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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 the 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 the Oregon Department of Geology and Mineral Industries.

Cover photo

Cascade Head, one of the largest headlands along the Oregon coast. The volcanic rocks that make up much of the headland were the subject of one of the papers presented at the 1990 meeting of the Cordilleran Section of the Geological Society of America. See p. 136 for abstracts of several of the papers on Oregon geology that were presented there. Photo courtesy of the Oregon State Parks and Recreation Department.

OIL AND GAS NEWS

NWPA holds symposium, elects new officers and directors

The Northwest Petroleum Association (NWPA) held its annual symposium in Roseburg, Oregon, on September 30 and October 1-3, 1990. The geology of the Tyee and Coos Basins was discussed in both talks and field trips. Officers elected for 1990-91 are Barbara Portwood, president; Lanny Fisk, vice-president; Bill Connelly, treasurer; and Dick Bowen, secretary.

The Directors in office for 1990-91 are Peter Hales, Harry Jamison, Bob Deacon, Bob Fujimoto, Jerry Fish, Delores Yates, and Dennis Olmstead.

Oil and gas studies open to public

The Oregon Department of Geology and Mineral Industries (DOGAMI) maintains a collection of drilling records, well logs, and well samples and makes them available to the public for study. Whenever well samples are subjected to analyses that cause loss of a portion of the sample, DOGAMI receives a copy of the data and results of the study and makes them available to the public. Recently acquired data from such studies include the following:

1. **Analysis of the petroleum hydrocarbon source potential and geochemical characteristics of Clarno Formation strata in the Steele Energy Keys no. 1 well, Wheeler County.** This study, done by Conoco Oil Co., concludes that the Clarno Formation has several zones of shales that are potential source rocks and are composed predominantly of oil-prone terrestrial kerogens.
2. **Subsurface and geochemical stratigraphy of northwestern Oregon,** a Master of Science thesis (1990) by Olga B. Lira, Portland State University. The study is based on analyses of well logs, sample geochemistry, lithology, and paleontology.
3. **Palynologic foraminiferal and nannofossil study of the Standard Oil Kirkpatrick no. 1 well, Gilliam County.** The report, done by Unocal Oil and Gas, concludes that no definitive age can be applied to the strata at the bottom of this well, but it is likely Mesozoic in age.
4. **Stratigraphy and depositional setting of the late Eocene Spencer Formation in the west-central Willamette Valley,** a Master of Science thesis (1988) by Linda Baker, Oregon State University, that analyzes the Spencer Formation using well logs and lithologies, including grain size analysis.
5. **Instrumental neutron activation analysis (INAA) for selected Mist Gas Field wells,** a portion of the studies for a Master of Science thesis, by David Long, Portland State University. The analysis attempts to determine whether the radioactive decay of certain elements may have ionized and released nitrogen from surrounding rocks and from organic matter in the rocks.
6. **Palynologic examination of samples from the Standard Oil Pexco State no. 1, Sunray Bear Creek no. 1, and Texaco no. 17-1 well, Crook County, and Oregon Petroleum Clarno no. 1 well, Wheeler County,** by Unocal Oil and Gas. Ages for various strata in these wells were determined by palynologic correlations.
7. **Radiometric age dating and thermal maturity of strata in the Fenix and Scisson Old Maid Flat well, Clackamas County,** by Shell Oil Company. The report finds that the samples show evidence of rapid heating in the condition of organic matter and in high reflectance readings. Age data indicate a 20.3±1.2-million-year and 20.9±1.1-million-year age for certain strata in this well.

*(Continued on page 138, **Oil and Gas**)*

REMEMBER TO RENEW!

Field trip guide to the central Oregon High Cascades Part 2 (conclusion): Ash-flow tuffs in the Bend area

by Brittain E. Hill, Department of Geosciences, Oregon State University, Corvallis, Oregon 97331-5506, and William E. Scott, David A. Johnston Cascades Volcano Observatory, U.S. Geological Survey, 5400 MacArthur Boulevard, Vancouver, Washington 98661.

This field trip guide was created for the September 1988 meeting of the Friends of the Pleistocene, which was held in the Mount Bachelor area. It was released in a slightly different form and with additional material as U.S. Geological Survey (USGS) Open-File Report 89-645 (Scott and others, 1989). The entire volume was edited by William E. Scott, Cynthia A. Gardner, and Andrei M. Sarna-Wojcicki, all of the USGS. Individual sections of the report by Scott; Gardner; Lundstrom and Scott; Scott and Gardner; Hill; Hill and Taylor; and Sarna-Wojcicki, Meyer, Nakata, Scott, Hill, Slate, and Russell are cited in the references. The complete report may be purchased from USGS, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, Colorado 80225, phone (303) 236-7476, for $10.25.

This second part of the field trip represents the third day of the original trip and is accompanied by one connected paper by Hill and Taylor. Part 1 of the central High Cascades field trip guide (the original first two days of the field trip) was published in the last (September 1990) issue of *Oregon Geology*. The combined references in this issue are for both parts of the field trip guide.

The mileage in this guide differs slightly from that in the open-file report, because the first day of this trip started in a different location, and the first two days of field trip guides by Scott and Gardner were combined into Part 1. Readers may choose to run the trip in a different order, depending on where they are staying. There are several campgrounds near various portions of the trip. Readers are urged to obtain the USDA Forest Service map of the Deschutes National Forest or USGS topographic maps of the area before following the guide, because some features mentioned in the log are not easily found on the maps used for the guide. Also, because some of the side roads are not paved, reasonable caution should be taken in following the road log. *—Editor*

INTRODUCTION

This concluding portion of the field excursion to the central Oregon High Cascades highlights aspects of the ash-flow tuffs in the Bend area. The guide contains brief descriptions of the stops, and some of the key features and interpretations of the stops are discussed further in the paper by Hill and Taylor at the end of the guide. For the map of the field-trip area, see Figure 1, p. 100, in the September 1990 issue of *Oregon Geology.*

ROAD LOG

0.0——Part 1 ended at mile 85.1, the point where Highway 46 (Cascade Lakes Highway/Century Drive) reached the **Bend city limits** from the west. Part 2 will now begin with mile 0.0 at the same point. **Continue into Bend for 1.6 mi.**

1.6——Turn left toward the Bend city baseball fields and Cascade Junior High School. Park in the lot at the baseball fields and walk north across the fields. Head northeast on unpaved roads to abandoned pumice quarry on north side of old Brooks-Scanlon road, which is closed to traffic by line of large boulders. Quarry is on private land.

STOP 8—LAVA ISLAND ASH-FLOW TUFF, TUMALO ASH-FLOW TUFF, AND BEND AIR-FALL PUMICE

This abandoned quarry exposes a 7-m-thick section of Bend Pumice of Taylor (1981) overlain directly by Tumalo Tuff of Taylor (1981) (Figures 1 and 2). The tuff shows lateral and vertical changes in welding and also has a locally well-developed basal layer that contains coarse pumice clasts. Lava Island Tuff of Taylor (1981) lies disconformably on Tumalo Tuff and is thoroughly devitrified. See paper by Hill and Taylor immediately following the field trip guide for information about these units.

Return to intersection with Century Drive (Cascade Lakes Highway).

2.1——Intersection with Century Drive; turn left.

2.4——Intersection with Colorado Avenue; continue on Century Drive.

3.5——Intersection with three-way stop; stop and continue straight ahead (north) on 14th NW St.

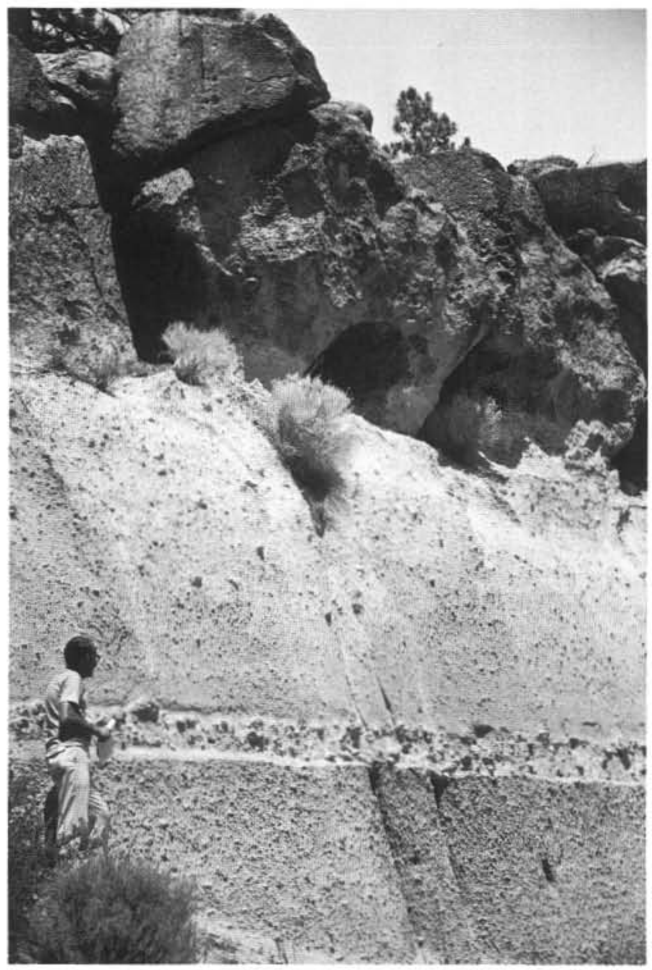
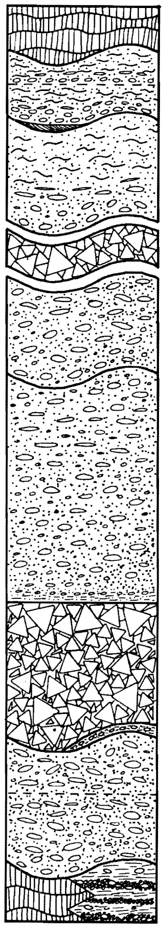


Figure 1. Bend Pumice overlain by Tumalo Tuff at Stop 8.

BEND AREA PYROCLASTIC UNITS



UNIT	THICKNESS (m)
Pre N. Sister Mafic flows	>10
Shevlin Park Ash-flow Tuff	0-6
Century Drive Ash-flow Tuff	0-10
Pumice of Columbia Canyon	0-3
Lava Island Ash-flow Tuff	0-9
Tumalo Ash-flow Tuff	0-22
Bend Air-fall Pumice	0-13
Desert Springs Ash-flow Tuff	0-12
Upper (?) Deschutes Fm.	>10

Figure 2. Schematic stratigraphic section of pyroclastic units erupted from the Tumalo Volcanic Center.

3.9——Intersection with NW Newport Ave.; turn left on Newport. Much of the following is taken from Taylor (1981).

4.2——Road to Central Oregon Community College on right. Newport Ave. becomes Shevlin Park-Market Rd. at milepost 0. The road lies in a valley between two early(?) Pleistocene basaltic shield volcanoes (Awbrey and Overturf Buttes) through which four pyroclastic flows passed from west to east.

5.4——Curve to right. Pumice quarries on left reveal Tumalo Tuff overlying Bend Pumice.

5.7——Curve to left. The last 0.5 mi of road has followed the northwest-striking Tumalo fault. Rocks on the southwest side (rangeward) of the fault have been displaced downward. In this vicinity, Desert Springs Tuff of Taylor (1981), Bend Pumice, and Tumalo Tuff have all been faulted; Shevlin Park Tuff of Taylor (1981) has not but has been faulted farther to the southeast.

6.9——Cross Tumalo Creek; entrance to Shevlin Park, which contains many good exposures of Shevlin Park Tuff. Road becomes Johnson Road.

RECOMMENDED SIDE TRIP

Turn left into Shevlin Park. Follow park road 0.6 mi southwest to Red Tuff Gulch on the north side of Tumalo Creek. A 3-m-thick section of Desert Springs Tuff, which contains two flow lobes, crops out here. Moderately welded Tumalo Tuff and Shevlin Park Tuff are exposed about 150 m up the gulch. Reworked pumice lapilli, ash, and obsidian of basal Bend Pumice are well exposed along the park road just to the southwest. Large blocks of welded Tumalo Tuff and Desert Springs Tuff occur in alluvium overlying Bend Pumice.

7.2——Top of grade; turn left on gravel road to Bull Springs Tree Farm. Bear right at first two roads that head off to left.

7.7——First of two roads to right; bear left at both.

8.4——Intersection with the old Brooks-Scanlon road (Road 4606) at abandoned quarry; turn right. Skirt and cross margins of several High Cascade basalt lava flows.

10.0——Road descends and turns sharply to right, crossing shallow canyon. **Pull off either side of road and park in flat area around Columbia Southern Canal.**

STOP 9—TUMALO TUFF, BASALTIC ANDESITE LAVA FLOW, AND SHEVLIN PARK TUFF

At this stop, one can examine outcrops of approximately 0.3-Ma Shevlin Park Tuff (Figure 1) near the canal and in the road cuts and also have a good view of the Tumalo volcanic center, from which the mid-Quaternary pyroclastic-flow deposits and tephras were erupted.

The road cut exposes Tumalo Tuff, which is overlain disconformably by a High Cascade basaltic andesite lava flow from an unknown vent. The tuff has been locally reddened and welded by the heat of the lava flow. The lava flow is overlain by Shevlin Park Tuff, the youngest pyroclastic unit erupted from the Tumalo volcanic center. The Shevlin Park Tuff, which is gray and andesitic in composition, fills a channel cut through the lava flow and Tumalo Tuff.

CAUTION: THE ROAD CUTS ARE TREACHEROUS. THE LAVA FLOW OVERLYING TUMALO TUFF IS LOCALLY UNDERCUT AND CONTAINS LARGE OPEN FRACTURES. DO NOT FURTHER UNDERMINE THE LAVA FLOW. BE CAUTIOUS WHILE EXAMINING THE CONTACT AND BE AWARE OF THE IMPACT OF YOUR ACTIVITIES ON OTHERS AND THEIRS ON YOU. LESS DANGEROUS OUTCROPS OF SHEVLIN PARK TUFF OCCUR ON THE NORTH SIDE OF THE CANYON.

End of field trip. Turn around and head back to Johnson Road.

If you are heading south of Bend, return along trip route to mileage 2.4 (intersection with Colorado Avenue), turn east on Colorado Avenue, and continue to Division Street and U.S. 97.

If you are heading north on U.S. 97 or west on U.S. 20, turn left on Johnson Road as you leave Shevlin Park and continue 4.2 mi to junction with Tumalo Market Road. (At junction, good exposures of Desert Springs Tuff, below road, and Bend Pumice and Tumalo Tuff, in quarries above road, occur 0.4 mi to north along Tumalo Market Road). Turn right on Tumalo Market Road and then immediately turn left (north) and continue about 1 mi to U.S. 20. Late Pleistocene outwash gravels underlie the valley bottom. If you are heading north on U.S. 97, turn right on U.S. 20 and continue to junction with U.S. 97.

