OREGON GEOLOGY

Oregon Department of Geology and Mineral Industries

Volume 62, Number 1, January/February 2000

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Retrospective: *The Ore Bin* and *Oregon Geology*, 1939–1999

THROUGH THE EYES OF THE STATE GEOLOGIST

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Oregon State Geologist

Oregon is increasingly challenged with earth-resource and geologic-hazard related decisions. New housing development is often on property with higher risks, or done to increase the density of urban areas. Both these factors are adding to increased losses from natural disasters, a pattern that is evident statewide, nationwide, and even worldwide.

Here in Oregon, local decision-makers are increasingly driven to make decisions without adequate information or training. Some people are calling for state authorities to peer-review geologic reports, believing this alone will solve the problem. But that effort has failed in other states. What is needed is to improve the quality of reports to match the increasing need.

The Department of Geology and Mineral Industries (DOGAMI) is working to improve the information available to Oregon citizens and communities:

1. Our Department conducts research for, compiles, and distributes data the public needs. We have five offices, including a new field office being established in Newport, to better serve the needs of coastal residents. In addition, we have a service center in Portland and a web site to provide information to the public.

2. Better training must be offered to local residents, governments, and communities on the content and the use of technical data. To accomplish this, DOGAMI is targeting public education efforts to audiences who most need the information we have. We are also establishing traveling workshops to bring information to users.

3. Oregon requires geologists and engineers to be registered by the state, requiring certain standards of training and experience.

4. To be effective, the contents of geotechnical reports must meet certain standards. DOGAMI plans to cooperate with the Board of Geologist Examiners to provide better advisory information on the content of properly prepared geologic reports.

5. The quality of information in the reports must also be assured. Some communities are developing mechanisms for peer review within their areas of interest. These success stories must be broadcast by entities like DOGAMI and the Board of Geologist Examiners.

6. For some issues that are of a large scale, or significant in terms of state policy, DOGAMI sometimes does provide review services for local governments. In the past, we have asked that all requests be made through the Governor's Office to help assure proper coordination.

With progress on each of these fronts, we can continue to move toward a culture of high-quality reports and better geologic understanding.

OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 62, NUMBER 1 JAN./FEB. 2000

Published bimonthly in January, March, May, July, September, November by the Oregon Department of Geology and Mineral Industries. (Volumes 1 through 40 were entitled The Ore Bin.)

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Periodicals postage paid at Portland, Oregon. Subscription rates: 1 year, $10; 3 years, $22. Single issues, $3.

Address subscription orders, renewals, and changes of address to Oregon Geology, Suite 965, 800 NE Oregon Street # 28, Portland 97232.

POSTMASTER: Send address changes to Oregon Geology, Suite 965, 800 NE Oregon St. # 28, Portland, OR 97232-2162.

Cover photo

The magnitude 5.6 "Spring Break Quake" of March 1993 caused several million dollars of damage throughout the mid-Willamette Valley. In this brick building in Newberg, the top story was red-tagged, or declared unsafe to enter, but the street-level floor was not as seriously damaged. *(Photo courtesy of Evelyn Roeloffs, U.S. Geological Survey)*

Through the years of Oregon Geology

Compiled by J.L. Clark and Neva Beck, Oregon Department of Geology and Mineral Industries

For more than 60 years, the Oregon Department of Geology and Mineral Industries has regularly published information about Oregon's geology for technical and nontechnical audiences alike. From 1939 through 1978, the periodical was known as the *Ore Bin,* reflecting the importance of mining to the state and the department's activities (originally, in a somewhat whimsical wordplay, with an additional period and hyphen as *Ore.-Bin*). Since 1979, our magazine has been known as *Oregon Geology,* reflecting a change in the department's contribution to society. Although mining processes and products are still important to Oregon, our growing population has required more information about natural hazards, earthquakes, tsunamis, landslides, floods, and volcanic eruptions.

The following is a compilation of excerpts and articles, mostly without editorial comment, from our magazine with the two names. These articles do not necessarily reflect the typical substance of the periodical. Some articles could have been written only during World War II, and some were written because of the space race in the 1960s. Above all, coverage of new geologic insights or mining practices or other scientific study projects cannot adequately be extracted in a paragraph or two. Instead, the selected articles tend to reflect subjects that can be condensed and made sense of without the context of the times and without technical or scientific expertise.

Please join us on a journey back through time, as seen through the eyes of a magazine devoted to Oregon's natural history, beauty, resources, and—yes—risks.

1939: The beginning

THE ORE.-BIN

This is the first issue of THE ORE.-BIN . . .The State Department of Geology and Mineral Industries will use THE ORE.-BIN to advise the public of the work of the Department, and of new and interesting developments in mining, metallurgy, and geology . . .

Newspapers are encouraged to use any of the material contained in THE ORE.-BIN. It is designed primarily for such use. A credit-line of acknowledgement is requested.

Your comments and criticisms will be appreciated. It is our desire to make THE ORE.-BIN an effective medium for "telling the world" about Oregon, its mineral resources, and possibilities.

January 1939

INTRODUCTION TO THE VERY FIRST COLUMN BY A STATE GEOLOGIST

Ever notice that once in a while at any man's mine the lead mule kicks hell out of the trammer boss, or the track tender drops a Jim Crow on his foot, or the timber gang comes to work on the night shift soused to the ears, or the motor-man forgets to duck a chute timber — anyway, once in a while the boss of the outfit (who never does anything but look down the backs of employees' necks) has to don slicker and hard hat and really do a little work?

Earl Nixon, August 1939

TOPOGRAPHIC MAPPING IN OREGON

Last year a grant of some $80,000 of PWA funds, the bulk of it ear-marked for topographic work, was allocated to Oregon. Most of this is being used for aerial topographic mapping of the coastal area from about opposite Eugene north to the Columbia River, on account of the need of maps in that area for War Department use in connection with coast defense.

Whether or not more funds will be available this coming year is not known, but since the funds were intended to be used in part in connection with the Federal government's study of strategic minerals, it is hoped that a substantial part of any further funds from this source may be utilized to cover large parts of certain Oregon areas now unmapped, where strategic minerals, particularly chromite and quicksilver, are known to exist.

March 1939

1940s: War and peace

2000 WILLOWS DOING FINE, DREDGED LAND

A project aiming at the rehabilitation of land over which gold dredges have passed was begun this year on tailings of the Porter and Company operating near Granite, a report from the Whitman National Forest headquarters indicates.

According to the information on the project, the work is done under an agreement as to dredging federal forest land and involved the planting of 2000 willow trees on the leveled tailings piles. In addition, the dredging company is said to have planted crested wheat grass directly in the rock and that a stand was obtained. The company has done similar planting in Montana, it is said.

The willows, native to the district, were cuttings from 18 to 24 inches in length and were set out during the spring under the supervision of Mel Burke, forest service staff member. Ninety percent of the trees were growing, he indicated Tuesday. Plantings were made along the winding creek channel reconstructed by the company over the ground mined.

August 1941

MINING LABOR

During the past year, the shift of miners to the so-called defense industries because of the high wages paid by "cost-plus" government contracts became so serious that production of metals was adversely effected . . .

Incidentally welders can be trained in two or three weeks; not so with miners. Mining is more than running a machine. After his first year's work underground a miner would have picked up the rudiments of underground mining — if he had had proper instruction, but he would still be a beginner. Real miners, who can recognize and take care of bad ground, who can safely handle explosives, and who can break ground by placing drill holes properly are made only after years of work under a variety of conditions common in underground mines.

September 1942

ALUMINUM DUST TREATMENT FOR SILICOSIS

According to ROCK PRODUCTS, August 1944, interesting results on the use of aluminum dust as an inhalant treatment of silicosis have been published by the Canadian Medical Association.

The treatment used at the McIntyre mine consists of inhalation of aluminum powder. This material is produced by pounding small pieces of thin aluminum sheets into a fine dust, according to a process worked out at the Pittsburgh plant of the Aluminum Company of America. When the aluminum powder is inhaled, the reaction in the lungs coats silica particles with a thin gelatinous film, inhibiting the serious effect of silica on the respiratory organs.

Sept. 1944

CLEAR WRITING IN GEOLOGY

It seems that in our hunt for general principles we feel the need of tagging each observed fact with some word that may connect it with the language in which the great fun-

WELL, WHAT ARE WE GOING TO DO ABOUT IT?

We're in a war! A real, sea-going, man-sized, knock-hell-out-of-'em-kind of a contest in which men and machines and fuel for the machines and ammunition and BRAINS will win. That's all it takes . . .

All the smelters, all the machine shops, all the factories, all the skilled workmen, and all the money in the land — can't turn out a fighting plane or a battleship unless all of the various essential raw materials are on hand to start with. True, we are taking nitrogen out of the air and making ammunition out of it; we are taking iodine and bromine and even magnesium out of sea water, – but nobody has ever taken quicksilver or chromite or manganese or tungsten or antimony out of air or sea water. They have to be first found and then dug out of the earth. And you can't turn on a flow of chromite, manganese, etc. . . . as you turn on water from a spigot.

Let us all — and the Congress — remember that we can order planes, tanks and boats 'till Hell won't have it, and we can raise taxes to pay for them, but they can't be produced without raw materials. We must supply those raw materials. That's our job — and THAT'S WHAT WE ARE DOING ABOUT IT.

