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Oregon Department of Geology and Mineral Industries

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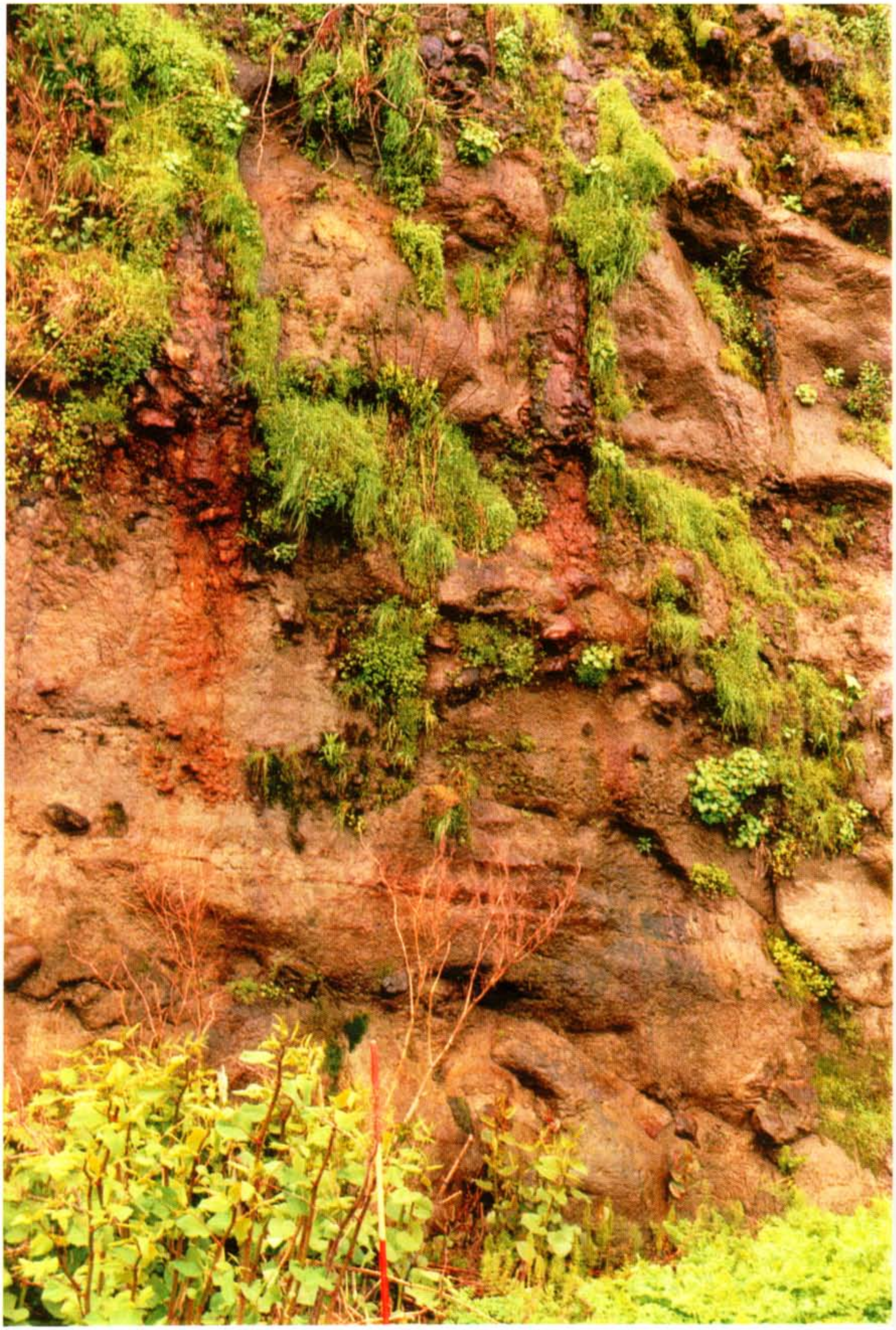

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THROUGH THE EYES OF THE STATE GEOLOGIST

After discovering parts of the West, John Wesley Powell proposed in the late 1800s that governmental entities be structured around watersheds. But with rail lines, various Homestead Acts, Mining Districts, post-Civil War politics, and the rush to make a living off the land, settlers soon developed other patterns—more attuned to "progress" than to ecosystems. Today, however, ecosystems, including watersheds, have become keys for our survival.

Effectively working with ecosystems requires that diverse sciences and interests develop new ways of working together to solve regional problems. While each organization is used to approaching issues according to its own mandate, history, and resources, we had better find ways to integrate those approaches into comprehensive goals. This calls for nonregulatory as well as regulatory efforts. And while today the emphasis is on individual endangered species, primarily fish, future years may see a balancing towards broader concerns as well.

In the Department of Geology and Mineral Industries (DOGAMI), many of our current successes with ecosystem health are in the Mined Land Reclamation (MLR) Program, located in our Albany field office. Many disciplines come together there to provide for additional beneficial uses of mined land. MLR staff work with government agencies, the private sector, and environmental groups on projects that affect ecosystems, such as sediment management at mine sites, creation of a "Best Management Practices" manual with our neighboring states of Idaho and Washington, and participation in river initiatives and other stream channel morphology efforts.

More new efforts are emerging in the agency, as we focus on sustainability for both economic progress and ecosystem health. We are, for example, beginning to focus our mapping efforts to produce detailed geologic mapping in key areas of groundwater concern. In the future, we also hope to make appropriate enhancements to geologic maps, so that they better meet the needs of ecosystem and watershed managers.

By itself, this agency certainly is not going to solve boundary problems as they relate to governance of watersheds. And DOGAMI alone can not produce answers where current government structures are trying to relate to ecosystem structures. However, DOGAMI can help with focused efforts on the ground to put good information in the hands of watershed and ecosystem managers when they need it.

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Cover photo

Eagle Creek Formation outcrop at Tanner Creek in Multnomah County, near the Columbia River and Bonneville Dam. In the upper half of the picture, three upright petrified trees can be seen, which are, in this formation, typically accompanied by orange-colored staining below. Article beginning on page 111 by William Krause reports on a fossil location in what appears to be a low section of the Eagle Creek Formation, on the south shore of the Columbia River and about 2 mi west of Bonneville Dam. Photo by Rachel A. Carlin (see reference list at end of Krause's article).

The 1997 Vida, Oregon earthquake swarm

by Sue Perry and Ray Weldon II, University of Oregon, Eugene, Oregon

ABSTRACT

Three small earthquakes (magnitudes 2.1–2.6) occurred near Vida, Oregon, in May, 1997. We have redetermined their locations with a one-dimensional velocity model and constructed focal mechanisms and a net moment tensor. Earthquake locations, focal mechanisms, and moment tensor all indicate that the preferred slip plane is steeply dipping and trends north-northwest. The net sense of motion is right lateral with a reverse component, similar to that of the Scotts Mills earthquake (1993, magnitude 5.7), which had a more pronounced reverse component. The Vida focal mechanisms and moment tensor are consistent with regional maximum horizontal stress that is essentially north-south, as has been documented by several other workers.

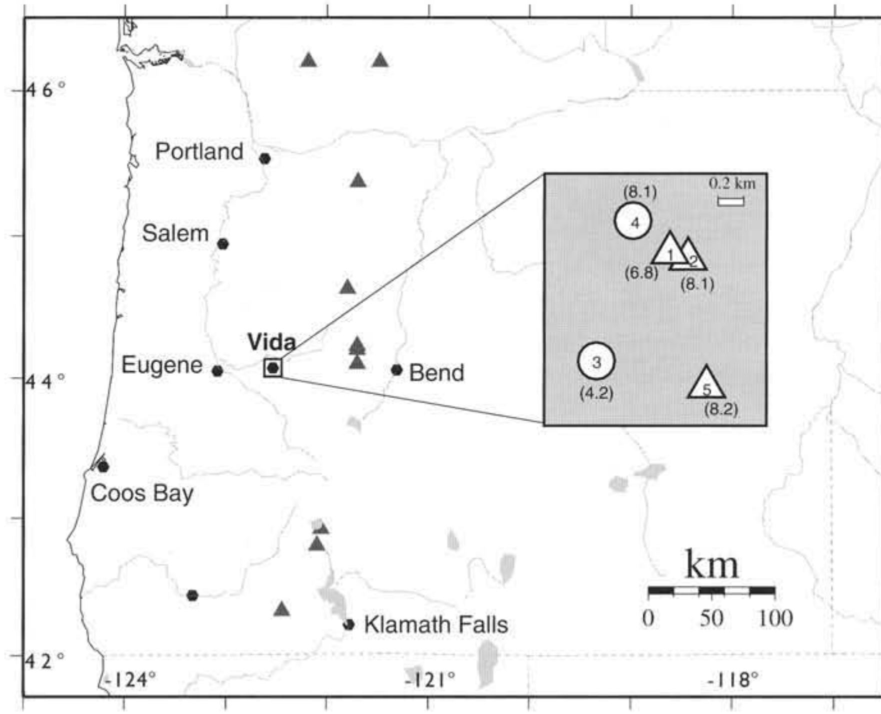

Figure 1. Map of Oregon showing locations of principal rivers, Cascade volcanoes (triangles), towns (dots), and 1997 Vida earthquake swarm (boxed circle). Inset: Epicenters of the five largest earthquakes, with event numbers keyed to Table 1 and depths (km) in parentheses. Triangles represent epicenters newly redetermined for this study. Other data are from catalog of Pacific Northwest Seismic Network (PNSN).

INTRODUCTION

In May 1997, five small earthquakes (magnitudes 1.5–2.6) occurred in the western Cascades. The Pacific Northwest Seismic Network (PNSN) located them near Vida, Oregon, about 45 km (28 mi) east of Eugene (Figure 1, Table I). Although small, the earthquakes were felt locally. Further, ground shaking triggered a landslide on a steep, logged slope that had become unstable during the previous winter's rains (Mortenson, 1997).

Staff at the Department of Geological Sciences, University of Oregon (UO), deployed three available Sprengnether S-6000 seismometers, and got usable results from one (site DHN, Figure 2). Analyzing these, we discovered that the five earthquakes were the biggest in a vigorous swarm. That is, the Vida earthquakes occurred quite close to one another in time and space and had magnitudes similar enough that no event was clearly the main shock. During nearly twelve days of continuous operation, DHN recorded as many as 80 earthquakes per day. Only five were large enough to be located by the PNSN and thus preserved in the network catalog.