Paper connected with field trip

Oregon Central High Cascade pyroclastic units in the vicinity of Bend, Oregon

*by Brittain E. Hill and Edward M. Taylor, Department of Geosciences, Oregon State University, Corvallis, Oregon 97331-5506**

The stops at two Bend sites (see map in field trip guide, Part 1, Figure 1) are to allow you to view several pyroclastic-flow and tephra-fall deposits of mid-Quaternary age (Figure 2). Investigations of these deposits by Taylor (1981), Hill (1985, 1987, 1988), and Hill and Taylor (this paper) have concluded that the units were all erupted from vents in a silicic eruptive center (Tumalo volcanic center) that lay east of present Broken Top volcano (Figure 3). In addition, recent work by Sarna-Wojcicki and others (1989) has provided age constraints on some of these units based on K-Ar dating and tephrostratigraphic correlations. Formerly assumed to be of late Tertiary or early Pleistocene age, the units are now thought to range in age from about 0.65 to 0.3 Ma.

Unlike most areas in the Oregon High Cascade Range, the area west of Bend, Oregon, contains at least five ash-flow tuffs and two major pumice-fall deposits (see field trip guide, Part 1, Figure 16). These pyroclastic units were not erupted from the present stratovolcanoes (Three Sisters, Broken Top) of the Oregon central High Cascades area. Instead, they were erupted from a large silicic vent complex, the Tumalo volcanic center (Hill, 1988), which is located east of Broken Top and west of Bend. The Tumalo volcanic center encompasses the "silicic highland" of Taylor (1978) and forms a 25-km-long, south-trending belt of silicic domes and andesitic cinder cones from Three Creek Butte to Edison Butte. The most significant results of ongoing investigations are that the Tumalo volcanic center produced the largest silicic eruptions in the Oregon central High Cascades less than 0.4 Ma, and that these eruptions preceded the construction of the Three Sisters and Broken Top stratovolcanoes. The purpose of the field trip in the Bend area is to examine some of the features of the pyroclastic units around Bend and to show that these units represent major eruptions from the Tumalo volcanic center.

DESERT SPRINGS TUFF

The Desert Springs Tuff of Taylor (1981) is the oldest of the Pleistocene High Cascade pyroclastic deposits. Where the basal contact is exposed, the Desert Springs overlies the Miocene to upper Pliocene(?) Deschutes Formation (Smith and others, 1987). The Desert Springs contains at least two distinct flow lobes that form one cooling unit. Although complete sections are not exposed, the Desert Springs has an average thickness of about 12 m, with one preserved section 30 m thick. An idealized vertical section contains a poorly welded 2-m-thick basal zone, a 5- to 10-m-thick, pink-to-tan, firmly welded zone of vapor-phase alteration, and an upper poorly welded zone of fresh black glass about 5 m thick. Where preserved, the contact between the flow lobes occurs in the pink welded zone. The Desert Springs Tuff is characterized by black dacitic pumice lapilli and bombs that are up to 0.5 m in diameter and contain up to 15 percent phenocrysts: plagioclase (An_{40}); orthopyroxene ($Wo_3En_{55}Fs_{42}$) and augite ($Wo_{40}En_{38}Fs_{22}$) (both with abundant inclusions of apatite); and titanomaghemite. Outcrops of the Desert Springs Tuff are scattered, but their distribution and westward increase in extent of welding indicate that the tuff was erupted from the Tumalo volcanic center area. The mineralogy and chemistry of the Desert Springs Tuff are also similar to several Tumalo volcanic center domes near Bearwallow Butte.

BEND PUMICE

The Bend Pumice of Taylor (1981) is a rhyodacitic, vitric lapilli-fall tuff that is best exposed along the roads leading to Tumalo State Park. The 2-m-thick basal zone of the Bend Pumice consists of pumice lapilli, ash, and perlitic obsidian and has been locally reworked and mixed with gravel and sand. The basal zone is thought to represent the preliminary stage of a climactic eruption (Hill, 1985). The basal zone is overlain by 3-13 m of air-fall lapilli and ash, which progressively increase in average grain size up-section. Westward increases in average grain size, unit thickness, and size of volcanic rock fragments (Hill, 1985) all indicate that the Bend Pumice was erupted from the Tumalo volcanic center. In addition, the major- and trace-element composition of the Bend Pumice is nearly identical with several of the silicic domes that are preserved in the area of Three Creek Butte and Triangle Hill (Hill, 1987).

The Bend Pumice has been correlated with the Loleta ash bed (Sarna-Wojcicki and others, 1987, 1989), which has an estimated age of 0.35 to 0.39 Ma. K-Ar determinations for plagioclase separates from the overlying Tumalo Tuff yielded an average age of 0.29 ± 0.12 Ma, while obsidian fragments from the basal zone

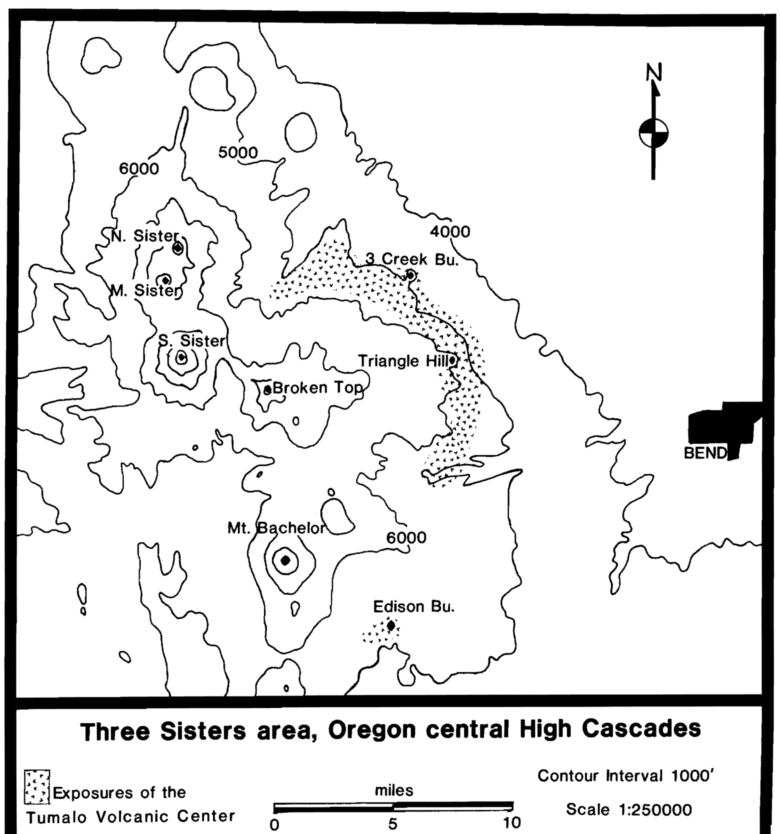


Figure 3. Map showing exposures of the Tumalo Volcanic Center in the Three Sisters area (Brittain Hill, unpublished research, 1990).

**Data tables printed with the original paper (Hill and Taylor, 1989) are not reproduced here.*

of the Bend Pumice have an average age of 0.42 ± 0.01 (Sarna-Wojcicki and others, 1989). As the obsidian is interpreted to mark a preliminary stage of the eruption that climaxed with the emplacement of the Bend Pumice and Tumalo Tuff, a best age for the eruption is thought to be about 0.4 Ma, which is at least 0.5 million years younger than previous estimates for this eruption (Armstrong and others, 1975).

TUMALO TUFF

The Tumalo Tuff of Taylor (1981) is a pink-to-tan, rhyodacitic, vitric ash-flow tuff that overlies the Bend Pumice. The absence of a normally graded top to the Bend Pumice and the nonerosive basal contact of the Tumalo Tuff indicate that the Tumalo Tuff was produced through collapse of the Bend Pumice eruption column. The Bend Pumice and overlying Tumalo Tuff represent the eruption of at least 10 km^3 of nearly homogeneous rhyodacitic magma (Hill, 1985).

Both the Bend Pumice and Tumalo Tuff have a distinct mineral assemblage: plagioclase (An_{20}), ferrohypersthene ($Wo_3En_{40}Fs_{57}$), augite ($Wo_{41}En_{41}Fs_{18}$), fresh black hornblende, magnetite, ilmenite, apatite, and zircon. The ferrohypersthenes are the most iron-rich orthopyroxenes that have been observed in the Oregon central High Cascades. Banded pumice, which represents the mingling of rhyodacitic and unrelated dacitic magmas (Hill, 1985), is found in proximal (western) exposures. Although imbrication of pumice clasts in the Tumalo Tuff indicates a northeast direction of flow (Mimura, 1984), the direct association with the Bend Pumice indicates that the Tumalo Tuff was erupted from the Tumalo volcanic center and channeled by northeast-trending drainages (Hill, 1985).

LAVA ISLAND TUFF

The Lava Island Tuff of Taylor (1981) is a purple to gray, intensely devitrified ash-flow tuff that directly overlies the Tumalo Tuff. It is best exposed along the Deschutes River at Meadow Campground (sec. 23, T. 18 S., R. 11 E.). The basal contact with the Tumalo Tuff is sharp and erosive, with no intervening deposits. The Lava Island Tuff closely resembles welded sections of the Tumalo Tuff and has a similar composition and mineralogy except for the fact that the ferrohypersthene is rimmed with iron-rich augite ($Wo_{40}En_{20}Fs_{40}$) and that both pyroxenes contain abundant apatite inclusions. The Lava Island Tuff may thus represent a flow lobe of the Tumalo Tuff that was derived from a deeper, gas-rich part of the magma chamber.

PUMICE OF COLUMBIA CANYON

This informally named dacitic, vitric lapilli-fall tuff occurs underneath the Shevlin Park Tuff in a steep canyon along the Columbia Canal (sec. 17, T. 17 S., R. 11 E.) and overlies several mafic lava flows north of the Tumalo volcanic center. The pumice contains phenocrysts of plagioclase (An_{40}), augite ($Wo_{40}En_{43}Fs_{17}$), hypersthene ($Wo_3En_{63}Fs_{34}$), hornblende, magnetite, ilmenite, and apatite. It has an average grain size (about 1 cm) that is similar to the Bend Pumice at the Columbia Canyon outcrop and contains abundant angular fragments of black obsidian up to 4 cm in diameter, both of which suggest that this unit was erupted from a Tumalo volcanic center vent. While the composition of the pumice of Columbia Canyon is distinctive, it has not been correlated with any other unit in the Oregon central High Cascades. Owing to its limited distribution and obsidian content, the pumice of Columbia Canyon is probably related to a small dome-forming eruption in the Tumalo volcanic center.

CENTURY DRIVE TUFF

The Century Drive Tuff of Taylor (1981) is a variably welded vitric ash-flow tuff containing both rhyodacitic(?) and andesitic pumice. The phenocryst mineralogy of the Century Drive Tuff is plagioclase (An_{35}), augite ($Wo_{41}En_{42}Fs_{17}$), hypersthene ($Wo_2En_{67}Fs_{31}$),olivine (Fo_{71}), and titanomagnetite. It is best exposed along Tumalo Creek west of Shevlin Park, where it forms large, densely welded outcrops. The Century Drive Tuff is restricted to scattered outcrops in the area south and west of Bend, and it appears to be more densely welded in exposures closer to the Tumalo volcanic center, suggesting eruption from one of its vents.

SHEVLIN PARK TUFF

The Shevlin Park Tuff of Taylor (1981) is an andesitic vitric ash-flow tuff that is distributed around a 180° sector east of and centered on Triangle Hill in the Tumalo volcanic center (Hill, 1988). The Shevlin Park Tuff forms one cooling unit and may contain two flow lobes and base-surge deposits in more proximal exposures. The Shevlin Park Tuff contains plagioclase (An_{36}), hypersthene ($Wo_3En_{65}Fs_{32}$), augite ($Wo_{42}En_{43}Fs_{15}$), olivine (Fo_{71}), and titanomagnetite. The distribution of the Shevlin Park Tuff, along with increases in degree of welding and average pumice size, indicates that this unit was erupted from the Tumalo volcanic center. It is probably associated with the Triangle Hill vent complex, which consists of silicic domes and andesitic cinder cones arranged in a roughly circular pattern around Triangle Hill. This complex has a diameter of about 3 km and is centered on a -10 mgal gravity anomaly (Couch and others, 1982). A noteworthy Shevlin Park Tuff outcrop occurs in the upper reaches of the North Fork of Squaw Creek (secs. 29 and 30, T. 16 S., R. 9 E.). At this location, the Shevlin Park Tuff is overlain by a basaltic andesite flow of normal magnetic polarity, which is in turn overlain by the oldest basaltic andesites clearly associated with North Sister (Taylor, 1987). Because North Sister is the oldest stratovolcano of the Three Sisters, this exposure clearly demonstrates that pyroclastic volcanism associated with the Tumalo volcanic center predated construction of the Three Sisters. Basaltic andesite flows from the Tam MacArthur Rim area partly cover the Triangle Hill vent complex, indicating that Tam MacArthur Rim and contemporaneous Broken Top volcanism (Taylor, 1978) postdate Tumalo volcanic center volcanism as well.

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*(Continued on page 139, **Field Trip**)*

Earthquake waves and nonstructural effects

by William M. Elliott, Water Utility Engineer, Portland Water Bureau, 1120 SW Fifth Avenue, Portland, OR 97204

INTRODUCTION

Although earthquakes in Oregon are rare, they nevertheless do occur. Scientific research conducted during the last five to ten years has shown that Oregon's earthquake potential is real. The more frequent shallow earthquakes (magnitude 5-6.5) can occur at any time. Research into the probability of large (magnitude 6.5-7.5) and great (magnitude 8-9) earthquakes is continuing.

This article deals with two concepts: (1) the type of waves that an earthquake generates, and (2) the type of "nonstructural" damage that even moderate earthquakes can cause.

EARTHQUAKE SHAKING

As rocks move within the earth, stresses build up between the masses of material over time. When the strength of the rocks is exceeded or when weak areas such as faults give way and slip, the release of the accumulated strain results in vibrational waves of several types.

Seismologists have identified four wave types that fall into two general wave categories. The two categories are body waves and surface waves. Body waves are of two types: *P* waves and *S* waves. Surface waves are also of two types: Love waves and Rayleigh waves. The ways in which the different wave types produce ground shaking are illustrated in Figure 1.

Body waves of both types travel through the entire mass or "body" of the earth materials in all directions. First to arrive at a given site, the *P* wave is the initial compression wave and travels the fastest. The *S* wave is somewhat slower and resembles an ocean wave arriving on a beach.