December 1941

damental laws of the universe are proclaimed at the seats of learning. For this reason — I prefer to suggest no other — a Survey author refers to cracks and crevices in rocks as "spaces of discontinuity." . . .

In our writing I believe, however, we are tending to write more plainly — to say "sand" instead of "arenaceous deposit,""clay" instead of "argillaceous stratum," "close folding" instead of "intense plication," "river banks" instead of "riparian borders," "mouth" instead of "debouchure," "shore" instead of "littoral margin," and "the overlying bed is limestone" instead of "the superincumbent material consists of a stratum of calcareous composition."

November 1945

MT. HOOD'S VANISHING GLACIERS

Oldtimers who are fond of telling people that "the winters aren't as severe as they used to be . . ." may very well be telling the truth if present glacial activity on Mt. Hood and other continental peaks is taken into consideration . . .

Glacial markings on rocks 500 feet above the present surface of Reid Glacier indicate the amount of shrinkage of one of Mt. Hood's now shrivelled glaciers.

September 1946

EARTHQUAKE FELT AT KLAMATH FALLS AT NOON DECEMBER 24, 1947

Klamath Falls (central section). (VI) Motion trembling. Felt by several. Rattling of loose objects; buildings creaked. One report of cracked plaster. "Those reporting in rather wide area. Radio Station KFLW reported a momentary distortion at noon." Ground; Rocky.

Klamath Falls. (IV) Motion swaying, rapid onset. Felt by several. Rattling of loose objects and creaking of buildings heard by several. Faint, bumping sounds heard. Pictures on walls and suspended lighting fixtures swayed. Few alarmed.

July 1948

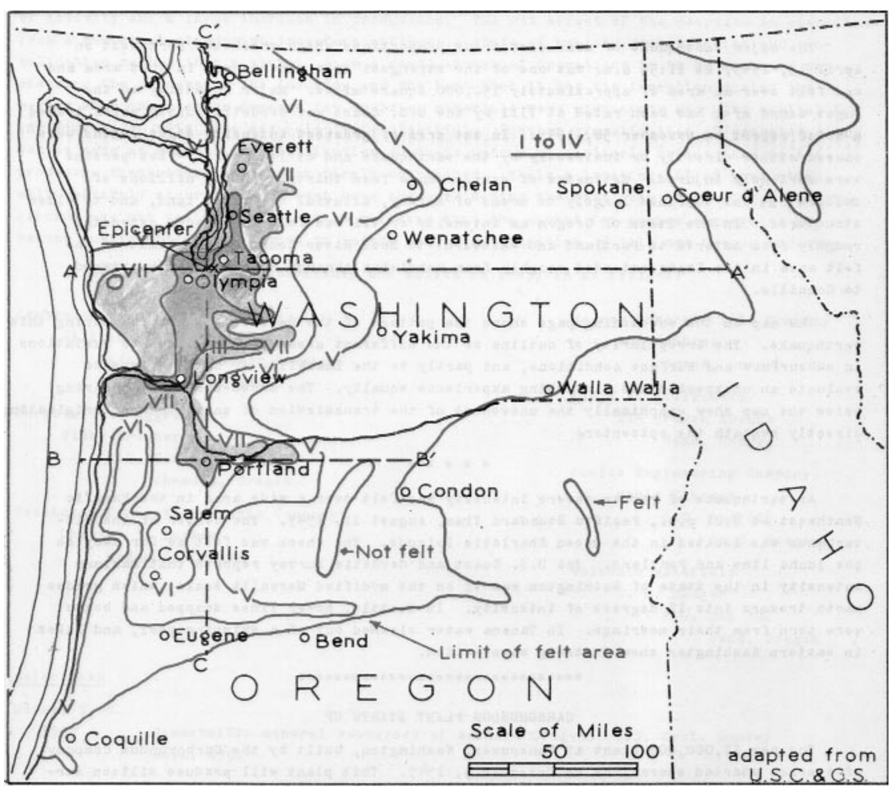
EARTHQUAKES

The recent quake which occurred April 13, 1949, although causing little damage in the Portland area, created considerable interest and concern among individuals, public agencies, engineering firms, power companies, and insurance firms. The State of Washington has inaugurated a special study of the earthquake, the epicenter of which was located by the U.S. Coast and Geodetic Survey between Olympia and Tacoma. Olympia suffered the greatest damage of the cities of the Puget Sound area.

Minor damage to several of its substations in southern Washington was reported by Bonneville Power Administration. The Oregon Section, American Society of Civil Engineers, has undertaken a comprehensive study of earthquake- resistant construction in buildings in Oregon. The study will include both the public safety and economic aspects of the problem.

As would be expected, local insurance firms were besieged by requests for earthquake insurance coverage immediately following the recent disturbance. One large international insurance firm made a study of the earthquake activity in the State, together with the subsurface conditions existing in the areas occupied by the principal cities in the State.

June 1949



Isoseismal map for earthquakes of April 13, 1949, at 11:55:41 PST. Adapted from map prepared by U.S. Coast and Geodetic Survey. **December 1949**

1950s: The cold war

NEW USE FOR OREGON VOLCANIC GLASS

A new use for Oregon volcanic glass has been developed by the State Department of Geology and Mineral Industries. The volcanic glass when used as a feldspar substitute in a ceramic glaze produces a glaze suitable for stoneware, artware, and terracotta products. Finely ground pumice, volcanic ash, and perlite, forms of volcanic glass found mainly in the central and eastern parts of the State, can be used to replace more costly material shipped into the area from considerable distances. The glaze was perfected after nearly two years of research by Mr. C.W.F. Jacobs, Department Ceramist, who experimented with numerous nonmetallic products found in Oregon.

September 1950

BLUE CHIP METALS

This atomic age is dependent on metals, and their importance is constantly being brought home to us. This is a development hastened by war and war preparation, but in any case, seemingly, it is an industrial evolution along the course set by the demand for more and improved machines and the inventions of new and more intricate instruments. A greater quantity of the common metals is continually demanded; and "new" metals — new in their practical applications — are becoming increasingly necessary in the ever-expanding industrial field. Cobalt, titanium, columbium, tantalum, germanium, and the so-called rare-earth metals are among those which have become essential to modern industry. Because of price, domestic needs, and metallurgical characteristics, they are the "blue chips" of present-day metallurgy.

February 1952

ASTORIA LANDSLIDES

This year, damage from landsliding in Astoria has centered in the western part of town at West Commercial and West First Streets. Twenty-seven houses have been affected, five of which were already abandoned as the result of slippage last winter. The houses in this area will be destroyed unless moved, and the streets, sidewalks, plumbing, landscaping, and other improvements are doomed. In 1950 twenty-three houses in the Coxcomb Hill area were removed or destroyed.

A loss of fifty houses in one city due to geological processes in a matter of a few years is a serious situation, and a brief review of the geology of the area is given so that a better understanding of the underlying cause of the destruction may be had.

January 1954

OREGON NATIVE STONE FOR ROOSEVELT MEMORIAL MUSEUM AT WARM SPRINGS, GEORGIA

As requested by Governor Douglas McKay, DOGAMI has prepared an Oregon stone for presentation to the Franklin D. Roosevelt Memorial Foundation museum at Warm Springs, Georgia. Typical stones from each state in the United States will be placed in the walls of the museum building. The Oregon stone is made out of a rectangular block of gray Ashland granite approximately 18 inches by 13 inches by 4 inches. One polished face, on which OREGON is etched, outlines the boundaries of the state. The stone, which has been on display in the Department's museum in the State Office Building, Portland, will be shipped in a few days to Warm Springs where a simple presentation ceremony has been planned.

March 1952

OIL AND GAS CONSERVATION WEEK PROCLAIMED BY GOVERNOR

The week of November 29 through December 4, 1954, was proclaimed as Oil and Gas Conservation Week by Paul L. Patterson, Governor of the State of Oregon. This State is one of many in which similar proclamations were issued. The need for conservation of natural resources is being recognized by progressive officials and agencies more than ever before. The State of Oregon is cognizant of this need. The 1953 Legislature passed a new oil and gas conservation law, even though the search for oil and gas in the State is in its infancy. In July, Oregon became an associate member of the Interstate Oil Compact Commission, a national organization whose sole purpose is to promote and encourage the conservation of oil and gas and to prevent physical waste.

December 1954

FOSSIL LOCALITIES IN THE COOS BAY AREA, OREGON

Fossil shells are abundant in the sedimentary rocks of the Coos Bay area. Good fossil specimens are most likely to be found where sedimentary rocks are freshly exposed, such as in recent, unweathered road cuts or at the base of cliffs along the coast and the bay where wave action is constantly uncovering new material. Ten easily accessible fossil localities are described in the following text and their location shown on the accompanying map. Localities along the water's edge can generally be reached only at low tide.

June 1955

MAGNETIC DECLINATION IN OREGON

Anyone who uses a compass for surveying or prospecting must take into account the effect of variations in the earth's magnetism on the compass needle. There are only a few places on the earth where the compass points truly north, and even there the direction is not constant for very long. In Oregon the compass points between 18° and 22° east of true north, with local variations of from 5° west to nearly 33° east. This deviation of the compass needle, or angle between magnetic north and true north, is known as magnetic declination.

June 1956

LANDSLIDE DAMAGE

Landslides are far more common than is generally realized. Lack of information about them is probably due to their intermittent occurrence and the relatively small number of people directly affected. The following cost estimates of slide damage in Oregon are given to illustrate their importance and to call attention to the need for further slide study.

