically induced landslides, tsunamis, and seiches. Numerous examples from major earthquakes in Alaska, Japan, Los Angeles, Chile, and the Puget Sound area documented the results of these seismically induced processes. Roger McGarrigle, president of the Structural Engineers Association of Oregon, discussed the effects of earthquakes on buildings, and he graphically demonstrated both poor and good earthquake design using Portland-area buildings as examples. Karl V. Steinbrugge, a consulting engineer from California, discussed the difficulty of assessing the monetary impact of future earthquakes and how this uncertainty influences earthquake insurance underwriters.

The afternoon portion of the professional enhancement session discussed earthquake preparedness and response and the application of earth science information to city and regional planning. Martha Blair-Tyler of William Spangle and Associates summarized earthquake hazard mitigation measures with regard to regional and urban planning. William J. Kockelman, USGS, discussed translating earthquake hazard information for non-technical users who may then influence their peers, supervisors, clients, or constituents. Myra Lee of the Oregon Emergency Management Division and Kate Heimbach of the Washington Department of Community Development moderated a panel discussion concerned with the reaction to earthquake hazards at the state level. Panel members included Walt Friday, Oregon Building Codes Agency; Judy Burton, Washington Department of Labor and Industries; Scott Boettcher, Intern for Washington Representative Dick Nelson; and Carol Martens, Washington Division of Emergency Management. Martha Blair-Tyler and Paula Gori, USGS, moderated a later panel discussion on the use of earthquake hazard information at the local level. Panel members included Paul Kostenaik, Boeing Company Puget Sound Seismic Review Group; Bill Elliot, Portland Water Department; and Bev Carter, Mothers for HELP (Help Everyone Learn Preparedness). Mothers for HELP is a non-profit organization established to educate and organize communities to be self-reliant for the period following a major disaster but before normal services are re-established.

The professional enhancement session concluded with a talk by Jim Tingey of the Utah Division of Comprehensive Emergency Management on the lessons learned in the implementation component of the Utah Regional Earthquake Hazards Assessment Program.

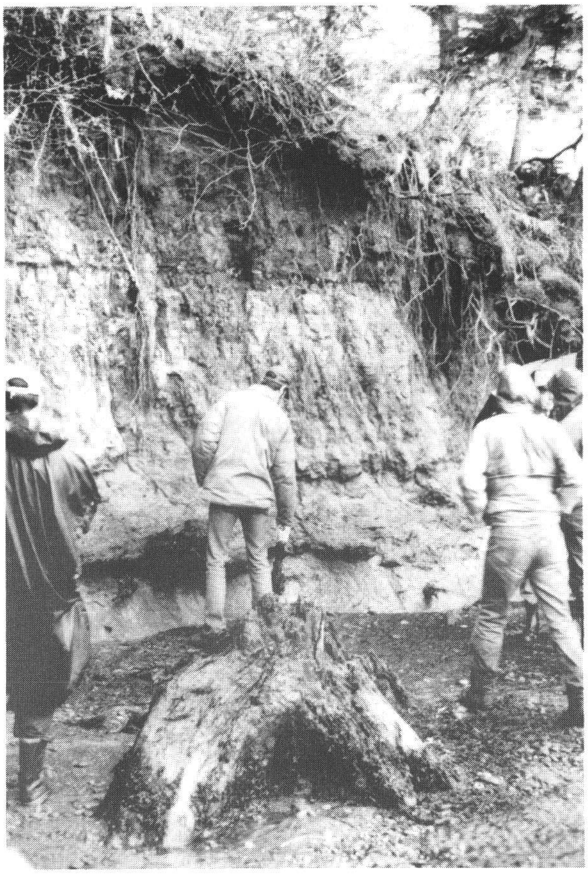
The geosciences session featured technical reviews of earthquake sources and site effects in the Pacific Northwest. Kaye Shedlock, chief of the Branch of Geologic Risk Assessment, USGS, outlined some of the more prominent earthquake-related issues in the Pacific Northwest, including seismological evidence of crustal, interplate, and intraplate earthquakes. She noted that a lack of seismicity along the boundary between the Juan de Fuca and North American plates is particularly disturbing to scientists in light of the geological evidence for "jerky" subsidence that is found in coastal marshes of Oregon and Washington. The evidence leads many scientists to conclude that there is a strong possibility for great earthquakes to occur in western Washington and Oregon.

Craig Weaver, USGS, described the seismicity of western Oregon and Washington and suggested the possibility that earthquakes similar to the 1949 and 1965 events could occur in Oregon.

Bob Crosson, University of Washington, discussed the seismicity of Puget Sound and southern British Columbia, showing through tomographic displays the inferred shape of the subducting Juan de Fuca plate and depths of some of the larger earthquakes identified in the region.

It was generally agreed that stress orientations vary with depth and that the resulting earthquakes have different causes. Major stress axes in the shallow crust are oriented north-south, whereas interplate stresses are oriented northeast-southwest, and intraplate stresses are tensional and down to the east. A talk presented by Paul Vincent, University of Oregon, provided geodetic evidence for north-south oriented stresses in the shallow crust.