Surface waves travel along the surface of the earth with motions slower than either *P* or *S* waves. The third wave to arrive at a site (and the first surface wave) is the Love wave, which is named after the English mathematician A.E.H. Love. This wave is described by Bruce Bolt in his book *Inside the Earth* as follows: "In Love waves, the ground moves from side to side in a horizontal plane but at right angles to the direction of propagation; there is no vertical motion" (Bolt, 1982, p. 44). This rapid side-to-side motion and the attendant reversal of direction are important to the damaging characteristics of Love waves.

The second type of surface waves and the last to arrive at a site are the Rayleigh waves, named for the British mathematician Lord Rayleigh. Again, Bolt's description: "In Rayleigh waves, the particles of rock vibrate both up and down and backward and forward,

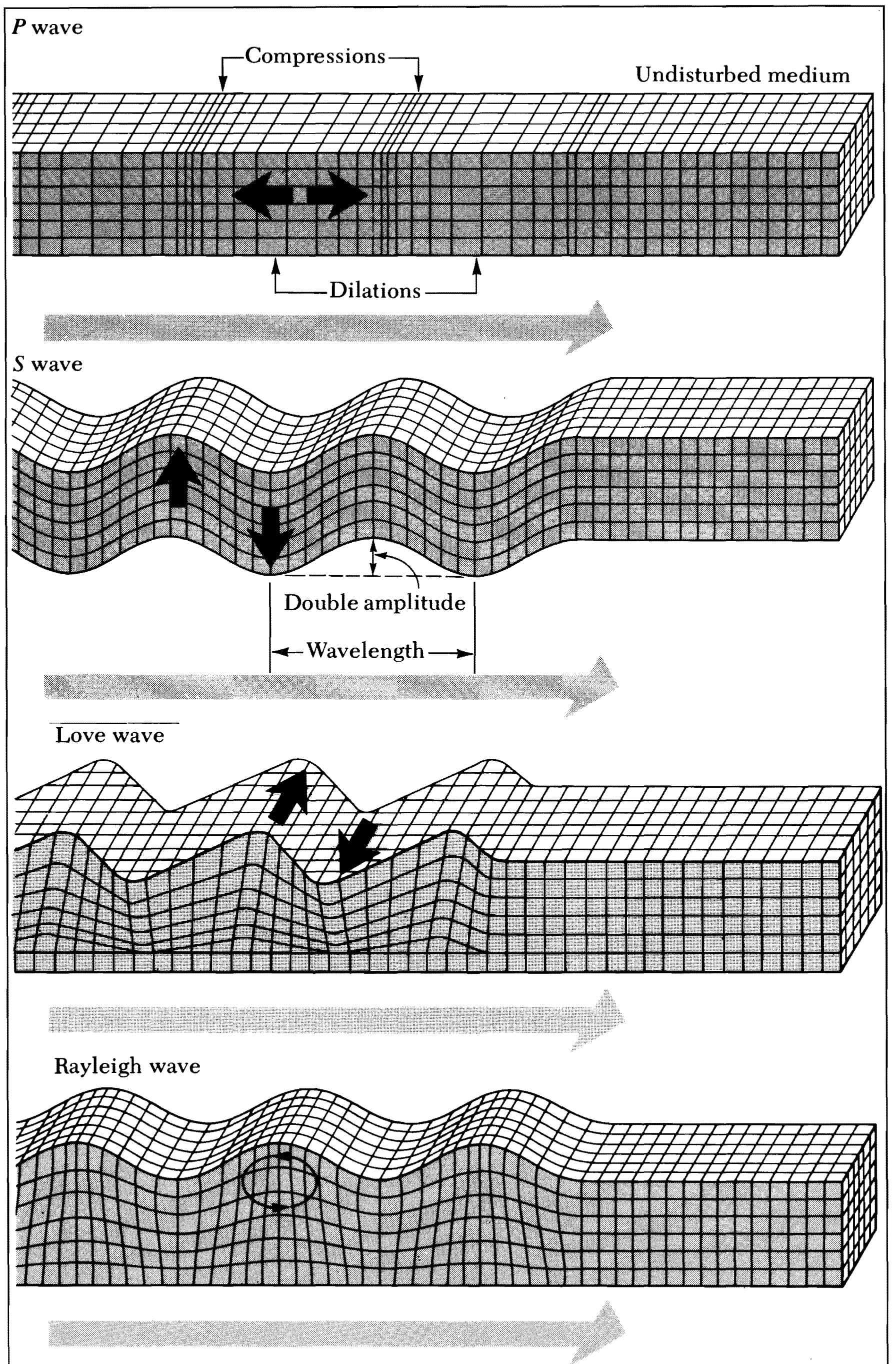

Figure 1. Diagram illustrating characteristics of major types of seismic waves by the types of ground motion they produce. Arrows below the diagrams indicate direction in which the waves are traveling. Arrows on the diagrams indicate ground movement caused by the waves. Sequence from top to bottom also is generally the sequence in which the four waves arrive at a given site. P *waves (compressional) and* S *waves (transverse) are body waves that travel in all directions from the source. Love waves (side-to-side) and Rayleigh waves (up-down and backward-forward) are surface waves that travel around the surface of the earth and are slower than the body waves. Modified from Bolt (1982).*

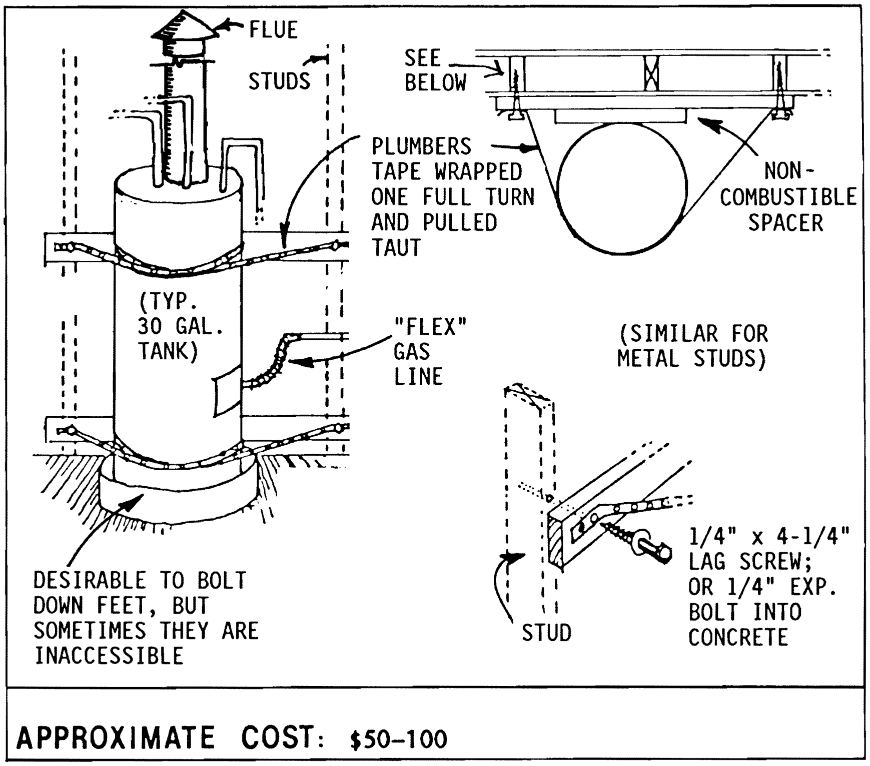

Figure 2. Simple ways to secure a water heater. Strap tank to rigid structure with metal tape, placing noncombustible spacer between tank and wall. Loop tape once all around tank, then attach tape ends to solid structure. Rigid gas pipes connected to the heater should be replaced with flexible gas line.

following in effect an elliptical orbit. However, the elliptical orbit is restricted to a vertical plane pointed in the direction in which the waves are traveling" (Bolt, 1982, p. 44). This rolling motion in a backward direction as the wave travels forward is yet another motion that can cause damage.

In order to distinguish these different wave forms, seismographs that record all the directions of motion (two to record horizontal motion, for example, north-south and east-west, and one to record up-down vertical motion) simultaneously are needed. At present, Oregon is attempting to establish a network of these types of sensitive devices.

The advent of the computer has enabled seismologists to unlock many of the mysteries of the earth and its interior. Readers are directed to other books by Bruce Bolt, such as *Nuclear explosions and earthquakes* (1976) and *Earthquakes* (1988).

GROUND RESPONSE

The vibrations created by an earthquake are not the end of the story. Once these disturbances are generated, they move in the earth as body waves or along the earth's surface as surface waves, decreasing in severity the farther they travel from the source. When these waves arrive at a particular site, the geologic characteristics of that site influence the intensity of the waves. Site geology may cause amplification of the shock (greater shaking than expected) or attenuation (damping or decrease in the shaking intensity). Depending on the site conditions, the ground shaking can trigger landslides, settlement, and slumping, even liquefaction. Liquefaction occurs where fine-grained materials such as sands or silts with adequate moisture can lose their strength temporarily during earthquake shaking. Numerous incidents of damage can be attributed to this phenomenon.

STRUCTURAL VERSUS NONSTRUCTURAL DAMAGE

This article does not discuss the relationships of earthquake damage to structures and buildings. Instead, the attempt made here is to discuss how ground shaking can have a

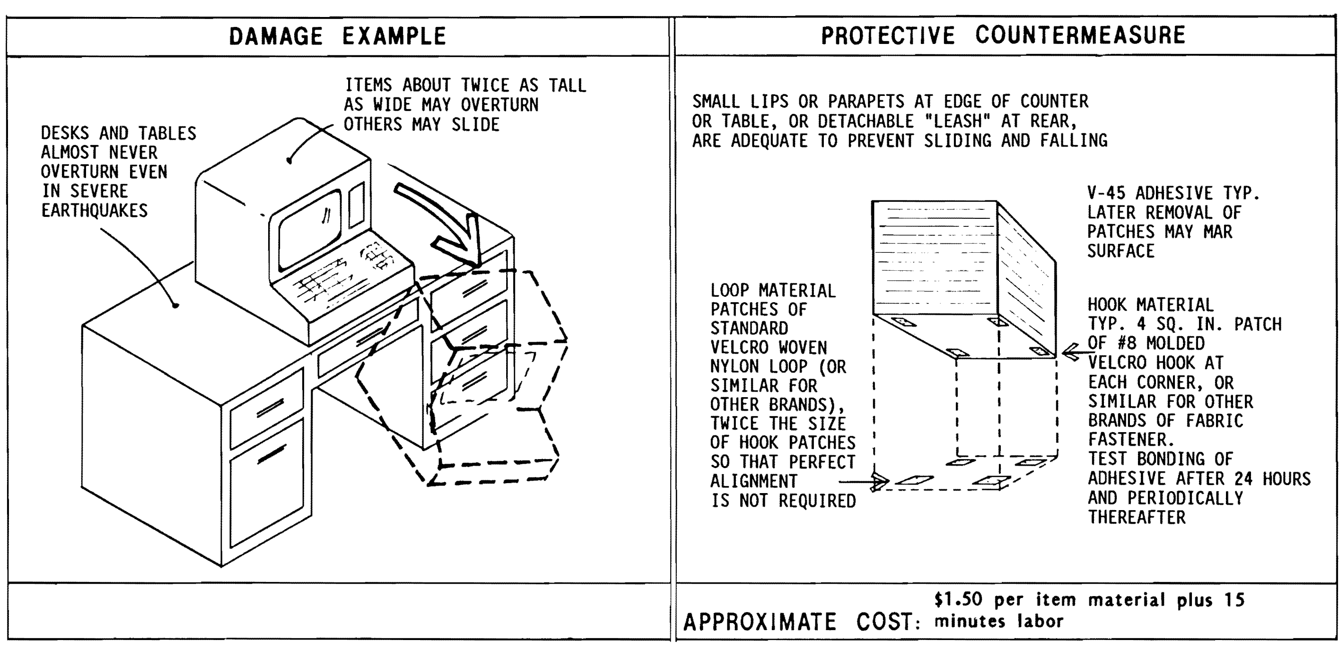

Figure 3. A computer is one of the typical items found on top of desks and tables. While the base may be stable, the equipment itself may topple or slide off. Velcro strips or similar hook-and-pile materials attached to desks can help keep equipment from moving.

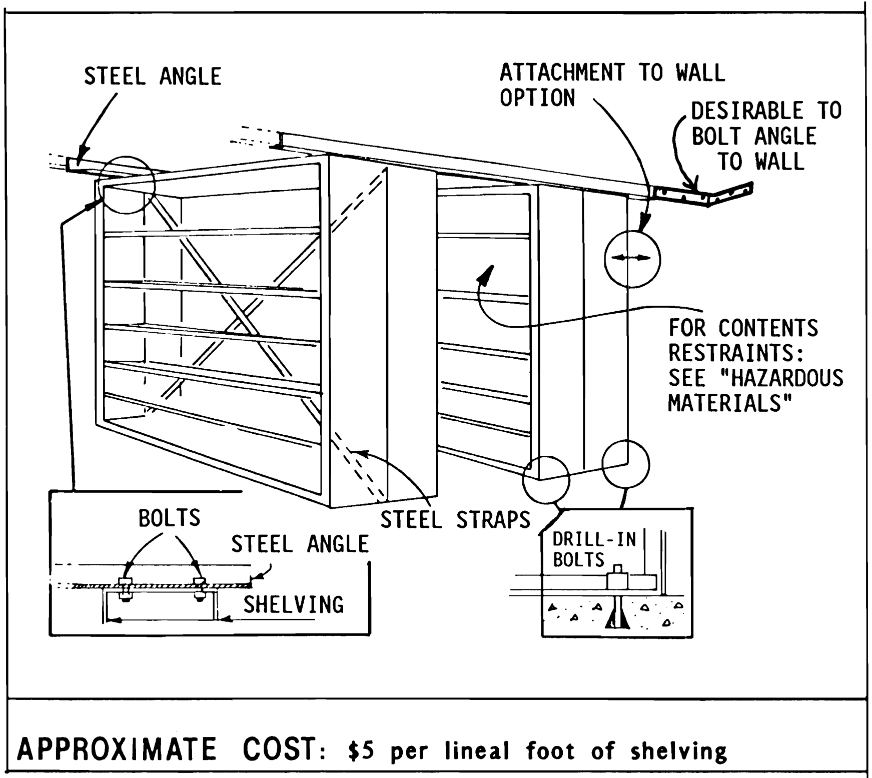

Figure 4. Tall shelving should be stabilized by connecting units rigidly to each other or anchoring them to walls.