The winter of 1955-1956 cost the Multnomah County road department an estimated $125,000 for slide repair, four times the normal yearly cost. Slides in that county, which numbered 109, are exclusive of those on highways and streets maintained by city governments and the State Highway Department. The Portland city water department reported a slide damage this past winter to the main water supply system which will cost an estimated $100,000 to repair. According to the city engineer's office, repairs to Portland city streets and parks necessitated by recent slides will cost about $100,000.

May 1956

1960s: The space race

LAKE COUNTY SPOUTER BECOMES TRUE GEYSER

The hot-water spouter on the Charles Crump ranch in Warner Valley, Lake County, is again making history. It is now a true geyser, erupting at approximately two-minute intervals to a height of 60 feet.

The original spouter, which burst forth from a well on July 1, 1959, sent up a continuous column of steam and hot water more than 150 feet high (see report by Norman Peterson in the September 1959 Ore.-Bin). That action continued for several months, until vandals threw boulders into the 20-inch casing at the top of the well, greatly reducing the volume of flow and height of eruption.

June 1960

GEOMORPHOLOGY OF THE CONTINENTAL TERRACE OFF THE CENTRAL COAST OF OREGON

The major submarine geomorphic features off the Oregon coast are the continental shelf, extending from low water to the first pronounced increase of slope to deeper water, and the continental slope, from the outer edge of the shelf to the decrease of slope at the edge of the abyssal plain. Together, these constitute the continental terrace. The terrace varies in width from more than 70 miles off Astoria to less than 40 miles off Cape Blanco, and extends to the 1,500- to 1,700-fathom depths of the southward-deepening abyssal plain. Off the Columbia River, Astoria Canyon and Astoria Cone alter the shape of the continental terrace.

Astoria Canyon, the only major submarine canyon off the Oregon coast, heads 10 miles west of the mouth of the Columbia at a depth of 70 fathoms, and extends some 60 miles to a depth of 1,000 fathoms, where its identity as a canyon is lost on Astoria Cone. . .

The continental shelf along the Oregon coast differs notably from the average continental shelf. According to Shepard, shelves around the world have an average width of 42 miles, an average slope of $0^{\circ}07'$, and an average depth at the outer edge of 72 fathoms. The shelf along Oregon is 9 to 40 miles wide, slopes $0^{\circ}08'$ to $0^{\circ}43'$, and has a depth at its outer edge of 80 to 100 fathoms. Thus, the Oregon continental shelf is characteristically narrower, steeper, and deeper than the average continental shelf.

May 1962

INDUSTRIAL MINERALS: BUILDING STONE

Interest in Oregon building stone continued at a high level during 1961. Increased use of ornamental stone in commercial buildings and private residences required quantities of local and out-of-state stone. The selection of such stone is based largely on its appearance, and individual tastes with respect to color, texture, and shape vary widely. It is little wonder that shipments come from considerable distances to supply a definite demand and local stones travel far from home for the same reason. Oregon quarries, scattered over the state, produced a variety of colorful stones which spanned the color spectrum from green through yellow and brown to pink. Most were of volcanic origin, with airborne and water-laid tuffs predominating. Some of the state's many lavas were also used, and although they tended to be less colorful they were more interesting texturally. A survey of building stones conducted by the department located a lava outcrop which emits a musical tone when struck. Lavas with warped fossil bubble holes and tuffs which can be carved, glazed, and fired are also available from Oregon quarries.

January 1962

LUNAR LANDSCAPES IN OREGON

As the race to be the first mortals on the moon continues, the questions of how the lunar surface features originated and what rock types they contain are still not answered.

Many of the lunar configurations that are telescopically visible certainly resemble volcanoes and features associated with them. Even if only a part of the moon's surface has been formed by volcanic processes, some of the smaller volcanic forms, such as hummocky lava flow surfaces, spatter cones, and lava tubes could be present. If these features exist, they could provide ready-made shelters to protect men and vehicles from the hostile environment of radiation, high temperatures, and meteorite and dust bombardment.

A reconnaissance of the Bend-Fort Rock area in central Oregon shows that it has a wealth and variety of fresh volcanic landforms that should be of interest to the planners of our lunar programs as well as to the students of volcanology or to those curious about the rocks of Oregon.

March 1963

TSUNAMIS ON THE OREGON COAST

During the early hours of the morning of March 28, 1964 a tsunami struck the Oregon coast. This phenomenon, commonly called a "tidal wave," was generated by the earthquake that had shaken Alaska the evening before. The seismic waves forming the tsunami originated in the vicinity of the earthquake's epicenter and traveled in all directions to ocean shorelines where they were eventually dissipated; in some areas there was substantial loss of life and property.

Residents along the Oregon coast can be thankful that this tsunami caused relatively little loss along our shores. A tsunami of comparable magnitude struck the Hawaiian Islands in 1946, resulting in the loss of 159 lives and a $25 million property damage. Hawaii was 2,300 miles away from the epicenter in the Aleutians of that devastating earthquake, whereas our coast is only about 1,500 miles from Alaska. Oregon was fortunate this time for several reasons: the initial direction of impetus imparted to the seismic waves was away from our coast; the intervening continental shelf topography aided in refracting and dissipating the waves; and, finally, the generally high and rugged coastline of Oregon resulted in ultimate dissipation of the waves on unpopulated shorelines.

. . . Each estuary has its own peculiarities. The location of jetties and sea walls, the existence of tidal flats and sloughs, the shape and length of the channel and the depth and width of the basin enter into the effects abnormal waves can produce. For example, (1) At Coos Bay, the initial wave of about 10 feet above mean high water was dissipated in its travel up the channel by the wide tidal flats and was of negligible height by the time it reached Pony Point about 7 miles up the channel. (2) At Florence, on the Siuslaw River, the initial wave was about 8 feet above mean high water at the Coast Guard Station near the entrance, but due to a fairly narrow channel the wave was apparently only slightly dissipated by the time it reached Florence in the South Slough and surrounding tidal flats. (3) At Reedsport, about 10 miles up the Umpqua River only negligible indications existed of the 14-foot wave that was measured at the entrance. The meandering river with its wide tidal flats quickly dissipated the wave's energy. (4) In Yaquina Bay, four large waves of almost equal height were observed; whereas, in the other estuaries the subsequent waves generally decreased in magnitude following the second wave. This effect at Yaquina Bay could possibly be attributed to a seiche characteristic which is similar to the rocking motion of water from side to side in an open basin.

December 1964

HISTORY OF OREGON EARTHQUAKES

Oregon has experienced many more earthquakes than is generally realized, and a good share of them have occurred in the vicinity of Portland. Since 1841, at least 160 earthquakes have been recorded in Oregon, not including those originating out of the state or at sea but felt here. Prior to 1900, only about 30 quakes had been known. Undoubtedly many more occurred but were not reported because of the scattered population, poor communications, and lack of instrumentation.

Earthquakes having intensities of VIII on the modified Mercalli scale have been reported for Oregon at Port Orford in 1873, at Portland in 1877 and in 1880, and at Milton-Freewater in 1936. Earthquakes with intensities of VII were reported at Umatilla in 1923 and at Portland in 1962; and intensity quakes of VI occurred in Portland in 1953 and at Salem in 1957. Portland alone has been the epicenter for at least 46 earthquakes ranging from II to VII in intensities. Nine of these were V and above.

December 1964

THE TACOMA EARTHQUAKE OF APRIL 29, 1965

About the time Seattle and Tacoma people were going to work on the morning of April 29, 1965, the Pacific Northwest states were shaken by their largest earthquake in decades. The shock was as large, or larger, than the famous Tacoma shock of April 13, 1949. The recent quake was felt over Washington, Oregon, Idaho, and British Columbia, and as far away as Coos Bay, Oregon. Considerable damage occurred in the Tacoma-Seattle area, where at least three persons were killed. The shock was so strong that recordings at most seismograph stations in the Northwest went off scale, and subsequently recorded vibrations were so large that the different waves could not be identified. Consequently, the magnitude of the shock could be determined only at distant stations, where recorded amplitudes were smaller.

The magnitude of the shock was reported to be 6½ (Richter scale) by the Seismological Laboratory in Pasadena, California, and 7 by the Seismographic Stations in Berkeley, California. The maximum intensity was estimated to be VIII (Modified-Mercalli scale) in the Tacoma-Seattle region, decreasing to intensities of VII at Longview, Washington; IV at Corvallis, Oregon; and III at Coos Bay, Oregon. . .

May 1965

INVESTIGATIONS OF THE NOVEMBER 1962 EARTHQUAKE, NORTH OF PORTLAND

The Portland earthquake was the largest shock to occur in Oregon since the recent installations of the several new seismic stations in the Pacific Northwest. Although damage resulting from this shock was minor, as indicated in a preliminary report (Dehlinger and Berg, 1962), the shock is of considerable seismological importance. Because it was large enough to be recorded at the newly installed as well as at many of the older seismic stations, and because its epicentral location was known approximately from the felt area and from on-site recordings of aftershocks, this earthquake has provided the first significant data to be used for constructing travel-time curves for Oregon. The seismograms also provided data for a better understanding of the source mechanism associated with the Portland shock.

. . . Aftershocks nearly always occur subsequent to an earthquake. Numerous aftershocks followed the Portland temblor, about 50 of which were recorded over a period of 18 days by three portable seismic stations in the Portland area.