To adequately determine an earthquake epicenter (the point on the Earth's surface that is directly above the earthquake's origin), it takes three seismometers surrounding the event. To determine the event's depth, at least four seismometers are required. Earthquakes of small magnitudes do not radiate enough energy to be clearly located by distant seismometer stations. PNSN collects data from fewer than 40 seismometers in Oregon (Figure 2). In northern and western Oregon, they provide a complete record of earthquakes of magnitudes 2.5 and above (R. Ludwin, PNSN geophysicist, written communication, 1998). The level of small-magnitude, background seismicity is well known only near Portland, where instrumentation is densest.

The Vida swarm is not the only recent swarm near Eugene. In June 1998, PNSN located magnitude 2 earthquakes northwest and southeast of Eugene. Our staff was testing seismometers in Eugene and recorded two distinctive groups of waveforms that suggest swarms in different locales. Additionally, in early 1996, while we deployed seismometers in Eugene and Springfield to assess seismic hazard, we recorded a series of small earthquakes with virtually identical waveforms. These events appeared to be part of a swarm located about 15 km (10 mi)

Table I. Source parameters of the five largest 1997 Vida earthquakes, determined by the Pacific Northwest Seismic Network (PNSN)

Event no.	Date	Time (UTC)	Lat N.	Long W.	Depth (km)	Magnitude
EV 1	5/22/97	10:35	44.066	122.517	6.8	2.3
EV 2	5/22/97	13:57	44.066	122.520	8.1	2.6
EV 3	5/22/97	14:07	44.061	122.529	4.2	1.8
EV 4	5/22/97	17:17	44.072	122.525	8.1	1.5
EV 5	5/24/97	09:00	44.062	122.515	8.2	2.1

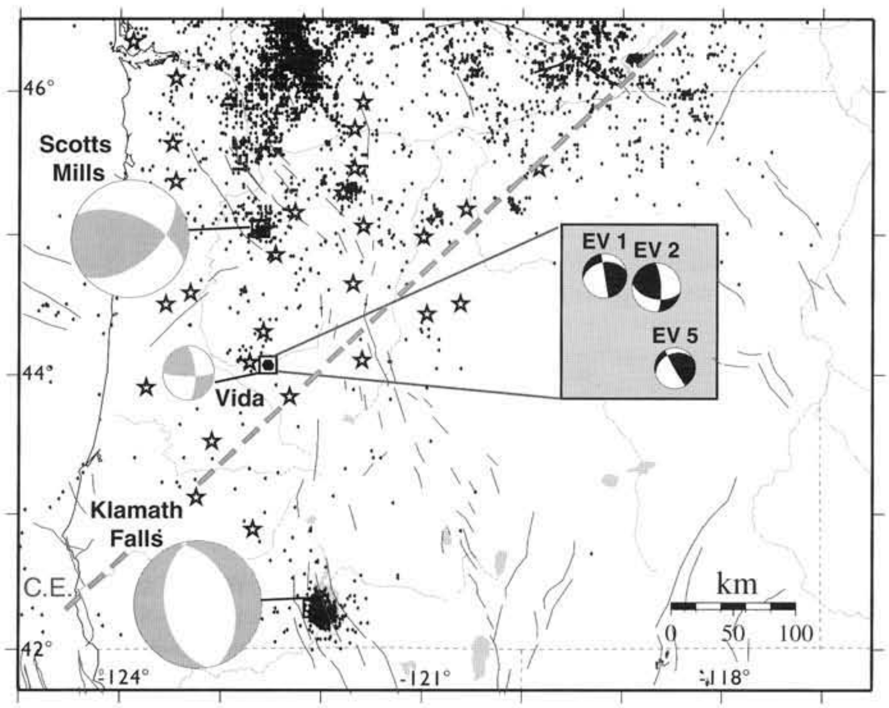

Figure 2. Map of Oregon locating active faults (dark lines) compiled by Pezzopane and Weldon (1993); PNSN earthquake epicenters 1970-1998 (black dots); the 1997 Vida swarm (boxed circle); and seismometer sites (stars) used in this study. The site west of the swarm, and closest to it, is site DHN, deployed by the University of Oregon. Other sites are PNSN stations. The gray-and-white "beach balls" are moment tensors for the 1997 Vida swarm (central ball), the M 5.7 Scotts Mills earthquake of 1993 (northern ball), and the M 5.9 and 6.0 Klamath Falls main shocks of 1993 (southern ball). The dashed gray line labeled "C.E." indicates the southern edge of the Columbia Embayment (Riddihough and others, 1986). Inset: Individual focal mechanisms for the three largest earthquakes in the 1997 Vida swarm, arranged according to relative epicenters. For these focal mechanisms, we used a PNSN crustal model; the other models gave quite similar results.

east of Eugene (D. Toomey, UO seismologist, oral communication, 1996). None of the 1996 earthquakes were large enough to be well-located by PNSN.

DATA AND ANALYSIS

For the three largest earthquakes in the 1997 Vida swarm, we have made focal mechanisms and a summed seismic moment tensor (Figure 2). A focal mechanism uses seismic energy radiation patterns to identify nodal planes, the two most likely orientations of the fault plane on which earthquake slip occurred. Two orientations are possible because the energy radiates symmetrically. Other geologic or seismologic evidence is then required to determine which nodal plane represents the fault plane. Summed moment tensors use nodal planes and earthquake sizes to calculate net deformation (strain) and can be represented as focal mechanisms. Focal mechanisms and moment tensors both allow inferences about regional tectonic stresses.

The making of our focal mechanisms required (1) knowledge of first-motion polarities at our seismometer sites (did the first seismic energy move the ground up or down?) and (2) a model of crustal structure in order to estimate the velocities of the seismic waves as they traveled from the fault plane to seismometers. We used P-wave polarity data from PNSN phase files, and we made additional first-motion picks (determinations) (Figure 3) after scrutinizing PNSN seismometer recordings of the events. We had from 15 to 26 picks per earthquake, and our results were all reasonably well constrained.

We tested three one-dimensional models of crustal structure. Two models assumed horizontal layers with unchanging velocities within layers: the model of northern and central Oregon used by PNSN in routine earthquake processing (R. Ludwin, written communication, 1998) and an amendment of a model used in Scotts Mills, Oreg. (Thomas and others, 1996), and Puget Sound, Wash. (Crosson, 1976). Our third model assumed linear increase of velocity with depth, with increases at a rate that best fit the layers of our two other models.

We employed widely used applications throughout our analysis: We made our polarity and arrival picks in SAC (Seismic Analysis Code, Tapley and others, 1990), redetermined event locations with HYPOINVERSE (Klein, 1989), and constructed focal mechanisms with FPFIT (Reasonberg and Oppenheimer, 1985). We calculated moment tensors using the equations of Aki and Richards (1980) and displayed results with Generic Mapping Tools (see Wessel and Smith, 1995).

RESULTS AND DISCUSSION

Our best constrained focal mechanisms and moment tensors are predominantly strike slip, with a component of reverse motion (Figure 2). All are consistent with regional maximum compressive stress that is roughly north-south, as has been found by many other workers (Thomas and others, 1996). Given the small, brief earthquake sequence and the forested epicentral area, we lack outside evidence to confirm a nodal plane; but the planes with right-oblique reverse slip are in best accord with other Oregon earthquakes (Pezzopane and Weldon, 1993). Right-lateral slip is consistent with the relative plate motion in this region of oblique subduction (Wells and others, 1998), where the Juan de Fuca and North American plates do not collide head-on.

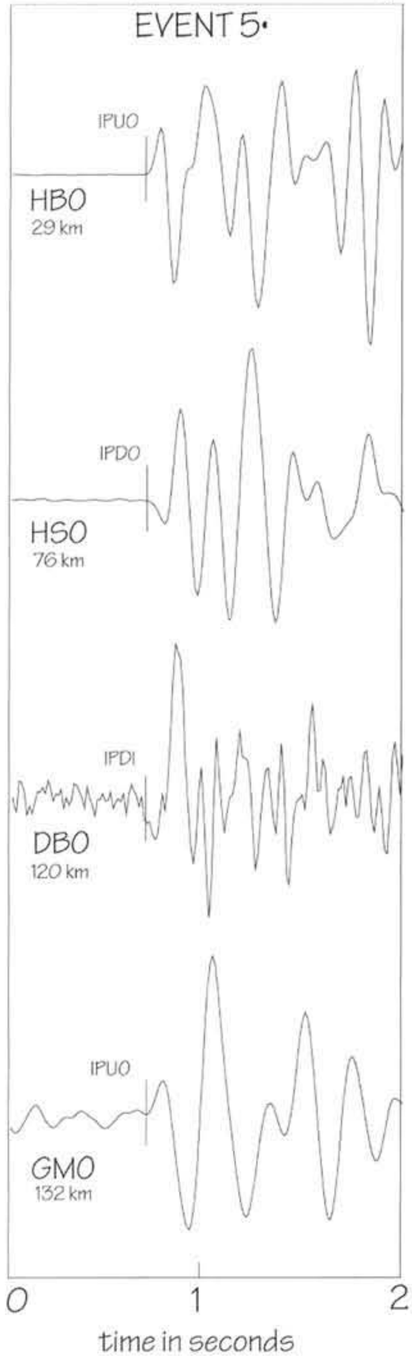

Figure 3. Representative first-motion P-wave picks for earthquake 5 of this study. PNSN station names and source distances are listed with each time domain trace. All are vertical components.

The most likely nodal plane is steeply dipping and trends north-northwest. All our focal mechanisms and summed tensors for all three of our crustal models had this plane in common. However, the dip is not unique: Some places dip steeply west and some dip steeply east. Additionally, the epicenters of the five largest swarm events (Table I and inset of Figure 1) delineate a north-northwest trend. If we assume they ruptured the same fault, then, because the event locations deepen to the east, they imply a fault plane dipping steeply to the east. Location uncertainties are greater than the distances among the events, so their absolute locations may differ from our results. However, the relative locations of the events are likely to be preserved.

It is doubtful that any one-dimensional model could fully represent the Oregon crust throughout the wide area covered by seismometers in this study. Given the two plates and the volcanic arc, modeling the crust with horizontal, homogeneous layers and linear increase of velocity with depth is clearly a simplification. However, the three models we tested gave generally quite similar results.

The Vida moment tensor is similar to that of the M 5.7 Scotts Mills earthquake of 1993, which was right-lateral with a much larger reverse component (Figure 2; Thomas and others, 1996). Both stand in contrast to the normal motion of the M 5.9 and 6.0 Klamath Falls earthquakes of 1993 (Figure 2; Braunmiller and others, 1995). In the Pacific Northwest, the sense of fault motion and stress regime changes as one moves from north to south (Pezzopane and Weldon, 1993; Blakely and others, 1995). It is not known where the change occurs. In Washington (Wells and others, 1998) and northwestern Oregon (Thomas and others, 1996), maximum compressive stress is approximately north-south, minimum compressive stress is vertical, and principal faulting style is reverse. In south-central Oregon, maximum compressive stress is vertical, minimum compressive stress (i.e., maximum extension) is roughly east-west, and faulting is primarily normal (Pezzopane and Weldon, 1993).