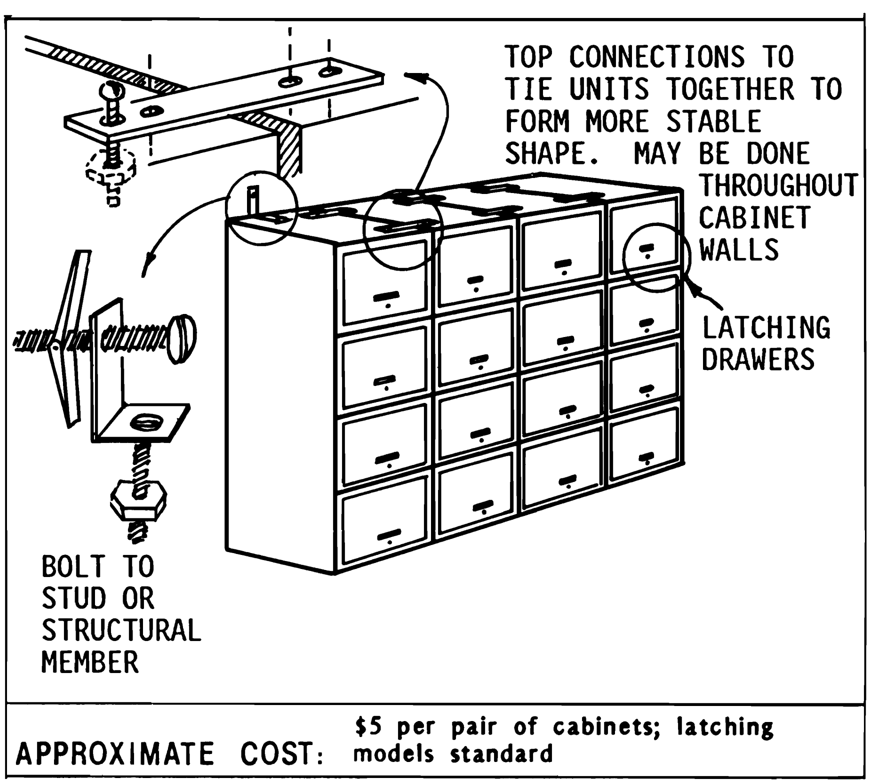

Figure 5. Tall file cabinets can be secured like tall shelves. Their drawers should be equipped with latches.

significant impact on building contents and nonstructural elements. These damages often occur even though the structure itself is not greatly damaged. Nonstructural damage can seriously affect the continued functioning of homes, offices, stores, and factories following an earthquake. Yet, such damage often cannot be anticipated in the planning and building of the structure itself, because it depends on the way in which the occupants furnish and use the structure. Therefore, the hazard of nonstructural damage calls not for the architects, engineers, and other experts but for the common people—all of us—to pay attention to it.

COUNTERMEASURES

Ground shaking and subsequent shaking of a structure affect the nonstructural elements inside, or attached to, that structure mainly in two ways: (1) their uncontrolled movement (swaying, sliding, toppling, falling) and (2) their response to the distortion of the structure to which they are attached (breaking or falling off). Consequently, the degree of danger depends much on how high these items are positioned, or how tall they are, or how well they are secured in their position. Of course, the bigger or heavier they are, the greater may be their vulnerability and danger potential.

When items are fragile, are resting by gravity without restraint, and are not firmly attached, they can break and/or fall and be damaged, cause damage, or injure people.

The following presents some practical examples of nonstructural hazards and inexpensive countermeasures that could be taken to reduce nonstructural earthquake damage. The illustrations are taken with permission from a booklet published by the Bay Area Regional Earthquake Preparedness Project (BAREPP, 1985). BAREPP is a joint project of the California Seismic Safety Commission and the Federal Emergency Management Agency. The included cost estimates are to be considered rough guides and do not include architecture or engineering services that may be needed to perform certain countermeasures.

Homes

A good way to prepare for potential earthquakes is for all of us to take action to safeguard our homes. Simple measures such as securing water heaters and exposed fuel tanks can go a long way toward reducing damage and inconvenience (Figure 2).

Offices

In general, items that are loose and detached (Figure 3), items that are tall and otherwise "tippy" (Figures 4 and 5), and items that are suspended (Figures 6 and 7) are vulnerable and potentially dangerous. Chairs, desks, and tables are comparatively stable, whereas bookcases and file cabinets fall over easily.

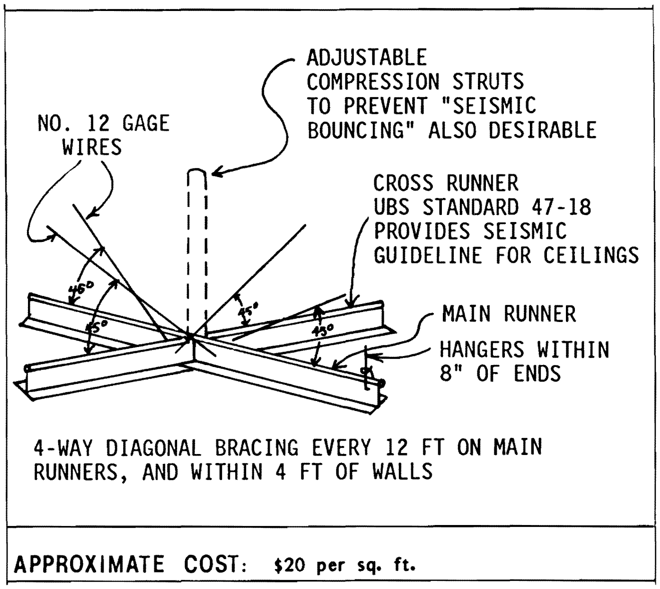

Figure 6. Suspended ceilings, vulnerable from distortion of the support grid and from "bouncing" up and down, can be secured with additional hanging wires and compression struts.

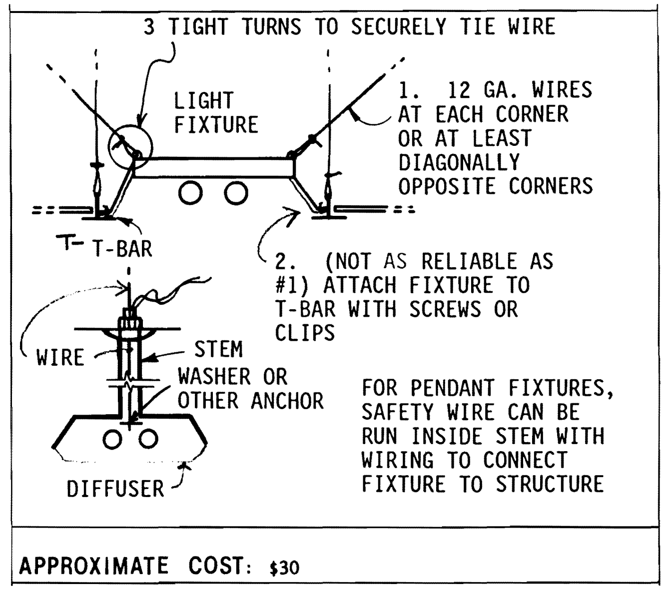

Figure 7. Hanging light fixtures can be made safer with additional wires or anchoring to keep them from swaying and with reinforced suspension to keep them from falling.

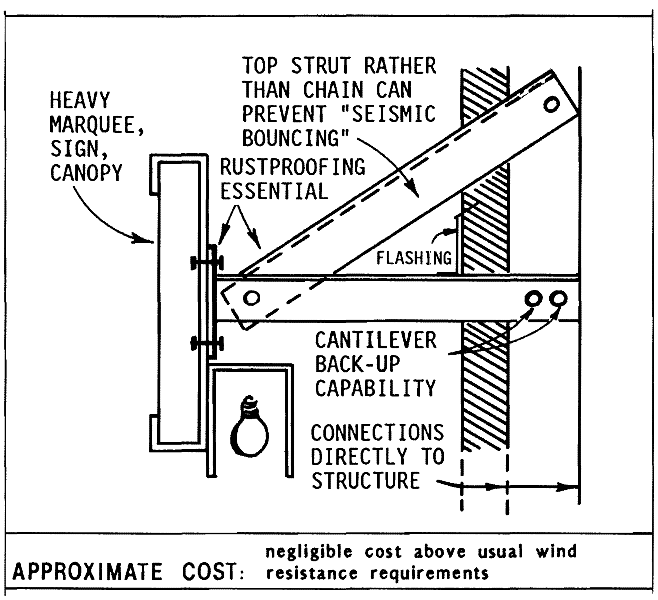

Figure 8. On exterior attachments to a structure, not only strength and rigidity of support but also protection against weakening by rust are important.

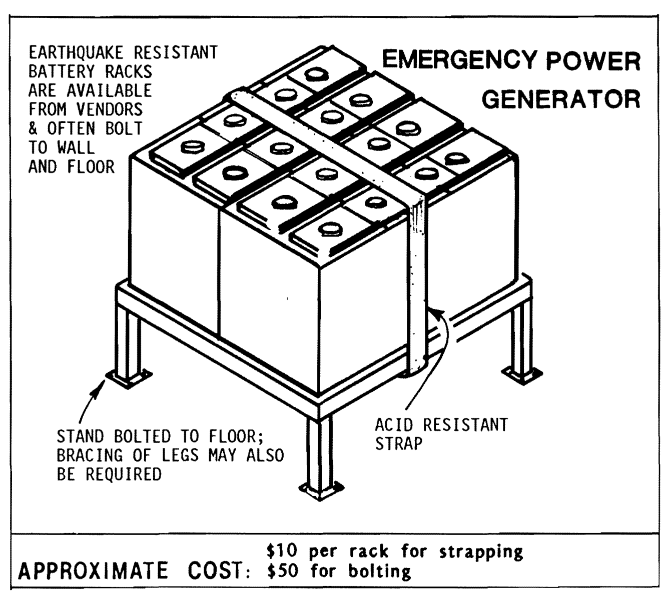

Figure 9. In emergency power equipment, one of the greatest hazards is the sliding of batteries, which may disrupt the entire system. Attach battery racks to floor and strap batteries into racks; add adequate anchorage to generator.

Commercial and industrial

Often stores and factories have significant amounts of glass such as large windows or skylights that present hazards. Addition of tinted solar film, use of laminated glass, or reducing window size are possible countermeasures. Suspended signs or marquees are often quite vulnerable (Figure 8). Shaking can cause items stored on shelves to fall. Simple restraints or similar devices can lessen the risk of these occurrences.

Lights, wires, and equipment can all be vulnerable and dangerous. Those areas where machinery and heavy equipment are used can be made safer by adequate anchoring or bracing of the equipment. Particular care should be taken in securing emergency power supplies (Figure 9).

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(See literature note on page 135.) □

Preliminary assessment of potential strong earthquake ground shaking in the Portland, Oregon, metropolitan area

by Ivan G. Wong and Walter J. Silva, Woodward-Clyde Consultants, Oakland, California 94607, and Ian P. Madin, Oregon Department of Geology and Mineral Industries, Portland, Oregon 97201

ABSTRACT

Strong ground shaking resulting from possible moderate- to large-magnitude earthquakes near the Portland metropolitan area has been estimated deterministically for the soil site of the new State Office Building based on a state-of-the-art ground motion methodology. The earthquakes considered were three crustal events of magnitude (M) 5.5, 6.0, and 6.5 located at an epicentral distance of 10.0 km and a focal depth of 10.0 km and a M 8.0 Cascadia subduction zone event located at a closest distance of 73 km. Region-specific information on crustal structure and seismic attenuation and a detailed but preliminary geologic profile of the site were used in the ground motion estimates. The estimated peak ground accelerations ranged from 0.17 to 0.32 *g* for the crustal earthquakes and 0.20 *g* for the M 8 Cascadia earthquake. Acceleration response spectra estimated for the site for these events were compared with Uniform Building Code (UBC) design spectra; all but the M 5.5 crustal earthquake exceed the currently recommended UBC zone 2B spectrum. This comparison, however, should be viewed in the context of two critical assumptions made in the study: (1) the chosen epicentral distance and focal depth of the crustal earthquakes and (2) the choice of magnitude for the Cascadia event. Existing geologic and seismologic data cannot preclude the possibility of a crustal earthquake occurring closer to Portland nor a subduction zone earthquake significantly larger than M 8. 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.

INTRODUCTION

Recent geologic and seismologic studies indicate that the Pacific Northwest may be subjected to a significant level of seismic hazard in contrast to what has been experienced in historic times (Noson and others, 1988; Weaver and Shedlock, 1989; Madin, 1989). This is particularly true for the Portland metropolitan area, which has had only two damaging earthquakes, a M 5+ in October 1877 and a M 5.1 on November 5, 1962. Potential sources of strong earthquake ground shaking in the Pacific Northwest include (Noson and others, 1988; Weaver and Shedlock, 1989) (Figure 1): (1) the possible occurrence of a great earthquake (M ≥8) occurring along the Cascadia subduction zone; (2) a relatively deep intraplate event occurring within the subducted Juan de Fuca plate similar to the 1949 Olympia (M 7.1) and the 1965 Seattle-Tacoma (M 6.5) earthquakes; and (3) a shallow crustal earthquake in the North American plate such as the 1872 North Cascades (M 7.3) and the 1877 and 1962 Portland earthquakes (see Madin [1989] for schematic illustration of potential earthquake sources).

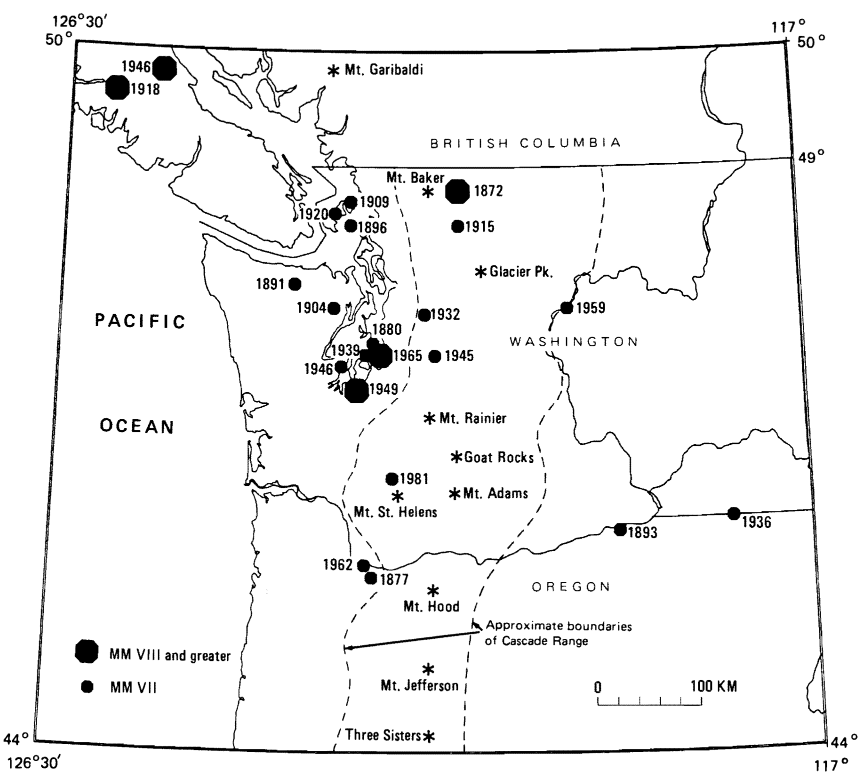

Figure 1. Largest historical earthquakes (Modified Mercalli [MM] VII and greater) of the Pacific Northwest, 1872-1987 (from Noson and others, 1988). Also shown are the principal Cascade volcanoes.

