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THIS MONTH:
GEOLOGIC LANDSLIDES AT THE DALLES and
RESULTS OF 5-YEAR STUDY OF MOUNT ST. HELENS

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Information for contributors

Oregon Geology is designed to reach a wide spectrum of readers interested in the geology and mineral industry of Oregon. Manuscript contributions are invited on both technical and general-interest subjects relating to Oregon geology. Two copies of the manuscript should be submitted, typed double-spaced throughout (including references) and on one side of the paper only. Graphic illustrations should be camera-ready; photographs should be black-and-white glossies. All figures should be clearly marked, and all figure captions should be typed together on a separate sheet of paper.

The style to be followed is generally that of U.S. Geological Survey publications (see the USGS manual *Suggestions to Authors*, 6th ed., 1978). The bibliography should be limited to "References Cited." Authors are responsible for the accuracy of their bibliographic references. Names of reviewers should be included in the "Acknowledgments."

Authors will receive 20 complimentary copies of the issue containing their contribution. Manuscripts, news, notices, and meeting announcements should be sent to Beverly F. Vogt, Publications Manager, at the Portland office of DOGAMI.

COVER PHOTO

Section of bent water pipe displayed as it was excavated in a compression zone of the landslide at The Dalles, Oregon. Resident at the site had complained about restricted water supply. Effects, such as this one illustrated, and causes of landslides at The Dalles are discussed in article beginning on next page.

OIL AND GAS NEWS

Columbia County — Mist Gas Field

Development of the field has spread to the southeast, 3½ mi from previous production, with the recent completion of Reichhold Energy's Crown Zellerbach 31-16 in sec. 16, T. 5 N., R. 4 W. The well was drilled and completed in July, with a total depth of 2,867 ft and an initial production of 5.9 MMcfd. This is one of the best initial production tests of any well in the field.

Reichhold has proposed a new well to offset this new producer (see table below).

ARCO drilled and abandoned Columbia County 23-19 in sec. 19, T. 6 N., R. 5 W. The well reached a total depth of 3,440 ft. The company has six additional permits and/or applications for permit in the county. One further permit, Columbia County 43-3 in sec. 3, T. 4 N., R. 3 W., was withdrawn by the operator. Instead, ARCO will work with Exxon on Exxon's new permit, number 310 (see table).

Coos County

AMOCO Production Company is drilling its second well in a year in southwest Oregon. Weyerhaeuser F-1, in sec. 10, T. 25 S., R. 10 W., was spudded in August with a proposed total depth of 5,900 ft. The company also has two permits for 15,000-ft wells in Douglas County.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
320	Exxon GPE Federal 2 009-00163	SE¼ sec. 3 T. 4 N., R. 3 W. Columbia County	Location; 12,000.
321	Tenneco Columbia Co. 12-15 009-00164	NW¼ sec. 15 T. 5 N., R. 5 W. Columbia County	Application; 1,000.
322	Tenneco Columbia Co. 24-10 009-00165	SW¼ sec. 10 T. 5 N., R. 5 W. Columbia County	Location; 1,000.
323	AMOCO Weyerhaeuser F-1 011-00022	NE¼ sec. 10 T. 25 S., R. 10 W. Coos County	Location; 5,900.
324	Reichhold Energy Crown Zellerbach 23-15 009-00166	SW¼ sec. 15 T. 5 N., R. 4 W. Columbia County	Application; 3,500.
325	Reichhold Energy Columbia Co. 41-6 009-00167	NE¼ sec. 6 T. 5 N., R. 5 W. Columbia County	Application; 2,500.
326	Reichhold Energy Columbia Co. 33-6 009-00168	SE¼ sec. 6 T. 5 N., R. 5 W. Columbia County	Application; 2,500.
327	Damon Petroleum Longview Fibre 3 041-00006	NW¼ sec. 21 T. 9 S., R. 11 W. Lincoln County	Application; 3,000.

□

The Dalles water study reprinted

The 1969 ground-water study by R.C. Newcomb that is mentioned in the article beginning on the next page (see Selected Bibliography) has been reprinted by the U.S. Geological Survey and is available again in its original form as USGS Professional Paper 383-C, $4. It can be bought at the regional USGS Public Inquiries Office in Spokane (678 U.S. Courthouse, West 920 Riverside, 99201) or by mail from the Text Products Section, U.S. Geological Survey, 604 South Pickett St., Alexandria, VA 22304. □

Geologic landslides in and near the community of The Dalles, Oregon

by J.D. Beaulieu, Deputy State Geologist, Oregon Department of Geology and Mineral Industries

INTRODUCTION

From the standpoint of tourism and scenery, the State of Oregon possesses a wealth of natural attractions. Commonly overlooked, however, is the manner in which some of these blessings in natural resources present special challenges to other facets of our society and economy. In the examples discussed in this article, landslides that underlie the scenic hills and ridges of the mid-Columbia River region pose serious threats to the safety and economic welfare of the residents.

Oregon's topography varies from broad, flat valleys to majestic peaks. Climate, too, shows more variation than that of most of the other states, creating near-rain forests in the west and true deserts in the southeast portions of the State. Geologically, Oregon displays all kinds of rocks, from layered clays to jagged, tilted, metamorphic outcrops — each kind with its particular physical characteristics that require special engineering considerations. When one realizes that all these factors are mixed in innumerable combinations throughout the State, one quickly appreciates the diversity of dynamic geologic processes that confront Oregonians. Add to this the many different ways in which a given land use may interact with the varied types of ground upon which it occurs, and one begins to see the full scope of the geologic processes that lie behind landslides, floods, subsidence, and other events that find their way into newspaper headlines.

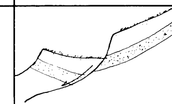
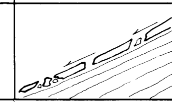
Type	Description
Deep bedrock slumps	 Slip of rock along a curved basal shear plane along with backward rotation of the slide block as a unit; characterized by irregular topography on a grand scale, sag ponds, and a pronounced headscarp.
Bedrock translational slides	 Sliding of large bedrock slabs downslope and downdip along incompetent interbeds with no backwards rotation and little or no disaggregation.

Figure 1. Classification and description of bedrock slides in the Chenoweth Formation (from Beaulieu, 1977).

