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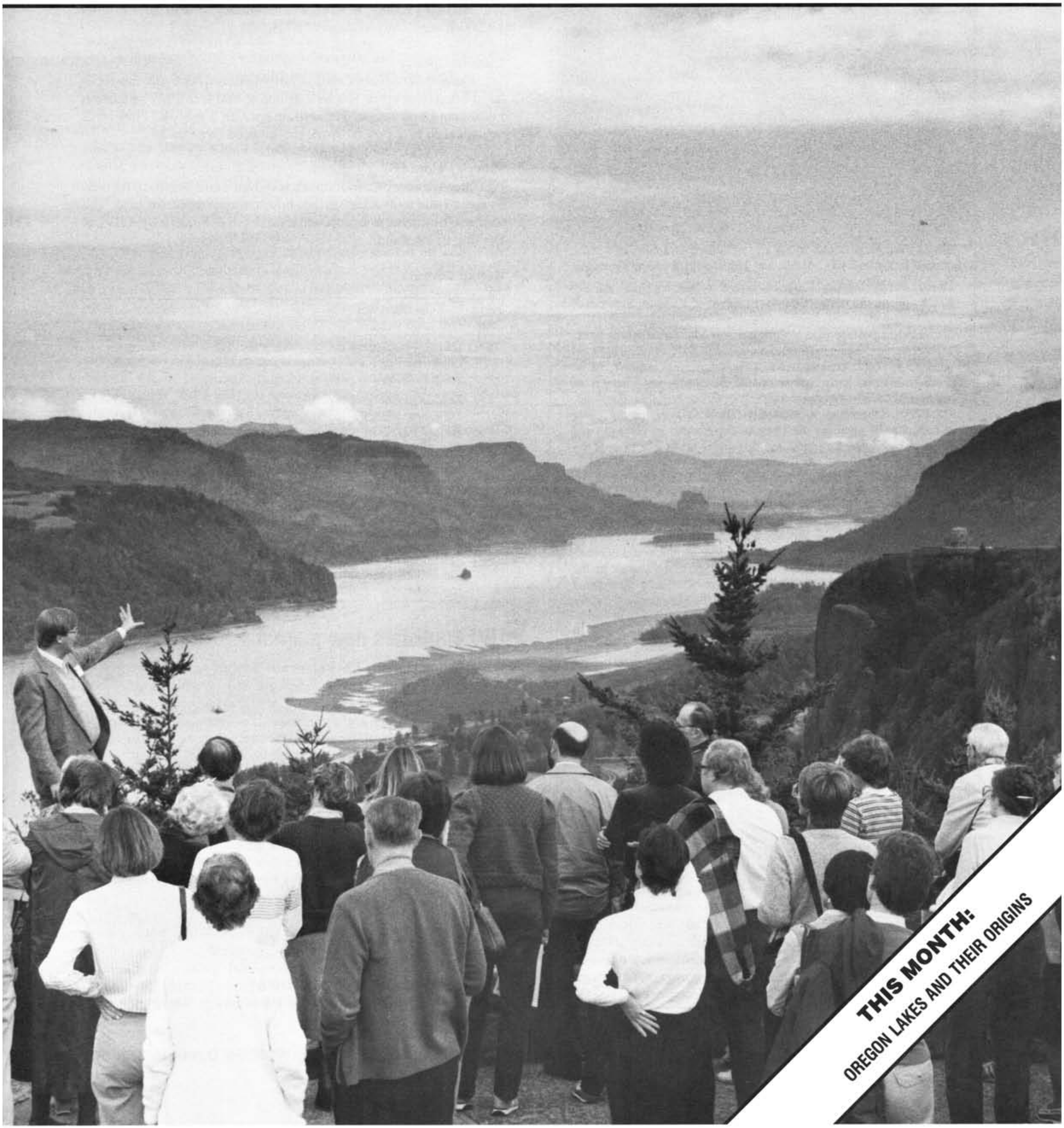

THIS MONTH:
OREGON LAKES AND THEIR ORIGINS

OREGON GEOLOGY
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Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133. Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496. Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039. Paul F. Lawson, Supervisor

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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

View east into Columbia River Gorge from Womens Forum State Park. Group of participants in field trip of American Earth Science Editors convention is guided here by Terry L. Tolan (left), co-author of field trip guide published in August and September issues of *Oregon Geology*. Compare this modern view with historical photo on page 145 of article on Oregon lakes beginning on next page. (Photo courtesy of Robert C. Haney, *Geotimes*)

OIL AND GAS NEWS

Columbia County—Mist Gas Field

Reichhold spudded Polak 31-12 on November 1 in sec. 12, T. 6 N., R. 5 W. The well is located about 1 mi from the nearest producer and is proposed for a depth of 3,000 ft.

Douglas County

Amoco Production Company continues to drill ahead on its 13,500-ft well, Weyerhaeuser "B" No. 1.

Lincoln County

Damon Petroleum Company of Woodburn, Oregon, has reentered Longview Fibre 1, a well drilled to 800 ft in 1981 by Ehrens Petroleum Corporation. The well, in sec. 20, T. 9 S., R. 11 W., will be deepened to 2,000 ft. Work commenced October 24.

Wheeler County

Steele Energy Corporation has moved a small drilling rig onto its Keys 1 site to drill the surface hole and run conductor pipe. The well will be drilled to a proposed total depth of 8,000 ft by ROVOR Drilling of Portland.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
167D	Damon Petroleum Co. Longview Fibre 1 36-041-00004	NE¼ sec. 20 T. 9 S., R. 11W. Lincoln County	Location; 2,000.
277	Reichhold Energy Corp. Longview Fibre 23-36 36-009-00132	SW¼ sec. 36 T. 6 N., R. 5 W. Columbia County	Application; 4,000.
278	Reichhold Energy Corp. Investment Mgt. 22-20 36-009-00133	NW¼ sec. 20 T. 6 N., R. 4 W. Columbia County	Application; 2,500.
279	Reichhold Energy Corp. Longview Fibre 42-22 36-009-00134	NE¼ sec. 22 T. 6 N., R. 5 W. Columbia County	Application; 2,600.
280	Reichhold Energy Corp. Columbia County 44-10 36-009-00135	SE¼ sec. 10 T. 6 N., R. 5 W. Columbia County	Application; 3,000.