Late Cenozoic deformation in northwestern Oregon was the topic of the talk by Bob Yeats, Oregon State University. He described an unnamed subsurface clay of probable Late Cenozoic age that is exposed in the Willamette trough and that may be offset by faulting. He concludes that further study needs to be done in that area. Other geological evidence for paleoseismicity was presented by Curt Peterson and Vern Kulm, Oregon State University, and by Don West, Golder Associates. Peterson discussed the geologically young coastal stratigraphic sequences of the Oregon coast, citing episodic, rapid subsidence of marsh deposits as evidence for great subduction zone earthquakes. Kulm compared geologic features in the marine portion of the Cascadia subduction zone with seismogenic subduction zones in other parts of the world. Evidence of periodic, large-scale deformation, massive sediment slumping, and fluid venting that are typical of other seismogenic subduction zones has also been found off the Washington-Oregon coast, suggesting that our currently aseismic subduction zone may be capable of generating great earthquakes. West compared coastal terraces of Oregon and Washington to those in other parts of the world. These comparisons suggest either that repeated great magnitude earthquakes have not occurred off the Oregon coast during the late Holocene, that the recurrence intervals for great events are longer than previously



Fieldtrip participants examining Pleistocene estuarine deposits at a site about midway along the east shore of Netarts Bay, Oregon. These deposits are cited as evidence of periodic subsidence along the Washington and Oregon coasts. The Pleistocene stump in the foreground is exposed in situ on the modern tidal flat. A younger organic layer containing tree remains is exposed in the cliff behind the observers. These deposits underlie the "Whiskey Run" wave-cut terrace that has been dated by amino-acid racemization at 80 to 85 ka. Much younger Holocene deposits that exhibit evidence of a similar history of subsidence can also be observed at the south end of the bay. A field guide to the Netarts Bay area by C. D. Peterson and others is in the September/October 1988 issue of *Oregon Geology*.

thought, that smaller magnitude thrust events are possible, or that the tectonic mechanism for our subduction zone is unique.

The geologic evidence presentations were followed by discussions of strong ground motions that could be expected from earthquakes in the Pacific Northwest. Emphasis was placed on megathrust ground motions, and models were presented by the speakers that predicted the strength and duration of the shaking to be expected in the region from various postulated events. Speakers included Ivan Wong and Paul Somerville, Woodward-Clyde Consultants; Bob Youngs, Geomatrix Consultants; and C. B. Crouse, Dames and Moore.

Efforts to determine actual ground response through field investigations and mapping were described by Ken King and John Tinsley, USGS. Tony Qamar, University of Washington, discussed historical earthquake intensity mapping near Seattle.

Paul Grant, Shannon and Wilson, Inc., described liquefaction associated with past Puget Sound events and stressed that the longer duration of ground shaking expected from a subduction zone earthquake could result in considerably more damage than inflicted by historical earthquakes. Robert Schuster, USGS, pointed out the existence of many large landslides located in Washington and suggested that some may have been seismically induced. Jane Preuss, Urban Regional Research, discussed the results of a tsunami case study done in Grays Harbor in which a methodology for defining characteristics of coastal risks and determining the geographic area of vulnerability was developed.

A poster session was held on the evening of March 28 to develop these topics more fully and provide the opportunity for discussion.

Future research, mitigation, and policy directions and needs were addressed during the second day. The need to hone and enhance our earthquake hazard policies was profoundly emphasized by Walt Hays, USGS, in a presentation on the Armenian earthquake. As tragic as the Armenian event was, the impact of a great earthquake in a heavily populated area in the United States could be even more devastating: not only would great loss of lives and property occur, but extreme repercussions on the national and world economy might also result, according to James Lett, Unigard Insurance. Hays, USGS, went on to suggest that such impacts could be reduced if mitigation and research efforts were enhanced. He further believes that an opportunity exists for such enhancement in the International Decade for Natural Disaster Reduction, which will begin next year, and he proposed that our efforts be directed toward increasing the number of "champions" for the earthquake hazard reduction cause. By doing so, we can make greater inroads into reduction of impacts from catastrophic events such as great earthquakes.

Political science professor Peter May, University of Washington, compared earthquake reduction policies of Washington and Oregon, and he provided useful insight into how these policies are perceived, derived, and implemented. John Beaulieu, DOGAMI, described his agency's experiences in attempting to secure funding and legislation for earthquake hazard mitigation. Lessons learned in response to major earthquakes in densely populated areas was the topic of a talk by Patricia Bolton, Battelle Research Institute.

John Nance, author of "On Shaky Ground", spoke at the luncheon. He emphasized the importance of bringing earthquake information to a broad audience and applauded the efforts represented by this workshop in that regard.

The field trip, led by Mark Darienzo, allowed all participants to observe first hand the field evidence interpreted to suggest past occurrences of great earthquakes (magnitude 8 or greater) along the Oregon coast. A guide for the field trip is available in the September/October 1988 issue of *Oregon Geology*, published by the Oregon Department of Geology and Mineral Industries.

Asbestos (Continued from page 2)

B. Asbestos Fibers - While any given asbestos particle may not exhibit all the listed criteria, asbestiform mineral fiber populations will have the following characteristics when viewed by light microscopy:

1. Many particles with aspect ratios ranging from 20:1 to 100:1 or higher for particles >5 micrometers in length.
2. Very thin fibrils generally <0.5 micrometers in width; and,
3. In addition to the mandatory fibrillar crystal growth, the asbestos mineral particles will have two or more of the following attributes:
   - (a) Parallel fibers occurring in bundles;
   - (b) Fibers displaying splayed ends;
   - (c) Matted masses of individual fibers; and
   - (d) Fibers showing curvature.

Another Cetacean (Whale) Fossil from the Olympic Peninsula

by Keith L. Kaler

On July 16, 1988, excavation began on a primitive fossil whale, the second to be unearthed in less than a year on the Olympic Peninsula. (The first of these fossils was described in volume 16, number 3, of the *Washington Geologic Newsletter*). Both fossils were found by the husband and wife fossil-hunting team of Jim and Gail Goedert, of Gig Harbor, Washington. They have been extensively searching for plant and animal fossils for more than 12 years in the Pacific Northwest and have contributed much scientifically valuable material for study by paleontologists.

Jim Goedert, an associate of the Natural History Museum of Los Angeles County, California, discovered the fossil 2 years ago. It was offered to the Northwest Museum of Natural History in Portland, Oregon. David Taylor, the museum's executive director, was in charge of organizing and directing the 1988 excavation and removal of the fossil to its final residence at Portland.