We hypothesize that (1) the Vida sequence demarcates a strike-slip transition zone between these regimes; and (2) the boundary between regimes aligns with, and may be controlled by, the edge of the Columbia Embayment. The Columbia Embayment consists of accreted oceanic terranes underlying northwestern Oregon (Figure 2, Riddihough and others, 1986). To test these hypotheses, we are currently analyzing focal mechanisms of small earthquakes that have occurred throughout the region.

CONCLUSIONS

While it would be a mistake to infer too much from any trio of magnitude 2 earthquakes, these three are internally and regionally consistent. This is encouraging, because it suggests that a coherent and valuable story can be told through ongoing measurement and analysis of Oregon's limited background seismicity. Additionally, this seismicity can be used to test hypotheses about styles of deformation and movement in the region.

ACKNOWLEDGMENTS

Thanks to Pat Ryan and Dennis Fletcher for their deployment efforts. This article was improved by the reviews of Miles Kenney and Yumei Wang. The study was funded by the Oregon Department of Geology and Mineral Industries.

REFERENCES

Aki, K., and Richards, P., 1980, Quantitative seismology. Theory and methods, v. I: San Francisco, Calif., W.H. Freeman and Co., 557 p.

Blakely, R.J., Wells, R.E., Yelin, T.S., Madin, I.P., and Beeson, M.H., 1995, Tectonic setting of the Portland-Vancouver area, Oregon and Washington: Constraints from low-altitude aeromagnetic data: Geological Society of America Bulletin, v 107, no. 9, p. 1051–1062.

Braunmiller, J., Nabelek, J. Leitner, B., and Qamar, T., 1995, The 1993 Klamath Falls, Oregon, earthquake sequence: Source mechanisms from regional data: Geophysical ResearchLetters, v. 22, p 105–108.

Crosson, R., 1976, Crustal structure modeling of earthquake data, 2. Velocity structure of the Puget Sound Region, Washington: Journal of Geophysical Research, v. 81, p 1133–1171.

Klein, F., 1989, A user's guide to HYPOINVERSE: U.S. Geological Survey Open-File Report 89–314, 61 p.

Mortenson, E., 1997, Earthquakes in Vida: Eugene, Oreg., The Register Guard, May 23, 1997, p 1.

Pezzopane, S., and Weldon, R. II, 1993, Tectonic role of active faulting in central Oregon: Tectonics, v. 12, no. 5, p 1140–1169.

Reasonberg, P., and Oppenheimer, D., 1985, FPFIT, FPPLOT, and FPPAGE: FORTRAN computer programs for calculating and displaying earthquake fault plane solutions: U.S. Geological Survey Open-File Report 85–739, 109 p.

Riddihough, R., Finn, C., and Couch, R., 1986, Klamath-Blue Mountains lineament, Oregon: Geology, v. 14, no. 6, p 528–531.

Tapley, W., Tull, J., Norman, L., and Goldstein, L., 1990, SAC Command reference manual, version 10.5d.

Thomas, G.C., Crosson, R.S., Carver, D.L., and Yelin, T.S., 1996, The 25 March 1993 Scotts Mills, Oregon, earthquake and aftershock sequence: Spatial distribution, focal mechanisms, and the Mount Angel Fault: Seismological Society of America Bulletin, v. 86, no. 4, p 925–935.

Wells, R.E., Weaver, C.S., and Blakely, R.J., 1998, Fore-arc migration in Cascadia and its neotectonic significance: Geology, v. 26, no. 8, p 759–762.

Wessel, P., and Smith, W., 1995, New version of the Generic Mapping Tools released: EOS, v. 76, no. 33, p 329.

Earthquake updates

A small earthquake that occurred on Thanksgiving Day near Woodburn has been upgraded to a magnitude (M) 3.5 (from M 3.2). The earth movement was about 18 mi deep, which is somewhat unusual, and probably accounts for the widespread reports from people feeling the small earthquake.

"It's a very small earthquake and we get these frequently in Oregon," explains Lou Clark, the Earth Science Information Officer for the Oregon Department of Geology and Mineral Industries (DOGAMI).

In the Woodburn-Molalla-Mount Angel area, there have been 12 other earthquakes this year. The largest was the M 2.7 earthquake on February 24, which cracked plaster at Oregon City High School. Other events were between M 1.5 and M 2.3. None of these events were related to the 1993 Spring Break Quake (M 5.6), which was centered near Scotts Mills.

On Sunday, November 28, a small earthquake located near the epicenters of the devastating 1993 quakes was felt in the Klamath Falls area. The M 3.4 earthquake struck at 8:04 p.m., came from a depth (hypocenter) of about 5 mi and was located 13.9 mi WNW of Klamath Falls. There have been no reports of damage.

Three small aftershocks were registered in the same area on the following day. They had magnitudes between M 1.5 and 1.8 and were not felt except by the seismographs.

"Due to the amount of faulting in the area, this is not unexpected for such a geologically active region," explained James Roddey, the Community Education Coordinator for DOGAMI.

"At this point we don't know how it relates to the magnitude 5.9 and 6.0 earthquakes that hit the area on September 20th, 1993. But it was in the general vicinity of those two quakes. Hundreds of small aftershocks followed the 1993 quakes, some larger than Sunday's quake, but the area has been quiet for some time," noted Roddey.

DOGAMI geologists recently finished field work and technical review for relative earthquake hazard maps of the Klamath Falls area. These maps will combine the effects of ground shaking amplification, liquefaction, and earthquake-induced landsliding to show the earthquake hazards relative to the local geologic conditions. Individual maps for ground shaking amplification, liquefaction, and earthquake-induced landsliding will also be produced as part of the set. No date has been set for the release of these maps, but they should be available sometime in the summer of 2000.

New earthquake hazard maps for western Oregon communities, including Grants Pass and Ashland, will be released January 26, 2000, the 300th anniversary of the last great Cascadia subduction zone earthquake.

Earthquake magnitudes are logarithmic, so each higher number means 30 times more energy was released. For example, the M 5.6 Spring Break quake released 900 times more energy than this morning's M 3.5 earthquake.

The Oregon Department of Geology and Mineral Industries has prepared earthquake hazard maps of the Portland and Salem metro areas and coastal communities. Maps for about 40 other communities in western Oregon are scheduled to become available in January.

To get information about how to protect yourself in an earthquake or to purchase maps, contact the Nature of the Northwest Information Center, 800 NE Oregon St., Portland, phone (503) 872-2750, http://www.naturenw.org.

The Miocene Metasequoia Creek[1] flora on the Columbia River in northwestern Oregon

by William F. Krause, 8730 N. Chase Avenue, Portland, Oregon 97217

ABSTRACT

Fossil plants from an exposure on Metasequoia Creek are identified and discussed in relation to vegetational, climatic, and oceanographic interpretations of similar floral assemblages from the Eagle Creek, Lyons, and Rujada floras. These floras are thought to be contemporaneous with floras of the John Day Formation.

The floral assemblage includes species of eight probable genera and several species as yet unidentified. The exposure's flora was first dominated by species of the conifer *Metasequoia*, the dawn redwood, and then, in progressively higher levels, by a broadleaf flora. This flora appears to correspond to that of the Mixed Northern Hardwood forest of eastern Asia.

INTRODUCTION

Metasequoia Creek (Figure 1) has been so named due to an abundance of Metasequoia needle and cone fossils found at the creek mouth on the south shore of the Columbia River, 37 mi east of Portland, Oregon, and 2 mi west of Bonneville Dam (lat 121°59′13″, long 45°37′12″; sec. 30, T. 2 N., R. 7 E.; U.S. Geological Survey Tanner Butte 7½-minute quadrangle). The location is difficult to find, which could explain the lack of published information.

[Editor's note: The location has no public access and is dangerously close to both the Interstate Highway and the parallel railroad tracks; various private and public authorities control different portions of the area. We advise strongly not to attempt any unauthorized visits.]

The only earlier description of this fossil exposure was published by J. Le Conte (1874), who found, near the mouth of Moffett Creek, a layer of conglomerate "limited above by a very distinct irregular dark line, traceable for a mile or more along the river, which had all the characters of a dirt-bed or old ground surface." And "resting directly on this ground surface . . . a layer of stratified sandstone two or three feet thick, filled with beautiful impressions of leaves of several kinds of

(Continued on page 114)

1 This name for the as yet unnamed creek has been formally submitted to the Oregon Board of Geographic Names, which is administered by the Oregon Historical Society.

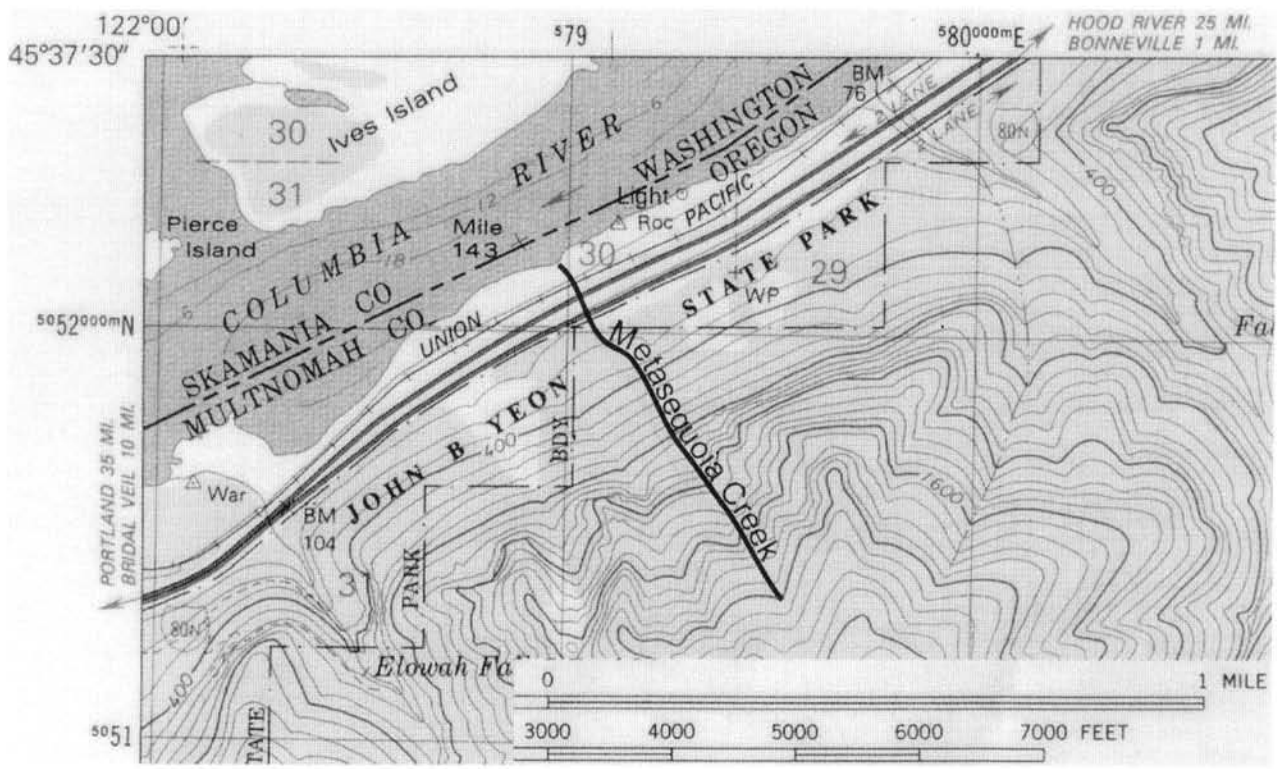

Figure 1. Map showing general area where fossils described in this paper were found. Metasequoia Creek runs between McCord Creek on the west and Moffett Creek on the east. It is as yet only informally named and here inserted by hand and approximately in the U.S. Geological Survey topographic map of the Tanner Butte quadrangle.