In 1977, the Oregon Department of Geology and Mineral

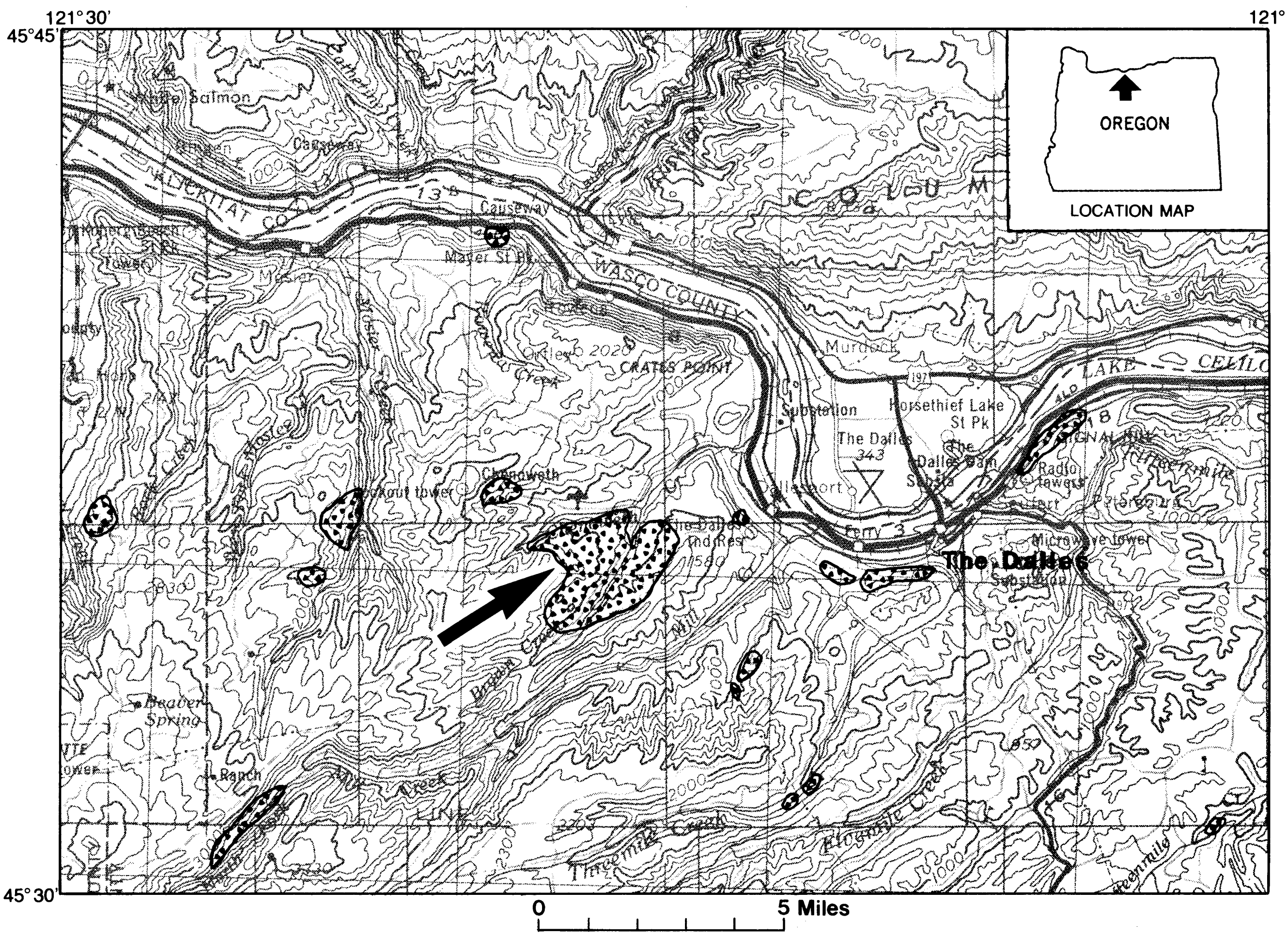


Figure 2. Areas of inferred deep bedrock landslides in the mid-Columbia region of Oregon, interpreted on the basis of topography, bedrock geology, dip and other mappable criteria. Arrow indicates position of headwall of Government Flat landslide shown in Figure 3.

Industries (DOGAMI) conducted a reconnaissance study of the geologic hazards of the mid-Columbia River region (Beaulieu, 1977). The interplay of topography, rock type, structure, climate, and land use described in that study is well illustrated by the landslide situation in The Dalles and by similar landslides in rural areas of Wasco and Hood River Counties.

GENERAL GEOLOGIC FACTORS FOR LANDSLIDES IN THE AREA

The two major geologic formations in the mid-Columbia region are (1) the Columbia River Basalt Group, a series of hard, jointed basalt flows with occasional intervening layers of sediment or soils; and (2) the Chenoweth Formation, a large, fan-shaped deposit of volcanic debris spreading from the Cascade Range to the north and east to form the sloping uplands and cliffs at The Dalles and in the surrounding area. The composition of the Chenoweth Formation includes alluvial gravel deposits, ash layers, agglomerates, and occasional lava flows. The fine grain size and composition of much of the unit, under conditions of weathering, commonly favors the formation of clay at shallow depths. The basalt flows of the Columbia River Basalt Group resist weathering in the arid eastern Oregon climate but locally contain interstitial clay which makes them impermeable. Such is the case for some of the uppermost flows of the Columbia River Basalt Group in the area around The Dalles.

The net result is that in various areas of the mid-Columbia region clay-rich derivatives of the Chenoweth Formation overlie impermeable rocks of the Columbia River Basalt Group. Ground water accumulates near the contact between the two units. Where the rocks tilt toward open slopes overlooking river valleys, massive landslides have occurred in many areas.

DEEP LANDSLIDES IN THE CHENOWETH FORMATION

Deep bedrock slides in the Chenoweth Formation include translational slides and combination slump-translational slides (Figure 1) near the contact with the Columbia River Basalt Group as well as deep slumps higher in the section (Figure 2). The major translational slides near the base of the Chenoweth Formation are developed where topographic slope and dips in the regional bed rock are generally parallel and where undercutting has exposed the contact. Examples are slides in the middle reaches of Mosier Creek and along Rock Creek, the Government Flat landslide along Brown Creek, and the landslide in the community of The Dalles.

The Government Flat landslide (Figure 3) has downdropped parts of the Chenoweth Formation several hundred feet and is bordered on its upper edge by a prominent headscarp. Anomalous dips, large hummocks, and gentle slopes characterize the slide mass. The base of the slide is above the present stream level and is fronted by stream terraces. Stream drainage on the slide is moderately well integrated. The slide is probably mid-Pleistocene in age. Although it is no longer active, active secondary slides are present along major streams within the slide mass east of Brown Creek and should be carefully studied prior to any development. The cause of the Government Flat slide is obscure but may be partly attributed to the wetter mid-Pleistocene climate and to active undercutting by Brown Creek before it was captured in its upper reaches by Mill Creek.

Older slides in the middle reaches of Mosier Creek are situated along the contact of the Chenoweth Formation with the Columbia River Basalt Group and are deeply dissected by streams. They are no longer active.