The excavation effort lasted 9 days and required an estimated 275 worker-hours to complete. A total of 15 volunteers, including the Goederts and Taylor, worked on removing the bones from the enclosing sediments. (See Figs. 1-4.) Some of the other workers included Bill Buchannon of Clallam Bay; and Corbin Cook, Charles Strawn, Russ Dowell, and Bob Barker, all from Port Angeles.

Only hand tools were used at this site because the bones were in soft siltstone, not encased in concretions as is typical with so many marine fossils. Through careful work with picks and chisels, piece by piece the bones were laid bare. The larger of these, notably the skull and jaw (mandible), were then encased in plaster of Paris for the long trip to the museum. Smaller pieces, such as the vertebrae and ribs, were not as vulnerable to damage as was the skull and did not need to be so well protected.

The recovered material consists of the entire skull with one mandible, some cervical vertebrae, some front limb bones (a humerus, radius, and ulna), two bones from the "hand" (phalanges), and several ends of ribs. Unfortunately, an important portion of the exposed skeleton, the shoulder blade (scapula), was destroyed by unknown visitors to the site between the time of discovery and the excavation.

The whale is a primitive Mysticete, a baleen whale, and was toothless. It will undoubtedly prove to be a new and important species once it is studied. Because the enclosing matrix is soft siltstone, preparation of the fossil will be easy. The sedimentary unit from which it was dug is part of the Pysht Formation and is upper Oligocene to lower Miocene in age. Cetacean fossils are not plentiful in these rocks, which makes this discovery all the more important.

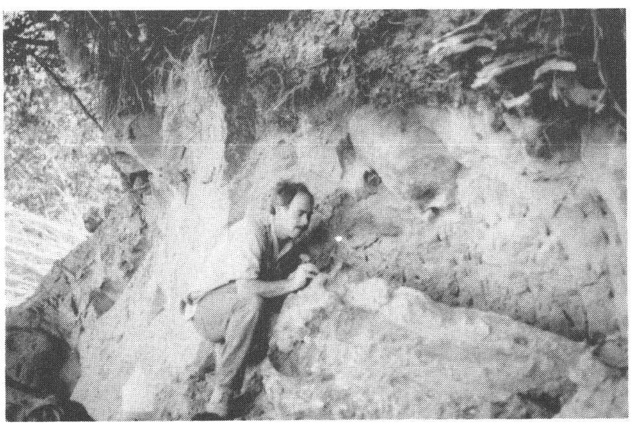


Figure 1. David Taylor, the excavation's organizer, chipping matrix from the back of the whale skull, some of which is exposed as the dark, smooth material in the rock. The anterior of the skull, in this and subsequent photos, is to the viewer's right.

Figure 2. Bill Buchannon adding some final touches prior to encasing the skull in plaster. The skull is oriented such that the main view is of the underside (ventral part) of the snout (rostrum). This area is fragile in a skull of this size and will be protected during removal and shipment. The 'platform' on which the skull rests is the lower mandible.

A note to would-be fossil vertebrate hunters: Hunting for and collecting vertebrate fossils requires permits, and it is the responsibility of the fossil hunter to acquire the appropriate form of permission to collect. The penalties for collecting without permits are stiff. State, local, and federal acts (particularly the Antiquities Act of 1906, the Minerals Leasing Act of 1920, and Historic Sites Act of 1935) are the basis for protection of fossils. Getting a permit may be a complex process, and the first step in obtaining a permit is to determine the legal ownership of the land in question. County offices or local offices of federal agencies can help identify ownership. The second step is to contact the appropriate agency or landowner to find out what the requirements for a permit are.

A helpful source of information about fossil collection is *Paleontological Collecting*, a 1987 book published by the National Academy of Sciences. Examples of several kinds of permits are included. Write for information about the price to the Committee on Guidelines for Paleontological Collecting, Board on Earth Sciences, 2101 Constitution Ave., Washington, DC 20418.

A vertebrate fossil that consists of several parts, whole bones, or teeth may be of scientific importance. Amateur collecting has the potential for destruction of potentially valuable material. To be sure a fossil is collected correctly, the finder should contact a paleontologist at the nearest museum. Paleontologists at the Northwest Museum of Natural History in Portland, Oregon, are an excellent source of help; call the staff at (503) 464-3022. Another museum that will be interested in vertebrate finds is the Burke Museum in Seattle. The Burke staff can be reached by calling (206) 543-6776. Or contact members of the geology departments of the University of Washington or Washington State University. These persons can put you in touch with a qualified professional who can direct the excavation and protection of the fossil materials.

With the cooperation of the public in respecting the scientific value of vertebrate fossils and bringing finds to the attention of appropriate professionals, paleontologists will have an easier time unravelling the mysteries of Washington's earlier faunas.

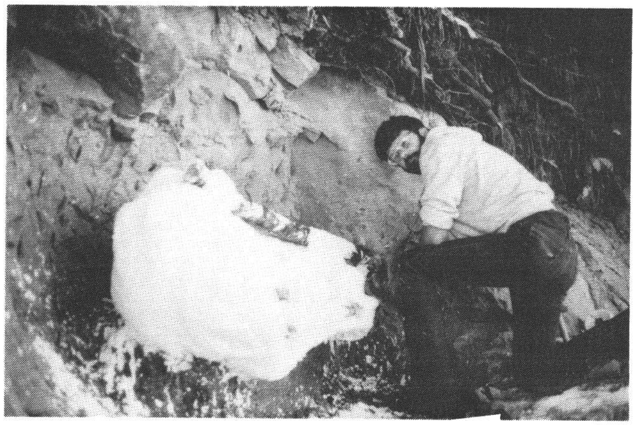


Figure 3. Most of the skull is encased in plaster; some parts still adhering to the rock wall. The next step is to use long, thin steel bars to separate the plaster-skull block from the wall. These bars are driven into the matrix at a sufficient distance behind the block and will not come in contact with the bone. The block, with matrix clinging to its backside will be pried off the cliff face in one piece, undamaged. Jim Goedert, the finder of the cetacean fossil, waits for the next step.