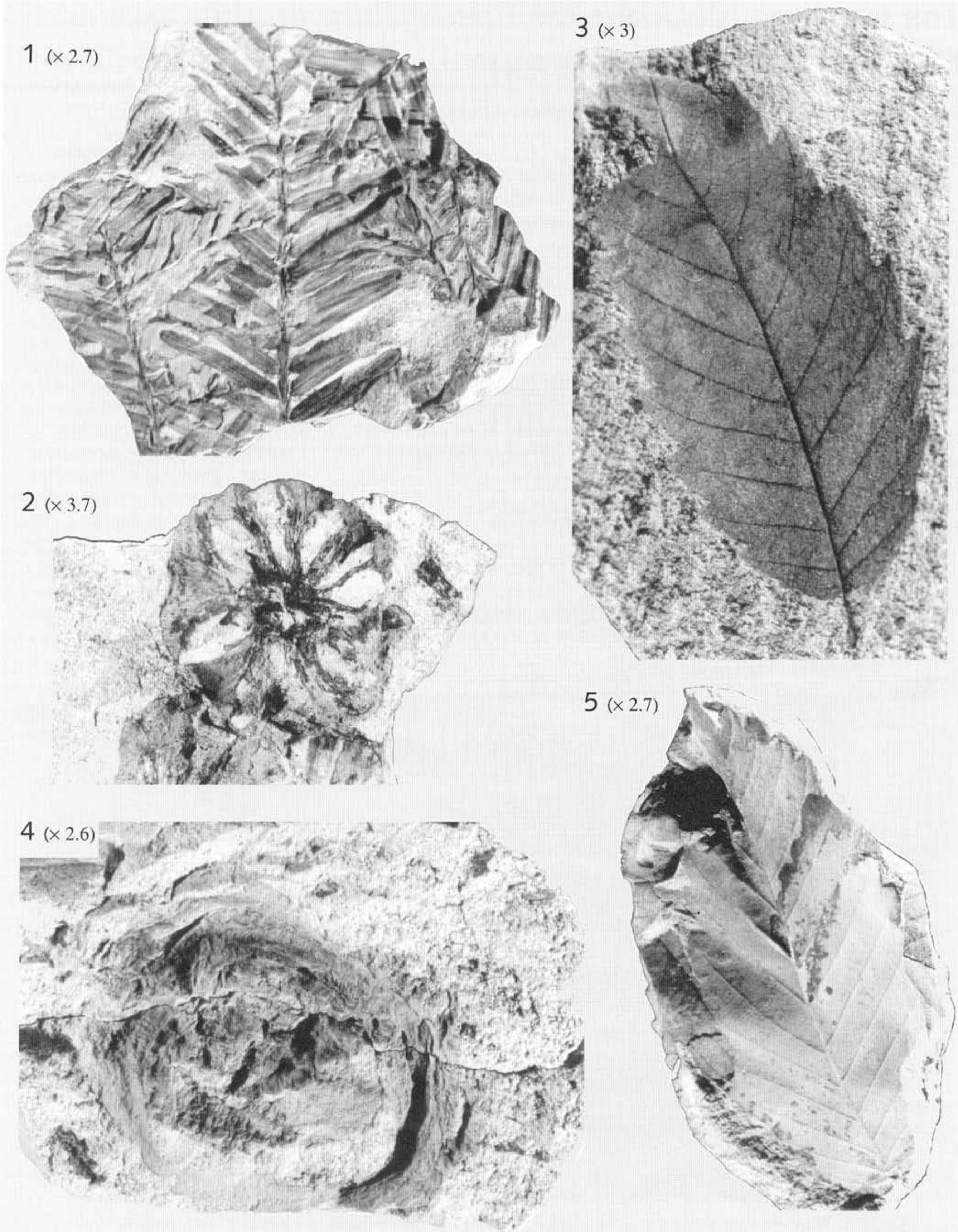

Plate 1. Plant fossils from Metasequoia Creek. 1–2. Conifers: *Metasequoia occidentalis* (leaves and seed cone); 3. *Incertae sedis* (*Fagus* sp.?); 4. Beech family: Nut of *Fagus pacifica* (beechnut); 5. Elm family: *Ulmus pseudoamericana* (elm).

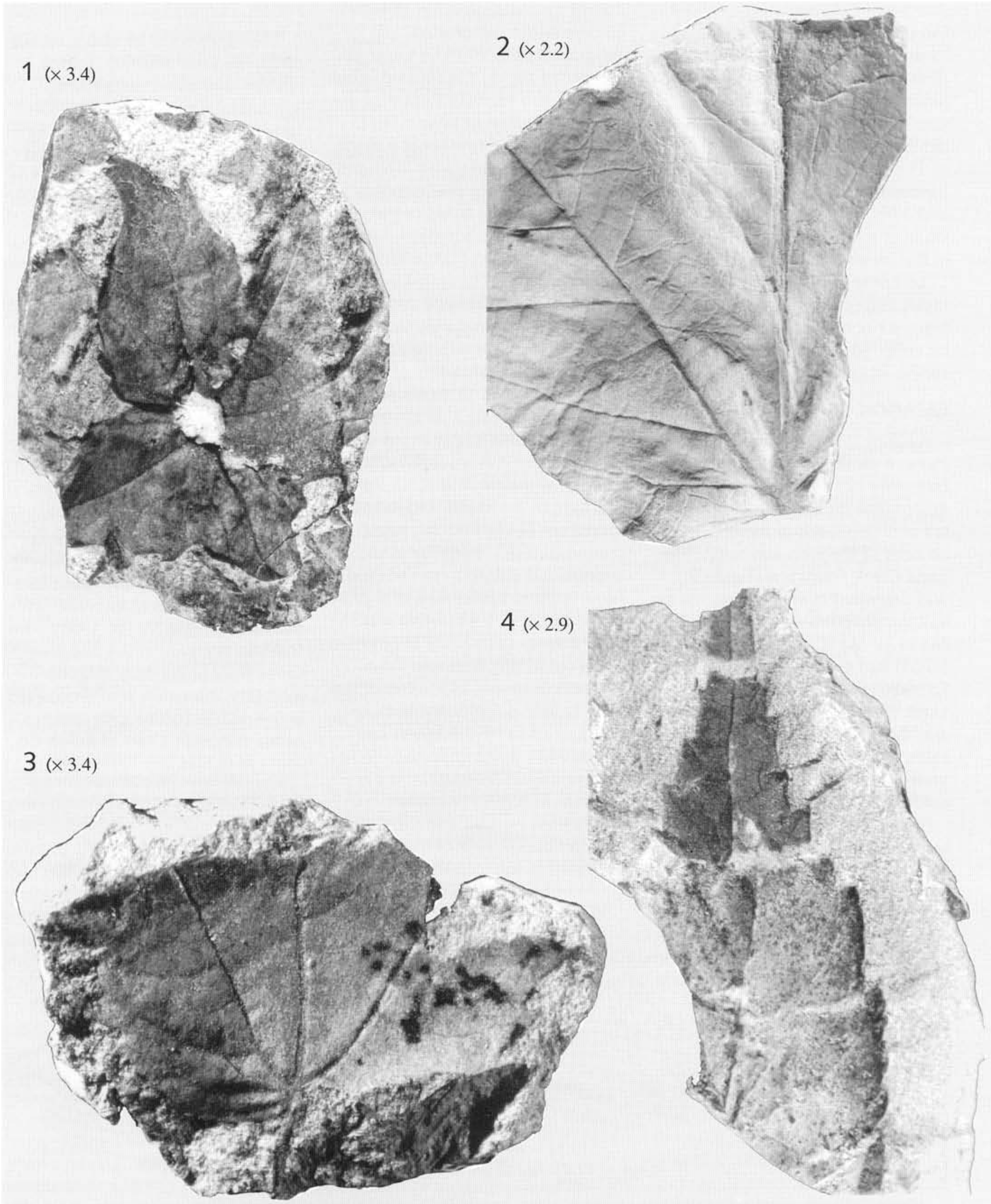

Plate 2. Plant fossils from Metasequoia Creek. 1–3. Sycamore family (Platanaceae): *Platanus* stipule and leaves; 4. Birch family (Betulaceae): *Alnus* leaf.

(Continued from page 111)

forest trees." Silicified tree stumps, "with their roots spread out and penetrating the boulder material beneath, and therefore evidently in situ," convinced him that it was "an old forest-ground surface."

This description matches the dark band containing carbonaceous fossils and overlain by several feet of siltstone at the fossil locality described in the present paper.

Le Conte also reported that the highly respected paleobotanist Leo Lesquereux had identified some of his collected specimens as oak and conifer of probable Miocene age.

GEOLOGIC SETTING

Chaney (1918) described 80 species in a nearby, younger, Eagle Creek Formation floral assemblage and suggested that the Eagle Creek flora resembled the fossils in the upper Clarno beds of the John Day basin. The Eagle Creek Formation (Figure 2) was deposited toward the end of the volcanically quiescent period from 38 Ma to 18 Ma (Carlin, 1988). Wise (1961) had divided the Eagle Creek Formation into the lower Miocene Eagle Creek Formation (24–18 Ma) and the upper Oligocene Weigle Formation (30–24 Ma), with the two units being separated by a slight unconformity and a saprolite layer.