Deep bedrock slumps that occur above the base of the Chenoweth Formation at scattered localities between Hood River and Fifteenmile Creek can be recognized by their pronounced headscarps and gentle slopes.

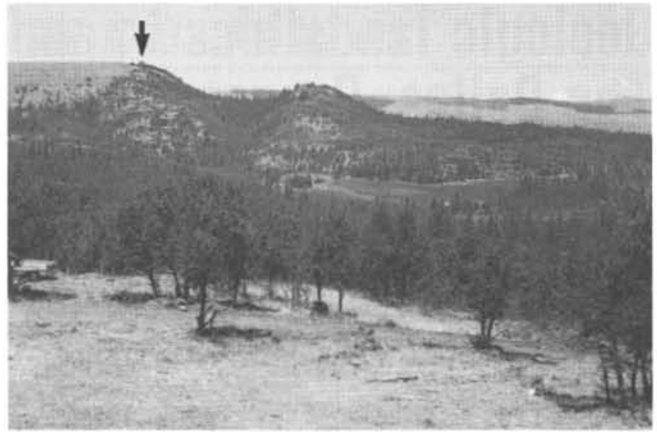


Figure 3. View of Government Flat landslide looking west across Brown Creek. All terrain to the right of the headwall (arrow) has moved to the right.

Commonly the headscarps are mantled with talus composed of broken and disoriented blocks of the Chenoweth Formation. The series of large slump blocks between the Chenoweth Formation and the mouth of Threemile Creek show apparent vertical offsets of several hundred feet. Slumps high in the Chenoweth Formation are not presently active but could be reactivated after development if the subsurface water budget were greatly modified by drainfields, drainage modifications, or irrigation. Detailed on-site geologic investigations are needed to guide development.

The key insight that arises from a study of these slides is that in some key areas mappable geologic factors (rock type, ground-water conditions, dip of rocks, and topography) combine to produce a mix of conditions that favors and, in fact, produces landslides. An understanding of these conditions should guide judgments for future land use or construction in these areas.

THE LANDSLIDE AT THE DALLES

General geology

The landslide at The Dalles (Figure 4) occurs at the north-dipping contact between the clay-rich Chenoweth Formation and the planar, locally impermeable flow rock of the Columbia River Basalt Group. Additionally it occurs on the steeply cut outer bend of a large meander of the Columbia River which was eroded approximately 12,000-13,000 years ago by the rapid release of immense volumes of glacial melt water from glacially dammed lakes in Idaho and Montana. The Missoula Flood, as it is now called, delivered floodwaters to an elevation of 1,150 ft in The Dalles area and greatly eroded the pre-existing terrain. In the area now occupied by the community of The Dalles, slopes and hillsides already predisposed to landsliding owing to the geologic factors mentioned above were oversteepened to further contribute to the potential for landsliding. Rapid drawdown of Pleistocene floodwaters may also have been a contributing factor.

Historical milestones

Geologic insights that are available to us now certainly were not available, especially in a systematic way, to the early settlers of The Dalles area. Given our present knowledge of landslides, it is relatively easy to look back in time and speculate how the slide situation should have been handled. Such speculation may seem pointless but is of value if it allows us to deal more effectively with landslide problems in the future.

Aside from the geology, an early hint of a slide problem is found in an obscure ground-water study by Piper (1932) where

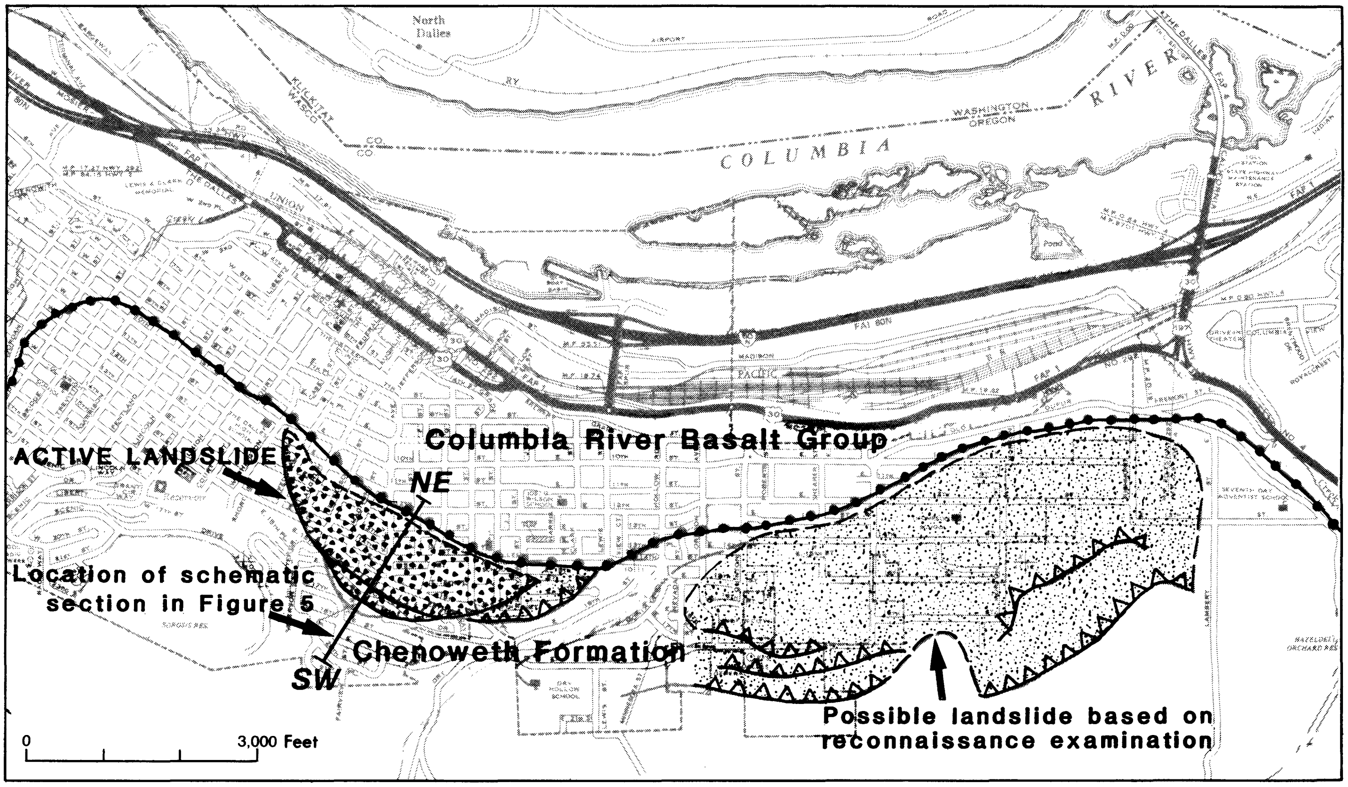


Figure 4. Landslide areas of a portion of The Dalles, Oregon.

reference is made to ground-water discharge in an area presumably located in the slide area but now given to urban development. The area was vegetated by willows prior to development (Ron Bailey, oral communication, 1976). Springs supporting willow growth in arid areas sometimes hint of shallow ground-water conditions that, in turn, may relate to landslide activity.