A critical element in the estimation of strong ground motions for the Portland area, as well as other areas in the Pacific Northwest, is to account for the effects of the near-surface geology. It has long been recognized that near-surface unconsolidated sediments and structure can significantly influence, if not dominate, the characteristics of strong ground shaking. Soft cohesionless soils up to 50 m thick are widespread in the Portland metropolitan area (Madin, 1989).

Previous studies of strong ground motion in the Pacific Northwest have focused on either the deep intraplate earthquakes or the Cascadia subduction zone event in the Puget Sound region. Site-specific studies, in particular for a local crustal earthquake in the Portland area, have not been performed to date (Madin, 1989). In the following paper, we describe deterministic estimates of site-specific peak ground accelerations and acceleration response spectra recently determined for the site of the new State Office Building in northeast Portland for four earthquake sources: (1) crustal earthquakes of M (moment magnitude) 5.5, 6.0, and 6.5 located at epicentral distances of 10.0 km from the site and focal depths of 10.0 km; and (2) a Cascadia subduction zone event of M (moment magnitude) 8.0 with the postulated rupture plane located at a closest distance of 73 km. (A response spectrum depicts the peak response of a series of simple harmonic oscillators of different natural periods when subjected to earthquake ground motion. Such a representation has direct engineering relevance because a simple harmonic oscillator with the appropriate natural period can be used as a model for a structure.)

METHODOLOGY

The methodology employed in this study is a state-of-the-art approach combining the Band-Limited-White-Noise (BLWN) earthquake source model with random vibration theory (RVT). This approach has been remarkably successful in predicting the peak ground motions as well as spectral values in different tectonic regimes (Hanks and McGuire, 1981; Boore, 1983; Boore and Atkinson, 1987; Silva and Darragh, 1990). This ground motion model appears to capture well the essential aspects of the earthquake source and one-dimensional rock site effects upon the spectral content of strong ground motions.

The simple BLWN-RVT model also represents a useful analytical tool to approximate site effects on strong ground motion. The effects of unconsolidated sediments upon strong ground motion have been well documented and studied analytically for many years. Results of these studies and other observations have shown that during both small and large earthquakes, surface soil motion can differ in significant and predictable ways from that on adjacent rock outcrops. An additional advantage of the methodology is the ability to address non-linear soil response by using RVT in an equivalent-linear formulation. A detailed description of the methodology is contained in Silva and others (1990).

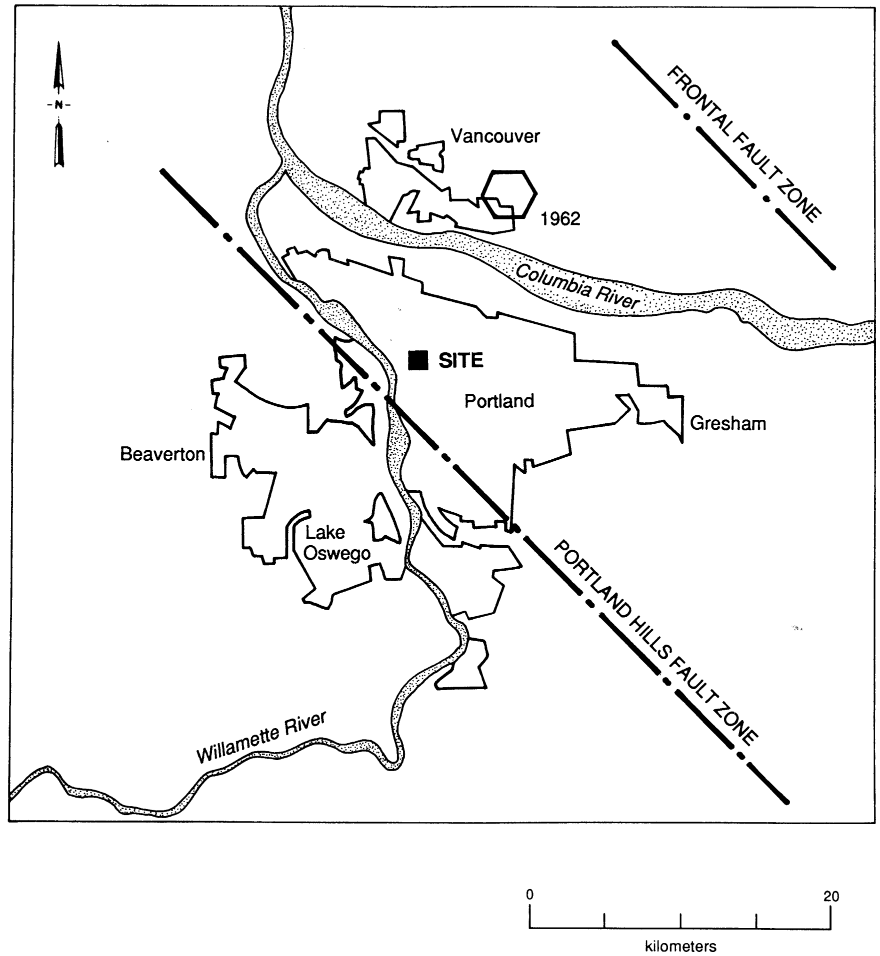

Figure 2. Map of the Portland metropolitan area showing the site of the new State Office Building. Also shown are the Portland Hills and the Frontal fault zones and the epicenter of 1962 earthquake as depicted by Yelin and Patton (1990).

INPUT PARAMETERS

For the estimation of strong ground motions, a characterization of the earthquake source, propagation path, and site geology parameters is required.

Earthquake source

A subduction zone earthquake of M ≥8 or a crustal earthquake of M 5.5 to 6.5 are assumed to dictate seismic design in the Portland area. Considerable uncertainty, however, is associated with the upper-bound value of M 6.5 for the crustal earthquake. Although the largest known earthquake in the Portland area is only approximately M 5+, crustal earthquakes as large as M 7 have occurred in the Pacific Northwest, as evidenced by the 1872 event (Figure 2). Grant and Weaver (1990) have similarly suggested that a M 6.2 to 6.8 is the expected maximum magnitude for an event on the St. Helens zone north of Mount St. Helens. Although the evidence does not exist to conclusively argue for or against the possibility of a M 6.5 earthquake to occur in the Portland metropolitan area, such an event was considered in the strong ground motion estimates to represent a conservative value. Certainly for critical facilities such as hospitals and schools, conservatism should be used both in design and in the seismic safety evaluation of such existing structures.

Although the source locations of such crustal earthquakes are not presently known, an epicentral distance of 10 km was assumed as a reasonable value to use for strong ground motion estimates. Two possible sources in the Portland metropolitan area that may be capable of generating moderate to large earthquakes include the presently aseismic Portland Hills fault zone and the microseismically active Frontal fault zone recently postulated by Yelin and Patton (1990) (Figure 2). The assumed 10-km depth represents the depth to the apparent top of the seismogenic portion of the crust, an assumption based on the distribution of microearthquakes in the Portland area (Yelin and Patton, 1990). The closest distance to the rupture zone is thus calculated at 14.1 km. A stress parameter of 50 bars was assumed for all three crustal earthquakes. This value is typical for western U.S. earthquakes compared to 100 bars for eastern U.S. events (Boore and Atkinson, 1987).

The M 8.0 Cascadia earthquake was assumed to occur at a rupture distance of 73 km, which is based on an epicentral distance of 61 km and a depth of 40 km to the eastern edge of the postulated rupture zone along the interface, as proposed by Somerville and others (1989). A stress parameter of 50 bars was also assumed for the subduction earthquake. Boore (1986) observed that such a value gave a good fit to matching the peak accelerations and velocities of 19 earthquakes ranging from M 6.5 to 9.5, of which the majority were subduction zone earthquakes.

Propagation path

For the propagation path between the crustal earthquakes and the site, a crust characterized by a shear-wave velocity (V_s) of 3.5 km/sec and a density (ρ) of 2.7 g/cm^3 was assumed based on a crustal velocity model for the Cascades (Qamar and others, 1987). To describe the frequency-dependent attenuation in the crust, $Q(f) = Q_o f^\eta$, the coda Q_o of 200 and η of 0.35, based on Singh and Herrmann (1983), were assumed.

The propagation path of the subduction zone earthquake was assigned a V_s of 3.5 km/sec, a ρ of 2.7 g/cm^3, and a constant Q_o of 3,000. The latter value was based on a parametric analysis of the attenuation relationship proposed by Youngs and others (1988) for large subduction zone earthquakes.

Site

The top 28 m of the geologic profile beneath the site was developed based on an exploratory borehole and a downhole V_S survey performed at the site (Figure 3). Layer thicknesses beneath 28 m were estimated on the basis of other available borehole data in the Portland area. V_S values for the lower Troutdale Formation and the Columbia River basalt were based on a downhole V_S survey performed near the existing State Office Building in southwestern Portland. The *P*-wave velocities from a seismic refraction survey (Nazy, 1987) and an assumed Poisson's ratio of 0.30 were used to estimate the V_S for the mudstone. Although considerable uncertainty is involved in such an approach, this value was used in lieu of better information that is currently unavailable. The V_S for the Eocene sediments was based on downhole *P*-wave measurements (also a Poisson's ratio of 0.30) in several deep exploration boreholes in the Portland area (Jack Meyer, Northwest Natural Gas, personal communication, 1990). In general, this geologic profile must be considered to be only a first-order approximation of the actual structure beneath the site because of the possibly large uncertainties in the individual layer velocities as well as in the assumptions that were required on the layer thicknesses (Figure 3).

DEPTH (m)	GEOLOGY	V_S (m/sec)	ρ (g/cm³)	Q_S
9	Flood Silts	204	1.84	10
28	Troutdale Formation (cobbly, pebbley, gravel)	421	2.00	10
107±30		768	2.00	10
229 ±46	Sandy River Mudstone	817	2.40	15
686	Columbia River Basalt	1220	2.8	27
	Eocene Sedimentary Rock	1304	2.70	20

Figure 3. Geologic profile beneath the site of the new State Office Building.

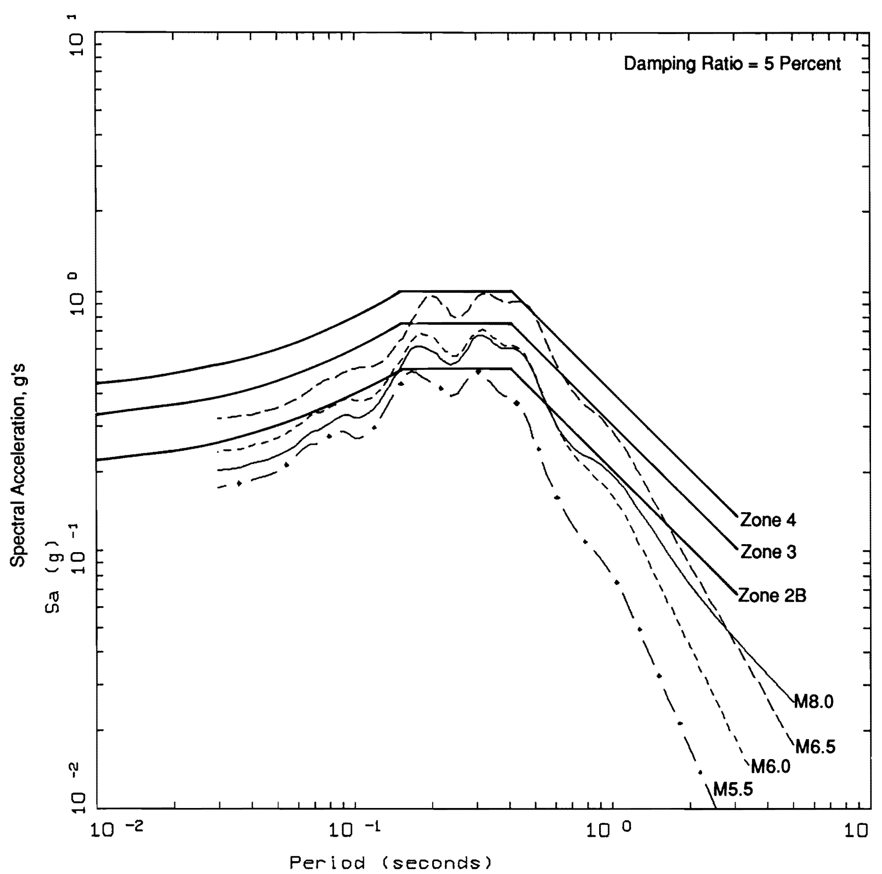

Figure 4. Comparison of the site-specific acceleration response spectra of the four modeled earthquakes and the UBC design response spectra. Zone 2B represents the currently recommended design spectrum for the Portland metropolitan area.

To incorporate the increase in the amplitudes of the seismic waves due to the velocity gradient in the upper crust beneath the geologic profile, Boore's (1986) amplification factors for the western U.S. were also utilized. Estimated densities and shear-wave values of *Q* were also assigned to each layer in the profile. Modulus reduction and damping curves for sand and gravel (Silva and others, 1990) were used to characterize the dynamic properties of the unconsolidated sediments.

RESULTS AND DISCUSSION

The 5 percent damped acceleration response spectra for the site of the new State Office Building, based on the BLWN-RVT methodology, are shown in Figure 4 for the four earthquakes. The spectral shapes are similar for all four events, reflecting the influence of the site geology with only a slight shift to shorter periods (or higher frequencies) as the magnitude decreases due to the corresponding increase in the source corner frequency. The peak horizontal accelerations are 0.17, 0.23, and 0.32 *g* for the M 5.5, 6.0, and 6.5 crustal earthquakes, respectively (Table 1 also lists the peak horizontal velocities). The peak horizontal acceleration for the M 8 Cascadia earthquake is 0.20 *g* at the ground surface and 0.14 *g* for the site without the unconsolidated sediments (equivalent to a rock site) (Table 1). Thus the sediments appear to amplify the ground motions by a factor of 1.4. These strong ground motion estimates probably have a standard error corresponding to a factor of at least 1.5, especially in view of the possible uncertainties in the geologic profile.

A comparison of the Cascadia M 8 and crustal earthquakes shows that the M 6.5 earthquake provides the largest ground motions out to a period of approximately 3.0 sec (Figure 4). The subduction zone event does not become significant in terms of spectral acceleration until a M 6.0 crustal earthquake is being considered at periods greater than 0.50 sec or frequencies less than 2 Hz. However, a significant factor not considered in this study and relevant to engineered structures is the duration of strong ground shaking. The duration of shaking from the Cascadia M 8 event will be significantly longer than the shaking from a crustal M 6.5 earthquake and, hence, potentially far more damaging to certain structures.