□

UW publishes new journal

The Institute for Environmental Studies at the University of Washington has started a brand-new publication which will serve as a forum for research and analysis of the environmental issues of the Pacific Northwest. *The Northwest Environmental Journal* is intended for a broad audience of researchers, educators, public and corporate decisionmakers, and concerned citizens.

In the new journal, "Northwest" includes the region from Alaska to Oregon and east to the continental divide (encompassing the Canadian Northwest as well as the U.S. Northwest). The first issue contains articles on Northwest electric power planning, Idaho river protection, Mount St. Helens research, and the decision-making process of two major Northwest cities (Seattle and Tacoma) in trying to decide whether to buy into two nuclear power plants. Authors include government researchers, biologists, political scientists, an attorney, and a U.S. Senator.

Subscriptions to the new journal are $12 U.S. for one year (two issues) and are available from: *The Northwest Environmental Journal*, c/o Institute for Environmental Studies, Engineering Annex FM-12, University of Washington, Seattle, WA 98195. Checks should be made out to the University of Washington. □

Oregon lakes and their origins

by John Eliot Allen, Department of Geology, Portland State University, P. O. Box 751, Portland, OR 97207

INTRODUCTION

Forty-five years ago, a 23-page paper on the lakes of Oregon was written by Warren D. Smith, geology professor at the University of Oregon, and Wilbur Greenup, one of his students (Smith and Greenup, 1939). It represented the "state of the art" at that time and was a major step in the understanding of the origin, distribution, and characteristics of Oregon lakes.

I have just had the privilege of reading the manuscript of the most recent update of our knowledge of Oregon lakes, a new publication entitled *Atlas of Oregon Lakes*, by Daniel M. Johnson, associate professor of geography at Portland State University (PSU), and four other contributors: Richard Peterson, Department of Biology, PSU; Richard Lycan, Department of Geography, PSU; James Sweet, consulting limnologist; and Andrew Schaedel, Oregon Department of Environmental Quality (DEQ). The 350-page study, which was conducted in cooperation with the DEQ, is to be published early in 1985 by the Oregon State University Press (Johnson and others, in press).

The new book will give detailed information on 202 of the Oregon lakes with an area of over 50 acres and reservoirs containing over 5,000 acre-feet of water. Exhaustive information (two to four pages) is given for 53 lakes, generally those with major recreational facilities.

I too have long been interested in Oregon lakes and was able to update with data from Johnson's book some of the following information I have been collecting for years. Water now covers over 500,000 acres (797 mi^2), or somewhat less than one percent of the state. (During the ice age, water covered at least 10,000 mi^2, or more than 10 percent of the state – more about this later.) Currently, we know of over 6,000 bodies of standing water in Oregon. Only slightly more than 1,400 of them have been given a name.*

*The most recent complete listing of such names is the *Geographic Names Information System* (GNIS) of the U.S. Geological Survey. It covers all geographic names used on major topographic maps and is available for the state of Oregon in a two-volume, spiral-bound printout for $29 from U.S. Geological Survey, NCIC, 507 National Center, Reston, VA 22092.

Anthony Lake, in the Blue Mountains west of North Powder, a glacier-produced tarn. (State Highway Division photo)

Oregon's deepest lake, Crater Lake with a depth of 1,932 ft, is the second deepest lake on the North American continent, exceeded only (by a mere 83 ft) by Great Slave Lake in Athabaska, Canada. In Oregon, Waldo Lake follows Crater Lake in depth with 420 ft, then Blue in the Cascades (314 ft), Wallowa (299 ft), Odell (282 ft), Crescent in the Cascades (265 ft), and Paulina (250 ft) Lakes. (There are no "bottomless" lakes – if they were bottomless, the water would run out!)

Malheur Lake has grown to be Oregon's largest body of water, currently covering approximately 280 mi^2. Goose Lake, near Lakeview, averages 152 mi^2 in area, but two-thirds of it is in California. Next largest are the combined Upper Klamath and Agency Lakes, covering 141 mi^2. Abert Lake follows with 57 mi^2, then Harney (41 mi^2), Summer (39 mi^2), Crater (20 mi^2), Agency (14 mi^2), Crump in the Warner Valley (12 mi^2), and Waldo (10 mi^2)

Suttle Lake, near Santiam Pass in the High Cascades, is located in a valley scoured out by glaciers and was dammed by glacial moraines. Black Butte is in the background. (State Highway Division photo)

Lakes. Each of the remaining lakes covers less than 10 mi^2. The continuing rise of Malheur Lake has brought the water level to within approximately 10 ft of spilling over into the South Fork Malheur River. Several plans are currently being considered to drain off the excess water.

Note that all but two of these large lakes lie in the Great Basin of southeastern Oregon, where faulting of the originally horizontal lavas produced a series of seven uplifted, north-south-trending blocks with intervening downdropped basins.

During the ice age, these lakes of the Great Basin were immensely larger (see Morrison, 1965). Many of the more than 150 closed basins were occupied by lakes, the largest of which were Lake Bonneville (19,940 mi^2, almost the size of Lake Michigan) and Lake Lahontan (8,665 mi^2).

Ira S. Allison, emeritus professor at Oregon State University, mapped the ancient shorelines of two of these ice-age lakes: pluvial Fort Rock Lake (Allison, 1979), which covered nearly 1,400 mi^2 of northern Lake County, and pluvial Lake Chewaucan (Allison, 1982), which covered 500 mi^2 in southern Lake County. Samuel N. Dicken, emeritus professor of geography at the University of Oregon, described pluvial Lake Modoc (Dicken, 1980), which covered 1,069 mi^2 in the Klamath basins and extended into California. Other basins in Oregon formerly occupied by lakes were the Malheur (900 mi^2), Alvord (550 mi^2), Warner and Catlow (500 mi^2 each), Alkali Lake (300 mi^2), Goose (250 mi^2 in Oregon), Elgin (180 mi^2) and Guano (75 mi^2) basins.