April 1963

OREGON'S LOST METEORITES

Oregon's Port Orford meteorite has gained worldwide fame as a lost meteorite. Interest in the search for this meteorite has now extended over a period of a hundred years without success. In addition to the Port Orford meteorite, there is evidence that other lost meteorites exist in Oregon . . .

1. One of the largest meteors on record fell on the head of South Slough, Coos County, January 17, 1890, at 11:00 at night, knocking a hole in the hill thirty feet across.

It came from the Northwest and lighted up the heavens in fine style.

A report, as of thunder, awoke people for many miles around. It was plainly heard at Coquille City. Excavations reveal a chunk of lava twenty-two feet across that resembles slag from an iron furnace.

2. Listed as a doubtful fall in the Prior-Hey catalog of meteorites published by the British Museum is a stony meteorite from Mulino, Oregon. A small stony meteorite was sent to the U.S.National Museum in 1927. The meteorite supposedly fell May 4, 1927.

3. In January 1952, an unidentified rancher brought in to J.D. Howard of Klamath Falls a small piece of nickel-iron for analysis. This piece was broken off from a 30-pound mass. Mr. Howard, suspecting the specimen to be meteoritic, forwarded it to Dr. H.H. Nininger at Winslow, Arizona, for verification. Dr. Nininger found it to be a meteorite. He then attempted to learn the location of the main mass, but so far has been unsuccessful. The small piece of the so-called Klamath Falls meteorite is in the Nininger collection at Arizona State University in Tempe. Somewhere in the Klamath Falls area there must be a 30-pound meteorite.

February 1965

WHAT IS A THUNDER EGG?

Thunder eggs are spherical masses of rock that range in size from less than an inch to 4 feet in diameter. Most are about the size of a baseball. They have a knobby rind of drab, siliceous rock and a cavity filled with agate. . .

Thunder eggs are always associated with silicic volcanic rocks such as welded tuffs and rhyolite flows. Millions of years ago, fiery avalanches of this type of molten rock poured out of volcanoes and flowed over the land. In central and south-eastern Oregon there are wide areas in which rocks of this type are well exposed.

October 1965

A IS FOR ALBANY, Z IS FOR ZIRCONIUM

Albany, Oregon, and zirconium are inextricably linked, at least in the thinking of the metallurgists in the Free World who concern themselves with the space-age metals. It was at Albany in 1945 that Dr. W.J. Kroll started work with the United States Bureau of Mines on a research program to develop a process for producing ductile zirconium. . .

Such was the beginning of a development involving many other metals which was to change the economy and character of the city of Albany — and indeed to affect the entire state. The transition from an abandoned small college campus to a nationally recognized center for exotic metals required only 10 years. Starting with an original investment of $140,000 for the old Albany College buildings and ground, the federal government's Albany installation is now valued at $4.5 million.

October 1967

SAMS VALLEY METEORITIC SHOWER

One of Oregon's important meteorites is the 15-pound Sams Valley iron found in 1894 by George P. Lindley of Medford. Recent investigations give evidence to the fact that the Sams Valley meteorite was not an individual fall as was commonly reported, but a shower of which five specimens were found. Three individuals can definitely be accounted for. Other specimens may yet be in the possession of residents of the Sams Valley and Medford areas. It is also quite likely that other meteorites will be found in the Sams Valley area.

August 1967

THE WARNER VALLEY EARTHQUAKE SEQUENCE

A series of earthquakes struck the Warner Valley in southeast Oregon in May and June 1968. The earthquakes caused rockslides and building damage in and near the community of Adel, Oregon, and were of sufficient intensity to rattle dishes in Lakeview, Oregon, 30 miles west of Adel. The largest earthquake with an estimated magnitude of 5.1 on the Richter magnitude scale occurred on May 29, 1968.

. . . The steep cliffs which form the east and west walls of the Warner Valley are upraised blocks or horsts while the valley, containing shallow lakes, is formed by a down-dropped crustal block or graben. . . The horst and graben structure of southeast Oregon is characteristic of the physiographic Basin and Range province and extends over Utah, Nevada, Arizona, New Mexico, and parts of Idaho and California.

June 1968

PLEASE SEND US YOUR PHOTOS

Since we have started printing color pictures on the front cover of *Oregon Geology*, we are finding ourselves woefully short of good color photographs showing geologic motifs in Oregon.

We also want to make recommendations for scenery well worth looking at in a new series of black-and-white photos on the back cover of *Oregon Geology*. For that, too, your contributions are invited.

Good glossy prints or transparencies will be the best "hard copy," while digital versions are best in TIFF or EPS format, on the PC or Mac platform.

If you have any photos that you would like to share with other readers of this magazine, please send them to us (you know, "Editor, etc."). If they are used, the printing and credit to you and a one-year free subscription to *Oregon Geology* is all the compensation we can offer. If you wish to have us return your materials, please include a self-addressed envelope.

Information for Contributors

Oregon Geology is designed to reach a wide spectrum of readers interested in the geology and mineral industry of Oregon. Color photos for publication on the front cover are highly welcome, as are letters or notes in response to materials published in the magazine and notices of meetings that may be of interest to our readers.

Two copies of the manuscript should be submitted. If manuscript was prepared on common word-processing equipment, a file copy on diskette should be submitted in place of one paper copy (from Macintosh systems, high-density diskette only). Hard-copy graphics should be camera ready; photographs should be glossies. All illustrations should be clearly marked; captions should be together at the end of the text.

Style is generally that of U.S. Geological Survey publications. (See USGS *Suggestions to Authors*, 7th ed., 1991, or recent issues of *Oregon Geology*.) Bibliography should be limited to references cited. Authors are responsible for the accuracy of the bibliographic references. Include names of reviewers in the acknowledgments.

Conclusions and opinions presented in articles are those of the authors and are not necessarily endorsed by the Oregon Department of Geology and Mineral Industries.

Authors will receive 20 complimentary copies of the issue containing their contribution.

Manuscripts, letters, notices, and photographs should be sent to Klaus Neuendorf, Editor, at the Portland office (address in masthead on first inside page).

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Send order form to **The Nature of the Northwest Information Center, Suite 177, 800 NE Oregon Street, Portland, OR 97232-2162,** or to **FAX (503) 731-4066**. If you wish to order by phone, have your credit card ready and **call (503) 872-2750** or access the Center's homepage: **http://www.naturenw.org**. Payment must accompany orders of less than $50. Payment in U.S. dollars only. Publications are sent postpaid, except where noted. All sales are final. Subscription price for Oregon Geology: $10 for 1 year, $22 for 3 years.

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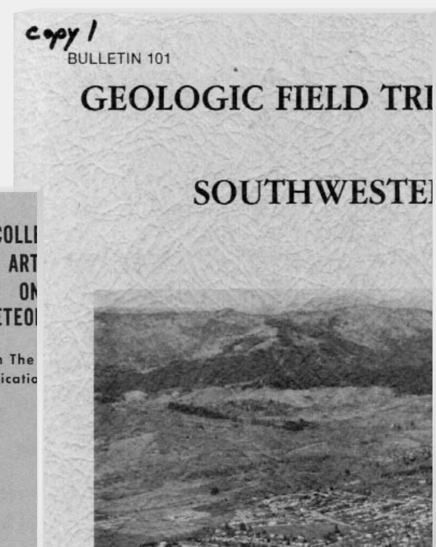
Highlighting Publications

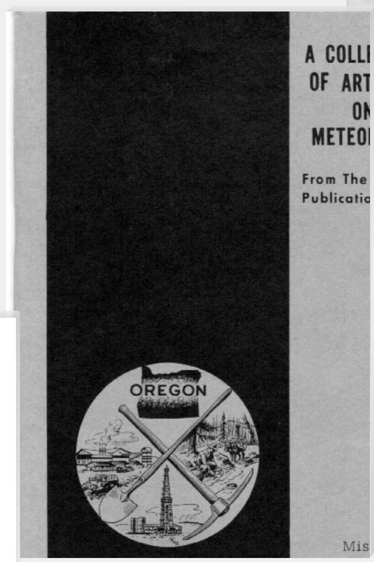
now available from The Nature of the Northwest Information Center

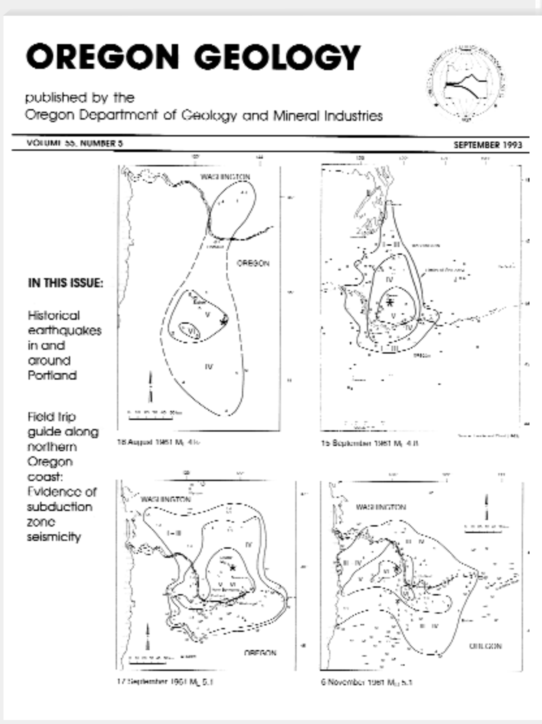
Have any of the excerpts of articles in this issue intrigued you? Do you want to know more? Previous issues of *Oregon Geology* (the *Ore-Bin*, its predecessor) are available, as well as two other publications with compilations of articles. Here are three examples of what is available.