The fossils occur in a 4-ft band of six fossiliferous siltstone layers. This band has a 3-in. base of dark, carbonaceous material that is interpreted here as the compressed "old forest-ground surface" of Le Conte as mentioned above. It is situated above the clay-rich saprolite surface of the Weigle formation of Wise (1961).

The dark base consists of a single compressed carbonaceous layer and contains exclusively *Metasequoia* fossils. The middle layers contain *Metasequoia* and broadleaf flora. The upper layers contain exclusively broadleaf flora.

About 23 silicified and carbonaceous log and stump sites occur in the ¾-mi fossil zone centered on Metasequoia Creek. Some of these were described by Le Conte (1874). Some contain agate and common opal. The largest tree stump is 15 ft tall and about 4 ft around and is held up by matrix on its back side. The base of this stump and its roots spread out below the "old forest-ground surface," evidently in situ. It appears that volcanic ash and mud flows covered the remains of a grove of *Metasequoia* trees, which were subsequently covered by progressive layers containing broadleaf flora.

The rediscovery, as it were, of this fossil locality is significant because this appears to be the lowest and perhaps oldest known locality within the Eagle Creek Formation. It has not been described previously and differs from typical Eagle Creek Formation flora because of the presence of *Metasequoia*.

FOSSIL PLANTS[1]

The fossils occur as carbonaceous compressions in siltstone. Leaves, needles, and cones were found. Specimens were recovered by surface examination of the laminated bedding planes that had separated from sandy layers of matrix.

Identification of the flora is based on comparison with photos and descriptions of similar specimens in the Lyons and John Day floras. The result is that the assemblage from the Metasequoia Creek area contains eight possible species, one conifer and seven broadleaf plants, and several specimens best assigned to *incertae sedis*.

Needles and cones of the conifer *Metasequoia occidentalis* (dawn redwood) are abundant in the lowermost layers of the exposure (Plate 1, nos. 1, 2). This conifer has deciduous rather than evergreen foliage and differs from other conifers in having opposite rather than alternative needles along the axis of its branchlets (Manchester and Meyer, 1987). This tree was common in the Bridge Creek flora of the early Oligocene John Day Formation. It also occurred in the middle Eocene peat swamps of the Princeton Chert of British Co-

[1] All specimens are still in the possession of the author, who is in contact with several possible repository institutions for a final disposition of the fossils.

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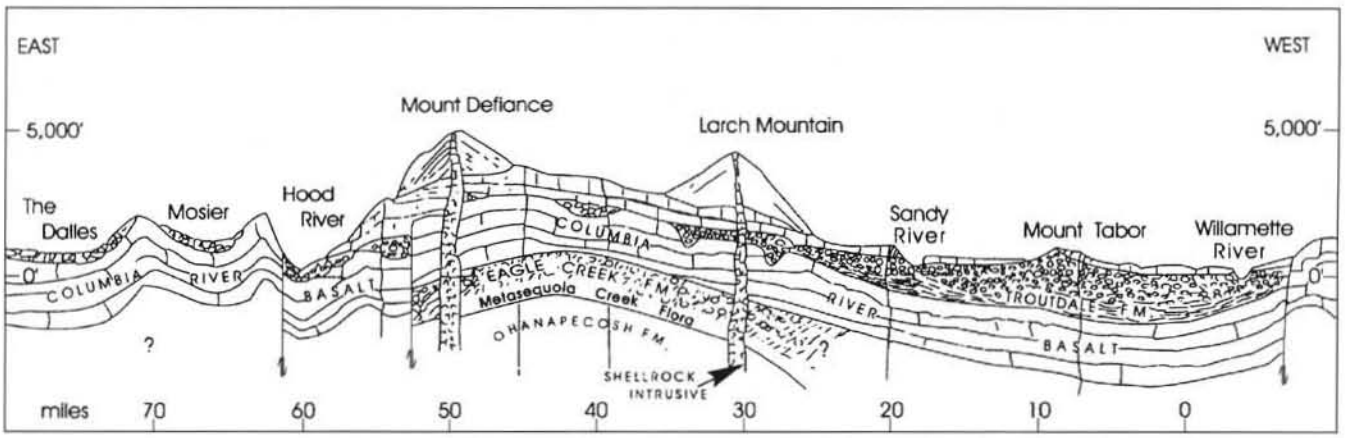

Figure 2. Diagrammatic cross section showing relative positions and attitudes of geologic formationson the south side of the Columbia River Gorge and including relative position of Metasequoia Creek flora. Vertical scale is exaggerated. Modified from Allen (1979).

PLEASE SEND US YOUR PHOTOS

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

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

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

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

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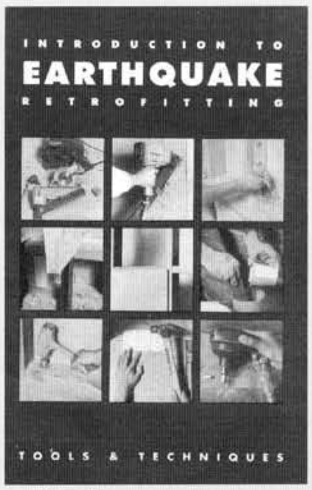
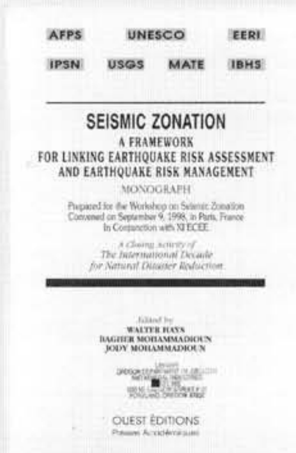
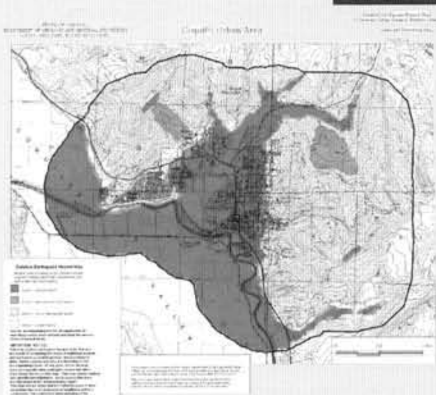




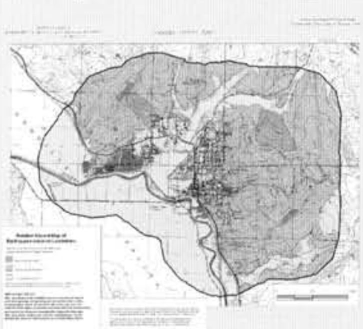
The United Nations recently published a monograph on using earthquake risk assessment as tool in reducing earthquake losses. Among the multinational list of authors are Oregon's State Geologist John Beaulieu and Earthquake Program Director Yumei Wang. Oregon is a leader in earthquake risk assessment; a preliminary report this year estimated more than $12 billion of damage and 5,000 deaths in the event of a magnitude 8.5 Cascadia subduction zone earthquake. The monograph is a summary of how other countries and states are dealing with earthquake hazards: **Seismic Zonation: A framework for linking earthquake risk assessment and earthquake risk management.** $40, 157 pages



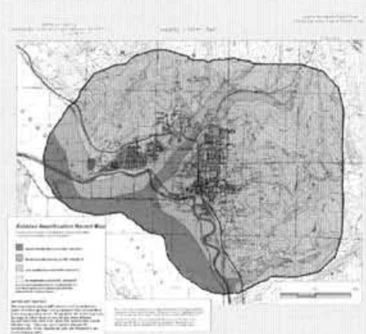
Coquille combined hazard map

Earthquake damage depends on a number of factors, including the rock and soil types that make up the ground in a given area. A new series of maps focuses on the relative ground response of coastal communities during an earthquake: Maps are available for Astoria-Warrenton, Brookings, Coquille, Florence-Dunes City, Lincoln City, Newport, Reedsport-Winchester Bay, Seaside-Gearhart-Cannon Beach, and Tillamook.

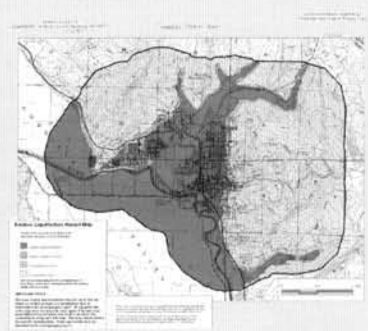
For each city, four maps are included, each showing a different hazard: amplification, liquefaction, landslides, and combined hazards. A CD with GIS information is included. The area mapped was slightly larger than the urban growth boundary of each city. These are relative ground response maps and should be used in conjunction with GMS 100, which shows where known faults are and what the extent of bedrock shaking may be. **Relative Earthquake Hazard Maps for Selected Urban Areas,** IMS–10, $20.



Coquille landslide map



Coquille amplification map



Coquille liquefaction map

(Continued from page 114)
lumbia. It was a peat-swamp plant like swamp cypreses today and may be of the same species as the living *M. glyptostroboides* (Retallack and others, 1996).

The Platanaceae (sycamore family) are represented by *Platanus* cf. *P. condoni*, with fan-shaped, five-lobed leaves (Plate 2, nos. 1–3). Some fruiting heads and a petiole were also found.

Two species of Ulmaceae (elm family) were found: *Ulmus* cf. *U. pseudo-americana* (Plate 1, no. 5) has compound teeth and an asymmetrical base; *Tremophyllum* cf. *T. hesperium* has leaves that are relatively narrow and have blunt teeth.

The Betulaceae (birch family) are represented by *Alnus* cf. *hollandiana* (Plate 2, no. 4). The leaves are ovate to elliptical with numerous small blunt teeth and have nonparallel, slightly concave secondary veins.

The Fagaceae (beech family) are represented by *Quercus* cf. *Q. consimilis* and *Fagus* cf. *pacifica* (Plate 1, nos. 3? and 4), whose leaves both have secondary veins that enter a tooth at the margin.

CONCLUSION

In comparison with floras of similar age in central and western Oregon, the Metasequoia Creek fossil flora appears to resemble the Lyons (Meyer, 1973) and Rujada (Lakhanpal, 1958) floras—closer to the Oregon coast and thus with a higher annual temperature than the inland area with floras in the John Day Formation (Wolfe, 1981; Manchester and Meyer, 1987).

The upper layer fossils at this locality are much like the present flora alive in the area. Elm, birch, and oak are quite common. Sycamores are no longer native. The lower layer's dominant fossils of *Metasequoia* have been replaced by western hemlock. Then and now, the assemblage is similar to temperate, hardwood, deciduous forests of eastern Asia (Wang, 1961). In general, the flora and vegetation would look similar but contrast in a few species changed due to cooling weather. At present, there are more shrubs than trees, which seems opposite the fossil record.