There were also two temporary lakes filled by the Bretz floods at the end of the ice age (12,000 to 14,000 years ago): Lake Condon in the Umatilla Basin (1,000 mi^2) and Lake Allison in the Willamette Valley (3,000 mi^2).

Most lakes are ephemeral, geologically speaking. They are usually eliminated over a few tens of thousands of years by filling up with sediments or by cutting down the outlets by erosion. Those in southeastern Oregon are the oldest lakes, since they occupy fault-block valleys, or grabens, and there is no outlet to be cut down at present. In the past they were much larger, as we will see, and did overflow.

Oregon owes its abundance of lakes to the relatively recent action of glaciers that formed them, the lava flows that dammed them, or the faulting that produced the basins they occupy. We may not have the 10,000 lakes of Minnesota or the 55,000 of Finland (its Finnish name is "Suomi," meaning "Land of Lakes"), but we certainly have more than our share.

Crump Lake in southeastern Lake County, one of the many lakes in Oregon's Basin and Range province that occupy downdropped fault blocks or grabens. It is also one of several remnants of pluvial Warner Lake. (State Highway Division photo)

ORIGIN OF OREGON LAKES

Lakes in Oregon have been formed by (A) glaciers, (B) earth movements, (C) volcanic activity, (D) deposition of sediments, (E) erosion, (F) organic and human activity, and (G) thermal springs, in about that order of abundance. Lakes are also infrequently caused by meteor impact, but not in Oregon. Within the above seven categories, there are 26 sub-headings, and there are lakes in Oregon that fit into all but five of these.

A. Glacial lakes

1. Eroded by ice. These are the dozens of cirque lakes, or tarns, in the Wallowa Mountains especially. The Enterprise, Joseph, Eagle Cap, and Cornucopia topographic quadrangles alone show the following lakes: In the East Fork Wallowa River drainage are Aneroid, Roger, and Jewett Lakes. In the West Fork drainage there are Ice, Razz, Unit, Horseshoe, Lily, Lee, Craig, Crescent, Douglas, Moccasin, Mirror, Pocket, Glacier, Prospect, Frazier, and Little Frazier Lakes. In the Hurricane Creek drainage are Deadman, Echo, and Billy Jones Lakes. In the Lostine River drainage there are Little Storm, Wood, Hobo, Chimney, Laverty, Frances, Maxwell, Minam, Blue, and Upper Lakes. In the Minam River drainage are Bear, John Henry, North Minam, Green, Long, Steamboat, Swamp, Cheval, Diamond, and Tombstone Lakes. In the Eagle Creek drainage are Hidden, Moon, Eagle, Cached, Arrow, Heart, Bear, Culver, Lookingglass, Traverse, Echo, and Olive Lakes. In the Imnaha River drainage are Dollar, Crater, and Pine Lakes.

2. Formed behind glacial moraines. Wallowa Lake is the outstanding example (perhaps even in the entire United States). Horse Lake on the Lake Fork of the Imnaha River is the only other example known with certainty. In the Cascades, Bull Run, Crescent, Odell, and Suttle Lakes occupy valleys scoured by ice, but the lakes themselves are dammed by morainal deposits.

3. Lakes filling irregularities on a surface of glacial debris. Although abundant in the Middle West, these are rare in Oregon. In the Imnaha drainage in the Wallowa Mountains, Bonny, Frances, Warm, Fish, Twin, and Duck Lakes probably fit into this category.

4. Kettle holes left by melting of buried ice. Several examples are present in glacial deposits in the Wallowa Mountains, but they are too small to have been given names.

5. Lakes formed when ice dams failed and catastrophic floods scoured the landscape. Many lakes were formed in the scablands of eastern Washington by ice-age floods first described by Bretz (1923); a few in Oregon, such as Lake Oswego, the lakes around Tonquin, and Crystal Springs Lake were so formed. Toward the end of the Pleistocene, glacial ice dammed meltwater in the Clark Fork River drainage in western Montana and eastern Idaho, forming glacial Lake Missoula. The ice dams periodically failed, producing catastrophic floods downstream in western Washington and along the Columbia River and associated drainages. Ephemeral Lake Condon east of The Dalles and Lake Allison in the Willamette Valley were produced by "hydraulic dams". So much water came down through the Columbia River that it could not get through the narrows below The Dalles and below Portland fast enough.

Ancient "pluvial lakes," produced by the increased precipitation during the Pleistocene, once filled many of the basins in eastern Oregon. From west to east, they included Lake Modoc, Fort Rock Lake, Lake Chewaucan, Goose Lake, Alkali Lake, Warner Lake, Guano Lake, Catlow Lake, Malheur Lake, Alvord Lake, and Lake Elgin.

B. EARTH MOVEMENTS

1. Warping of the crust to form a lake-filled basin. Malheur Lake is the only lake in Oregon that may fall into this category, although its basin may have been formed by an ancient caldera, and its present drainage is also dammed by a lava flow.

2. Block faulting of the crust, with lakes forming on the subsided blocks. Most of the lakes in southeastern Oregon, from

Klamath Lake on the west to Alvord Lake on the east, lie in downdropped blocks or grabens. They were much larger during the ice age. Examples of similar lakes around the world are Lake Tahoe in California, Lake Baikal in Siberia, and Lakes Tanganyika and Nyassa in Africa. Past lakes of this origin are also Lake Bonneville in Utah (Great Salt Lake is a remnant) and Lake Lahontan in Nevada (Pyramid Lake is a remnant).

Lakes of Oregon formed by block faulting, listed from north to south in each basin, include: (a) Klamath Basin – Klamath Marsh, Agency, and Upper Klamath Lakes; (b) Winter Rim, Abert, and Goose Lake Basins – Silver, Alkali, Bottomless, Thorne, Summer, Abert, and Goose Lakes; (c) Warner Valley Basin – Bluejoint, Stone Corral, Campbell, Flagstaff, Mugwump, Swamp, Anderson, Hart, Crump, and Pelican Lakes; (d) Catlow Valley – Guano, Shallow, and Catlow (dry) Lakes; (e) Alvord Basin – Mann, Alvord, and Tumtum Lakes; and (f) Grande Ronde Basin – Elgin Lake.