Geologic Field Trips in Western Oregon and Southwestern Washington, Bulletin 101, published 1980, 232 p.

Ten field trips were compiled for the 1980 GSA conference. These detailed trip guides will help you explore and understand the geology of the area. Each has a discussion of the area's geology and a road log to use for finding sites.





A Collection of Articles on Meteorites (From the Ore-Bin), Miscellaneous Paper 11, published 1968, 39 p.

If you are interested in finding out more about the Sams Valley Meteorite mentioned in this issue, the Willamette Meteorite some are trying to get returned to Oregon, or other meteorites that have fallen on Oregon, these seven articles will be of interest.

Previous issues of *Oregon Geology* and the *Ore-Bin*, published since 1939.

If you want information about these topics in this issue, or some other part of Oregon's geology, all previous issues of the *Ore-Bin* and *Oregon Geology* are for sale at $3 each (If the issue is out of print, we will make a photocopy).

1970s: Plate tectonics

VOLCANIC ERUPTIONS: THE PIONEERS' ATTITUDE FROM 1800 TO 1875

. . . Western Oregon and Washington, and much of northern California, are rather effectively walled off from the rest of the nation by the Cascade Range. Any overland routes of approach from the East would bring the traveler into close proximity to these steep and rugged mountains . . . Where and when were volcanic eruptions reported and how many of these reports represent real events?

From the earliest obscure story by the Indian John Hiaton in 1820 to the newspaper comment in the *Washington Standard* of Olympia in 1873 . . . there have been at least 40 reported volcanic events involving seven western mountains:

Reported volcanic eruptions from 1820-1873

Peak	Years
Mt. Baker	1842, 1843, 1846, 1847, 1853, 1854, 1858, 1859, 1860, 1870
Mt. Olympus*	1861
Mt. Rainier	1820, 1841, 1843, 1846, 1854, 1858, 1870, 1873, plus an undetermined date between 1820 and 1854
Mt. St. Helens	1802, 1831, 1832, 1835, 1842 to 1848, 1852 to 1854, 1857
Mt. Hood	1831, 1846, 1854, 1859, 1865
Feather Lake Cinder Cone	circa 1851
Mount Lassen	1857

** Mt. Olympus is not a volcano—ed.*

April 1970

SEISMIC ENERGY RELEASE

Portland area

Of the areas of Oregon, the Portland area has the longest and most complete earthquake history . . . The average seismic energy release rate during the 100-year period from 1870 through 1970 was . . . approximately equivalent to one earthquake of magnitude 4.8 (unified magnitude scale) (intensity MM V) each year. Couch and others (1968) noted that beginning about 1950 the rate of seismic energy release in the Portland area appeared to increase approximately ten times. The higher rate suggests a seismic level equivalent to one magnitude 5.2 earthquake (MM V-VI) approximately each decade. Historical records span too short a time period to indicate whether the change is a singular event or a cyclic change.

Coast Range

The average seismic energy release in the Coast Range for the 100 year period (1870 through 1970) is . . . approximately equivalent to one magnitude 5.0 earthquake (intensity V) each decade.

Willamette Valley

The earthquake activity in the Willamette Valley is distributed over the area with concentrations of epicenters occurring west of Salem and in the vicinity of the middle Santiam River . . . The average seismic energy release for the 100 year period from 1870 through 1970 is . . . approximately equivalent to one magnitude 5.3 (intensity VI) quake each 30 years.

Klamath Mountains

The average energy release rate for the 100 year period from 1870 through 1970 was 2.8 x 1018 ergs per year . . . the total energy released during the 100 year period is clearly dependent on the intensity VIII earthquake which reportedly occurred near Port Orford in 1873. The intensity and location of this earthquake are questionable; consequently, the computed energy release rate may be much too high.

Cascade Range

. . . The average seismic energy release rate during the 100 year period from 1870 through 1970 was 2.7 x 1018 ergs per year. The computed energy release rate is largely dependent on the occurrence of an intensity VIII earthquake near Cascade Locks in 1877. The intensity and location of this earthquake are questionable; consequently, the computed energy release rate may be much too high.

April 1971

OREGON HIGHWAY DEPARTMENT MARKERS

1. On Oregon Highway 18 . . . is a geological marker defining the term "glacial erratic" and pointing to one of the largest of such rocks . . .

2. Beacon Rock, a giant stone pillar of volcanic origin that rises out of the Columbia River on the Washington side, is noted by a historical marker on Interstate 80–N.

3. Also along Interstate 80–N . . . is a marker dedicated to Celilo Falls, ancient fishing grounds of various Indian tribes.

4. In the far northeast corner of Oregon . . . is a geological marker describing the formation of Wallowa Lake . . .

5. Looking out across the John Day River to Sheep Rock on Oregon Highway 19 . . . is a geology marker describing the John Day Fossil Beds.

6. On . . . U.S. 26, about 4 miles west of Millican is a marker that describes a prehistoric river which flowed across the central

Wallowa Lake was formed by glacial moraines. (Photo courtesy of Oregon Department of Transportation)

Oregon desert at this point.

7. On U.S. Highway 20 . . . is a marker that shows the northern limit of the great inland basin, which had no drainage to the sea.

8. A historical marker for Klamath Lake is located on U.S. Highway 97 about nine miles north of Klamath Falls.

9. . . . Fort Rock is noted by a historical marker on Oregon Highway 31 . . .

10. Abert Rim . . . is described by geological markers in two locations, one on Oregon Highway 31 . . . and the other on U.S. Highway 395 . . .

11. A bronze marker describes the origin of a well-preserved lava tube situated on U.S. Highway 97 . . .

October 1971

THE METOLIUS RIVER

The Metolius Springs rise from two groups of orifices about 200 yards apart at the northern base of Black Butte. The water bubbles out of bouldery valley fill at a chilly temperature of 48°F, and the two flows join within a short distance to make up the headwaters of the Metolius River. Total flow from the springs consistently measures from 45,000 to 50,000 gallons per minute the year around. In its 35-mile course northward and eastward to the Deschutes River, the Metolius gains an additional 600,000 gallons of water per minute from springs and tributary streams that drain the east flank of the Cascades.

March 1972

PORTLAND AREA FAULTS

It is concluded that the Portland Hills-Clackamas River alignment is part of a major structural fault system which extends across the state of Oregon to the southeast as far as Steens Mountain. A series of regionally co-aligned morphologic and structural features striking N. 40–50° W. are aligned with the Portland Hills-Clackamas River alignment. Surface and subsurface geology and gravity and magnetic data in the Portland region all support this interpretation.

June 1972

Multnomah Falls, one of the highest in the US, is one of 11 waterfalls within an 11-mile stretch of the Columbia Gorge. (Photo courtesy Oregon Department of Transportation) February 1979

PLATE TECTONICS

The plate tectonic history of Oregon is but one piece of a worldwide jigsaw puzzle encompassing much of geologic time. With the splitting of Pangaea in Mesozoic times, Oregon has occupied the leading edge of the North American Plate as it has impinged upon the ancestral oceanic East Pacific Plate. In the process Oregon has undergone profound subduction type tectonism. In addition, it may have acquired much lithospheric material from other plates, possibly some of the Paleozoic rocks of the Klamaths from Asia, ultramafic rocks and volcanic rocks from the Triassic oceanic crust, and the Siletz River Volcanics from the Eocene deep-sea floor.

In middle Tertiary times, Oregon, along with the rest of western North America, actually caught up with the East Pacific Rise, an event which profoundly altered the pattern of tectonic behavior within the state. Flood basalts and block faulting replaced andesitic volcanism and thrust faulting as the dominant mode of tectonism. The pattern of deformation in late Tertiary times is extremely complex and a plate tectonic model consistent with all the data has yet to be formulated.

August 1972

DEFINITION OF SUNSTONE

"Sunstone" [the Oregon state gemstone] is the name given to a certain variety of feldspar that exhibits a brilliant pink to reddish metallic glitter or shimmer. The metallic glitter results from the reflection of light from myriads of minute flat scales of hematite or other mineral impurities . . .

December 1972

AN ACRE IS MORE THAN JUST 43,560 SQUARE FEET

Geologists take a different view of "land" . . . What lies immediately below the surface is much like the mythical Pandora's Box, which loosed many ills and blessings when opened. Lurking beneath an innocent looking land surface may be a plague of geologic hazards or a wealth of mineral resources which may be set free if the surface land cover is removed and the "box" opened . . . Landslides, subsidence, changes in water table, contamination of potable water, and destruction of natural springs are some of the geologic hazards which may become all too apparent when the land is disturbed.

Mineral resources that may be underlying the land surface include such things as sand and gravel, crushable rock, dimension stone, jetty rock, fill material ground water, oil and gas, coal, metallic ores, and industrial minerals.

January 1973

BEACH EROSION ON SILETZ SPIT

In the winter of 1972–73 severe erosion occurred on Siletz Spit on the central Oregon Coast. One partially constructed house was lost, and others were saved only by the immediate placement of riprap, large rocks installed at the base of the property to prevent wave erosion. This episode of erosion received widespread news coverage. For a time it was feared that the spit might breach, much as Bayocean Spit, on the northern Oregon Coast, had in 1952.