Comparison of the site-specific acceleration response spectra with Uniform Building Code (UBC) zones 2B, 3, and 4 design spectra for a type 1 (rock and stiff soils) site is also shown in Figure 4. Three of the four response spectra exceed the currently recommended zone 2B spectrum, and the M 6.5 crustal earthquake spectra exceed the zone 3 spectrum at periods of approximately 0.2 to 0.6 sec. Preliminary acceleration response spectra for the existing State Office Building in southwest Portland and a hypothetical site in the Portland Hills from a M 6.5 crustal earthquake at a distance of 12 km also exceed the UBC zone 2B response spectrum at periods of engineering concern. Although the UBC spectra are probabilistic (based on a 10 percent chance of exceedance in 50 years), and the site-specific response spectra presented here are deterministic (based upon current thoughts on the recurrence of crustal earthquakes and possibly the Cascadia event in the Pacific Northwest), zone 2B appears to underestimate the level of potential strong ground shaking that may affect much of the Portland metropolitan area. This is especially the case since the possibility exists that a crustal earthquake could occur closer to areas in Portland than the assumed 12 to 14 km (Figure 2) and that a Cascadia earthquake could well be larger than M 8 (Noson and others, 1988; Weaver and Shedlock, 1989). Additionally, the UBC does not directly account for the duration of strong ground shaking, which may be significant in a M 8 or greater Cascadia earthquake.

Table 1. *Peak horizontal accelerations and velocities for the site*

Earthquake	Distance (km)	PHA (g)*	PHV (cm/sec)
Crustal M 5.5	14.1	0.17	9.42
Crustal M 6.0	14.1	0.23	15.31
Crustal M 6.5	14.1	0.32	24.26
Cascadia M 8.0	73	0.20	16.01

* g is the acceleration due to gravity at the earth's surface and is equal to 980 cm/sec^2.

CONCLUSIONS

The growing body of geologic and seismologic evidence suggests that a previously unrecognized level of seismic hazard may exist in the Portland metropolitan area. Despite the perceived infrequent occurrence of damaging earthquakes, the present assignment of the UBC zone 2B to the Portland area probably underestimates this hazard. Because of the wide variability in unconsolidated sediments in the Portland metropolitan area, further site-specific estimates of potential strong earthquake ground motions will be required to fully characterize the range of possible ground shaking during future moderate to large earthquakes. Such estimates can eventually lead to maps depicting the relative ground shaking hazard that can be used by government agencies, the engineering and planning communities, and the public at large for hazard mitigation.

ACKNOWLEDGEMENTS

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Correction

With apologies, we must report that some computer goblin gobbled up two numbers in the last issue of *Oregon Geology* (Volume 52, Number 5, September 1990): On page 115, in Table 1 of W.E. Scott's paper in connection with the field trip guide to the central Cascades, the ages given with eruptive products of "Mount Bachelor summit cone and shield" and "Red Crater tephra and lava flows" should both read "12,000-18,000 B.P." We suggest to our readers that they enter this correction in their own copies. □

New geologic maps describe parts of southeastern and southwestern Oregon

New geologic maps that describe in detail the geology and natural-resource potential of portions of the Owyhee region in eastern Oregon and the Coast Range in southwestern Oregon have been released by the Oregon Department of Geology and Mineral Industries (DOGAMI).

Geology and Mineral Resources Map of the Sheaville Quadrangle, Malheur County, Oregon, and Owyhee County, Idaho, by Norman S. MacLeod. DOGAMI Geological Map Series GMS-64, 2 plates (One two-color geologic map, scale 1:24,000, and one sheet containing tables of geochemical data), $4.

Geology and Mineral Resources Map of the Mahogany Gap Quadrangle, Malheur County, Oregon, by Norman S. MacLeod. DOGAMI Geological Map Series GMS-65, one two-color geologic map, scale 1:24,000, $4.

The two 7½-minute quadrangles, located side by side between Lake Owyhee and the Idaho border, cover an area that includes Sheaville and the southeastern flank of Mahogany Mountain. The region has experienced extensive exploration for gold and silver during the last decade. Significant discoveries of gold prospects have been made in areas north of the two quadrangles, and similar geologic conditions extend south into both of the newly mapped quadrangles. Nonmetallic resources identified in the area include zeolites, diatomite, blue agate, and jasper.

The geologic maps show rock units and faults of the area and locations of the samples taken. The descriptive text that is printed on the approximately 40- by 27-inch map sheets includes discussions of geology, structure, and mineral and water resources. Each map also includes geologic cross sections and two tables showing results of whole-rock and trace-element analyses of samples.

Geologic Map of the Reston Quadrangle, Douglas County, Oregon, by DOGAMI geologist G.L. Black, Geological Map Series GMS-68. One two-color geologic map, scale 1:24,000, and a four-page text discussing geologic history and hydrocarbon potential, $5.

This map describes in detail the geology and oil and gas potential of the Reston Quadrangle in the Tyee Basin in southwestern Oregon. The 7½-minute quadrangle covers an area just west of Roseburg in Douglas County and centers on Reston Ridge and the Flournoy Valley. The general geology of the quadrangle, the occurrence of natural gas seeps, and the fact that coal was mined here in the early years of this century suggest that the area might have some source rock potential for oil or gas. In addition to the completed mapping, however, more analytic studies are needed for a more definitive assessment.

The Tyee Basin study project examines the oil, gas, and coal potential of a 4,000-mi^2 area in the southern Coast Range. The project is funded by a consortium of nine corporations or agencies from private industry and federal, state, and county government and has now completed year two of the planned five-year investigation. The new map represents a significant step toward accomplishing a major goal of the project: to resolve some of the stratigraphic problems the area presents.

The map of the Reston Quadrangle shows the distribution of the approximately 50-million-year-old sedimentary rocks that dominate the geology of the area. The area's geology reflects a history of volcanic activity, sedimentary deposition, and sometimes intense deformation and faulting during times when the region was at or near the edge of the continent.

The new maps are now available at the Oregon Department of Geology and Mineral Industries, 910 State Office Building, 1400 SW Fifth Avenue, Portland, OR 97201-5528. Orders may be charged to credit cards by mail, FAX, or phone. FAX number is (503) 229-5639. Orders under $50 require prepayment except for credit-card orders. □

Helpful earthquake literature available

In addition to the literature mentioned in W.M. Elliott's article on pages 127-130 of this issue, two new sources provide information on earthquakes and earthquake preparedness and are called to our readers' attention:

1. *Sunset Magazine* has published a "Guide to help you prepare for the next quake" in the 1990 issues of October (p. 163-177) and November (p. 132-137). Obviously, the title addresses Californians in the first place and refers to last year's Loma Prieta earthquake, in which San Francisco was hit hard. But the article quite correctly points out that much of the West has an earthquake history or geologic conditions similar to California.

The October part of the article deals with the question of "How to secure your house and possessions," the November part with "How to secure your family and your neighborhood . . . and what to do during and after a big quake."

The publishers invite you to send requests for reprints in large quantities (100 or more, at a price of 50 to 75 cents each) to Sunset Quake '90 Reprints, Sunset Publishing Corporation, 80 Willow Road, Menlo Park, CA 94025.

2. A 24-page, colorful tabloid was prepared by the U.S. Geological Survey in cooperation with numerous California agencies and such national organizations as the Red Cross, United Way, the Earthquake Engineering Institute, the Federal Emergency Management Agency, and the Applied Technology Council. The title of the brochure says: "The next big earthquake in the Bay area may come sooner than you think. Are you prepared?"

This document was distributed originally in California newspapers, but it is still available to the public and very useful anywhere. It is currently in its second printing, since of the three million copies of the first printing, all that remained was a waiting list with unfilled requests for 200,000 more copies.

The richly illustrated tabloid addresses all major aspects of what one should know about earthquakes and the likelihood of future ones. It gives advice about preparing for the next quake and about measures to reduce the risk of earthquake damage. It also contains extensive assorted lists of materials and addresses for obtaining further information. It is available in English, Spanish, Chinese, and Braille and in recordings for the blind from Earthquakes, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025. □

USGS open-files Oregon quadrangle maps

Preliminary geologic maps of three Oregon 7½-minute quadrangles have been released recently by the U.S. Geological Survey (USGS) as open-file reports.

OFR 90-202: Nestucca Bay Quad., Tillamook Co., $3.25.
OFR 90-312: Dooley Mountain Quad., Baker Co., $7.
OFR 90-413: Neskowin Quad., Lincoln/Tillamook Co., $3.25.

The maps are available from U.S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, CO 80225. The prices mentioned are for paper copies. □

New Youngquist book available

Mineral Resources and the Destinies of Nations, by Walter Youngquist. Hardcover, 280 p., $17.95. Available through bookstores or from the publisher, National Book Company, P.O. Box 8795, Portland, OR 97207-8795, phone (503) 228-6345.

Youngquist shows how minerals, at all times, have had a decisive influence on the fates of individuals, nations, and civilizations. The author looks at the various hard-mineral and energy-mineral resources and their uses and leads to the resource questions that will shape our future. The book includes a bibliography and an index and should be of particular interest to government and industry planners, economists, sociologists, and political scientists. □

ABSTRACTS OF PAPERS

The following abstracts are of selected papers presented at the 1990 meeting of the Cordilleran Section of the Geological Society of America (GSA) in March in Tucson, Arizona. They were published in the GSA Abstracts with Programs, v. 22, no. 3, p. 16, and are reproduced here with permission. The sequence here is geographical, leading counterclockwise around Oregon, from the southwest to the central coast.

A NEWLY-RECOGNIZED DUCTILE SHEAR ZONE IN THE NORTHEASTERN KLAMATH MOUNTAINS, by M.M. Donato, U.S. Geological Survey, MS 910, 345 Middlefield Road, Menlo Park, California 94025.

A wide and laterally continuous ductile shear zone in southwestern Oregon marks a major lithologic contact between amphibolite-facies metasedimentary rocks of the May Creek Schist (MCS) and structurally underlying amphibolites. Kinematic analysis reveals the sense of movement on the shear zone and provides constraints on the accretionary geometry of the region.

The shear zone trends generally east-west and has been traced approximately 15 km along strike. Its thickness is estimated at two locations as 800 m and 1,500 m. Metaserpentinite bodies within the shear zone were probably tectonically emplaced during deformation. The shear zone was also the locus of intrusion of quartz diorite bodies which display textural evidence of solid-state deformation.

Petrographic criteria, including S-C fabrics and rotated porphyroblasts in semipelitic schists and quartzofeldspathic gneisses, indicate northwestward thrusting (present-day geographic framework) of the metasedimentary rocks over the underlying amphibolites. Quartz petrofabric analyses of 8 of 12 samples within the zone consistently demonstrate top-to-the-northwest sense of shear. Four other samples displayed strong lattice preferred orientation but did not yield shear sense information.

Although the metamorphic age of the MCS and the age of thrusting are poorly constrained, field evidence suggests they predate the nearby undeformed 141-Ma White Rock pluton. Thus the shear zone may be a manifestation of convergence during the Nevadan orogeny, during which an incipient back-arc spreading center (represented by the amphibolites) and its sedimentary cover (MCS) were shortened by faulting.

Geochronologic studies to test this hypothesis are currently under way.

EVOLUTION OF PALEOGENE DEPOSITIONAL SYSTEMS, SOUTHWESTERN OREGON; RESPONSE TO CHANGING FARALLON-NORTH AMERICAN PLATE CONVERGENCE, by P.T. Ryberg, Department of Geology, Union College, Schenectady, New York 12308.

Major changes in sedimentary and structural style occur in Paleogene strata exposed along the southern margin of the Oregon Coast Range. Lithofacies of the early Tertiary Umpqua Group include submarine fan and slope facies (upper Roseburg Formation) which overlie Paleocene basaltic basement (Farallon Plate) rocks to the north. Fan-delta and shallow marine facies (Lookingglass Formation) overlie Franciscan-equivalent strata to the south along the flank of the Klamath Mountains. This depositional system prograded northwestward (actually westward, with paleomagnetic rotation restored) until about 52 Ma. Sandstones and conglomerates of the Roseburg and Lookingglass Formations were derived from recycled orogen and arc-continent collision source rocks in the Klamath Mountains. The structural style and syndepositional deformation of marine slope facies suggest sedimentation in an obliquely convergent subduction complex prior to 52 Ma.

Farallon-North America convergence velocity decreased markedly about 52-50 Ma, ending subduction at this location, as incoming seamounts on the Farallon Plate clogged the trench. In middle Eocene time, a new subduction zone began in a more outboard position. The older, inactive zone accreted to North America and became the site of a rapidly subsiding forearc basin. Flournoy-Tyee sediments comprising a sandy fluvial-deltaic-turbidite ramp depositional system overlapped the old suture and filled the basin from south to north (actually west-northwestward, with paleomagnetic rotation restored), fed by a much larger river system tapping more distal source areas, including the Idaho Batholith. The forearc basin was nearly filled by Narizian time, and the fluvial-deltaic depositional system represented by the coeval Payne Cliffs, Bateman, and Coaledo Formations records the maximum progradation westward across the basin. Coaledo deposition was affected by tectonically induced bathymetry changes offshore, causing local regression-transgression patterns, but these did not greatly affect more proximal fluvial facies. Compositional changes within the upper Coaledo and Payne Cliffs Formations signify the initial transitional onset of western Cascade volcanism by late Eocene time.

HYBRIDIZATION OF ENCLAVES IN THE GRAYBACK PLUTON, KLAMATH MOUNTAINS, SOUTHWEST OREGON, by K. Johnson, C.G. Barnes, M.A. Barnes, and B.L. Schmidt, Department of Geosciences, Texas Tech University, Lubbock, Texas 79409.

Enclave swarms in the Grayback Pluton commonly separate the main body of diorite/quartz diorite from later gabbroic intrusions. The enclaves are lensoid shaped and fine grained and are as much as 2.5 m in length. Two types of enclave are predominant: hypersthene-rich microgabbro and hornblende-quartz microdiorite. The microgabbro consists of plagioclase (>60 percent) with ubiquitous apatite inclusions and abundant pyroxene with minor hornblende rims. The microdiorite contains plagioclase, sparse pyroxene, prismatic hornblende (>50 percent), and interstitial quartz. The host consists of plagioclase (>50 percent), large poikilitic hornblende, minor pyroxene, ± quartz. Individual enclaves are oriented subparallel to the foliation in the host, suggesting a common flow direction. All enclaves display prominent igneous lamination parallel to the enclave/host contact. Field evidence suggests this may, in part, be due to compression acting perpendicular to flow. The compressive stress may have been applied when later gabbroic magmas were intruded nearby.

Enclave/host contacts are sharp, and the enclaves generally lack grain size variation near contacts. Many enclaves are cut by veins of host, some of which are now marked only by stringers of poikilitic hornblende. This suggests that the rest of the vein material was either squeezed out of the vein by local compression or hybridized with the enclave. Some veins of the host diorite contain fragments torn from the enclave during vein formation. Field evidence suggests that chemical interaction between these enclaves and the host magma was accomplished in two ways: (1) diffusion-controlled exchange between veins of host in the enclave, introducing host material into the enclave, and (2) fragmentation of the enclave, introducing enclave material into the host.