C. VOLCANIC ACTIVITY

1. Maars. These are small circular depressions caused by explosion of steam coming into contact with hot volcanic rocks. In other countries such as Germany, for example, such depressions are occupied by lakes, but in the dry, high desert country of eastern Oregon the maars known as Big Hole and Hole-in-the-Ground do not have water. However, 314-ft-deep Blue Lake just west of Suttle Lake on the Santiam Pass is believed to be a maar. Little Crater Lake (east of Timothy Lake) and North and South Twin Lakes in the Deschutes Basin may also be maars.

Blue Lake, in the High Cascades near Santiam Pass, is believed to be a maar. View is approximately south, with Mount Washington in background. (State Highway Division photo)

2. Crater lakes. There is only one true crater lake in Oregon, lying at an elevation of 10,000 ft in the crater of the South Sister is the highest lake in Oregon.

3. Caldera lakes. Oregon has perhaps the outstanding example of a caldera lake in the world in Crater Lake. It covers 20 mi^2 at an elevation of 6,176 ft and, with a depth of nearly 2,000 ft, is the deepest in the United States and the second deepest in the western hemisphere; only Great Slave Lake in Canada is a few feet deeper. Crater Lake was formed only 6,845 years ago by the explosion and collapse of Mount Mazama. Oregon also has at least three other caldera lakes: Paulina and East Lakes in the Newberry caldera southeast of Bend, and Harney Lake south of Burns, which many geologists now believe also occupies a large, low, ancient caldera.

4. Lakes formed by lava-flow barriers. These are perhaps the most abundant types of lakes in the High Cascades. Clear, Crescent, Cultus, Davis, Diamond, Elk, Lost, and Marion Lakes and Lake of the Woods were all formed by lava dams, as were Cow and Malheur Lakes in eastern Oregon.

5. Lakes formed by mudflow barriers. None are known in Oregon, but Spirit Lake in Washington is an outstanding example.

D. DEPOSITION OF SEDIMENTS

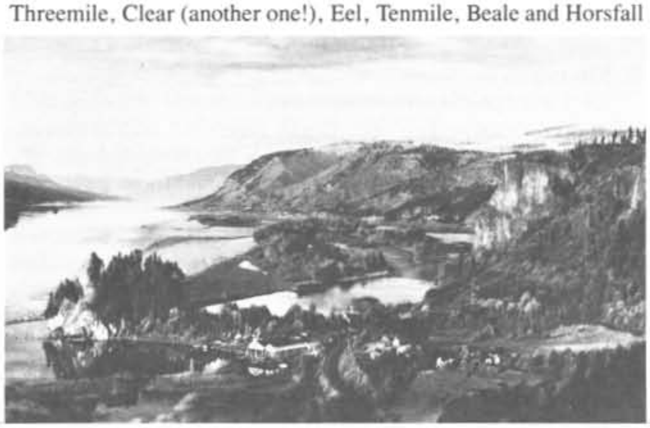
1. Landslide lakes. Triangle Lake in western Lane County was caused by a large landslide which produced a lake once much larger than the small remnant of today. Loon Lake south of Scottsburg in northwestern Douglas County was similarly formed, possibly by an earthquake in 490 A.D., according to carbon-14 analysis. Numerous lakes formed about 1260 A.D. on the surface of the great Bonneville landslide on the Washington side of the Columbia River Gorge.

2. Lakes produced by river deposits *(a) Alluvial fans:* Although the basin occupied by Lake Oswego was scoured by the Bretz floods, its west end was dammed by an alluvial fan deposited by the flood. This same deposit also formed a prehistoric lake at Onion Flat, a few miles to the west. Several of the smaller lakes in the Great Basin of eastern Oregon (such as Mann and Juniper Lakes in the Alvord Basin) have been dammed by alluvial fans deposited by tributaries flowing into the grabens. *(b) Cut-off meander loops or oxbow lakes*: There are several examples of oxbow lakes along the meandering courses of the Willamette River and its tributaries. The Pudding River west of Canby has particularly good examples of these mostly unnamed lakes. *(c) Lakes formed by natural levees and bars*: Old maps show numerous lakes along the Columbia River, such as Ramsey, Bybee, Smith, Force, Mud, and Switzler Lakes, that were enclosed by levees and bars. Most of these have been filled and no longer exist. Guild Lake in northwest Portland was dammed by the natural levee, but it was filled for the Lewis and Clark Exposition in 1905.