August 1976

AN EXTINCT EVODIA *WOOD FROM OREGON*

During the early Eocene in Oregon, approximately 35 million years ago, a relatively level lowland reached from the base of the Blue Mountains in northeastern Oregon to the Pacific Ocean, which at that time extended into western Oregon. Since the Coast and Cascade Ranges had yet to develop, the entire area was influenced by ocean currents and had a subtropical climate largely free from frost.

. . . The genus *Evodia* can be included among trees which were native to Oregon during Eocene times but which are extinct in the western hemisphere.

September 1976

THE DESCHUTES VALLEY EARTHQUAKE OF APRIL 12, 1976

. . . Reports obtained by personal interviews with the inhabitants of north-central Oregon on April 14, 15, and 16 indicated houses shook, swayed, rattled, creaked, and rocked in the Deschutes Valley during the earthquake. Associated sounds were reported as rumblings like distant thunder, booms similar to sonic booms, and a roaring noise like a strong wind or blasting. At locations more distant from the epicenter, people reported rocking or rolling motions and feelings of queasiness or nausea.

October 1976

THE AGE OF LAVA BUTTE

Lava Butte and its jagged black fields of lava, located 10 mi (16 km) south of Bend along U.S. Highway 97, have been major scenic and geologic attractions since at least 1900.

. . . The radiocarbon age of the carbonized wood, and thus Lava Butte and its associated lava fields and plume deposit, is 6,160±65 years B.P. . .

October 1977

LATE PLEISTOCENE SEDIMENTS AND FLOODS IN THE WILLAMETTE VALLEY

The Spokane Flood produced many effects in the Willamette Valley. The erosional channels near Rocky Butte are especially noteworthy . . .

The Spokane Flood surged westward through the Tualatin River and Lake Oswego channels and, upon reaching the wide-open portion of the Tualatin Valley, deposited loose, poorly sorted, rubbly and bouldery gravel and sand . . .

The flood level in the Tualatin Valley rose high enough to spill with great force across the divide separating the Tualatin and Willamette drainage basins . . . The divide, of unknown preflood elevation, was lowered locally to a little less than 150 ft above sea level . . .

A large flow of Spokane Flood water poured southward through the Oregon City water gap; at the north edge of the Mollala River trench near Canby . . .

The inflow of flood water from the Columbia River temporarily raised the water level in the Willamette Valley to an elevation of 400 ft, forming a body of water named Lake Allison. This 400-ft water level contrasts with the 1,100-ft level of the Spokane Flood east of the Columbia River Gorge, which cuts through the Cascades.

December 1978

(The Spokane Flood is now generally known as Missoula Floods—*ed.*)

STAY OUT OF OLD MINES! (AND OPERATING ONES, TOO)

The recent near-tragedy involving two youngsters at an operating mine in central Oregon prompts the Department to once again issue a warning about the hazards involved with poking around in mines. Mines, particularly old mines, can be most dangerous to life and limb at any time. Rotting timbers, foul air, and weathered rock about to collapse are only a few of the deadly hazards that are encountered by those who decide to explore.

Active mines, even during periods when operations are shut down temporarily, can trap the unwary.

December 1978

Musick mine and Bohemia City, with restored stage house and post office. In foreground is covered portal and mine track. June 1978

1980s: Mt. St. Helens erupts

MOUNT ST. HELENS—AN AERIAL VIEW

. . . the Oregon Army National Guard initiated aerial surveillance activity over Mount St. Helens volcano, Washington, as it began erupting during the afternoon of March 27, 1980.

The first activity sighted was the formation of an explosion crater, flanked by numerous impact craters and accompanied by ash trailing off to the southeast.

By March 30, continued phreatic discharges (ground water explosively flashed into steam) had significantly enlarged the original crater and given birth to a new, smaller crater 100 m (300 ft) to the east. Significant ash fall littered the areas east of the activity, and continuing seismic activity along with thermal melting triggered a series of debris avalanches on the southeast flank of the volcano.

May 1980

REMOTE SENSING OF THE MOUNT ST. HELENS ERUPTION, MAY 18, 1980

. . . a sharp increase in the thermal activity in the crater area of Mount St. Helens was observed at 5:30 a.m. on Sunday, May 18. An increased number of hot spots were noted on the "Boot" and in the bulge area, which had been swelling at a rate of about 5 ft per day since mid-April. However, just as the thermograph recording film was being developed, information was received that a passing aircraft had witnessed an explosive eruption at 8:30 a.m.

The first of four day-time photo missions was launched from Salem. Initial reports indicated that the top of the mountain had been lowered from the old elevation of 9,677 ft to about the 8,300-ft level. A dense, mushroom-shaped plume of ash rose ominously into the stratosphere, obscuring everything to the north and east of the mountain. Large debris flows were moving down the North and South Forks of the Toutle River, destroying roads and bridges and carrying off log decks in the flooding caused by the rapid melting of the mountain's glaciers.

Hot ash flows have continued down the north flank of Mount St. Helens into the former valley of the North Fork of the Toutle River, producing explosions described as "phreatic" upon contact with water in the valley. An infrared thermograph, flown before dawn on Tuesday, May 20, shows a hot ash flow at the base of the north flank and numerous pits caused by phreatic explosions in the North Fork of the Toutle Valley.

June 1980

PLUVIAL LAKE MODOC, KLAMATH COUNTY, OREGON, AND MODOC AND SISKIYOU COUNTIES, CALIFORNIA

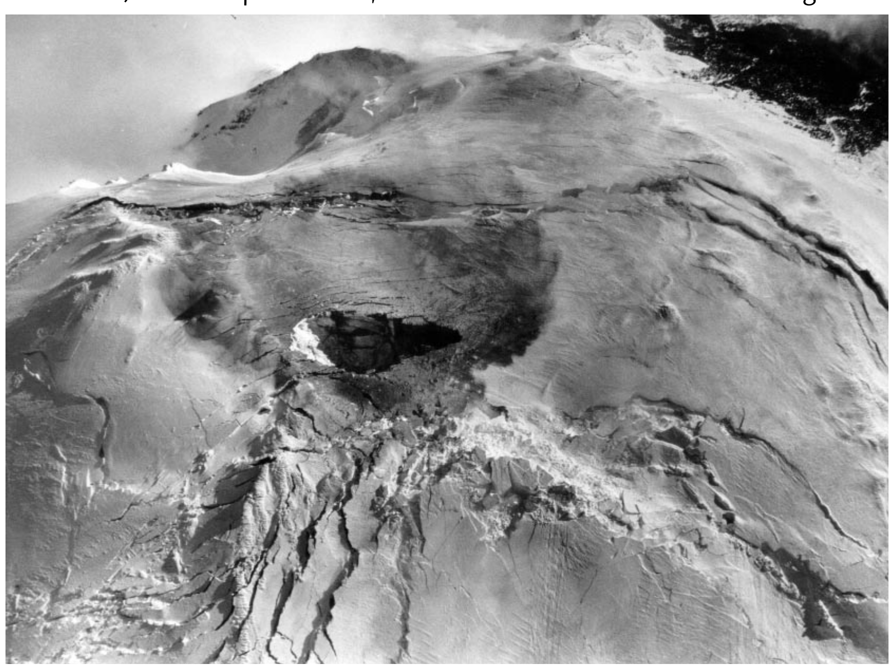
The Klamath Lakes, Upper and Lower, together with Tule Lake are the shrunken remnants of pluvial Lake Modoc (named in this article by the author). The old pluvial lake, which existed in Pleistocene time, consisted of several connected arms with an overall length of nearly 75 mi (120 km). The southern end was in California, south of Tule Lake; the northern end was near Fort Klamath in west-central Klamath County. At maximum extent, the 400 mi (663 km) of shoreline was at the nearly uniform elevation of 4,240 ft (1,292 m) above sea level.

November 1980

OMSI SOUND PROJECT: THE ACOUSTIC EFFECTS OF THE MOUNT ST. HELENS ERUPTION ON MAY 18, 1980

In Hamilton, Montana, about 400 mi due east of Mount St. Helens, the sound of the volcano's eruption on May 18 was described as heavy artillery fire very close by. In the San Juan Islands, people wondered if the Canadian Navy was having gunnery practice. Residents along the central Oregon coast thought they were hearing sonic booms, thunder, and dynamiting all rolled into one 15-minute barrage.

Yet, some who were within 10 mi of the mountain heard nothing.



The beginning of the eruptive phase of Mount St. Helens: The first explosive eruptions on March 27, 1980, at 12:36 p.m. PST, sent an ash column about 6,000 ft above the volcano and opened this 250-ft-wide crater. Photo was taken at about 2 p.m. on that day by Michael Lloyd of *The Oregonian*. May 1980

Since the author was able to hear this house-shaking, window-rattling noise near Netarts on the Oregon coast, 116 mi distant from Mount St. Helens, she was surprised to learn that her daughter in Portland, only 45 mi distant, had heard nothing at all.

December 1980

SURFACE MINED LAND RECLAMATION IN OREGON, 1981

The Mined Land Reclamation (MLR) Program completed a busy and successful year that saw a 17-percent increase in the total acreage bonded; a 34-percent increase in the number of field inspections; major changes in the law, including much stricter requirements for coal and metal mines; and the initiation of an awards program to recognize outstanding reclamation.