Slow-moving landslides often are carefully studied through the use of sophisticated monitoring equipment placed on and around the slide. Until recently, the slide at The Dalles had not been subject to that kind of analysis. Ironically, however, the actual grid of city streets and the rows of houses, each with its own tolerance for displacement, has served over the years as a sort of large, two-dimensional slide-monitoring program.

Using a plot of the damage to residences, roads, and utilities, this author outlined the slide mass in a 1977 study (Beaulieu, 1977) while working as a geologic hazards specialist for DOGAMI under contract to the Department of Land Conservation and Development and the Mid-Columbia Development District (Figure 4). Depth configurations, mechanisms of movement, and an understanding of the slide sufficiently detailed to guide mitigation are the subject of ongoing studies by the City of The Dalles and Shannon and Wilson, Inc., a Portland consulting firm.

DOGAMI briefly assisted the Community of The Dalles and the Intergovernmental Relations Division of the State Executive Department in pursuing mitigation of the slide in 1983. On June 11, 1982, a large interpretation of the slide area was printed in *The Dalles Weekly Reminder*. On May 17, 1984, the slide was featured in an article in the Portland newspaper, *The Oregonian*, and in 1984, it was briefly mentioned, along with other Columbia River slides in a volume for an international symposium on landslide hazards that was held in Toronto (Schuster and Hays, 1984).

The landslide today

Damage by slide motion is concentrated along the edges of the slide mass where it is in contact with stable ground. Damage has included bent water lines, separated sewer pipes, warped sidewalks and streets, a variety of structural damages to houses, and subtly modified topography. On larger structures, load-supporting beams have separated from vertical supports, which necessitated the installation of supplemental pillars or led to monitoring, abandonment, and removal of a building, as at The Dalles Junior High School several years ago. The upper parts of the slide are particularly striking along Scenic Drive, where terrain south of the road is sinking relative to the road, even though it is nearer the headscarp. Presumably a graben of strata analogous to the keystone of an arch is dropping between the headwall to the south and the block on which the highway is located immediately to the north (Figure 5).

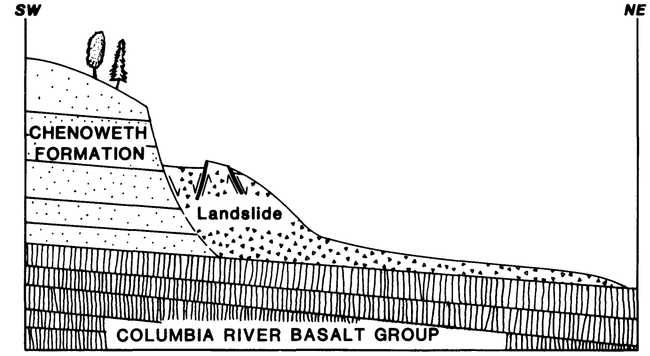


Figure 5. Schematic drawing of the landslide at The Dalles. For location, see Figure 4.

The potential for sliding produced by geologic factors may be aggravated by human activites that increase the amount of water in the ground. Such activities include lawn watering, extensive irrigation of upslope orchards, and the blocking of springs by the construction of houses and roads. Dealing with the slide is made difficult both by the high density of development and also by the present lack of detailed information regarding the mechanics and rates of sliding and the distribution of actual ground deformation. Possibly the city could obtain more information by funding additional engineering studies, sponsoring a master's thesis or a doctoral dissertation, receiving additional grant support, or becoming involved in future Federal pilot investigations of urban landslide problems, should such studies materialize. Engineering solutions must be keyed to site-specific conditions on the ground and may require closer control of water infiltration, the dewatering of parts of the slide, the use of innovative foundation designs for new structures, or the banning of construction in highly critical areas.

In studying the slide and the resulting damage, it is instructive to pause for a moment and reflect on our knowledge of the local geology. General geology provides a strong rationale for the location of the existing slide. Observation of actual damage to streets and buildings allows us to map in detail the outline of the slide and to better understand its dynamics. But we might ask ourselves: Would the actual presence of the landslide have been evident to an engineering geologist prior to development, while there was as yet no damage to structures?

The answer to this question is difficult, because the slide is difficult to delineate based on present-day topographic details. Urbanization has obscured the hummocks and swales for which one would routinely look, and the original topographic expression probably also was very subtle. However, it is safe to say that a proper engineering study complete with detailed examination and appropriate monitoring would have properly identified the slide area. Such a study on a site-specific basis would have bridged the gap between a preliminary identification of the slide based on regional geologic data and a conclusive description of the slide in a manner suitable to guiding site-specific policies. Engineering geology successfully performs this kind of function daily, and, as was mentioned earlier, such studies are now underway at The Dalles.

Yes, properly designed engineering geologic studies can identify stable, potentially unstable, or unstable and sliding areas. The slide could have been recognized, and the recency of movement probably could have been inferred.

The mental exercise just concluded in the above paragraphs is not entirely academic. Deep bedrock failures are suggested on a reconnaissance basis east of Dry Hollow in terrain analogous to that of the Scenic Drive-Kelly Avenue slide (Figure 4). The region is approximately 1½ mi long and up to 1 mi wide and is characterized by a series of large slumplike blocks in the south and hummocky terrain in the north. The terrain is located in the Chenoweth Formation immediately above the contact with the Columbia River Basalt Group. Gentle northerly dips, incompetent lithology of parts of the Chenoweth Formation, location above a possibly impermeable horizon of the Columbia River Basalt Group, and oversteepening by the Columbia River increase the possibility of sliding. If the terrain is a slide, future developments may need to (1) provide adequate facilities for all runoff to assure that local increased infiltration does not occur, (2) avoid plugging springs, (3) require engineering-geology reports for all large developments, (4) establish low-density development, and (5) discourage increased infiltration of ground water upslope. Curbs and roads in densely developed areas along Oregon Street show dislocations possibly related to reactivated sliding.

PLANNING OPTIONS

Currently there is little guidance in Oregon at the state level for handling the practical aspects of sliding for communities confronted with significant landslide problems. A number of avenues are available for consideration, however, and have been pursued by slide-prone communities elsewhere.