Table 1. Fossil plant list

Conifer:

TAXODIACEAE

Metasequoia cf. *M. occidentalis* [needles, cones, pollen cones]

Flowering plants:

DICOTYLEDONS

Platanus cf. *P. aspera* [leaves, stipules, fruiting heads)

Platanus cf. *P. condoni* [leaves, petiole, fruiting heads]

ULMACEAE

Ulmus cf. *U. pseudo-americana* [leaves]

Tremophyllum cf. *T. hesperium* [leaves]

FAGACEAE

Quercus cf. *Q. consimilis* [leaves, cupule]

Fagus cf. *F. pacifica* [leaves]

BETULACEAE

Alnus cf. *A. hollandiana* [leaves, catkin]

ACERACEAE

Acer cf. *A. ashwilli*

JUGLANDACEAE

Carya sp. [hickory nut]

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REFERENCES CITED

Allen, J.E., 1979, The magnificent gateway. A layman's guide to the geology of the Columbia River Gorge: Forest Grove, Oreg., Timber Press, 144 p. .

Carlin, R.A., 1988, A geochemical study of the Eagle Creek Formation in the Columbia River Gorge, Oregon: Portland, Oreg., Portland State University master's thesis, 90 p.

Chaney, R.W., 1918, The ecological significance of the Eagle Creek flora of the Columbia River Gorge: Journal of Geology, v. 26, no. 7, p. 577–592.

Lakhanpal, R.N., 1958, The Rujada flora ot west-central Oregon: University of California Publications in Geological Sciences, v. 35, no. 1, 66 p.

Le Conte, J., 1874, On the great lava flood of the Northwest; and on the structure and age of the Cascade Mountains: American Journal of Science, 3d ser., v. 7, p. 167–180, p. 259–267.

Manchester, S.R., and Meyer, H.W., 1987, Oligocene fossil plants of the John Day Formation, Fossil, Oregon: Oregon Geology, v. 49, no. 10, p. 115--127.

Meyer, H.W., 1973, The Oligocene Lyons flora of northwestern Oregon: Oregon Department of Geology and Mineral Industries, Ore Bin, v. 35, no. 3, p. 37–51.

Retallack, G.J., Bestland, E.A., and Fremd T.J., 1996, Reconstructions of Eocene and Oligocene plants and animals of central Oregon: Oregon Geology, v. 58, no. 3, p. 51–69.

Wang, C.W., 1961, The forests of China: Cambridge, Mass., Harvard University, Publication of the Maria Moors Cabot Foundation, 313 p.

Wise, W.S., 1961, The geology and mineralogy of the Wind River area, Washington, and the stability relations of celadonites: Baltimore, Md., John Hopkins University doctoral dissertation, 2 vols., 258 p.

Wolfe, J.A., 1981, Paleoclimatic significance of the Oligocene and Neogene floras of the northwestern United States, in Niklas, K.J., ed., Paleobotany, paleoecology, and evolution: New York, Praeger, p. 79–101.

New DOGAMI field office in Newport

The last Legislature approved funding for a new coastal field office of the Oregon Department of Geology and Mineral Industries (DOGAMI). DOGAMI will thus be able to offer coastal communities a wider range of geologic information services.

The office will be staffed with Dr. George Priest, already part of the DOGAMI staff, and a new coastal specialist. It will be located at the office of the Oregon Coastal Zone Management Association (OCZMA) on Highway 101 in Newport. OCZMA has offered some secretarial support and provides a link to local government and port districts.

The office will be opened early next spring. An open house at that time will celebrate our expanded capabilities for dealing with coastal geologic hazards and give interested people an opportunity for a first visit. More information will be distributed at a later date.

Site-specific seismic reports in DOGAMI library nearing 200

Part 2—Second half of Oregon counties outside Portland metropolitan area

On May 1, 1994, the Oregon Structural Specialty Code, a part of the Oregon Administrative Rules, was changed to order that a copy of each legally required "seismic site hazard report" should be deposited with the DOGAMI library and accessible to the public for inspection. This growing collection now holds nearly 200 reports. The following list is derived from the records in the library's bibliographic database. It is organized by county and USGS 7½-minute topographic quadrangle.

This list covers the second half of the quadrangles in counties outside the Portland metropolitan area. The Portland metropolitan area will be included in the next issue of Oregon Geology. A few reports are associated with more than one quadrangle.

LINCOLN COUNTY QUADRANGLES

Lincoln City

15660. Braun Intertec Corporation (1996): Site-specific seismic evaluation, proposed Taft-Nelscott-Delake fire station, 4500 block of SE Hwy. 101, Lincoln City, Oregon. (Report for Taft-Nelscott-Delake Rural Fire Protection District, Project No. EAAX-95-0459), 14 p., 3 figs., 11 p. app.

Newport North

15610. Fujitani Hilts and Associates,Inc (1997): Site-specific seismic site hazards evaluation, Ambulance Service Building, NW 6th and Coast Streets, Newport, Oregon. (Report prepared for Miller Consulting Engineers, Portland, Oregon, Project No. F-2893-01), 10 p., 2 figs.

Newport South

15641. Robert Deacon,Staff Consultant (1994): Geologic, tectonic, and seismic studies, proposed new addition, Hatfield Marine Science Center, Newport, Oregon. (Report by Foundation Engineering,Inc., Project No. 94200038), 11 p., 3 figs., 1 table.

Toledo North

962. David J. Newton Associates (1996): Geotechnical investigation and seismic hazard report for the Toledo High School additions, 1800 NE Sturdevant Road, Toledo, Oregon. (Report for Luey Architects, 11945 SW Pacific Hignway, Suite 301, Tigard, Oregon 97223; Project no. 644 111), 19 pages, 4 figs., 14 p. app.

Waldport

13350. David J. Newton Associates (1995): Geotechnical investigation and seismic hazards report, Waldport High School Gymnasium, Waldport, Oregon. (Report for Lincoln County School District, Facilities and Maintenance, South Beach, Oregon, Project No. 621 121), 18 pages, 12 p. app.

14880. David J. Newton Associates (1996): Geotechnical investigation and seismic hazards report, new Taft High School, High School Driveat SE Spyglass Ridge Drive, Lincoln City, Oregon. (Report for Lincoln County School District, Project No. 621 101), 19 pages, 5 figs., 15 p. app.

14886. David J. Newton Associates (1996): Geotechnical investigation and seismic hazards report, proposed new Newport Middle School, Newport, Oregon. (Report for Luey Architects, Portland, Project No. 644 101), 23 pages, 5 figs., 24 p. app.

14879. David J. Newton Associates (1996): Geotechnical investigation and seismic hazards report, proposed Waldport Elementary School, Crestline Drive, Waldport, Oregon. (Report for Lincoln County School District, Project No. 621 111), 19 pages, 5 figs., 7 p. app.

MALHEUR COUNTY QUADRANGLES

Malheur Butte

16551. Geocon Northwest (1999): Site-specific seismic hazard study, water reservoir, Ontario, Oregon. (Report for Keller Associates, Meridian, Idaho, Project No. P1016-05-01), 7 p., 2 figs.

MARION COUNTY QUADRANGLES

Mission Bottom

12582. Redmond & Associates (1995): Seismic site characterization and hazard evaluation, proposed Opengate Church of the Nazarene, Keizer (Marion County), Oregon. (Report for Multi/Tech Engineering Services, Inc., Salem, Oreg., Project No. 101.021.G), 6 pages, 8 figs.

Salem East

15302. Kleinfelder,Inc (1996): Phase I geotechnical study, Oregon Department of Corrections, Hay Field site, Salem, Oregon, ODC #MN-SM-3. (Report for KPFF Consulting Engineers/ODC, Project No. 60-8080-13), 3 tables (text missing?)

Salem West

12588. AGRA Earth & Environmental (1995): Site-specific seismic study, proposed Siltec silicon facility, Fairview Industrial Park, Salem, Oregon. (Report prepared for Takenaka International (U.S.A), Ltd., Job No. 21-07612-02), 6 pages, 2 figs.

12070. Carlson Testing,Tigard (1994): Seismic hazards report, Far South Middle School site, Liberty and Davis Roads, Marion County, Oregon. (Report prepared for Salem/Keizer School District Facilities Planning, CTI Job No. 93-8867), 26 pages.

15640. Foundation Engineering,Inc (1996): Leslie Middle School replacement, site-specific seismic study, Salem, Oregon. (Report for Salem-Keizer School District, Salem, Oregon, Project No. 96100050), 6 pages, 2 figs.

Silverton

14871. David J. Newton Associates (1996): Geotechnical investigation and seismic hazard report for the Silverton Main Fire Station, 819 Railway Drive, Silverton, Oregon. (Report for Silverton Fire District, c/o Arbuckle Costic Architects, P.C., Salem; Project no. 634 101), 23 pages, 4 figs., 1 table, 16 p. app.

MORROW COUNTY QUADRANGLES

Boardman

12562. Ebasco (1994): Seismic hazards evaluation and dynamic analyses for Coyote Springs power generation project. (Report prepared for Portland General Electric Company) (Gray Literature Collection, Earthquakes-power plant siting.) Ebasco Division of Raytheon Engineers and Constructors, Bellevue, Wash. var. pages.

12563. Ebasco (1994): Site densification report for Coyote Springs power project, Boardman, Oregon. (Report prepared for Portland General Electric Company), var. p.

15297. Kleinfelder,Inc (1996): Phase I geotechnical study, Oregon Department of Corrections, Pasture (Kunze Road) site, Boardman, Oregon, ODC #MR-BD-2. (Report for KPFF Consulting Engineers/ODC, Project No. 60-8080-11), 5 pages, 1 fig., 3 tables.

Crow Butte

15286. Kleinfelder,Inc (1996): Phase I geotechnical study, Oregon Department of Corrections, Boeing site, Boardman, Oregon, ODC #MR-BD-1. (Report for KPFF Consulting Engineers/ODC, Project No. 60-8080-10), 5 pages, 1 fig., 3 tables.

POLK COUNTY QUADRANGLES

Dallas

16053. Braun Intertec Corporation (1999): Site-specific seismic evaluation, proposed Aquatic Center, SE La Creole Drive, Dallas, Oregon. (Report for City of Dallas, Project No. EAAX-99-0131), 14 pages, 3 figs., 10 p. app.

15831. David J. Newton Associates (1997): Preliminary geotechnical investigation and seismic hazards evaluation for the proposed Polk county jail facility, property bounded by Jefferson, Court, and Shelton Streets, Dallas, Oregon. (Report for Polk County, Project No. 764-101), 27 pages, 4 figs., 21 p. app.