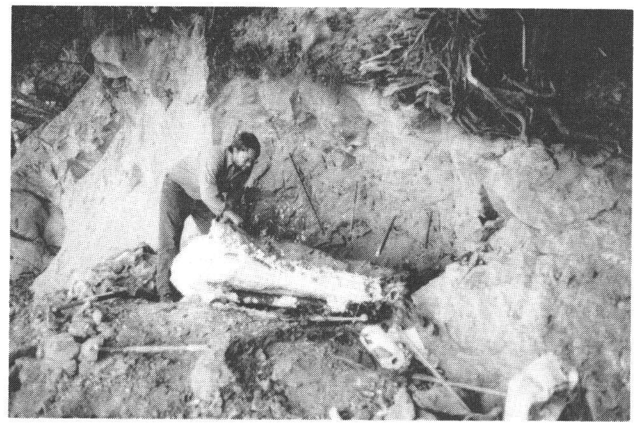


Figure 4. Bob Barker removing matrix clinging to the backside of the block. The skull is now separated from the cliff, has been turned over, and is lying with its top (dorsal) side up. Sturdy alder branches (seen in figure 3) help give support to the base of the block. A trailer was later backed up against the pile of material that was removed by hand from around the skull, and the block was slid onto the trailer bed and secured. With these precautions, it travelled safely to Portland.

GEOLOGIST POSITIONS OPEN

The Division of Geology and Earth Resources will hire one economic geologist and one environmental geologist in the summer of 1989. Both positions will be based in Olympia. Minimum qualifications are a bachelors degree with major study in geology, mining engineering, geophysics or geochemistry and two year's professional geologic experience in economic or environmental geology. Starting salary of both positions is $26,220/year plus an attractive package of benefits. For information, contact Susan Davis, Dept. of Natural Resources, Div. of Geology and Earth Resources, MS PY-12, Olympia, WA 98504; (206) 459-6372.

The Washington State Geological Survey in 1909

HISTORICAL NOTE: Henry Landes, author of the following article, was State Geologist from 1901 until 1921. At that time the Washington State Geological Survey, a predecessor of the Division of Geology and Earth Resources, was located at the University of Washington, where Landes was also Chairman of the Department of Geology. The state survey was particularly active between 1910 and 1921, during which time Landes supervised the publication of 23 bulletins on the geology, geography, mineral resources, and irrigation potential of Washington. In addition, the survey was involved in cooperative investigations with the Federal Bureau of Soils to map the soils of logged-off lands in the Puget Sound area and with the U.S. Geological Survey to make topographic maps, gauge stream flows, and measure river profiles.

This article illustrates Landes' concept of the role of a state geological survey and summarizes the activities of the Washington State Geological Survey. The article is undated, but its contents indicate a 1909 or early 1910 date. The original text is from the University of Washington Archives, Accession Number 75-70-53, Henry Landes papers. There is no evidence that this article was ever published. – *J. E. Schuster*

All literature contains references to the observations made by human beings upon the earth, the water, and the air. In consideration of these three things, not of each alone, in their mutual action and reaction of one upon another, we obtain the facts and principles of the great earth science, known as geology. In the group of sciences we find no one isolated from its fellows, but the subject matter of one is very closely interwoven with the subject matter of all the others. So universally is this true that a great advance in one science is only possible by ample help from the others, and the lagging behind of any science seriously affects the progress of them all. In proof of the inter-dependence of some of the sciences we have only to recall that all questions concerning the origin of the earth and the early chapters of its history belong equally within the provinces of astronomy and geology; that all studies upon the composition of minerals and rocks, the nature of soils, etc., are at once within the fields of both chemistry and geology; that many questions regarding the effects of changes of temperature upon the earth's surface, the flow of rivers and glaciers, belong equally well in the domain of physics as well as geology; and that any consideration of the tribes of plants and animals that inhabited the earth in by-gone ages takes one as far into the science of biology as into geology.

When we confine our attention to geology alone the fact is brought home to us that a large variety of subjects is included under the one head. If we consider the character of the earth's surface alone, such as land and sea, mountains and valleys, plateaus and plains, rivers and lakes, we are dealing with topographic or physiographic geology; if our attention is fixed upon the minerals or rocks which compose the earth's crust we have to do with mineralogy or lithology; if we study the fossil faunia [sic] and flora embedded in the layers of rock we are in the domain of palentology [sic]; if we concern ourselves chiefly with a quest for the useful things hidden away beneath the earth's surface we are in the field of economic geology.

It is the search for useful things upon and within the earth, of a mineral character, that affords the basis for geological surveys. Such surveys are carried on in a rude way by individuals, when they prospect for the metals, fuels, and all things which may be profitably won from the earth and sold; they are carried on much more thoroughly by corporations when they make detailed studies of the mineral resources of large tracts of ground which they may control; but geological surveys at their best are conducted by the state or the general government, since the results thereby obtained are not only authoritative but they are replete with details and are at once the property of the whole people.

In the U.S. we have an efficient Federal Survey and about forty State Surveys. In many states geological surveys have long been maintained and they are regarded as among the most essential and valuable bureaus of the state government. It is the general purpose of a geological survey to set before the people of a state the truth about the mineral resources of their commonwealth; to point out what useful things exist, where they occur, in what quantities, how they may be obtained economically, how conserved, etc. The fact should not be overlooked that it is one of the chief functions of a geological survey to make known the useful things which do not occur in a state as well as those that do occur. In every state large sums of money are often spent by individuals and companies in prospecting and seeking after improbable or impossible substances, when such sums could have been saved by advice secured from the geological survey. It has been estimated that the farmers of New York spent one million dollars in prospecting their farms for coal, when a few thousands of dollars spent by a geological survey would have made it clear to every one that the search for coal in that state could not help but be fruitless.