A landslide reduction program is a budgetary consideration within the U.S. Geological Survey. Many Federal agencies have programs to deal with landslides within their own land holdings. Landslide insurance was explored by Congress in the late 1970's. DOGAMI had opportunity to review some of the background material for that effort. Several states have geologic hazard programs to collect and disseminate geologic hazard data.

Locally, landslides are dealt with on a day-to-day basis by such mechanisms as liability waiver forms issued by permitting agencies, moratoriums on construction, specialized construction standards, corrective engineering, or land exchanges. In this latter mechanism the community exchanges stable land for slide land under houses (which are then moved), and the slide land is converted to neighborhood open spaces. In many California counties (e.g., Ventura, San Jose, San Mateo), the county requires and reviews geologic reports in hazardous terrain prior to construction. The reports must conform to standards and must be prepared by appropriately registered specialists. In Oregon, Engineering Geologist is a recognized specialty registered by the State.

Without an appreciation of local conditions and specific legal liabilities, the mechanism selected by a community may be either inadequate or overly burdensome. A properly researched mitigation strategy based on a consideration of specific needs and goals is, of course, recommended.

CONCLUSION

The landslide at The Dalles, Oregon, results from a particular combination of geologic factors including rock type, dip, slope, ground-water movement, and geologic history. It may be aggravated to some extent by human activities. Elsewhere in Oregon, mappable geologic factors produce coastal erosion landslides, landslides in forested terrain, and unstable ground at countless other locations. Astoria, Portland, Newport, John Day, La Grande, Rainier, Elsie, and many other communities have experienced and will continue to experience landslide problems. Consideration of the increasing demands being placed on the land in Oregon and the decreasing tolerances of new industries such as some technology industries lead one to conclude that landslides will attract increasing attention in future years.

ACKNOWLEDGMENTS

The author acknowledges and greatly appreciates the specific review of this manuscript, many helpful suggestions, and early landslide training provided by Herbert G. Schlicker, a former colleague at the Oregon Department of Geology and Mineral Industries. Additional technical comments by Frank Fujitani of Shannon and Wilson, Inc., are also appreciated.

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Beaulieu, J.D., 1977, Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 91, 93 p.

Schuster, R.L., and Hays, W.H., 1984, Irrigation-induced landslides in soft rocks and sediments along the Columbia River, south-central Washington State, U.S.A.: International Symposium on Landslides, IV, Toronto, 1984, Proceedings, v. I, p. 431-436.

*(Continued on page 108, **Landslides**)*

1985 member clubs of Oregon Council of Rock and Mineral Clubs listed

The following clubs are all members of the Oregon Council of Rock and Mineral Clubs, Inc. Listed with each club are name and address of the club's president.

Blue Mountain Gem Club, La Grande. James Wittmeyer, 2109 Washington, La Grande, OR 97850

Columbia Gorge Rockhounds, Corbett. Marion Kirkham, 34820 S.E. Smith Road, Corbett, OR 97019

Columbia Rock and Gem Club, St. Helens. Calvin Gump, 35475 Spence St., St. Helens, OR 97051

Columbia Willamette Faceters' Guild. Louise Schwier, 1535 N.W. 136th Ave., Portland, OR 97229

Corvallis Rock and Gem Club, Corvallis. Ernest Rudisill, 2605 S.W. 49th, Corvallis, OR 97333

Eugene Mineral Club, Eugene. Larry Mitchell, 27908 Stonehenge, Eugene, OR 97402

Far West Lapidary and Gem Society, Inc., Coos Bay. Bert Sanne, 2475 Chester, North Bend, OR 97459

Illinois Valley Mineral and Hobby Club, Cave Junction. George Cornelius, 920 Kirkham Rd., Cave Junction, OR 97523

Lebanon Geological Society, Lebanon. Frank Groves, 147 Main St., Lebanon, OR 97355

Laneco Earth Sciences Organization, Springfield. Harry Waggoner, 33468 Hampton Rd., Eugene, OR 97401

Mile Hi Rock Rollers, Lakeview. Louis W. Nelson, P.O. Box 51, New Pine Creek, OR 97630

Newport Agate Society, Newport. Henry T. Norman, S.R.N. Box 604, Newport, OR 97365

Oregon Coast Agate Club, Newport. Jess Pullam, 219 N.E. 54th, Newport, OR 97365

Oregon Agate and Mineral Society, Portland. Cynthia Simon, 7006 S.E. 21st, Portland, OR 97202

Polk County Rockhound Society, Dallas. Howard Brunson, 281 N. Cattron, Monmouth, OR 97361

Portland Earth Science Org. (Peso Club), Portland. Priscilla Dornath, Box 03445, Portland, OR 97203

Rock and Arrowhead Social Club, Klamath Falls. Janice Rasdal, 1020 Bismark, Klamath Falls, OR 97601

Rogue Gem and Geology Club, Grants Pass. Walt Lunceford, 1135 Waldo Rd., O'Brien, OR 97534

Roxy and Gem and Mineral Club, Medford. Roland Glass, 4290 Old Stage Road, Central Point, OR 97502

South Douglas Gem and Mineral Club, Myrtle Creek. Esther Trenholm, Box 75, Myrtle Creek, OR 97457

Tek Rock Club, Beaverton. Jim Simmons, Route 1, Box 64B2, Gaston, OR 97119

Trails End Gem and Mineral Club, Astoria. Russel Bristow, Route 2, Box 575A, Astoria, OR 97103

Willamette Agate and Mineral Society, Inc., Salem. Robert Lucas, 392 Hilder Lane S.E., Salem, OR 97302

USGS appoints new Western Regional Hydrologist

Dr. T.J. Conomos, 46, of Menlo Park, Calif., a U.S. Geological Survey (USGS) research hydrologist well known as an authority on San Francisco Bay studies, has been named regional hydrologist for the USGS Western Region, headquartered in Menlo Park.

Dr. Conomos has been serving for the past four years as the USGS regional research hydrologist in the western states, working in the dual role of research scientist and administrator. He was honored earlier this year for his scientific achievements and contributions to the water resources programs with a Department of Interior Meritorious Service Award.

As regional hydrologist, he succeeds Dr. John Bredehoeft, of Menlo Park. Dr. Bredehoeft has returned to research studies on ground-water resources following a four-year term in the regional hydrologist office. In recent months, he has been especially concerned with water studies involving seismic activity along the San Andreas fault in the Parkfield, Calif., area.

In his new post, Dr. Conomos will direct and coordinate the Survey's region-wide water resources programs and investigations, which involve a staff of more than 750 professional and technical employees, including experts in all scientific disciplines related to the field of hydrology.

The Western Region programs cover the states of Alaska, Arizona, California, Hawaii, Idaho, Nevada, Oregon, and Washington. The national water resources programs are estimated at a total cost of more than 340 million dollars annually, carried out in cooperation with 200 State cooperating agencies and Federal agencies.