LATE MIOCENE VOLCANISM IN THE INLAND PACIFIC NORTHWEST, by D.W. Hyndman, D. Alt, and J.W. Sears, Department of Geology, University of Montana, Missoula, Montana 59812.

Viewed in its entirety, the assemblage of late Miocene basalt and rhyolite in the Pacific Northwest comprises a single volcano of a type and scale hitherto unrecognized. Its development began about 17 million years ago, probably with impact of a large bolide in southeastern Oregon.

Collapse of the initial transient crater opened a basin probably more than 200 km in diameter and many kilometers deep. Pressure relief partial melting in the upper mantle would produce a column of basalt magma with a hydrostatic head proportional to the depth of the basin. The deeper the basin, the deeper partial melting penetrates, and the higher the magma buoyancy will raise the top of the magma column. The crater basin filled with magma to become a lava lake which periodically erupted basalts that flooded nearby lowlands in Oregon, northeastern California, western Idaho, and eastern Washington. Each major eruption would unload the top of the magma column, prompting further pressure relief melting at depth.

Such a deep lava lake would melt crustal rocks and differentiate into coexisting felsic and basaltic components. Basalt plateaus typically contain felsic rocks which include granophyric rhyolites. Felsic magmas erupted as superhot rhyolites in southeastern Oregon and nearby areas of Nevada and southwestern Idaho. Their greater viscosity confined them to the region of the lava lake, thus identifying the site of the impact.

Volcanic activity ended at the impact site after about two million years, but volcanism over the hot spot has since generated the giant rhyolite calderas of the Snake River Plain. Hot-spot volcanism continues in the Yellowstone volcano. Basin and Range volcanism continues to generate basalt and rhyolite in large parts of the region.

STRATIGRAPHY, STRUCTURE, AND MINERALIZATION OF THE DEER BUTTE FORMATION, WEST OF LAKE OWYHEE, MALHEUR COUNTY, OREGON, by M. L. Cummings, Department of Geology, Portland State University, Portland, Oregon 97207.

Felsic volcaniclastic sediments and primary air-fall tuffs are interfingered with basalt palagonite tephra deposits, basalt flows, and rhyolitic flow-dome complexes in the Deer Butte Formation of Miocene age. Geologic mapping in The Elbow, Twin Springs, and Hurley Flat Quadrangles showS formation of successive volcanic-sedimentary basins that become smaller and younger to the east. The volcanic and sedimentary deposits in the older basins were faulted, uplifted, and eroded as successively younger basins were formed. Nonporphyritic to weakly porphyritic rhyolite flows and domes are the oldest deposits in the map area. Xenoliths of rhyolite occur in basalt palagonite tephra deposits for at least 8 km east of rhyolite outcrops, suggesting that rhyolite underlies the volcanic-sedimentary basins.

Hydrothermal systems developed concurrently with faulting and sedimentation. Within two stratigraphic sequences of the Deer Butte Formation, lacustrine sediments that were deposited after extensive basalt hydrovolcanism contain sediments that were altered near the time of deposition. These sediments contain anomalous concentrations of Au, Hg, As, Sb, W, and Mo. As the stratigraphy of the Deer Butte Formation evolved, faulting and uplift of older deposits within the Hurley Flat Quadrangle allowed erosion of hydrothermally altered clasts and transport in east-flowing streams into developing sedimentary basins in the east.

The stratigraphy of the Deer Butte Formation contains a record of sedimentation and volcanism within basins controlled by north-trending fault zones, uplift and erosion within areas of the older basins during the formation of younger basins, and concurrent hydrothermal activity.

SIGNIFICANT DISCOVERIES DURING 1989 INVOLVING DIKES OF COLUMBIA RIVER BASALT IN PRE-TERTIARY ROCKS IN EASTERN OREGON AND WESTERN IDAHO, by W.H. Taubeneck, Department of Geosciences, Oregon State University, Corvallis, Oregon 97331-5506.

The study area includes 6,000 mi^2 (15,540 km^2). Much field work remains.

Four major eruptive axes occur south of an east-west zone (canyon of Powder River along Highway 86 is included) of few dikes at about latitude 44°48′ N. From west in Oregon to east in Idaho, each of the four axes extends northward, passing in turn beyond the Amelia stock for 3.7 km, beyond the Pedro Mountain stock for 3.3 km, beyond the Big Lookout Mountain (BLM) stock for 0.3 km, and beyond the Iron Mountain stock in Idaho for 24 km. Dike distribution in relation to the four stocks, as well as elsewhere in Oregon for the Little Lookout Mountain stock, the Wallowa batholith (WB), and the Bald Mountain batholith, suggests that all axes of dike eruptions were appreciably constrained geographically in longitude by the location of stocks and batholiths.

The highest dike densities are along the four aforementioned eruptive axes rather than in WB as is commonly believed. Some areas contain more than 30 dikes per mi^2. Major sources of Grande Ronde Basalt and Imnaha Basalt are south of latitude 44°48′N. Scores and scores of Grande Ronde feeders are more than 13 m thick, whereas two Imnaha feeders are 23 and 24 m thick.

The best examples of partial melted wall rocks are within 4 km of BLM and in the western two-thirds of the WB. Field relations indicate turbulent flow. Crustal xenoliths are more abundant than is commonly believed but nowhere on the scale of those in the WB, where a few dikes contain more than 200,000 xenoliths. Many dikes in WB contain between 25 and 100,000 xenoliths.

The attitudes of dikes in granitic rocks rather commonly are controlled by joint patterns.

GEOCHEMISTRY OF FERRUGINOUS BAUXITE DEVELOPED FROM COLUMBIA RIVER BASALT, SOUTHWESTERN WASHINGTON, by J.M. Fassio and M.L. Cummings, Department of Geology, Portland State University, Portland, Oregon 97207.

Ferruginous bauxite deposits are developed from flows of the Columbia River Basalt Group in northwestern Oregon and southwestern Washington. The geochemistry of samples of the pisolitic, gibbsite nodular, and fine-grained gibbsite zones from 9 m of drill core from Wahkiakum County in southwestern Washington have been analyzed by instrumental neutron activation. In this core, the upper 1 m is of the pisolitic zone, and the gibbsite nodular zone is 1.2 m thick. The thickness of the pisolitic zone ranges from 0.3 to 4.9 m in different cores from the area.

Within the fine-grained gibbsite zone, ratios of V, TiO_2, Cr, Co, Sc, Ta, and Hf to Fe_2O_3 are similar among samples from over 3 m of core. The Al_2O_3:Fe_2O_3 ratio increases in the same interval. In the gibbsite nodular and into the pisolitic zones, the ratios of Th, Ta, and Hf to Fe_2O_3 increase, and those of Co, Al_2O_3, and Sc to Fe_2O_3 decrease.

La:Lu ratios for basalt and the fine-grained gibbsite zone are consistent with preferential depletion of LREE (basalt = 33; gibbsite zone = 11-16). However, La:Lu ratios increase to 45 from the fine-grained gibbsite into the pisolitic zone. A positive Ce anomaly on chondrite-normalized plots is most pronounced in the gibbsite nodular zone.

Within the pisolitic zone, the order of enrichment of elements in iron-rich pisolites relative to bulk samples is $Fe_2O_3 > Cr >$ Th, Hf $> TiO_2$, Eu, Ta; the order of depletion is Al_2O_3, La, Ce > Sm > Co, Sc > Lu.

The patterns in trace element abundances and ratios is believed consistent with changing climate conditions from continuously wet during formation of the bauxite profile to alternating wet and dry during formation of the pisolitic zone.

PLUTONISM AND HYDROTHERMAL MINERALIZATION ASSOCIATED WITH THE DETROIT STOCK, WESTERN CASCADES, OREGON, by J.M., Curless, M.W. Vaughan, and C.W. Field, Department of Geosciences, Oregon State University, Corvallis, OR 97331.

The Detroit Stock is a composite pluton (10 m.y.) that consists of at least five stages and intrudes volcanic rocks of early Miocene age in the Western Cascades of Oregon. Cross-cutting relationships exposed near Detroit Dam reveal the relative ages between five intrusive stages. Oldest to youngest, these are: (1) quartz diorite, (2) porphyritic hornblende quartz diorite, (3) porphyritic diorite, (4) porphyritic hornblende granodiorite, and (5) aplitic tonalite.

Intrusive rocks within the adjacent Sardine Creek and Rocky Top areas have mineralogical, textural, and chemical features similar to the nearby Detroit Stock. Early quartz diorites at Sardine Creek and Rocky Top are exposed as dikes with sharp to slightly brecciated contacts that were emplaced along preexisting northwest-trending fractures. Later hornblende granodiorites, with contacts defined by well-developed intrusive breccias, are exposed as irregularly shaped northwest elongate dikes and small stocks. Stratigraphic reconstruction from Sardine Creek to Rocky Top suggests that the later hornblende granodiorites were emplaced at a minimum depth of roughly 1.5 km, with the earlier quartz diorites intruding to shallower levels.

Propylitic alteration is widespread throughout the area and intensifies with proximity to northwest-trending fractures. Potassic alteration is limited to the Detroit Stock where several samples contain incipient veinlets and diffuse replacement zones of hydrothermal biotite. Late-stage quartz-sericite alteration is structurally controlled and overprints earlier propylitic and potassic alteration.

More than 80 rock-chip samples from the Detroit Stock, Sardine Creek, and Rocky Top areas were analyzed for Cu, Pb, Zn, and other trace metals. Threshold values were determined to be 80 ppm Cu, 50 ppm Pb, and 90 ppm Zn. The relative proportions of these metals in mineralized samples depict a progressive change with increasing horizontal and vertical distance from Cu (Zn) at the Detroit Stock, through Zn (Cu) at Sardine Creek, to Pb (Zn) at Rocky Top.

Although plutonism and hydrothermal mineralization associated with the Detroit Stock have many features in common with nearby mining districts of the Western Cascades, the absence of well-developed breccia pipes, through-going veins, and zones of intense pervasive alteration are consistent with the lack of extensive exploration and previous mining activity in this area.

GEOCHEMISTRY OF UPPER EOCENE BASALTS FROM THE OREGON COAST RANGE, by M.A. Barnes and C.G. Barnes, Department of Geosciences, Texas Tech University, Lubbock, Texas 79409.

The Yachats Basalt at Cascade Head is one of three volcanic centers in the Oregon Coast Range from which alkalic basalt was erupted in late Eocene time. At Cascade Head, the volcanic rocks are interbedded with thin-bedded, tuffaceous, brackish-water to marine siltstones of the Nestucca Formation. The volcanic sequence is 300 m to 600 m thick and marks the transition from submarine to subaerial eruption. Rhyolitic ash deposits are locally present.

The volcanic pile is dominated by mildly alkaline basaltic rocks with lesser hornblende trachyandesite. The suite is characterized by enrichments in high field strength elements (HFSE) and by steeply negative rare earth element (REE) patterns ($[La/Lu]_n$ = 15-20). Transition metal contents are low (Ni, 7-53 ppm; Cr, 5-86 ppm; Sc, 1-22 ppm), indicating that all of the lavas are differentiated. Spidergrams are typical of continental alkalic basalt in that they show K depletion and Nb and Ta enrichment. Most spidergrams also indicate the relative depletion of Sr and Ti. Spidergrams of interbedded rhyolitic ash are distinct from the basalt, are depleted in Nb, Ta, and Ti, and indicate an arc source. The mass-balance calculations and incompatible element ratios are consistent with differentiation from basalt to trachyandesite by fractional crystallization of olivine + clinopyroxene + plagioclase ± oxides ± apatite. The geologic and geochemical evidence is consistent with a forearc tectonic setting that was undergoing extension. ☐

And the winner is . . .

The response to our contest in the July issue of *Oregon Geology* was a pleasant surprise in many ways. We regret that we cannot answer each individual letter and postcard or print all the interesting extra comments. However, we thank all contestants most deeply for their participation.

Yes, the landmark on the July cover was indeed Sheep Rock—never mind that the name officially applies to 12 "summits" or "pillars" in Oregon! It is, of course, the relationship of this particular Sheep Rock with the John Day Fossil Beds National Monument that gives it a special place in the geology of Oregon—well, at least the paleontology of Oregon. And even if not all contestants could get the name quite right or determine that the view was "probably N. 5° E." or recognize the "sheep atop that funny spire," most of the participants in our contest in the July issue did identify the view correctly. In fact, among 45 valid entries there was only one that had to be disqualified as wrong.

And the winner of the free one-year subscription is—Larry Chitwood of Bend. Congratulations! Since Larry is already a faithful subscriber to *Oregon Geology*, his expiration date will be moved back one year.

Since quite a number of contestants said that they would like to see more such contests, we feel confirmed in our plan to continue the practice—at irregular intervals. We wish all our readers many opportunities to enjoy the visual pleasures that are such an essential part of Oregon's geology! ☐

NWMA announces convention

The Northwest Mining Association (NWMA) will hold its 96th Annual Convention, Short Course, and Trade Show on December 2-7, 1990, in Spokane, Washington, at the Sheraton-Spokane Hotel, Cavanaugh's Inn at the Park, Spokane Convention Center, and Agricultural/Trade Center.

The theme for this year's convention is "The 90's—Strength Through Balance." The program will consist of 22 technical and practical sessions and present more than 100 speakers on the most important topics of the mining industry. Special sessions and social events will offer additional opportunities to exchange ideas.

This year's short course is entitled "Drilling for Minerals—Management, Techniques, and Systems." The course will take place the first three days prior to the convention, December 2, 3, and 4. The cost of the course is $425.

For more information, contact Northwest Mining Association, 414 Peyton Building, Spokane, WA 99201, phone (509) 624-1158.

—NWMA news release

(***Oil and Gas,*** continued from page 122)

8) **Volcanic magnetic susceptibility and wet bulk density analyses of strata from the Texaco Federal no. 1 well, Crook County, and the Standard Oil Kirkpatrick no. 1 well, Gilliam County.** The study by Terra Exploration concludes that there is sufficient contrast between the volcanic rocks and underlying Cretaceous and older rocks to warrant the use of gravity data for mapping basement structures in the study area. However, the lack of contrast in the magnetic susceptibility of these rocks rules out the use of aeromagnetic data to map such structures.