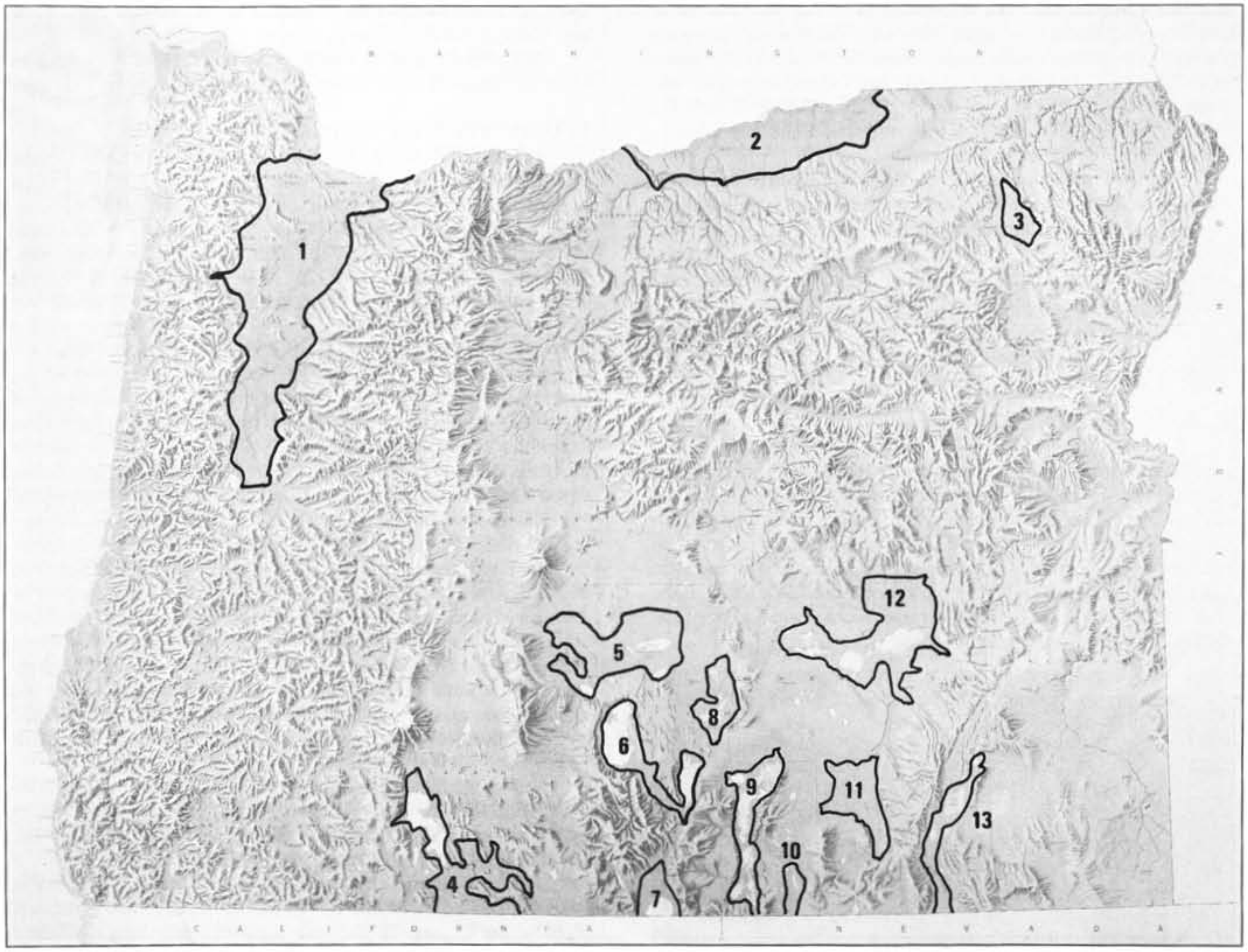
Vancouver Lake in Washington is the largest of such lakes on the Columbia River. The best examples in Oregon are the lakes on Sauvie Island: Sturgeon, Little Sturgeon, Mouse Island, Marquam, and Dry Lakes, and many others unnamed.

3. Lakes formed by wind deposits. Many of the Oregon coastal lakes were formed by advancing sand dunes, especially those on the Clatsop Plains, such as Coffenbury, Smith, Slusher, Sunset, Cullaby, and Stanley Lakes. Lakes farther down the coast were originally formed by marine deposits such as offshore and barrier bars (and are discussed later), but have also been moved inland by advancing dunes.

4. Lakes formed by marine deposits. The area around Florence and farther south has the greatest concentration of such lakes on the coast. From north to south, they are Sutton, Mercer, Collard, Clear, Munsel, Cleawox, Woahink, Siltcoos, Tahkenitch, Elbow, Threemile, Clear (another one!), Eel, Tenmile, Beale and Horsfall



Historical view of the Columbia River Gorge, looking east, with Crown Point and Rooster Rock in the foreground. The center of the photo illustrates how lakes are formed by natural levees and bars along a river. (Photo courtesy Oregon Historical Society)



Pleistocene lakes of Oregon. 1. Lake Allison and 2. Lake Condon were ephemeral lakes produced by jökulhlaups (glacier outburst flood) from glacial Lake Missoula in Montana, 12,000-14,000 years ago. The remaining ones were pluvial lakes: 3. Elgin, 4. Modoc, 5. Fort Rock, 6. Chewaucan, 7. Goose, 8. Alkali, 9. Warner, 10. Guano, 11. Catlow, 12. Malheur, 13. Alvord.

Lakes. South of Coos Bay, they are Round, Fahys, Bradley, Laurel, Croft, New, Floras, and Garrison Lakes.

5. Lakes produced by glacial deposits. These have been discussed under **A**.

E. EROSION

1. Lakes produced by solution of limestone. Although these are very common in areas underlain by limestone, such as Florida, they are absent in Oregon, which has few limestone deposits.

2. Lakes produced by glacial erosion. These have been discussed under **A**.

3. Lakes produced by wind erosion. The soft lake deposits in pluvial Fort Rock Lake are easily excavated by the wind to produce basins with ephemeral lakes such as Fossil Lake and possibly Christmas Lake in central Oregon.

F. ORGANIC AND HUMAN ACTIVITY

1. Coral reef lagoons. Such lakes are formed only within 30 degrees latitude of the equator.

2. Lakes produced by beaver dams. These were formerly quite important and numerous but are now very rare and usually too small to be named.

3. Lakes produced by man-made dams. There are over 60 dams in Oregon. The lakes produced by those dams containing more than 5,000 acre-feet of water are discussed in detail in Dan Johnson's new book but will not be covered here.

G. THERMAL SPRINGS

Borax Lake in the Alvord Basin, Hot Lake east of La Grande, and Hunter's Hot Spring Lake just north of Lakeview are all fed by hot springs.