— *USGS news release*

Platinum nugget found in southwestern Oregon

Platinum group metals, generally in the form of particles smaller than 2 mm, are often recovered in placers in southwestern Oregon. The nugget shown in the accompanying photograph, however, is unusual because of its large size (1 cm x 1.5 cm). Named the Liberty Nugget by its owners, Platinum,

Liberty Nugget. Coin is 1899 nickel. Photo courtesy Dean Givens.

Inc., of Cave Junction, and found on upper Sucker Creek in Josephine County, this platinum nugget weighs 0.286 troy oz (8.9 grams). Platinum nuggets weighing up to 9 kg have been reported in other parts of the world, but nuggets the size of the Liberty Nugget are rare in southwestern Oregon. □

BOOK REVIEW

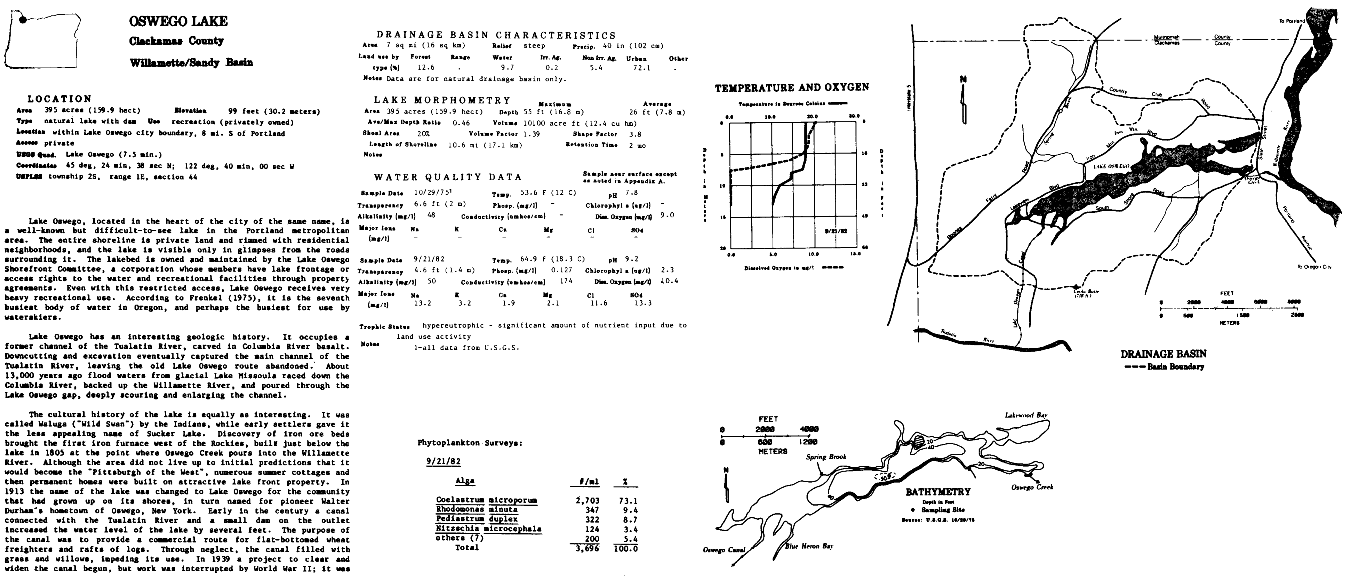
by Ralph S. Mason, former State Geologist

Atlas of Oregon Lakes, by Daniel M. Johnson, Richard R. Petersen, D. Richard Lycan, James W. Sweet, and Mark E. Neuhaus, in cooperation with Andrew L. Schaedel, Corvallis, Oregon, Oregon State University Press, 1985, 317 p., cloth $30, soft cover $17.95.

Reviewing the ordinary atlas is about as interesting as perusing a bus schedule for a route you never intended to take. Not this one, however! Although the *Atlas of Oregon Lakes* contains all of the usual maps, photos, tables, and data, the accompanying text lifts it far above the norm for this type of publication. The *Atlas* is the end product of three years of intensive field and laboratory work by many scientists in a variety of disciplines, and their combined efforts have produced a most informative and readable body of material. A total of 202 of Oregon's more than 6,000 bodies of standing water is included in the *Atlas.* The lakes were selected as representative of various lake types and their associated regimens, with special attention to their biologic productivity.

Work on the *Atlas* was carried out by the Biology and Geography Departments of Portland State University (with much help from State and Federal agencies and other organizations). The study is part of Oregon's contribution to the Federal Clean Lakes Program, administered and funded through the U.S. Environmental Protection Agency and implemented at the state level by the Oregon Department of Environmental Quality.

(A preview of this book, written by J.E. Allen, was published in the December 1984 issue of Oregon Geology. Ed.) □



Parts of the two pages on Lake Oswego, Clackamas County, in Atlas of Oregon Lakes *(reduced).*

Fireballs sighted

The following fireball sightings in Oregon were reported in the recent past:

May 16, 1985, 10:00 p.m. PDT, observation by Hank Tanski at Crater Lake National Park headquarters, Klamath County, lat. 42°51′ N., long. 122°10′ W., through thin clouds. The fireball was first seen 45° west of north at an altitude of 90° and last seen 45° east of south at an altitude of 75°. The angle of descent of the fireball was 25°, and the duration of its flight was 4-5 seconds. It was ¾ the size of the full moon and brighter than the full moon, casting a shadow. Its color was a pale blue, and it had a white tail 15°-20° long. No sound was heard during the fireball event, but an explosion was heard 1½-2 minutes after the fireball went out, the sound coming from the southeast. There was no breakup or smoke trail.

May 25, 1985, 10 p.m. PDT, observation by Mary Ann Sohlstrom at Davis Lake, Klamath County, lat. 43°30′ N., long. 122°14′ W., in a clear sky with a half moon. The fireball was first seen 30° east of south at an altitude of 30° and last seen 15° west of south at an altitude of 30°, where it went behind trees. The angle of descent was 0°, and the flight lasted 3 seconds. The fireball was ¼ the size of the full moon, very bright, and of a blue-white color. A white tail extended the full length of the flight path. One large fragment dropped off the fireball near the end of its path. No sound or shadow was observed.

June 13, 1985, 10:00 p.m. PDT, observation by Larry McKillips in Millican, Deschutes County, lat. 43°51′ N., long. 120°55′ W., in a clear sky without moon. The fireball was first seen in the east at an altitude of 75°, and it was last seen 45° north of east at an altitude of 45°. The angle of descent was 30°, and the duration of the flight was 5 seconds. The fireball was ½ the size of the full moon and very bright. Its color was orange-red, and it had a short, orange-red tail. No sound or breakup was observed.