The legislature of Washington at its 1909 session appropriated $55,000 for the work of the State Geological Survey during this biennium. In cooperation with our own survey the U.S. Geological Survey will expend at least $30,000 so that we have $85,000 available for this class of work. In most of the immediate problems which face the Geological Survey the principles of conservation are of large importance. In pointing out a few of these problems it might be well to begin with the making of the topographic maps. A topographic map is designed to show the form and slope of the surface of the land and the elevation of all points above sea level. It is made with such accuracy and in such detail that it is useful to almost every citizen. From it the positions of streams and lakes may be seen and the possibilities of these for purposes of irrigation or water power may be largely determined. Such a map is valuable in order to show the location of desirable farm lands and the general character of the country; and it facilitates the construction of wagon roads and railroads, since upon it available routes and grades may be laid out without the preliminary surveys ordinarily necessary for improvements of this kind.

In the making of topographic maps the areas selected for survey are defined by lines of latitude and longitude and are called quadrangles. The State of Washington contains in round numbers 90 quadrangles, complete or fractional, each embracing when complete about 825 square miles. Thus far the task of making the topographic surveys has been carried on solely by the U.S. Geological Survey, and that organization has, since it began work in 1893, completed 25 of the 90 quadrangles. In order to expedite the topographic survey, and render the results available when they are most needed by a developing state, a scheme of cooperation has been entered into between the Federal and the State Geological Surveys. Under this arrangement each party contributes $20,000 during the years 1909-10, and it is expected that five additional quadrangles will be surveyed.

Topographic maps, more than any other one thing, give us detailed and accurate information about our state. They are the necessary bases for good roads, and all irrigation enterprises. They show at a glance the location and amount of arable lands, the swamp lands, and all areas unsuited for agriculture; give full information regarding the lakes, mountains, glaciers, and all things of great scenic value. Upon such maps the distribution of coal, iron, clay, and all mineral substances of value may be faithfully portrayed. In short there are few phases of conservation where the topographic maps are not urgently needed, and in which their cost of making, in the long run, is not met over and over again.

A second way in which cooperation between the U.S. Geological Survey and the State Survey is to be followed is in the making of an hydrographic survey. Such a survey comprises an examination of the water resources of the state, in order to determine the possible supplies of potable water, water for power purposes, or for use in irrigation. The water supply of the state is of prime importance to the life and pursuits of the people, since the health and economic development of every community are directly dependent on the character and volume of the available supply.

An hydrographic survey gives accurate and detailed information regarding the great natural storage reservoirs of the state, such as the lakes, snow-fields, glaciers, and the mantle of soil. In addition the possibilities are made known for the artificial storage of water by elevating the outlets of lakes, by the construction of dams in the narrows of streams, and elsewhere. The profiles of the streams, with the data obtained from the gauging stations, yield the estimates as to the water power afforded. The water power of the state is perhaps the most important subject with which the Geological Survey has to deal, and at the same time it is one of the most vital topics today from the standpoint of conservation. If amply protected and properly conserved the mighty power of our streams, descending from mountain summit to sea-level, may be depended upon as our sole source of power when our coal, gas, and oil are wholly consumed.

Another problem which confronts the State Geological Survey is a classification of the soils of the state, with particular reference to their utility. At the present time this work is demended [sic] by those counties in which the areas of logged-off-lands have come to be large, and in which the question as to what to do with such lands has become a serious one. Such lands should be immediately classified in two groups — those which will make desirable farms when cleared, and those that because of their steep slopes, stony soil, or for other reasons, are not tillable and which should be at once reforested and amply protected from fires. All deforested hill-sides should be protected from fires, since burning speedily consumes the humus of the soil, rendering reforestry almost impossible, and at the same time affording an opportunity for the exposed soil of the steep slopes to be rapidly washed away. There is no more effective way of making desolate and barren hill-sides which may not be reclaimed for long years, that [sic] by their annual burning over. As a rule the logged-off-lands, when of a hilly nature, are usually considered of a non-agricultural character, and are very commonly abandoned by their owners. When such lands are of no taxable value, and are very constant menace because of the fires which prevail in them each summer, they should be purchased by the state and held, reforested, and fully protected as State Forests or State Parks. The state can well afford to own and protect such forest lands, not only for the successive timber crops which will be yielded, but because of the opportunity to protect the included lakes, waterfalls, and all natural objects of beauty, as well as keeping in our midst the natural fauna and flora which might otherwise suffer extenction [sic]. I know of no greater service which may be rendered by the conservation movement than that helping the movement for the establishment of State Parks or State Forests over those logged-off-lands where agriculture is impractical, and where the conditions are favorable for forest only.

Another place where the State Geological Survey rubs elbows with Conservation is in the investigation of our coal resources. In the next two years the survey hopes to obtain certain results which should be welcomed by all friends of the conservation movement. In the first place we expect to map with accuracy and detail the coal fields, setting forth their exact boundaries, so that our coal lands may be separated from the non-coal-bearing. In so far as possible the tonnage of every workable seam will be calculated, so that for the first time the coal reserves or resources of our commonwealth will be made known. When we consider that the State is a great business organization we realize how imperative it is for us to know the exact quantity and quality of our fuel supply, in order that the needs of the present and the interests of the future may receive just consideration. A second point is the fact that coal mining in Washington is accompanied by great waste. This wasteful condition arises in several ways, chiefly by the abandonment of much good coal in the pillars and other parts of the mine, by the loss of the slack or pulverized coal which should be briquetted, and otherwise. A third thing which the Survey proposes to do is to make tests upon the lignite coals of the state with the hope of finding ways whereby these low grade fuels may be made valuable. When accurate maps of the coal areas of the state are completed it will be found that at least one-half of the coal tonnage is to be found within the lignite fields. At present the lignite coals have only a trifling local use, and enter but little into any consideration of the valuable fuels of the state. It will be a great service to the state if ways can be found for the utilization of the fuel value of the lignites, and along this line we have much encouragement from similar work which has been undertaken in other states.