March 1982

AN ESTIMATE OF THE GEOTHERMAL POTENTIAL OF NEWBERRY VOLCANO, OREGON

Newberry Volcano is a large Quaternary volcano located in central Oregon about 32 km (20 mi) southeast of Bend (Figure 1). It covers an area of nearly 1,300 km (500 mi) . . . More than 400 cinder cones dot the flanks of the volcano. The most recent activity occurred approximately 1,400 years ago in the summit caldera and resulted in the formation of the Big Obsidian Flow. The volcano is considered dormant but capable of future eruptions (MacLeod and others, 1981).

. . . Fluids at a temperature of 265°C (509°F) were encountered in permeable rocks in the bottom 1.8 m (6 ft) of the hole (Sammel, 1981).

April 1982

THE SALEM METEORITE

The fifth meteorite to be found in Oregon fell on a house in Salem on May 13, 1981. . . The meteorite struck the house of Marion County Deputy Sheriff James P. Price, who was sitting on the curb in front of his home talking to Deputy Sheriff Vincent Wan, who was in his patrol car. Both officers heard a peculiar fast "fluttering" noise, an impact of something hitting the house, and then the sound of small rocks failing near them. Price examined the area by flashlight and within ten minutes found the first and largest piece of the meteorite in front of his driveway. This specimen, which was warm to the touch, had landed within 10 ft of the officers. Because of his training as a physics major at Linfield College, Price recognized the broken specimen as a meteorite.

June 1983

One of North Santiam Sand and Gravel Company's three trout-rearing ponds situated in mined-out sand and gravel pits near Stayton, Oregon. This company was one of the two runners-up for this year's award for the Outstanding Mined Land Reclamation Project. December 1982

STABILIZATION OF THE I–84 SAND DUNE

Wind-blown sand originating from a 50-acre sand dune is encroaching upon the travel lanes of Interstate 84 east of The Dalles, Oregon. This sand has been creating a safety hazard to vehicles on I–84 and trains on the adjacent Union Pacific tracks. Annual costs to both agencies have increased significantly in recent years and will continue to increase as the dune moves at a rate of about 250 ft every 10 years . . . At its current rate, and on level ground, this dune could move across the highway in about 130 years.

December 1983

GEOLOGY OF THE PORTLAND WELL FIELD

The Portland Well Field is one of the nation's largest groundwater development programs. It is designed to provide emergency water in case something happens to the Bull Run watershed, the current major source of water, and to meet peak demand for water during periods of heavy usage. Water-right applications have been filed for over forty production wells with a combined yield of over 150 million gallons per day. Twenty production wells have been constructed with capacities ranging from 1,000 to 10,000 gpm (gallons per minute), producing from fluvial-lacustrine aquifers 100 to 600 ft below ground level.

June 1984

THE 1984 LANDSLIDE AND EARTHQUAKE ACTIVITY ON THE BAKER-HOMESTEAD HIGHWAY NEAR HALFWAY, OREGON

The recent landslide on the north side of the Powder River between the Hole-in-the-Wall and Maiden Gulches closed Oregon Highway 86 at a point 31 mi east of Baker, Oregon . . . What caused the landslide? . . . Could it have been prevented, or, failing this, foreseen earlier so that preparations for more adequate detours could have been undertaken ahead of time? Two moderate earthquakes occurred in the general area at about the time the slide began to move. Were the earthquakes the cause of the Hole-in-the-Wall landslide, or was there another cause? . . . To answer these questions, we undertook an investigation to determine the likely causes of this landslide. Our preliminary determinations indicate that three factors were

An older home succumbs to wave erosion along the Waldport Bayfront. The event occurred during a moederate high tide, but without strong wave activity. May 1987

primarily responsible: Incompetent geological formations, the low angle of stability of these formations, and increased groundwater flow due to recent heavy rains.

May 1985

SCIENTISTS REPORT ON FIVE YEARS OF MOUNT ST. HELENS STUDIES

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 domebuilding 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 . . .

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.

September 1985

WALLS WORTH WALKING BY: A TOUR OF THE SOUTH PARK BLOCKS AREA OF DOWNTOWN PORTLAND

Immediately south of the downtown business district of Portland is a group of buildings that demonstrate the use of various industrial minerals and rocks to form exterior facings. Several of the structures are included in the National Register of Historic Places, but others range in age and importance from fairly new and uninteresting to somewhat older and more interesting . . . It is hoped that the present article will enable others to enjoy this hour-and-a-half-long stroll at their own pace and at a time best suited to them. The tour described here starts at Ira's Fountain and works its way west up Market Street to the South Park Blocks, thence back and forth a bit, emerging at last on Fifth Avenue at the County Courthouse and heading southward with a few digressions to the [former] State Office Building.

November 1985

Eagle-Picher Minerals diatomite mine near Juntura [Malheur County]. Diatomite ore is trucked to the mill near Vale and processed into filter-aid products. This was a field trip stop during the 25th Forum on the Geology of Industrial Minerals held in Portland in May 1989. November 1989

EAGLE-PICHER DIATOMITE MINE AND PROCESSING PLANT, EASTERN OREGON

Eagle-Picher Industries, Inc., has commenced production of diatomaceous-earth filter aids at a processing plant located 7 mi west of Vale, Oregon. Crude ore is hauled to the plant from mine sites located northwest of Juntura in Harney and Malheur Counties.

The capital investment for the project was $13.5 million, with the major part of financing provided by Industrial Development Revenue Bonds.

September 1986

OREGON BOASTS FIRST GAS STORAGE SITE AT MIST FIELD

Energy demands on Northwest Natural Gas Company next winter will be met, at least in part, with natural gas from the company's new Columbia County storage field at Mist, the first gas storage site in Oregon.

When it is filled, the storage field will hold 7.5 Bcf of gas, sufficient peaking supplies for "the coldest 60-100 days of winter."

. . . a crew of experienced archeologists "walked every mile" of the route finally used, before trenching of the line was even begun.

This careful attention was rewarded when in the path of the pipeline were found 20 prehistoric Indian sites and seven historic sites, where discoveries have included small Stone Age tools such as mortars, pestles, chopping implements, and small flakes. Such finds indicate, according to the experts, that these sites had been used periodically over the last 6,000–8,000 years.

September 1989

1990s: Understanding geologic hazards

PRELIMINARY ASSESSMENT OF POTENTIAL STRONG EARTHQUAKE GROUND SHAKING IN THE PORTLAND, OREGON, METROPOLITAN AREA

. . . Thus given the extensive unconsolidated sediments in the Willamette Valley and the possible future occurrence of earthquakes of M 6 and larger, strong earthquake ground shaking would appear to pose a potential serious threat to many existing buildings and possibly even to newly constructed buildings in the Portland metropolitan area.

November 1990

MAGNITUDE AND FREQUENCY OF SUBDUCTION-ZONE EARTHQUAKES ALONG THE NORTHERN OREGON COAST IN THE PAST 3,000 YEARS

. . . From these findings of synchroneity, we estimated the length of rupture for the late Holocene earthquakes. The corresponding magnitudes are at least 8.0, based on a rupture length of 175 km, a rupture width of at least 60 km, an average recurrence interval of 400 years, [and] an average convergence rate of 4 cm/yr . . . Using a range of convergence rates (3.5–4.5 cm/yr) and average recurrence intervals (300–500 years), rupture lengths (105–175 km), and rupture widths (60–90 km), calculated magnitudes for five of the last six earthquakes are greater than 8.0 for the central 175 km of the Cascadia subduction zone.

Average recurrence intervals between earthquakes for the estuaries on the northern Oregon coast range between 200 and 600 years . . .

January 1995

CRESCENT CITY'S DESTRUCTIVE HORROR OF 1964

The view of the tidal wave from the lighthouse as described by Peggy Coons, curator of Battery Point Lighthouse in 1964.

Good Friday, March 27th, 1964, the morning was mild. The trade winds that prevail along the Pacific Coast had subsided. Little did I realize, as my husband Roxey and I went about our chores at the lighthouse, that before the next day had dawned high on Battery Island, we would watch four waves play havoc with the town and its people, smashing the city's business center along with some of the beach front homes in Crescent City, CA, and we would have a spectacular view of the whole performance. And as curators here at the lighthouse we would be called on by friends and tourists alike to relive this one night of horror almost every day since.

Perhaps I should stop to explain that Battery Island, three hundred yards from the mainland, is solid rock at the base and about three quarters of an acre, fifty-eight feet at the highest point near the flagpole. The lighthouse, completed in 1856, is 74 feet above mean sea level. The only access to this Historical Monument is walking across the ocean floor at low tide.

. . . We might have slept through the whole thing if I hadn't gotten up to go to the bathroom a little before midnight. I stood at the window, a full moon shining on the water below me. Somehow the first moment I saw the ocean I sensed something was wrong, for all the rocks around the island had disappeared. They were covered with water. I realized it was almost time for high tide, but the rocks are always visible even in the severest of storms. Suddenly I became alarmed and called Roxey. We quickly slipped on some clothes, rushed down the stairs, and grabbed our jackets as we ran outside.

The air was still, the sky had an unusual brightness about it. It was light as day. The water shimmering in the moonlight was high over the outer breakwater. We headed for the highest point overlooking the town. The first wave was just reaching the town. Giant logs, trees and other debris were pitching and churning high on the crest of the water as it raced into the city. "My God, no!" I cried, "It will flood the town."