These sightings have been reported to the Scientific Event Alert Network, Smithsonian Institution. Anyone with any additional information about these or other meteorite sightings should contact Dick Pugh, Cleveland High School, 3400 SE 26th Ave., Portland, OR 97202, phone (503) 233-6441. □

(Landslides, continued from page 106)

Baker, V.R., 1973, Paleohydrology and sedimentology of Lake Missoula flooding in eastern Washington: Geological Society of America Special Paper 144, 79 p.

Piper, A.M., 1932, Geology and ground-water resources of The Dalles region, Oregon: U.S. Geological Survey Water-Supply Paper 659-B, 189 p.

Newcomb, R.C., 1969, Effect of tectonic structure on the occurrence of water in the basalt of the Columbia River Group of The Dalles area, Oregon and Washington: U.S. Geological Survey Professional Paper 383-C, 33 p. □

Scientists report on five years of Mount St. Helens studies

The eruptive history of Mount St. Helens and the cataclysmic 1980 eruption are described and colorfully illustrated in a new, special U.S. Geological Survey (USGS) publication entitled *Eruptions of Mount St. Helens: Past, Present, and Future.* The book was written by Robert Tilling, a USGS volcanologist at the Survey's headquarters in Reston, Virginia. (Single copies of the book are available free from the Text Products Section of the USGS at 604 South Pickett Street, Alexandria, VA 22304, or from most USGS Public Inquiries Offices.)

In 1980, Dr. Tilling was chief of the USGS office responsible for establishing the program of surveillance, monitoring, and research at Mount St. Helens. Under his direction, the USGS established the David A. Johnston Cascades Volcano Observatory, named in honor of a USGS volcanologist who was killed by the May 18, 1980, eruption while he was at an observation post north of the volcano. The Cascades Volcano Observatory provided the following briefs on important lessons for volcanic-hazard mitigation that have resulted from studies of Mount St. Helens during the past five years by scientists from the USGS, the University of Washington, and other organizations:

Eruption predictions: Since May 1980, the USGS has predicted most significant episodes of volcanic activity at Mount St. Helens several hours to three weeks in advance, using a variety of seismic, ground-deformation, and geochemical techniques. These episodes have consisted chiefly of dome-building extrusions of viscous lava but also included moderate explosive eruptions in 1980. Of the 17 eruptive episodes since May 1980, two occurred with only slight precursory activity and because of that were not predicted.

Anticipating volcanic landslides and blasts: Detailed observations of the volcano's activity leading to the May 18, 1980, eruption will help volcanologists to anticipate volcanic landslides and laterally directed blasts on other volcanoes similar to those that occurred at Mount St. Helens. The north flank of Mount St. Helens bulged dramatically before being shaken loose by an earthquake May 18, 1980, and sliding rapidly down the mountain into the Toutle River valley. This landslide, the largest in historic times, released pressure built up in the mountain by upwelling magma and triggered a lateral blast to the north that devasted an area of more than 200 mi^2. A vertical ash plume quickly reached 70,000 ft altitude.

Large volcanic landslide deposits: Study of the May 18, 1980, landslide deposit led to development of criteria for recognizing large volcanic landslides that occurred in the past at other volcanoes. These studies also led to the recognition that such large landslides are much more common than previously thought. More than 100 geologically young volcanic landslide deposits have been recognized by geologists throughout the world.

For example, USGS scientists recently re-interpreted a hummock-like deposit at the base of Mount Shasta in northern California as resulting from a massive volcanic landslide about 300,000 to 360,000 years ago from a previous volcanic cone. The deposit covers about 175 mi^2 and has a volume of 6.2 mi^3, which is about 10 times the volume of the 1980 Mount St. Helens avalanche deposit.

Lateral-blast deposits: New criteria were also developed for recognizing lateral-blast deposits. Lateral blasts such as the one that occurred at Mount St. Helens are among the most hazardous of volcanic phenomena. Their occurrence and frequency are difficult to determine, however, because these thin and fragile deposits are easily eroded, leaving little or no trace for geologists to study. The 1980 lateral blast at Mount St. Helens offers a rare opportunity to study such a deposit in detail.

Other Cascade studies: Other volcanoes in the Pacific Northwest's Cascade Range are being studied by scientists in the USGS Volcano Hazards Program. They are monitoring Mount Baker and Mount Rainier in Washington, Mount Hood and Crater Lake in Oregon, and Mount Shasta and Lassen Peak in California to detect any renewal of volcanic activity. USGS geologists also are studying the eruptive histories and potential hazards from future eruptive activity at these volcanoes as well as at Mount Adams and Glacier Peak in Washington and Mount Jefferson, the Three Sisters, and Newberry volcano in Oregon.

Hydrologic effects: Long-term hydrologic effects are a common major consequence of volcanic activity. The Toutle River, occupying the river valley most severely affected by the May 18, 1980, eruption of Mount St. Helens, delivered an average of 68,000 cubic yards per day of sediment to the Cowlitz River in 1984, roughly 100 times the pre-eruption yield.

At Mount St. Helens, removal of vegetation and deposition of large amounts of loose volcanic debris over a wide area greatly increased erosion during the first year after the 1980 eruption. Rates of sediment yield continue to be among the world's highest and produce extensive deposition in river beds downstream, reducing the amount of water these streams can carry without flooding. Detailed studies of the affected rivers will help provide a model for anticipating long-term flood hazards from rivers with high sediment yields.

Dome building: Observations of dome building following the May 18, 1980, eruption are more complete than for any other lava dome in the world. They document a complex history of dome growth. The lava dome inside the Mount St. Helens crater is now 800 ft high and 2,700 ft wide and has a volume of about 72 million cubic yards.

Between 1980 and 1982, the dome grew chiefly by the extrusion of many overlapping lava flows. Since early 1983, magma intrusion inside the dome has contributed more to its growth than has extrusion of lava onto its surface. Many small explosions and avalanches from the dome have occurred, in some cases removing portions of the dome, and vigorous emissions of ash are frequent. At present, Mount St. Helens remains in a period of generally non-explosive dome growth that has prevailed since October 1980.