The clay and limestone deposits of Washington are subjects which must always receive attention from the State Geological Survey. If we can apply the term inexhaustible to any mineral substances it would be to our clays and limestones. We have entered upon a great era in the production of things from clay and cement. It is of much interest to the conservation problem to find such excellent substitutes for wood and other things which are either exhausted in time or which are reproduced with great slowness. All persons who are interested in Conservation must look with much favor upon Good Roads. Conservation and Good Roads are among the greatest economic problems of the present day. In the making of good roads one of the important elements is the matter of the material used in their construction. Washington is particularly favored in the widespread distribution of rock deposits of the finest quality suitable for the building of macadam roads. In the next two years it is the purpose of the Geological Survey to make a thorough report upon the desirable road metals of the State, with complete tests, maps, and descriptions, so that our resources along this line will be accurately known.

It is unnecessary to stipulate further the close relationship which exists between the work of the State Geological Survey and Conservation. When the Survey is able to render marked assistance toward the complete establishment of the great principles of Conservation, whereby the right use of our great natural wealth may be acknowledged and established, then, and not till then, will it have wholly justified its creation in law.

A History of State Geological Surveys

Washington's state geological organization will join more than 30 state surveys that have been active for at least 100 years when it celebrates its centennial during 1990.

The Association of American State Geologists has recently published a 500-page hardcover book that describes the history and functions of each of the 50 state geological surveys. The accounts of the development and activities of the surveys shed light on a major component of geologic mapping and research in the United States.

The book, titled ***The State Geological Surveys–A History*** and edited by Arthur A. Sokolow, is available from the Geological Survey of Alabama, P.O. Box 0, Tuscaloosa, AL, 35486. The price is $20 and includes postage. Checks should be made payable to Association of American State Geologists.

The Division of Geology and Earth Resources Library

By Connie J. Manson, Senior Librarian

Where is the subducting Juan de Fuca plate? Have there been major earthquakes there, and will there be more?

Are there petroleum deposits off the coast of Washington?

What is the status of metals mining in Washington? Where's the gold?

Where are the sand and gravel deposits in Washington?

What is the geology of Seattle?

Why are there landslides along the banks of the Columbia River?

Are there any geologic maps of Wenatchee?

Is there a surficial geologic map of Everett?

What areas are open to rockhounds?

Will Mount St. Helens erupt again?

At the Division of Geology and Earth Resources, we deal with these kinds of questions every day, both in doing our own research and in helping others do theirs. Geologic research is unusually reliant on the literature. Answers to questions can be in the most current research, in reports or maps published 100 years ago, or somewhere in between. And the information comes from many different sources: reports of the U.S. Geological Survey (USGS), of our own agency, from journal articles, conference reports, theses, technical reports, and other sources.

To date, there have been more than 18,000 items written on the geology and mineral resources of Washington State, and more are written every day. But in order to understand how geologic processes operate in Washington, we need to know how they work in other places, or just in general, so we also have an extensive collection of general and non-Washington materials.

The importance of having a good source for geologic information was recognized very early in Washington State. The 1935 enabling legislation for the Division of Mines and Mining (one of our parent agencies) said that the Division shall (RCW 43.21.070):

> ...collect and assemble a library pertaining to mining, milling and metallurgy of books, reports, drawings, tracings and maps and other information relating to the mineral industry and the arts and sciences of mining and metallurgy;

and:

> ...preserve and maintain such collections and library open to the public for reference and examination...

The Division of Geology and Earth Resources Library, in our headquarters office in Olympia, is the result both of that need and of this legislative mandate. At the library, we try to have a copy of every report (or map, thesis, conference abstract, or other publication) on the geology and mineral resources of Washington ever issued, and we strive to also have a broad range of supporting materials. The library now includes approximately 60,000 books and documents, including:

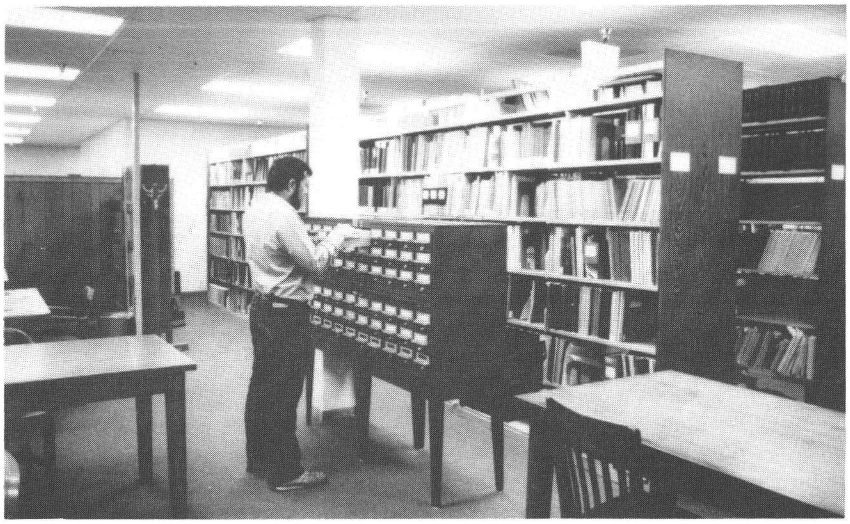
- The USGS published reports (Annual Reports, Bulletins, Circulars, and Professional Papers) issued from 1879 to date;
- The USGS open-file reports on the geology and mineral resources of Washington, and some open-file reports on the hydrology of Washington;
- All known (and available) masters and doctoral theses on the geology and mineral resources of Washington, issued from 1901 to date, and a few Bachelors theses and senior thesis reports;
- A full set of all reports issued by the Division or its parent agencies;
- Selected reports of the Geological Survey of Canada, and the British Columbia Ministry of Energy, Mines and Petroleum Resources;
- The U.S. Bureau of Mines Minerals yearbooks (1883 to date) and extensive collections of other Bureau of Mines reports;
- An extensive collection of other reports on Washington;
- Copies of approximately 5,000 journal articles and conference papers on Washington;
- Copies of approximately 3,000 conference abstracts on Washington;
- Subscriptions to about 100 current journals; and
- Other books, documents, and journals.