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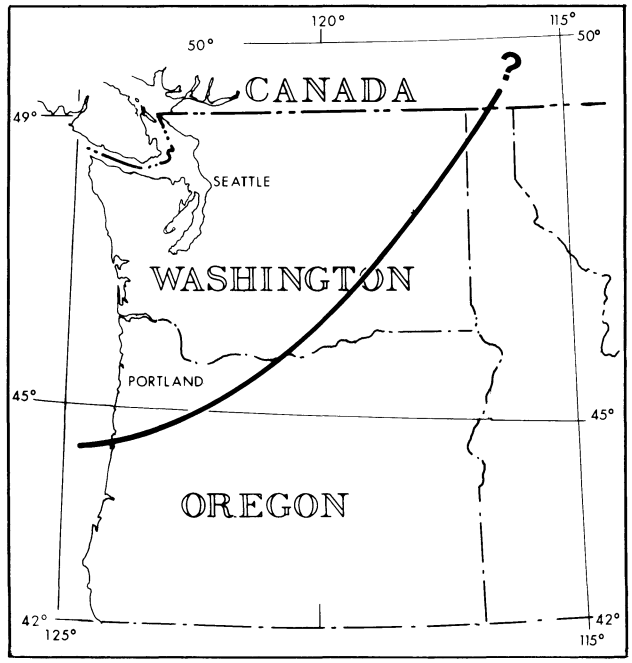
Large fireball sighted in Pacific Northwest: More information needed

A large, bright, long-duration fireball entered the earth's atmosphere over the central Oregon coast at 2:35 a.m. PDT on September 17, 1984. The fireball was first seen along the coast from a number of locations ranging from Westport, Washington, on the north to Roseburg, Oregon, on the south. Despite the fact that the fireball appeared in the middle of the night when there are relatively few observers, it was reported to the Smithsonian Scientific Event Alert Network (SEAN) by at least 24 observers. This author received twenty different reports of sightings, most of which are tabulated below.

The most easterly sighting in Oregon was at Pine Mountain, which is east of Bend. There Dan Kraus, Assistant Astronomer at Pine Mountain Observatory, reported that the fireball came straight at him from the west for 20 seconds, getting larger and brighter. It then appeared to skip 15° to the north, and after about five seconds broke into six orange fragments with tails that were visible for an additional five seconds.

The fireball was observed at Spokane, Washington, where a heavy sonic boom was also reported, and at Sandpoint, Idaho, where the fireball was last seen disappearing below the horizon to the northwest. The Washington and Idaho reports are from Eileen Starr, Planetarium Director, Eastern Washington University, Cheney, Washington, who is also a member of the SEAN team.

SEAN officials believe the fireball probably came down in southeast British Columbia or the extreme northeast corner of Washington State and are contacting Canadian scientists for any additional information.



Map showing possible path of September 17, 1984, fireball.

Table 1. *Summary of fireball sightings reported to author*

Place	Location	Path	Color	Angle of descent	Duration	Description
12 mi. W. of Westport, Wash.	46°52′ 124°20′	W. to E.	Orange/blue	Parallel	45 sec.	Very bright like full moon, yellow tail, fragments coming off every few seconds, total of 12 fragments.
10 mi. N. of Roseburg, Oreg.	43°19′ 123°47′	W. to E.	White	15°	7 sec.	⅓ full moon, very bright, cast shadow, 10-15 fragments dropping out of fireball at steep angle.
Sutherlin, Oreg.	43°23′ 123°30′	W. to E.	Green	10°	10 sec.	Long green tail, glowing trail, cast shadow.
Portland, Oreg.	45°15′ 122°50′	W. to E.	White	10°	10 sec.	⅕ full moon, yellow to red short tail, many fragments, like sparkler, cast shadow.
Portland, Oreg.	45°32′ 122°46′	W. to E.	Blue/white	15°	6 sec.	¼ full moon, eight fragments, glowing train, cast shadow.
Camas, Wash.	45°37′ 122°44′	W. to E.	White	5°	5 sec.	2 times size of Venus, short white tail, four fragments, glowing train.
Camas, Wash.	45°37′ 122°44′	W. to E.	Orange	15°	5 sec.	2 times size of Venus, 20° orange tail, five fragments following fireball, glowing train, cast shadow.
Portland, Oreg.	45°37′ 122°42′	W. to E.	Yellow/white	10°	4 sec.	2 times size of Venus, short yellow-white tail, one fragment, 2-sec. glowing train.
Estacada, Oreg.	45°17′ 122°24′	W. to E.	Red/orange	10°	1-2 sec.	½ full moon, very long red/orange tail, 12 fragments, cast shadow, lit up whole sky, swishing sound.
Lake Oswego, Oreg.	45°21′ 122°41′	W. to E.	Yellow/orange	Parallel	3 sec.	¼ full moon, tear-drop shaped orange tail, one large, several small fragments, glowing train.
Portland, Oreg.	45°31′ 122°33′	W. to E.	Blue/white	5°	4 sec.	2 times size of Venus, 30° red/orange tail, several fragments, smoke trail.
Clackamas, Oreg.	45°26′ 122°32′	W. to E.	White	10°	2 sec.	10 times size of Venus, no tail, four fragments plus many sparks dropping toward ground. Bright as full moon.
Clackamas, Oreg.	45°26′ 122°32′	W. to E.	Green/blue	Parallel	3 sec.	⅓ full moon, very long blue/green tail, six fragments, smoke trail, cast shadow, fast.
Portland, Oreg.	45°32′ 122°32′	W. to E.	Red/orange/ yellow	10°-15°	4-5 sec.	Went below horizon, ⅕ full moon, short yellow tail, four fragments with tails.
Bend, Oreg.	44° 0′ 121°29′	NW.	–	–	–	Observer awakened by bright light. Saw bright streak in sky.
Pine Mt. Observatory, Oreg.	43°47′ 120°56′	W. to ENE.	White/yellow-orange	10°	30 sec.	½ full moon, 30-40° tail, yellow/orange, five to six fragments, cast shadow.
Pine Mt. Observatory, Oreg.	43°47′ 120°56′	W., change direction to moving 15° W. of N.	White	–	30 sec.	Observation by Dan Kraus, Asst. Astronomer, described in article.

Anyone with any additional information about this fireball is urged to contact this author, because scientists hope to recover fragments of the meteorite. At least 50 to 100 good observations are required before there is much chance for recovery. The sonic boom, which generally occurs at low altitudes as a meteorite is slowing and approaching the earth, indicates that fragments may have survived their fiery plunge through the atmosphere and are now on the ground where they may be found.