13385. Foundation Engineering,Inc (1995): Geotechnical investigation, Dallas ambulance facility, Dallas, Oregon. (Report for City of Dallas, Oregon, Project No. 95100008), 8 pages, 4 p. app.

Grand Ronde

15638. Foundation Engineering,Inc (1994): Seismic hazard study, Gaming Center site development, Grand Ronde, Oregon. (Report for Spirit Mountain Development Corporation, c/o Mater Engineering, Ltd., Corvallis, Oregon, Project No. P93100052; fault map and tectonic map by Wright/ Deacon & Assoc., Inc.), 23 p., 9 figs., 14 p. app.

15290. Kleinfelder,Inc (1996): Phase I geotechnical study, Oregon Department of Corrections, Steel Bridge site, Willamina, Oregon, ODC #PK-WM-1. (Report for KPFF Consulting Engineers/ODC, Project No. 60-8080-05), 5 pages, 1 fig., 3 tables.

Salem West

15639. Foundation Engineering,Inc (1994): Seismic study, Walker Middle School additions, Salem, Oregon. (Report for Salem-Keizer School District, Salem, Oregon, Project No. 94100105; fault map and tectonic map by Wright/Deacon & Associates, Inc.), 21 pages, 6 figs., 1 table, 12 p. app.

TILLAMOOK COUNTY QUADRANGLES

Tillamook

15292. Kleinfelder,Inc (1996): Phase I geotechnical study, Oregon Department of Corrections, Port of Tillamook site, Tillamook, Oregon, ODC #TL-TL-1. (Report for KPFF Consulting Engineers/ODC, Project No. 60-8080-04), 5 pages, 1 fig., 3 tables.

UMATILLA COUNTY QUADRANGLES

Hermiston

12525. Bechtel Power Corporation (1994): Final subsurface investigation and foundation report for the Hermiston generating project, Hermiston, Oregon, var. pages, 10 figs., 84 p. app.

12579. Squier Associates (1994): Geology, slope stability, and seismicity. Exhibit G. in: Hermiston power project, application for site certificate. (Submitted to the Oregon Energy Facility Siting Council, Job No. 93804; revised version submitted April 1995 by Hermiston Power Partnership, Boise, Idaho, Job No. 93804.1), p. 1-23 (attachments 4 p., 3 tables, 6 figs.)

Pendleton

15751. Strata Geotechnical Engineering,Idaho (1997): Seismic site hazard evaluation, Umatilla Criminal Justice Center, Umatilla County, Oregon. (Report for Umatilla County, Pendleton, Oreg., submitted by Lombard-Conrad, Architects,P.A., Boise, Idaho, Project No. T9701B, 3 pages, 2 figs. (Accompanied by geotechnical engineering evaluation, job. no. T9701-C.)

Umatilla

15628. Geotechnical Resources,Inc (1997): Geotechnical investigation and site-specific seismic hazard study, Men's Medium-Security Corrections Institution, Umatilla, Oregon, for Oregon Department of Corrections. (Report for Oregon Department of Corrections, Job No. 2348), 11 pages, 3 figs., 34 p. app.

15298. Kleinfelder,Inc (1996): Phase I geotechnical study, Oregon Department of Corrections, Port of Umatilla site, Umatilla, Oregon, ODC #UT-UT-1. (Report for KPFF Consulting Engineers/ODC, Project No. 60-8080-12), 5 pages, 1 fig., 3 tables.

UNION COUNTY QUADRANGLES

La Grande

13379. AGI Technologies (1995): Site-specific seismic hazard evaluation, Grande Ronde Hospital, La Grande, Oregon. (Report prepared for Grande Ronde Hospital, Technical Services Dept., Project No. 30,166.005), 7 pages, 3 figs., 7 p. app.

15891. Foundation Engineering,Inc (1995): Geotechnical investigation, La Grande Armory, La Grande, Oregon. (Report for Carkin Arbuckle Costick Architects, Salem, Oregon, Project No. 95200087), 9 pages, 1 map, 14 p. app.

WASCO COUNTY QUADRANGLES

Dufur East

15557. Mark V. Herbert and Associates,Inc (1996): Seismic evaluation, New Gymnasium, Dufur School [Wasco County, Oregon]. (Report for Dufur School District, Project No. 96-050), 5 pages, 1 table, 2 figs.

The Dalles South

15620. Alder Geotechnical Services (1997): Seismic hazards report, proposed Calvary Baptist Church addition, 3350 Columbia View Drive, The Dalles, Oregon. (Report for FWL Architects (David D. Fisher), Portland, Oreg., Project No. 133-1), 12 pages, 26 p. app.

15957. Fujitani Hilts and Associates,Inc (1998): Seismic site hazard investigation, proposed new Armory, The Dalles, Oregon. (Report prepared for Architects Barrentine Bates Lee, Lake Oswego, Oregon, Project No. F-2970-02), 10 pages, 3 figs.

12592. H.G. Schlicker & Associates (1995): Seismic assessment, proposed theatre site, West 7th and Snipes, The Dalles, Oregon. (Report for Bruce Humphrey, The Dalles, Oreg., Project No. 951223), 7 pages, 5 figs., 8 p. app.

WASHINGTON COUNTY QUADRANGLES

Forest Grove

16005. Northwest Natural Gas Company,NW Natural (1998): Application to amend the site certificates for Mist underground natural gas storage and the South Mist feeder pipeline. (Report for Oregon Energy Facility Siting Council), 140 pages, at least as many pages app. (Second volume contains exhibits.)

Laurelwood

15283. Andrews,Desmond CA; Baez,Juan I; Martin,Geoffrey R (1996): Liquefaction mitigation: Use of vibro-stone columns for silty soils - Background and case histories [Fern Hill, Forest Grove, waste water treatment plant site], in: Ground stabilization and seismic mitigation. (Paper presented at seminar, Portland, Oregon, November 6-7, 1996, sponsored by American Society of Civil Engineers, Oregon Section Geotechnical Group, and Oregon Department of Geology and Mineral Industries), 18 p., 9 figs.)

Scholls

15633. Kleinfelder,Inc (1997): Butternut Orchard site #WA-SAFETY-222, Washington County, Hillsboro/Aloha. Final report, prison site location analysis, State of Oregon, Department of Corrections. (Report for KPFF Consulting Engineers/ODC), var. p.

15631. Kleinfelder,Inc (1997): Rood Bridge Rd. site #WA-HS-1, Washington County, Hillsboro. Final report, prison site location analysis, State of Oregon, Department of Corrections. (Report for KPFF Consulting Engineers/ODC), var. pages.

Vernonia

16005. Northwest Natural Gas Company,NW Natural (1998): Application to amend the site certificates for Mist underground natural gas storage and the South Mist feeder pipeline. (Report for Oregon Energy Facility Siting Council), 140 pages and app.; second volume contains exhibits.

WHEELER COUNTY QUADRANGLES

Mitchell

15294. Kleinfelder,Inc (1996): Phase I geotechnical study, Oregon Department of Corrections, BLM site, Mitchell, Oregon, ODC #WH-MI-1. (Report for KPFF Consulting Engineers/ODC, Project No. 60-8080-19), 4 pages, 1 fig., 3 tables.

15920. Siemens & Associates (1998): Results of seismic site hazard investigation, emergency services building, Mitchell, Oregon. (Report for City of Mitchell, Oregon, Project No. 981024), 8 pages, 7 p. field investigation, 4 p. app.

Spray

15558. Siemens & Associates (1996): Results of seismic site hazard investigation, Spray water tanks, Spray, Oregon. (Report for David Evans and Associates, Inc., Bend, Oregon, Project No. 961037), 9 pages, 6 figs., 2 p. app.

16078. Siemens & Associates (1999): Results of seismic site hazard investigation, emergency services building, Spray, Oregon. (Report for City of Spray, Oregon, Project No. 981066), 9 pages, 6 figs.

YAMHILL COUNTY QUADRANGLES

Newberg

12593. AGI Technologies (1995): Geotechnical investigation and report, proposed Sumitomo Sitix site, Newberg, Oregon. (Report prepared for Lockwood Greene, 1500 International Drive, Spartanburg, SC 29304. AGI Project No. 30,478.003), 21 pages, 9 figs., 4 p. app., 47 figs.; addendum: Seismic site hazard investigation, 3 p.

12069. Carlson Testing,Tigard (1994): Seismic hazards report, Crater Schools site, Yamhill County, Oregon. (Report prepared for Newberg School District 29JT, CTI Job No. 94-1662), 17 pages.

Sheridan

16077. Professional Service Industries,Inc (1999): Site-specific seismic evaluation for the Willamina fire station, East Main Street, Willamina, Oregon. (Report for Willamina Fire District, PSI Project no. 704-95004, Braun Intertec Project no. EAAX-99-0156), 14 pages, 3 figs., 13 p. app.

Silicic volcanism in the Cascade Range: Evidence from Bear Creek and Antelope Creek valleys, southern Oregon

by Roy F. Torley, Department of Geological Sciences, 1272 University of Oregon, Eugene, OR 97403-1272; and Frank R. Hladky, Oregon Department of Geology and Mineral Industries, Grants Pass Field Office

Evidence of silicic volcanism exists in the soil profile of Bear Creek and Antelope Creek valleys, southern Oregon (Figure 1). Limpid medium- to coarse-sand-size (¼–½ mm and ½–1 mm) quartz crystals having a hexagonal dipyramidal form (Figure 2) were found in sediments collected from various creeks in the two valleys. Although crystals were commonly shattered to varying degrees, many complete crystals were also seen. These crystals were identified during a regional sedimentological study that was conducted between 1993 and 1996. The study involved Fourier grain-shape analysis of detrital quartz grains in Holocene sediments (Torley, 1998).

Quartz crystals with the hexagonal dipyramidal form are called beta quartz or high quartz (Figure 2). Beta quartz is known to form in high temperature conditions (^{3}573° C) (Deer, Howie, and Zussman, 1966). When beta quartz cools to below 573° C, it inverts to alpha quartz (or low quartz) but commonly retains its original dipyramidal shape. In the rock record, beta quartz occurs in quartz-rich tuffs and much more rarely in high-temperature geothermal deposits. Because ash from silicic volcanic eruptions can cover large areas, it is very likely that the region around Bear Creek has been episodically covered with a significant amount of quartz-rich ash throughout geologic time. Tertiary age ash beds occur in the region primarily as relatively thin beds of tuff sandwiched between thick sequences of lava. Some volcanic ash occurs in Holocene soil horizons, a portion of which is identified with the climactic eruption of Mt. Mazama that produced Crater Lake about 6,700 years ago. Ash is part of the soil profile in and around Bear Creek and Antelope Creek valleys.