As the impact began, the loud blast of breaking glass and splintering wood reached us, buildings crumpled, cars overturned, some smashed through plate glass windows, while the water plowed down the streets. Within minutes the water came back just as fast as it had gone

Bretz Pond Turtles in the Columbia River Gorge differ visually from Western Pond Turtles in color and construction of their shells. As the importance of wetlands is better understood, geologists can play an important role in understanding wetland processes important to save endangered species. January 1994

in, bringing all manner of things with it. It drained away with terrific speed. The whole beach front was strewn with logs, cars, buildings, trash of every description. Some of the fishing boats were tossed high on the land, others drifted to sea. A few cars and two small buildings that were swept off Citizen's Dock floated away with the water. The water was gone. We could see it piling up a half mile or more beyond the end of the outer breakwater, higher and higher as the minutes passed.

We stood there stunned with fright for we knew there was no way out of here if the water came this high. The lighthouse, serene in the moonlight, had been battered with severe storms for over a century: could it protect us now? We have lived on the island since 1962 and watched the storms come and go, but this was unlike anything we had ever experienced. The light flashed in the tower. We knew we would have to notify the Coast Guard if there was any failure or discrepancy in it. I don't know how long we stood there for we were just too frightened to move, when the second wave churned swiftly by us, gobbling everything in its wake. It picked up all the ruins along the beach front and shoved them right back into town. It didn't seem as large as the first one to us, but it caused considerable damage. Some of the lights faded out along Front Street. As the backflow began we raced frantically around the place, watching the water drain from the bay. We glanced at the tower: the light was still flashing.

We watched the Coast Guard cutter, a big lumber tug, and some of the fishing boats that had received warning and left the harbor riding the tides a good three miles or more off shore. We were getting more frightened now, for the water had receded farther out than before. We knew it had to come back, but when? We screamed at one another in our fright, wondering if it would ever stop, for there was an ominous stillness about it, warning us of more to come.

. . . The water withdrew suddenly, as though someone had pulled the plug out of the basin. The water was here, then gone. We ran around the lighthouse again wondering if we were safe. We kept anticipating something more violent would happen, for the water had receded far out, three fourths of a mile or more beyond the end of the outer breakwater. We were looking down as though from a high mountain into a black abyss of rock, reefs, and shoals, never exposed even at the lowest of tides. A vast labyrinth of caves, basins and pits undreamed of in the wildest of fantasy.

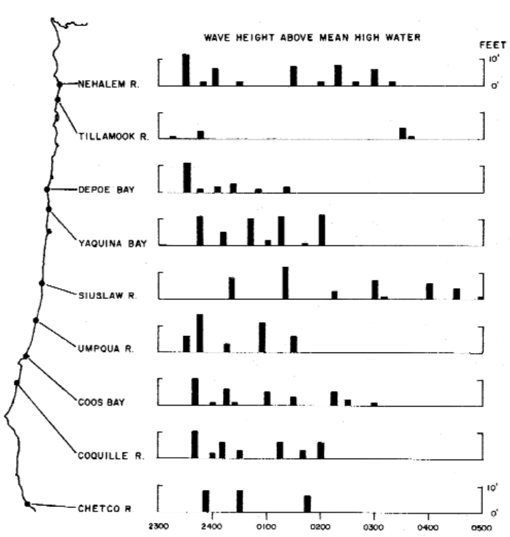
In the distance a dark wall of water was building up rapidly, so the Coast Guard cutter, the lumber tug, and small craft appeared to be riding high above it, with a constant flashing of white at the edge, as the water kept boiling and seething, caught in the rays of the moonlight. The basin was dry. At Citizen's Dock the large lumber barge, loaded with millions of board feet of lumber, was sucked down in the bay. The fishing boats still in the small craft harbor, were pulled down on the floor of the ocean. We clung to one another, asking God to have mercy on us. We prayed for the town and its people. We realized the water would return with more destruction to follow. We kept straining ourselves trying to visualize what would happen next, while the water piled higher and higher in the distance.

Suddenly there it was, a mammoth wall of water barreling in toward us, a terrifying mass of destruction, stretching from the floor of the ocean upwards: it looked much higher than the island, black in the moonlight.

. . . When the tsunami assaulted the town it was like a violent explosion, a thunderous roar mingled with all the confusion. Everywhere we looked, buildings, boats, lumber, everything was shifting around like crazy. The whole front of town moved, changing before our eyes. By this time the fire had raced across the water to the ruptured Texaco Bulk tanks: they started exploding one after the other. The whole sky lit up. It was fantastic.

As the tide turned it was sucking everything back with it: cars, buildings were moving seawards. The old covered bridge, from Sause Fish Dock, that had floated high on the land, came back to drop almost in place. Furniture, beds, mattresses, TVs, radios, clothing, bedding, and other objects were moving by us so fast we could barely discern what some of it was. A siren was blowing. There were lights now in the front of town or along Highway 101. The light in the tower continued to burn. The block on this end of town near the Seaside Peninsula was unharmed.

Across the bay the fire was still raging higher and higher as each tank exploded. Time passed quickly, for everywhere we looked was a



The above chart shows wave heights of 1964 tsunami at various Oregon sites. Four people died at Beverly Beach in the tsunami, and waves damaged property in several locations along the coast. December 1964

Two people died in the 1993 earthquakes in Klamath Falls. This bridge on Hwy 140 shows left lateral displacement across joints in the bridge deck, probably as a result of slumping and settling that caused the bridge deck to rotate.

November 1993

shambles: houses, buildings, lumber, boats, all smashed or moved blocks from where they had been by the onrush of water.

The fifth wave rushed swiftly by us back into town. It just pushed things around. We could observe no noticeable damage this time, but off and on the rest of the night the water kept surging in and out and slopping around in the harbor. At daybreak we made coffee and fixed our breakfast, but we kept checking each change of the tide. We had never seen so many in our knowledge of the sea. The boats continued to ride the surf offshore, waiting for another big one . . .

November 1995

EVALUATING THE EFFECTIVENESS OF DOGAMI'S MINED LAND RECLAMATION PROGRAM

Since 1972, the Mined Land Reclamation (MLR) Program of the Oregon Department of Geology and Mineral Industries (DOGAMI) has been responsible for directing reclamation at mine sites across Oregon. In that time, over 3,000 acres have been reclaimed under DOGAMI's MLR program. What happens to former mine sites after they have met reclamation requirements and have been released from the program? Has reclamation had long-term impact on the overall condition of the sites? What second uses are being supported by these lands? To begin addressing these questions, the MLR Program conducted a field study in 1995 to determine the condition of former mine sites. Field data were collected at 47 former mine sites across Oregon. The landform, vegetation, land use, and other primary site characteristics indicate that the reclamation process has had lasting, beneficial effects on site conditions. This strongly suggests that the MLR program has been effective over an extended period.

January 1996

SAND AND GRAVEL MINE OPERATORS DONATED SAND, EQUIPMENT, AND TIME TO FIGHT FEBRUARY FLOODS

Many Oregonians may not have thought about it at the time, but when they fought the February floods with sandbags, they were using a lot of donated sand. The Oregon Department of Geology and Mineral Industries (DOGAMI) has compiled a list of aggregate operators who provided voluntary assistance during the floods. Thousands of cubic yards of sand were provided at no cost to communities, organizations, and those individuals in need of sandbags. Heavy equipment and operators were donated to deliver materials, construct emergency berms, and in at least one instance rescue a stranded motorist. During the height of the flood, many operators staffed their plants and sales offices around the clock to coordinate delivery of materials. **July 1996**

The floods and landslides of 1996-97 caused several deaths and millions of dollars worth of damage across western and northeastern Oregon. Although flooding was more visible in the news media, more dollar losses were attributable to landslides. **December, 1999**

OREGON GEOLOGY
Suite 965, 800 NE Oregon Street # 28,
Portland, OR 97232-2162

Periodicals postage paid
at Portland, OR

Places to see—Recommended by the Oregon Department of Geology and Mineral Industries:

Lake Owyhee, Malheur County (photo courtesy Oregon Department of Transportation)

Lake Owyhee, created by a dam on the Owyhee River, offers boaters an extraordinary view of Miocene volcanism (about 15 million years ago). Ash from that time preserved plant and animal fossils that show a much wetter climate. Rhinoceroses lived next to ancestral horses, deer and antelope. The off-white ash layers, pinkish-gray rhyolite, and dark colored basalt create a colorful palette. The Owyhee Uplands have been uplifted to more than 4,000 feet above sea level, and the resulting stream erosion has produced the deep, narrow, winding canyons seen in the area today. The Owyhee volcanic field includes several calderas, such as at Grassy Mountain and Mahogany Mountain, that are large collapse features better recognized by the distribution of specific types of volcanic rocks rather than by present day topography. These same volcanic processes have been responsible for numerous gold occurrences which have been prospecting targets over the last few years. Typically, the gold occurs as microscopic particles that have been deposited by hot-spring systems. Portland State University graduate students often learn geologic mapping in this area (several theses have been written and abstracts published in *Oregon Geology*).

Access: From Interstate I–84 at Ontario south on State Highway 201 toward Adrian. Several roads branch off toward the west to Lake Owyhee State Park, which offers camping sites. Boat rentals are available in the area.