Three other fireballs occurring within a few days of the event described above were also reported to this author. The first was reported by Linda Jackson, who observed a fireball from between Salem and Portland at lat. 45°8′ N., long. 123°0′ W., on September 16, 1984, at 11:30 p.m. PDT. The fireball was first seen 40° W. of N. at an altitude of 45° and was last seen 10° W. of N., dropping at a 45° angle until it disappeared below the horizon. The duration of the flight was 8 seconds. The fireball, which was very bright, was about half the diameter of a full moon. It appeared to increase in size and brightness as it fell. It was white with a short, yellow-white tail and left a glowing smoke trail that lasted for a few seconds.

The second fireball was sighted on September 17, 1984, at 8:15 p.m. PDT from Battleground, Washington, at lat. 45°45′ N., long. 122°40′ W. by John Enright. It was observed moving from north to south, descending at an angle of 35° for 1 second. The color was orange. The sun had set, but the sky was still orange, and the orange color of the fireball was probably due to the sunset. This fireball is significant because it was essentially a daylight fireball.

The third fireball was reported by Sarah Frost from just north of Lincoln City, lat. 45°3′ N., long. 124°6′ W. on September 22, 1984, at 8:00 p.m. PDT. This fireball was first seen 45° E. of N. at an altitude of 50° and was last seen 30° E. of N. at an altitude of 20°. The angle of descent was 30°; the duration was 4 seconds. The fireball was white with a short white tail, three times the diameter of Venus, and very bright. It broke up into three or four pieces. There was no sound or shadow.

The occurrence of these three fireballs plus the large one reported above suggests that the four may have been related and that they may have been part of a group of meteoroids that were traveling together through space in orbit around the sun.

—Dick Pugh, Science Teacher
Cleveland High School
3400 SE 26th Ave.
Portland, OR 97202
Phone (503) 233-6441

DOGAMI releases new publications

The Oregon Department of Geology and Mineral Industries (DOGAMI) has released a number of publications during the past few months. Space limitations have kept us so far from giving you detailed information about the following releases:

GMS-30: The geology and mineral deposits of a mineral-rich southwest Oregon region are described in a new geologic map of the Oregon Department of Geology and Mineral Industries (DOGAMI).

Geologic Map of the Southeast Quarter of the Pearsoll Peak Quadrangle, Curry and Josephine Counties, Oregon, presents the results of a study conducted by DOGAMI geologist Len Ramp and funded in part by the U.S. Forest Service. Published as Map GMS-30 in DOGAMI's Geological Map Series, it covers an area that straddles the Curry/Josephine county line as well as the eastern edge of the Kalmiopsis Wilderness in the Siskiyou National Forest. "The map includes the area of greatest chromite production and probably the greatest chromite resource potential in the State of Oregon," explained author Len Ramp.

The first of the two sheets of GMS-30 contains a full-color geologic map (scale 1:24,000) with cross sections, a discussion of the geology and mineral deposits, and a table with basic data on 79 mines and prospects identified in the quadrangle. On the second sheet, a sample location map and a table of analytical data provide information on 178 rock samples from the area, approximately one-third of them collected at mine or prospect sites. The samples were assayed for ten metallic elements.

The rocks identified in this quadrangle are approximately 150-200 million years old. Their nature and structure suggest a complex geologic history. Originally formed on or under an ancient ocean floor, they were affected by two separate geologic environments: The volcanism of an island arc and the underthrusting and uplift associated with partial melting.

Purchase price of GMS-30 is $8.

GMS-33 and -34: The second and third maps in a planned series of three maps showing Tertiary seashore environments of approximately 20-40 million years ago in the Western Cascade foothills near Silverton are now available to the public.

Map GMS-33, *Geologic Map of the Scotts Mills Quadrangle, Oregon*, by Paul R. Miller and William N. Orr, covers the Scotts Mills 7½-minute quadrangle that straddles the Clackamas-Marion county line just to the northeast of the town of Silverton. The two-color map (scale 1:24,000) shows eight surficial and bedrock geologic units, the area's geologic structure, and two cross sections. Supporting the study's emphasis on aspects of sedimentation and paleontology and the reconstruction of paleoenvironments, an additional sketch map outlines the depositional environments of the middle Tertiary (Oligocene and Miocene) geologic units in and around the area covered by the map.

Map GMS-34, *Geologic Map of the Stayton NE Quadrangle, Oregon*, by William N. Orr and Paul R. Miller, covers the 7½-minute quadrangle to the southwest of the Scotts Mills quadrangle (GMS-33). This two-color map (scale 1:24,000) is similar in format to GMS-33. In addition, it contains a diagram showing the characteristic invertebrate fossils and the representative map units from seven mid-Tertiary environments in the Western Cascades.

The first map of this series, the Wilhoit quadrangle map, was released in June as GMS-32. All three maps are available at DOGAMI at a price of $4 each.

GMS-35: A new geologic map of the southwest portion of the Bates 15-minute quadrangle in eastern Oregon has just been released as Map GMS-35, *Geology and Gold Deposits Map of the Southwest Quarter of the Bates Quadrangle, Grant County, Oregon*, by Howard C. Brooks, Mark L. Ferns, and Dan G. Avery.

This new map is the latest eastern Oregon gold-country geologic map produced by DOGAMI in cooperation with and funded in part by the U.S. Forest Service. Earlier maps of this series, which are also available from DOGAMI, cover the Bullrun Rock, Rastus Mountain, Bourne, Mount Ireland, Granite, Greenhorn, Bates NW, and Bates NE 7½-minute quadrangles and the Mineral, Huntington, and Olds Ferry 15-minute quadrangles.

The four-color geologic map of the Bates SW quadrangle is at a scale of 1:24,000. It shows sedimentary, volcanic, and metamorphic geologic units that were deposited or formed over a period extending from the present day back to pre-Permian time (more than 280 million years ago). The complex geology of this area is further explained by two cross sections that show the relationships of the 17 geologic units presented on the map. One of these units is formally introduced here with a new stratigraphic name: The Dixie Butte Meta-andesite of Triassic to Permian age.

Parts of this area have been mineralized, and the map shows the location of numerous mines, prospects, and quartz veins, many of them in the historic Quartzburg mining district located in this quadrangle. Also included on the map sheet are data tables of mines, prospects, and sample analyses; a discussion of the mineral deposits in the quadrangle; and a list of literature references.