We also collect materials on timely and controversial issues, and thus have extensive collections on the geology of the Hanford Reservation; the potential for offshore petroleum resources; seismic hazards of the Puget Lowland-Willamette trough area; and other subjects of current concern.

There is no one single index to all these materials because they span such a wide range of date, form, and source. Instead, we use an overlapping combination of indices:

- The *Bibliography and index of the geology and mineral resources of Washington*, 1814 through 1989 series (our Bulletin 35, 1814-1936; our Bulletin 46, 1937-1956; our Bulletin 59, 1957-1962; our Bulletin 76, 1963-1980; our Open-File Report 86-5, 1981-1986; in-house computer for materials 1987 to date). All items included in these bibliographies are now in our in-house data base system and can be searched electronically. (See the *Washington Geologic Newsletter*, v. 15, no. 1, p. 25.)
- The *Bibliography of North American geology* series, 1785-1970, by the USGS, continued as the *Bibliography and index of geology*, 1971 to date, published first by the Geological Society of America and then by the American Geological Institute.
- Special indices such as the thesis bibliography (our Information Circular 80, with its update; our Open-File Report 89-1) and the index to geologic and geophysical mapping (our Information Circular 77, with its update, our Open-File Report 89-1). We have also issued bibliographies on landslides; Mount St. Helens; offshore geology and mineral resources; Ferry County; and seismic hazards of western Washington.

The Division of Geology and Earth Resources Library is a unique and valuable resource, both for our own staff and for others interested in the geology or mineral resources of Washington. The Library is open to the public Monday through Friday, 8 a.m. to 4:30 p.m. We do not loan and can offer only limited photocopying, but we can offer advice or referral to insure that researchers get the information and the materials that they need.



Division of Geology and Earth Resources Library in the main office.

Selected Additions to the Division of Geology and Earth Resources Library

February 1989 through April 13, 1989

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Bending, David A. G., 1983, A reconnaissance study of the stratigraphic and structural setting, timing, and geochemistry of mineralization in the Metaline district, northeastern Washington, U.S.A.: University of Toronto Master of Science thesis, 324 p.

Byrnes, Mark Edward, 1985, Provenance study of late Eocene arkosic sandstones in southwest and central Washington: Portland State University Master of Science thesis, 65 p.

Lindsay, C. S., 1988, The effects of urbanization on the water balance of the Fishtrap Creek basin, northwest Washington and south central British Columbia: Western Washington University Master of Science thesis, 65 p.

Nelstead, Kevin Torval, 1988, Correlation of tephra layers in the Palouse loess: Washington State University Master of Science report, 80 p.

Shultz, J. M., 1988, Mid-Tertiary volcanic rocks of the Timberwolf Mountain area, south-central Cascades, Washington: Western Washington University Master of Science thesis, 145 p., 1 plate.

U.S. GEOLOGICAL SURVEY

Published reports

Glicken, Harry; Meyer, William; Sabol, Martha, 1989, Geology and ground-water hydrology of Spirit Lake blockage, Mount St. Helens, Washington, with implications for lake retention: U.S. Geological Survey Bulletin 1789, 33 p., 3 plates.

Molenaar, Dee, 1988, The Spokane aquifer, Washington–Its geologic origin and water-bearing and water-quality characteristics: U.S. Geological Survey Water-Supply Paper 2265, 74 p.

Scott, K. M., 1988, Origins, behavior, and sedimentology of lahars and lahar-runout flows in the Toutle-Cowlitz River system: U.S. Geological Survey Professional Paper 1447-A, 74 p.

Silberling, N. J.; Jones, D. L.; Blake, M. C.; Howell, D. B., 1987, Lithotectonic terrane map of the western conterminous United States: U.S. Geological Survey Miscellaneous Field Studies Map MF-1874-C, 1 sheet, scale 1:2,500,000, with 19 p. text.

Stover, C. W., 1988, United States earthquakes, 1984: U.S. Geological Survey Bulletin 1862, 179 p.

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Harding, S. T.; Barnhard, T. P.; Urban, T. C., 1988, Preliminary data from the Puget Sound multichannel seismic-reflection survey: U.S. Geological Survey Open-File Report 88-698, 7 p., 17 plates.

Jacobson, M. L., compiler, 1988, National Earthquake Hazards Reduction Program, summaries of technical reports Volume XXVII: U.S. Geological Survey Open-File Report 88-673, 630 p.

Sapik, D. B.; Bortleson, G. C.; Drost, B. W.; Jones, M. A.; Prych, E. A., 1988, Ground-water resources and simulation of flow in aquifers containing freshwater and seawater, Island County, Washington: U.S. Geological Survey Water-Resources Investigations Report 87-4182, 67 p., in folder with 4 plates.

Tabor, R. W.; Booth, D. B.; Vance, J. A.; Ford, A. B.; Ort, M. H., 1988, Preliminary geologic map of the Sauk River 30 by 60 minute quadrangle, Washington: U.S. Geological Survey Open-File Report 88-692, 50 p., 2 plates.

DIVISION OF GEOLOGY AND EARTH RESOURCES REPORTS

Bentley, R. D.; Campbell, N. P.; Powell, J. E., 1988, Geologic map of the Bluelight 15-minute quadrangle, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-35, 1 sheet, scale 1:48,000.