Additional analyses are being done at this time and will be made available in the future. Other studies already completed are listed in DOGAMI's 1987 publication OGI-16, *Available Well Records and Samples of Onshore and Offshore Oil and Gas Exploration Wells in Oregon*, available at the DOGAMI Portland office (address on page 122 of this issue). Contact Dennis Olmstead or Dan Wermiel at DOGAMI if you are interested in reviewing any of these studies. ☐

SSPAC lays base for its work

The Seismic Safety Policy Advisory Commission (SSPAC) for Oregon was created by Governor's Executive Order earlier this year "to provide policy recommendations regarding the establishment of a statewide earthquake hazard reduction and emergency response program." The eight-member commission is composed of representatives from the Department of Geology and Mineral Industries, the Oregon State System of Higher Education, the Department of Human Resources, the Emergency Management Division, the Building Codes Agency, and, appointed by the Governor, one member of the legislative assembly, one person with expertise in structural engineering, and one person with expertise in building, contracting, or project development. The following is the mission statement the Commission has recently adopted:

"The mission of the Seismic Safety Policy Advisory Commission shall be to reduce exposure to earthquake hazards in Oregon by developing or influencing policy, facilitating improved public understanding, and encouraging identification of risk, implementation of appropriate mitigation, and preparation for response and recovery.

"The commission shall monitor and influence programs and policies at the federal, state, and local level to address Oregon's broad needs in terms of earthquake risk mitigation. Included are communication of Oregon's needs to federal programs, review of state legislative concepts related to earthquakes, and review of state and agency budget decision packages of program direction related to earthquakes. Also included is identification of program level oversights of earthquake related needs at the state program level.

"The commission shall utilize and influence existing agencies and institutions in meeting its goals and is in no way intended to replace or compete with existing authorities relative to earthquakes. Emphasis shall be on coordination and linking of existing resources and authorities.

"Policy areas of interest to the commission may include but not be limited to: earthquake risk data, building codes, land use plans, local government response, recovery, coordination, budgets, legislation, earthquake advice to policy makers, and public information." □

AEG elects Mavis D. Kent president

The Association of Engineering Geologists (AEG) has announced the election of new officers for 1990-1991. They are President Mavis D. Kent of Walnut Creek, California; Vice-President Stephen L. Garrison of Jessup, Maryland; Secretary Alvin L. Franks of Sacramento, California; and Treasurer Alan D. Tryhorn of San Francisco, California. The announcement was released during the 33rd annual AEG meeting held in Pittsburgh, Pennsylvania, October 1-5, 1990.

President Mavis D. Kent, a former Oregon resident and a graduate of Portland State University, is the first woman to be elected president of AEG. Kent, who served on the Oregon Board of Geologist Examiners during the early 1980's, stated that one of her goals will be to "remain committed to seeking the registration of geologists in all states." She plans to take action on specific concerns of AEG, including ethical practice in the environmental arena, a new editor for and a new category of technical publications, and enhanced computer utilization within AEG. She also noted that AEG has "sound prospects for growth and achievement" and will strive to retain AEG as the premier association to serve the special needs of the professional engineering geologist working in engineering, environmental, and ground water geology.

President Kent is employed as Senior Engineering Geologist by the California Water Quality Control Board for the San Francisco region in Oakland, California. She is completing her doctoral degree in geology at Texas A&M University. Ms. Kent is a Registered Geologist and Certified Engineering Geologist in California and Oregon.

The Association of Engineering Geologists was established in 1957 to aid public welfare in concerns of engineering geology and to promote engineering geology in the professions.

—*AEG news release*

Sweet Home club displays at Capitol

The Sweet Home Rock and Mineral Society is the current exhibitor for the display case of the Oregon Council of Rock and Mineral Clubs (OCRMC) at the State Capitol in Salem. The 55 specimens displayed were furnished by six members of the society and collected in 13 Oregon counties and will remain at the Capitol until January 15, 1991.

Sweet Home's own Linn County is represented by specimens of petrified wood, blue lace agate, an agate sphere, a frame of Holley Blue agate cabochons, two large crystal and three sagenite pieces, and six spectacular specimens of carnelian. The display also includes frames of cabochons of polka dot agate, thunder egg centers, petrified wood, and Carey Plume agate; slabs and rounds of petrified wood and bookends made from petrified wood; Biggs jasper; obsidian; Owyhee picture rock; spheres made from Lake County cinnabar and from petrified wood; and various pieces of jewelry made from Lincoln County beach agates and the State Gem, Oregon sunstone. —*OCRMC news release*

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*(**Field Trip**, continued from page 126)*

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MINERAL EXPLORATION ACTIVITY

MAJOR MINERAL-EXPLORATION ACTIVITY

Date	Project name, company	Project location	Metal	Status
April 1983	Susanville Kappes Cassiday and Associates	Tps. 9, 10 S. Rs. 32, 33 E. Grant County	Gold	Expl
May 1988	Quartz Mountain Wavecrest Resources, Inc.	T. 37 S. R. 16 E. Lake County	Gold	Expl
June 1988	Noonday Ridge Bond Gold	T. 22 S. Rs. 1, 2 E. Lane County	Gold, silver	Expl
September 1988	Angel Camp Wavecrest Resources, Inc.	T. 37 S. R. 16 E. Lake County	Gold	Expl
September 1988	Glass Butte Galactic Services, Inc.	Tps. 23, 24 S. R. 23 E. Lake County	Gold	Expl
September 1988	Grassy Mountain Atlas Precious Metals, Inc.	T. 22 S. R. 44 E. Malheur County	Gold	Expl, com
September 1988	Kerby Malheur Mining	T. 15 S. R. 45 E. Malheur County	Gold	Expl, com
September 1988	Jessie Page Chevron Resources Co.	T. 25 S. R. 43 E. Malheur County	Gold	Expl
October 1988	Bear Creek Freeport McMoRan Gold Co.	Tps. 18, 19 S. R. 18 E. Crook County	Gold	Expl
December 1988	Harper Basin American Copper and Nickel Co.	T. 21 S. R. 42 E. Malheur County	Gold	Expl
May 1989	Hope Butte Chevron Resources Co.	T. 17 S. R. 43 E. Malheur County	Gold	Expl, com
September 1989	East Ridge Malheur Mining	T. 15 S. R. 45 E. Malheur County	Gold	App
June 1990	Racey Billiton Minerals USA	T. 13 S. R. 41 E. Malheur County	Gold	Expl
June 1990	Grouse Mountain Bond Gold Exploration, Inc.	T. 23 S. Rs. 1, 2 E. Lane County	Gold	Expl
June 1990	Freeze Western Mining Corporation	T. 23 S. R. 42 E. Malheur County	Gold	Expl
August 1990	Lava Project Battle Mountain Exploration	T. 29 S. R. 45 E. Malheur County	Gold	Expl
September 1990	Bourne Simplot Resources, Inc.	T. 8 S. R. 37 E. Baker County	Gold	App
September 1990	Baboon Creek Chemstar Lime, Inc.	T. 19 S. R. 38 E. Baker County	Lime-stone	App
September 1990	Prairie Diggings Western Gold Exploration and Mining Co.	T. 13 S. R. 32 E. Grant County	Gold	App
September 1990	Pine Creek Battle Mountain Exploration	T. 20 S. R. 34 E. Harney County	Gold	Expl
September 1990	Calavera NERCO Exploration Company	T. 21 S. R. 45 E. Malheur County	Gold	Expl
September 1990	Cow Valley Butte Cambiex USA, Inc.	T. 14 S. R. 40 E. Malheur County	Gold	Expl
September 1990	Mahogany Project Chevron Resources Company	T. 26 S. R. 46 E. Malheur County	Gold	App

Explanations: App=application being processed. Expl=Exploration permit issued. Com=Interagency coordinating committee formed, baseline data collection started. Date=Date application was received or permit issued.

Mining Issues Forum

Three state agencies, the Departments of Geology and Mineral Industries, Environmental Quality, and Fish and Wildlife, and two federal agencies, the Bureau of Land Mangement and the Forest Service, sponsored the Mining Issues Forum held September 8, 1990, in Bend.

The purpose of the forum was to provide an opportunity for dialogue on controversial and polarizing issues regarding precious-metal mining. The numerous excellent questions generated by the speakers showed that the purpose was fulfilled. Proceedings of the conference will be available soon, and copies will be sent to those who attended. Additional copies will be available at cost.

The program included the following panel discussions:

1. *Anatomy of a mine: Financial aspects of the industry*, with moderator Don Fordyce of U.S. National Bank and panelists from FMC Gold Company and NERCO Minerals Company.

2. *Economic and social effects of large-scale gold mining in Oregon*, with Dr. Bill Lee as moderator and panelists from US Bancorp, the Northern Plains Resource Council, and Pegasus Gold Corporation.

3. *Environmental issues*, investment advisor Dennis Hanson as moderator and with panelists from the Mineral Policy Center, the Nevada Wildlife Department, EIC Corporation, and the Coeur d'Alene Mines Corporation.

4. *The regulatory framework*, moderated by public policy consultant Jim Mann and with panelists from the U.S. Bureau of Land Management, the USDA Forest Service, and the U.S. Fish and Wildlife Service and the Oregon Departments of Geology and Mineral Industries, Environmental Quality, Water Resources, and Fish and Wildlife.

Proposed legislation

The Department is proposing legislation that will mandate an economic and environmental evaluation of all major metal mining facilities. Public participation in the evaluation process would be encouraged. Another proposal calls for the use of 1½-in. square wooden stakes as claim corner monuments and reduces the required number of stakes per claim.

Status changes

Eight new applications were received for exploration projects in August and September. The location and status of those applications is shown in the table above.

Questions or comments about exploration activities in Oregon should be directed to Gary Lynch or Allen Throop in the Mined Land Reclamation Office, 1534 SE Queen Avenue, Albany OR 97321, telephone (503) 967-2039. □

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Numbers refer to volume and beginning page of entry. Most subject entries include cross-references to author entries (in parentheses).

AVAILABLE DEPARTMENT PUBLICATIONS

GEOLOGICAL MAP SERIES

		Price	√
GMS-4	Oregon gravity maps, onshore and offshore. 1967	3.00	
GMS-5	Geologic map, Powers 15-minute Quadrangle, Coos/Curry Counties. 1971	3.00	
GMS-6	Preliminary report on geology of part of Snake River canyon. 1974	6.50	
GMS-8	Complete Bouguer gravity anomaly map, central Cascade Mountain Range. 1978	3.00	
GMS-9	Total-field aeromagnetic anomaly map, central Cascade Mountain Range. 1978	3.00	
GMS-10	Low- to intermediate-temperature thermal springs and wells in Oregon. 1978	3.00	
GMS-12	Geologic map of the Oregon part of the Mineral 15-minute Quadrangle, Baker County. 1978	3.00	
GMS-13	Geologic map, Huntington and parts of Olds Ferry 15-minute Quadrangles, Baker and Malheur Counties. 1979	3.00	
GMS-14	Index to published geologic mapping in Oregon, 1898-1979. 1981	7.00	
GMS-15	Free-air gravity anomaly map and complete Bouguer gravity anomaly map, north Cascades, Oregon. 1981	3.00	
GMS-16	Free-air gravity and complete Bouguer gravity anomaly maps, south Cascades, Oregon. 1981	3.00	
GMS-17	Total-field aeromagnetic anomaly map, southern Cascades, Oregon. 1981	3.00	
GMS-18	Geology of Rickreall/SalemWest/Monmouth/Sidney 7½-minute Quadrangles, Marion/Polk Counties. 1981	5.00	
GMS-19	Geology and gold deposits map, Bourne 7½-minute Quadrangle, Baker County. 1982	5.00	
GMS-20	Geology and geothermal resources, S½ Burns 15-minute Quadrangle, Harney County. 1982	5.00	
GMS-21	Geology and geothermal resources map, Vale East 7½-minute Quadrangle, Malheur County. 1982	5.00	
GMS-22	Geology and mineral resources map, Mount Ireland 7½-minute Quadrangle, Baker/Grant Counties. 1982	5.00	
GMS-23	Geologic map, Sheridan 7½-minute Quadrangle, Polk and Yamhill Counties. 1982	5.00	
GMS-24	Geologic map, Grand Ronde 7½-minute Quadrangle, Polk and Yamhill Counties. 1982	5.00	
GMS-25	Geology and gold deposits map, Granite 7½-minute Quadrangle, Grant County. 1982	5.00	
GMS-26	Residual gravity maps, northern, central, and southern Oregon Cascades. 1982	5.00	
GMS-27	Geologic and neotectonic evaluation of north-central Oregon. The Dalles 1° x 2° Quadrangle. 1982	6.00	
GMS-28	Geology and gold deposits map, Greenhorn 7½-minute Quadrangle, Baker and Grant Counties. 1983	5.00	
GMS-29	Geology and gold deposits map, NE¼ Bates 15-minute Quadrangle, Baker and Grant Counties. 1983	5.00	
GMS-30	Geologic map, SE¼ Pearsoll Peak 15-minute Quadrangle, Curry and Josephine Counties. 1984	6.00	
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GMS-32	Geologic map, Wilhoit 7½-minute Quadrangle, Clackamas and Marion Counties. 1984	4.00	
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GMS-34	Geologic map, Stayton NE 7½-minute Quadrangle, Marion County. 1984	4.00	
GMS-35	Geology and gold deposits map, SW¼ Bates 15-minute Quadrangle, Grant County. 1984	5.00	
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GMS-38	Geologic map, NW¼ Cave Junction 15-minute Quadrangle, Josephine County. 1986	6.00	
GMS-39	Geologic bibliography and index maps, ocean floor and continental margin off Oregon. 1986	5.00	
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GMS-57	Geology and mineral resources map, Grassy Mountain 7½-minute Quadrangle, Malheur County. 1989	4.00	
GMS-58	Geology and mineral resources map, Double Mountain 7½-minute Quadrangle, Malheur County. 1989	4.00	
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GMS-64	Geology and mineral resources map, Sheaville 7½-minute Quadrangle, Malheur County. 1990	4.00	
GMS-65	Geology and mineral resources map, Mahogany Gap 7½-minute Quadrangle, Malheur County. 1990	4.00	
GMS-68	Geologic map , Reston 7½-minute Quadrangle, Douglas County. 1990	5.00	

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36	Papers on Foraminifera from the Tertiary (v. 2 [parts VII-VIII] only). 1949	3.00	
44	Bibliography of geology and mineral resources of Oregon (2nd supplement, 1946-50). 1953	3.00	
46	Ferruginous bauxite, Salem Hills, Marion County. 1956	3.00	
53	Bibliography of geology and mineral resources of Oregon (3rd supplement, 1951-55). 1962	3.00	
61	Gold and silver in Oregon. 1968 (reprint)	17.50	
65	Proceedings of the Andesite Conference. 1969	10.00	
67	Bibliography of geology and mineral resources of Oregon (4th supplement, 1956-60). 1970	3.00	
71	Geology of lava tubes, Bend area, Deschutes County. 1947	5.00	
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81	Environmental geology of Lincoln County. 1973	9.00	
82	Geologic hazards of Bull Run Watershed, Multnomah and Clackamas Counties. 1974	6.50	
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92	Fossils in Oregon. Collection of reprints from the *Ore Bin*. 1977	4.00	
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