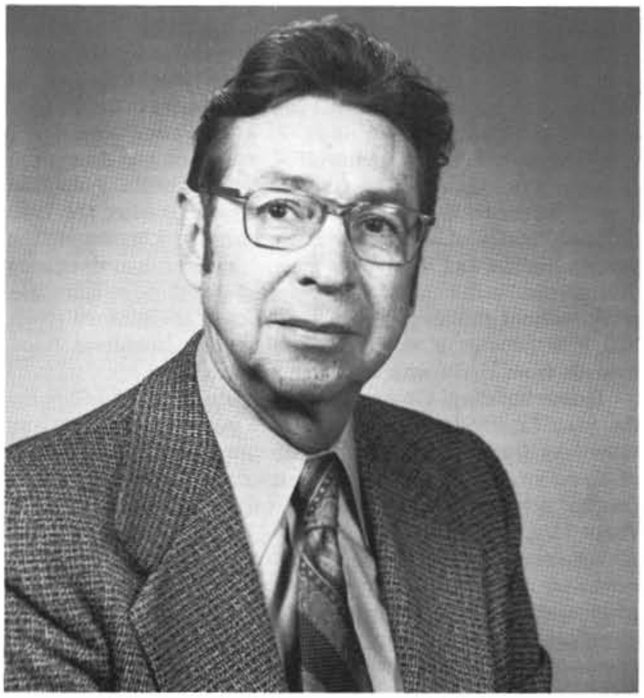
Mount St. Helens eruption summary
Post May 18, 1980

Date	Explosive Activity	Pyroclastic Flows	Dome-Building Activity	Mudflows
May 25, 1980	X	X		
June 12, 1980	X	X	X	
July 22, 1980	X	X		
Aug. 7, 1980	X	X	X	
Oct. 16, 1980	X	X	X	
Dec. 27, 1980			X	
Feb. 5, 1981			X	
April 10, 1981			X	
June 18, 1981			X	
Sept. 6, 1981			X	
Oct. 30, 1981			X	
March 19, 1982	(minor)		X	X
May 14, 1982			X	
Aug. 18, 1982			X	
Feb. 1983 to Feb. 1984	continuous dome-building activity			
March 29, 1984			X	
June 17, 1984			X	
Sept. 10, 1984			X	

— *USGS news release*

In memoriam: Harold E. Enlows

Harold E. Enlows, geology professor and former chairman of the Geology Department at Oregon State University (OSU), died at his home on August 8, 1985. Born on June 11, 1911, Enlows received his bachelor's degree in petroleum engineering from the University of Tulsa in 1935, his master's degree in geology from the University of Chicago in 1936, and his doctoral degree in economic geology from the University of Arizona in 1939. He taught geology and related subjects at the University of Tulsa from 1938 to 1963, except for the period from 1942 to 1946, when he served as lieutenant commander in the U.S. Navy. He taught geology at OSU from 1963 until his retirement from full-time teaching in 1976. His specialties included petrology, field geology, and economic geology. He also served as department chairman from 1969 until 1976.



Harold E. Enlows

Enlows was a member of the American Association of Petroleum Geologists; the Geological Society of America, as a fellow; the Mineralogical Society of America, as a fellow; the Society of Economic Geologists; the American Institute of Professional Geologists; and the Society of Economic Paleontologists and Mineralogists. He also served on the first Board of Geologist Examiners for the State of Oregon.

He authored or coauthored numerous reports and papers on the Mascall, Rattlesnake, Clarno, and Spencer Formations of Oregon. His particular interests were in ash-flow tuffs, and at the time of his death he was preparing a manuscript on the Rattlesnake Ash-flow Tuff of eastern Oregon. Publications he authored or coauthored for the Oregon Department of Geology and Mineral Industries include Short Paper 25 on the Rattlesnake Formation and Bulletin 72 on the geology of the Mitchell quadrangle, as well as field trip guides appearing in Bulletin 77 and the *Ore Bin*.

Those of us who had the pleasure of knowing and working with Harold remember his enthusiasm, sense of humor, warmth, vigor, and geologic competence. A fine man, he will be missed by his many friends and colleagues. He is survived by his wife Jeannette, nieces, a nephew, and several grandnieces and grandnephews. □

First mineral resources map for Oregon's offshore areas released

A comprehensive map of the offshore mineral resources west of the Oregon coast has been released by the Oregon Department of Geology and Mineral Industries (DOGAMI). It is the first such map ever produced and represents a contribution to the efforts of State and Federal research teams investigating the newly expanded offshore areas under United States jurisdiction that were proclaimed in 1983 as the Exclusive Economic Zone (EEZ).

On March 10, 1983, President Ronald Reagan signed a proclamation that established the EEZ, an area that is contiguous to the territorial sea of the United States and its territories and possessions. The EEZ extends 200 nautical miles seaward from the coastal low-water baseline from which the 3-mile width of the territorial sea is also measured. The effect of the President's action was to give the United States jurisdiction over the vast biological and mineral resources that exist within the almost four billion acres of the EEZ.

Produced by the joint efforts of the U.S. Minerals Management Service (MMS), the College of Oceanography of Oregon State University (OSU), and DOGAMI, the new publication, entitled *Mineral Resources Map, Offshore Oregon*, by DOGAMI economic geologist J.J. Gray and OSU marine geologist L.D. Kulm, has been published in DOGAMI's Geological Map Series as Map GMS-37. Major funding was provided by MMS.

The four-color map was produced at a scale of 1:500,000 and is approximately 42x59 inches large. Principally a nontechnical publication intended for use by the general public, it graphically depicts known mineral resources from the crest of the Coast Range to about 300 nautical miles beyond Oregon's coast line. It is also intended to aid Federal, State, and local authorities in assessing the impact of possible future mineral exploration and development and to serve as a guide to private industry in identifying areas favorable for discovery of new mineral deposits.

The area covered by the map extends almost 100 nautical miles beyond the EEZ and includes parts of the active sea-floor spreading centers known as the Gorda Ridge and the Juan de Fuca Ridge. The map also shows the direction and amount of movement along the crustal plates which are grinding past each other or are being subducted under one another. Shades of blue on the map indicate water depths down to 4,600 meters or almost 15,000 feet.

Offshore mineral resources shown and discussed include black sand (magnetite and chromite), cobalt-rich manganese crusts, glauconite and phosphorite, manganese nodules, petroleum and natural gas, polymetallic sulfides, and sand and gravel. Onshore mineral resource information was generalized and included on the map, so that it may be compared with information about the offshore mineral resources.

The first recorded mining of the Pacific Ocean off the Oregon coast occurred in 1805, when the Lewis and Clark expedition used wood fire to evaporate sea water and produce salt. Sand and gravel have been dredged commercially for harbor improvements and used for con-struction fill. Beaches south of Coos Bay have been mined for gold, platinum-group metals, and chromite. Continental-shelf exploration has included drilling for petroleum and natural gas and sediment sampling for gold and black sands containing heavy minerals such as magnetite, chromite, garnet, rutile, and zircon.

The new map GMS-37 is now available at the Oregon Department of Geology and Mineral Industries, 910 State Office Building, 1400 SW Fifth Avenue, Portland, OR 97201. The purchase price is $6. Orders under $50 require prepayment. □

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