Bentley, R. D.; Campbell, N. P.; Powell, J. E., 1988, Geologic map of the Logy Creek 15-minute quadrangle, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-37, 1 sheet, scale 1:48,000.

Bentley, R. D.; Campbell, N. P.; Powell, J. E., 1988, Geologic map of the Poisel Butte 15-minute quadrangle, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-36, 1 sheet, scale 1:48,000.

Joseph, N. L.; and others, editors, 1989, Geologic guidebook for Washington and adjacent areas: Washington Division of Geology and Earth Resources Information Circular 86, 369 p.

Manson, C. J., compiler, 1989, Geologic and geophysical mapping of Washington, 1984 through 1988, and, Theses on the geology of Washington, 1986 through 1988: Washington Division of Geology and Earth Resources Open-File Report 89-1, 26 p.

Reidel, S. P., 1988, Geologic map of the Saddle Mountains, south-central Washington: Washington Division of Geology and Earth Resources Geologic Map GM-38, 5 plates, scale 1:48,000, with 28 p. text.

OTHER WASHINGTON STATE AGENCY REPORTS

Palmer, S. P.; Lingley, W. S., Jr., 1989, An assessment of the oil and gas potential of the Washington outer continental shelf: University of Washington, Washington Sea Grant Program, Washington State and Offshore Oil and Gas, 83 p., 12 plates.

Strickland, Richard; Chasan, D. J., 1989, Coastal Washington–A synthesis of information: University of Washington, Washington Sea Grant Program, Washington State and Offshore Oil and Gas, 233 p.

Washington Natural Heritage Program, 1989, Biennial final–State of Washington natural heritage plan: Washington Department of Natural Resources, 175 p

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Barlee, N. L., 1988, Gold creeks and ghost towns of northeastern Washington: Old Okanogan Publishing Company [Oroville, Wash.], 224 p.

Bio/Tech Communications, 1989, Proceedings–Conference/workshop on recommendations for studies in Washington and Oregon relative to offshore oil and gas development, May 1988: U.S. Minerals Management Service [Los Angeles, Calif.] MMS 88-0090, 213 p.

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Geological Survey of Canada, 1989, Current research, Part E–Cordillera and Pacific margin: Geological Survey of Canada Paper 89-1E, 279 p.

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Geomatrix Consultants, Inc., 1988, Seismotectonic evaluation of the northern Cascade Mountains geomorphic province for Bumping Lake, Tieton, Keechelus, Kachess, Cle Elum, and Clear Lake dams: Geomatrix Consultants, Inc. [San Francisco, Calif., under contract to] U.S. Bureau of Reclamation, 154 p., 12 plates.

Kennedy/Jenks/Chilton, 1989, Earthquake loss estimation modeling of the Seattle water system–Year end project status report: Kennedy/Jenks/Chilton [under contract to U.S. Geological Survey], 54 p.

Northern Miner Press, Ltd., 1989, American mines handbook: Northern Miner Press, Ltd., 256 p.

Pistrang, M. A., 1981, Bedrock and bootsoles–An introduction to the geology of the Issaquah Alps: Issaquah Alps Trails Club [Issaquah, Wash.]. 10 p.

Puget Sound Water Quality Authority, 1988, State of the Sound 1988 report: Puget Sound Water Quality Authority, 225 p.

U.S. Bureau of Mines, 1989, State mineral summaries, 1989: U.S. Bureau of Mines, 187 p.

University of Washington Geophysics Program, 1988, Quarterly network report 88-D on seismicity of Washington and northern Oregon: University of Washington Geophysics Program, 21 p.

OTHER REPORTS OF INTEREST

Back, William; Rosenshein, J. S.; Seaber, P. R., editors, 1988, Hydrogeology: Geological Society of America DNAG Geology of North America, v. O-2, 524 p., 3 plates.

Bally, A. W., editor, 1987-1989, Atlas of seismic stratigraphy: American Association of Petroleum Geologists Studies in Geology 27, 3 v. (Note: Volume 1 was published in 1987; Volume 2 was published in 1988; Volume 3 will be published in 1989 and will complete the set.)

Boesch, D. F.; Rabalais, N. N., editors, 1987, Long-term environmental effects of offshore oil and gas development: Elsevier Applied Science, 708 p.

Clark, R. B., editor, 1982, The long-term effects of oil pollution on marine populations, communities and ecosystems: The Royal Society of London, 259 p.

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Northern Miner Press, Ltd., 1988, Canadian mines handbook: Northern Miner Press, Ltd., 603 p.

Western Snow Conference, 1986-1988, Proceedings of the Western Snow Conference annual meeting: Western Snow Conference [Portland, Ore.], 1 v. [DGER library has the 1986, 1987, and 1988 volumes]

New Division Releases

Information Circular 86: Geologic Guidebook for Washington and Adjacent Areas, Nancy L. Joseph and others, editors. This 376-page guidebook contains introductory texts and road logs for 15 excursions in Washington, northeastern Oregon, northern Idaho, and southeastern British Columbia. A wide range of topics is covered—from Precambrian rocks to late Pleistocene deposits and from biostratigraphy to gold deposits and engineering geology. The volume was prepared for the 85th annual meeting of the Cordilleran Section, Geological Society of America. The guidebook's price is $8.65 + .35 (tax) = $9.00. Add $1 per order for postage and handling.

Reprint 12: Geology of Washington. Reprinted from a report prepared for the U.S. Senate Committee on Interior and Insular Affairs in 1966. This concise report, which also includes a 12-in. x 14.5-in. geologic map of Washington, is a primer on the state's geology for lay persons and schools. It remains a useful overview even though it has not been updated to include changes in stratigraphic nomenclature. The price is $0.93 + .07 (tax) = $1.00. Add $1 per order for postage and handling.

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