Purchase price of GMS-35 is $5.

OGI-8: Oil and Gas Investigation 8, *Subsurface Stratigraphy of the Ochoco Basin, Oregon*, by G.G. Thompson, J.R. Yett, and K.E. Green, summarizes the results of a study of samples from four deep wells in southern Crook County, Oregon. The 22-page text discusses stratigraphic interpretations and presents summaries and detailed lithologic descriptions for each of the wells. Charts on the seven plates that accompany the text show palynomorphic and foraminiferal distributions and palynology correlations.

Subsurface geologic knowledge in central Oregon is limited to these four deep test wells that have penetrated a substantial section of Cretaceous marine and nonmarine clastic sediments beneath the Tertiary volcanic cover. This report documents the distribution of microfossils in samples from the wells and interprets the age and depositional environments of the rocks penetrated. Selected ditch and core samples were analyzed for pollen, spores, microplankton, foraminifera, radiolaria, and calcareous nannoplankton. The presence of Upper Cretaceous Albian through Campanian strata supports the authors' conclusion that there may be an extensive Upper Cretaceous basin, informally named the Ochoco Basin, with the potential for containing hydrocarbon-bearing reservoirs.

Purchase price of OGI-8 is $7.

OGI-12: The results of a study of nine wells drilled in the north Willamette Basin have been released as Oil and Gas Investigation 12, *Biostratigraphy of Exploratory Wells, Northern Willamette Basin, Oregon*, by Daniel R. McKeel. The 19-page report presents correlations of fossils and lithology and is based on the analysis of 918 samples from nine wells drilled in Washington, Yamhill, Marion, and Polk Counties to depths ranging from approximately 5,000 to over 9,000 feet. The publication is the third in a series of biostratigraphic studies published by DOGAMI. Earlier reports were on 15 wells in the adjacent Mist Gas Field area (Oil and Gas Investigation 9) and on nine wells in southwest Oregon (Oil and Gas Investigation 11).

Section I of the new report contains a summarizing overview, including a composite chart showing the subsurface stratigraphy and a paleobathymetric curve. Section II presents sample-by-sample descriptions of rock types and marine fossils for each well. These identifications are used to determine the age, water depth, and paleoenvironment for each distinctive well interval. Included with the report is a separate illustration sheet containing a surface location map for the wells and selected subsurface correlations for all but one of the wells in the form of a generally north-south-oriented cross section.

Cost of OGI-12 is $6. The earlier reports in this series, OGI-9 and -11, are also available at a price of $6 each.

OFR O-84-4: Two Cascade Range maps that were developed during earlier geologic investigations and that will aid further geologic and geothermal research have been re-released independently now: *Heat-Flow Map of the Cascade Range of Oregon and Index Map of Mapping in the Oregon Cascades*, DOGAMI Open-File Report O-84-4.

The first of the two blackline maps is a heat-flow map of the Cascade Range, produced by G.L. Black, D.D. Blackwell, and J.L. Steele. It originally appeared in DOGAMI Open-File Report O-82-7, *Geology and Geothermal Resources of the Cascades, Oregon*, which is now almost out of print. It was also included, at a smaller scale, in DOGAMI Special Paper 15, *Geology and Geothermal Resources of the Central Oregon Cascade Range* (1983). This heat-flow map has now been published at a scale of 1:500,000, showing heat-flow contours and the locations of all heat-flow data points for the Oregon Cascades.

The second map, an index to geologic mapping in the Oregon Cascades at scales larger than 1:250,000, by N.M. Woller and G.R. Priest, was also included originally in DOGAMI Open-File Report O-82-7. Reproduced now in Open-File Report O-84-4, this index map outlines the areas covered by geologic mapping in DOGAMI and U.S. Geological Survey studies and in master's and doctoral theses. For optimal clarity, the indexed mapping is distributed on three side-by-side repetitions of the base map. Full bibliographic references for all indexed maps are also included.

Purchase price of Open-File Report O-84-4 is $5.

OFR O-84-5: The results of a study in which samples from Clatsop and Morrow Counties were collected and analyzed for their potential as silica sand resources have been released as Open-File Report O-84-5, *Bench Testing of Silica Sand from Deposits in Clatsop and Morrow Counties, Oregon*, by Jerry J. Gray, in cooperation with the Port of Morrow, the Mineral Resource Institute of the University of Alabama, and a private industrial firm. This study identifies three deposits in Morrow County from which a silica sand product can be produced.

The areas from which samples were collected are along the course of the Columbia River and contain deposits of sandstone, fluvioglacial sand and gravel, dunes, and silt and sand of a glacial lake. The testing for silica sand potential was based on standards for the most stringent silica sand markets. Each sample was assayed, sized, subjected to magnetic and gravity separation, and re-assayed. The results of the tests are presented in tabular form in the 12-page report.

This open-file report may be purchased for $4.

All of the above-mentioned publications are available over the counter and by mail from the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, OR 97201. Orders under $50 require prepayment. □

Lectureship in Vancouver, B.C., offered

The Cordilleran Section of the Geological Association of Canada is sponsoring a three-month position for a visiting lecturer in Vancouver, British Columbia, and invites applications or nominations.

The Charlie Ney Visiting Lectureship is intended to bring prominent earth scientists to Vancouver's large geological community made up of exploration, government, and university geologists. It is aimed at, but is not restricted to, those on sabbatical leave and is tenable for three months, beginning at any time from September 1985 to February 1986. The lectureship carries an honorarium of $8,000 (Canadian), and office facilities will be made available at the University of British Columbia and the Geological Survey of Canada.

The Ney Lecturer is expected to contribute lectures to a pertinent course or courses at the University and to conduct a short course or series of lectures for the downtown mineral exploration community.

Applications or nominations will be accepted by Paul L. Smith, President of the Cordilleran Section, Geological Association of Canada, P.O. Box 398-Station A, Vancouver, B.C., V6C 2N2, Canada, before March 30, 1985. □

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