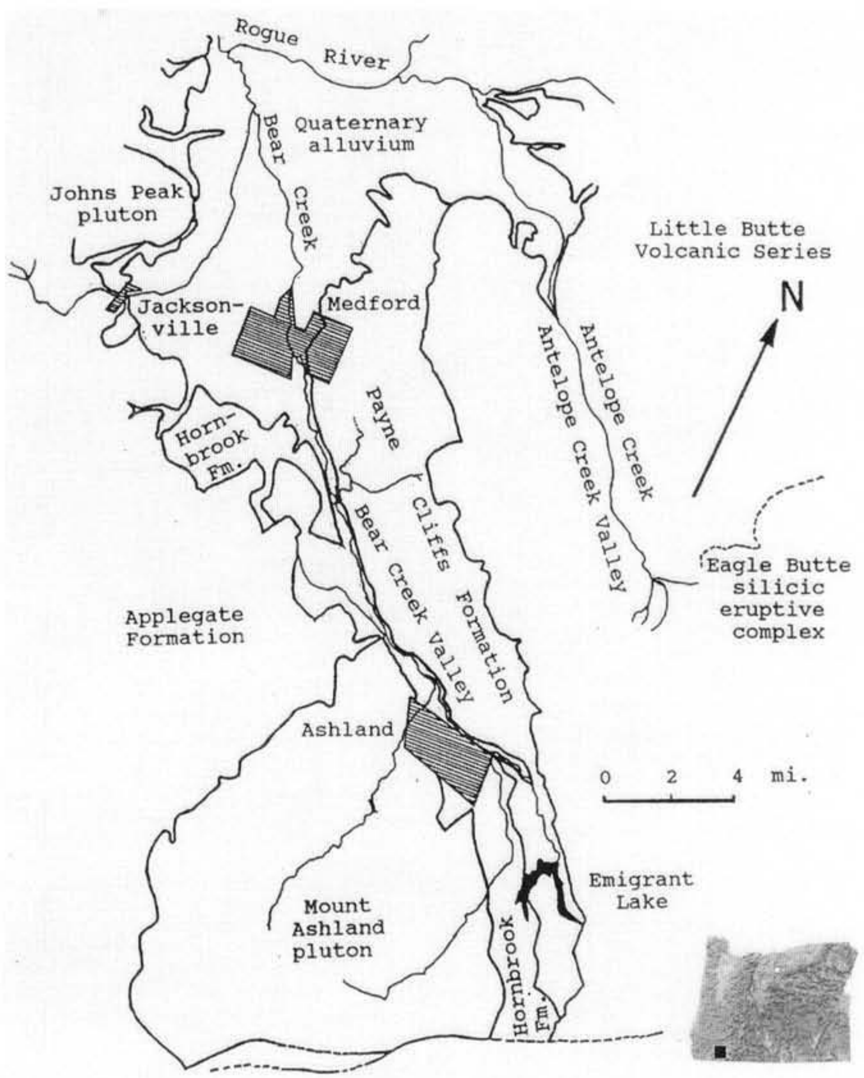

Figure 1. Generalized map of Bear Creek and Antelope Creek valleys, southern Oregon.

The creeks sampled in the sedimentological study include West Fork Ashland Creek and Neil Creek on the Mount Ashland pluton, Miller Gulch and South Fork Jackson Creek in the Siskiyou Mountains west of and flowing through Jacksonville, respectively, Payne Creek east of Phoenix, and Antelope Creek (Figure 2). Six to eight sediment samples were collected along the lengths of each creek in an effort to identify detrital quartz grain-shape populations that could be linked with certain source rock types, specifically volcanic, plutonic, metamorphic, and sedimentary rocks. Beta quartz pseudomorphs were found in all sediment samples.

Sediments collected around the

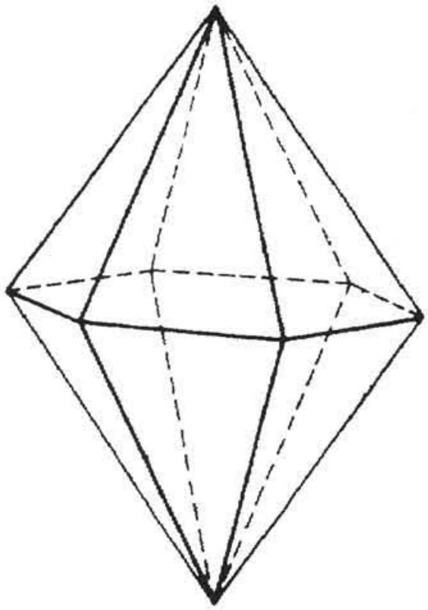

Figure 2. Schematic representation of hexagonal dipyra midal form typical of so-called "beta quartz" or "high quartz" (high-temperature quartz).

summit and on the sides of Mount Ashland contain identifiable hexagonal dipyramidal quartz crystals commonly amounting to five percent of quartz grains hand-picked for shape analysis (Figure 3). Samples collected from Miller Gulch have about the same proportion of crystals but proportions vary wildly along South Fork Jackson Creek from very few grains seen to about forty percent of hand-picked quartz grains.

Many beta quartz pseudomorphs were identified in Payne Creek and Antelope Creek sediments. Because Antelope Creek incises only the Little Butte Volcanic Series along its upper length, it is reasonable to hypothesize that all the detrital quartz in its sediments is volcanic in origin. This hypothesis is supported in that the head of Antelope Creek is located at the remains of the Eagle Butte silicic eruptive center where bodies of quartz-rich tuff are located (Hladky, 1997) (Figure 2).

The Eagle Butte silicic eruptive center is a possible source of the region-wide ashfall. It was active from 23 to 21 Ma before becoming extinct. Located 19 miles to the west southwest of Mount Ashland's summit, it erupted more than once during this period and with enough force and volume of ash to blanket the region that is now incised by Bear Creek and Antelope Creek, including Mount Ashland. The fact that Mount Ashland received ash on its summit corroborates the view that the pluton was already exhumed by the time Eocene volcanism commenced in the Western Cascades. The extent and volume of this ashfall has not been determined and it is doubtful that it ever will be because much of it has been removed from the valley by fluvial erosional and transport processes during Tertiary and Quaternary time.

Another possible source of ash is a caldera complex located about 30 miles north of Medford in the Western Cascades (Hladky and Wiley, 1993). During the late Oligocene (28 to 25 Ma), it produced extensive sheets of ashfall tuff (Hladky and Wiley, 1993; Frank Hladky, pers. comm. 1996; Jim Smith, pers. comm. 1996). If it did contribute quartz-rich ash to Bear Creek and Antelope Creek valleys, it may be difficult, if not impossible, to distinguish between beta quartz crystals originating from the two eruptive centers in Holocene sediments. Additionally, silicic eruptions during Holocene time from Mt. Mazama (now Crater Lake) and Mt. Shasta are possible, indeed probable, contributive sources for volcanically derived beta quartz in the Holocene soils of the Antelope Creek and Bear Creek Valleys.

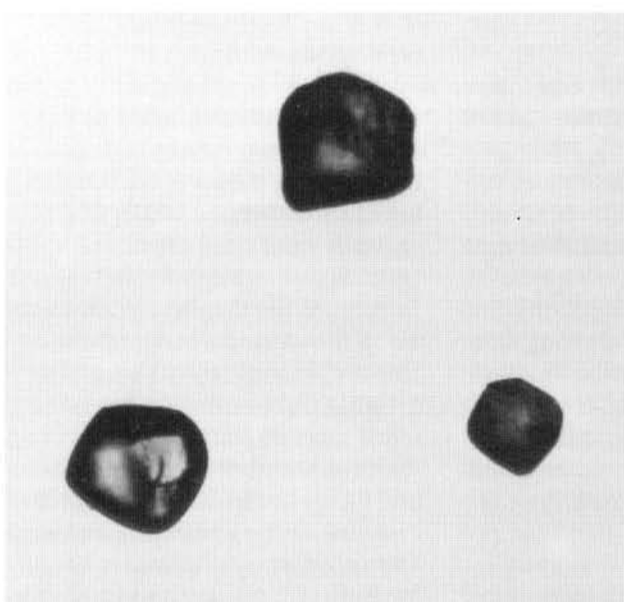

Figure 3. Beta quartz pseudomorphs found in creek sediment near the summit of the Mount Ashland pluton. The two larger grains are about 0.5 mm in size, the smaller grain about 0.25 mm in size.

REFERENCES

Deer, W.A., Howie, R.A., and Zussman, J., 1966, An introduction to the rock-forming minerals: Longman Scientific & Technical, New York, 528 p.

Hladky, Frank R., 1997, Geology and mineral resources of the Grizzly Peak Quadrangle, Jackson County, Oregon: Oregon Department of Geology and Mineral Industries Geological Map Series GMS-106, scale 1:24,000.

Hladky, Frank R. and Wiley, Thomas J., 1993, Ancient caldera complex revealed: Oregon Geology, v. 55, no. 3, p. 70.

Torley, Roy F., 1998, Fourier grain-shape analysis of quartz grains in sediments of Bear Creek Valley and adjacent Western Cascade Mountains, southern Oregon: unpubl. Ph.D. dissertation, University of Oregon, Eugene, Oregon, 264 p.

THESIS ABSTRACTS

The Department maintains a collection of theses and dissertations on Oregon geology. From time to time, we print abstracts of new acquisitions that in our opinion are of general interest to our readers.

Geochemistry of the Boring Lava along the west side of the Tualatin Mountains and of sediments from drill holes in the Portland and Tualatin basins, Portland, Oregon, by Michelle L. Barnes (M.S., Portland State University, 1995), 182 p.

Instrumental Neutron Activation Analysis (INAA) was used to identify geochemical groups in Boring Lava along the west side of the Tualatin Mountains, and in sediments of the Portland and Tualatin basins.

Samples of Boring Lava were obtained from TriMet drill core collected during planning of the tunnel alignment for the Westside Light Rail line. Additional samples of Boring Lava were collected from outcrops along the west side of the Tualatin Mountains. Samples of sediment from the Tualatin and Portland basins were obtained from drill core collected during an Oregon Department of Geology and Mineral Industries (DOGAMI) Earthquake Hazards Mapping project.

INAA of Boring Lava samples resulted in the identification of three geochemical groups. Additional data sets, including x-ray fluorescence geochemistry, magnetic polarity, and age dates, allowed for the distinction of three Boring Lava units. The Boring Lava of Barnes Road is a young, normal unit, the Boring Lava of Sylvan Hill is an older normal unit, and the Boring Lava of Cornell Mountain is the oldest, reversed unit. The surface distribution, identified using topography and outcrop geochemistry, is consistent with the subsurface distribution, identified using boring logs and core geochemistry. Volcanic vent locations are proposed at topographic highs within the identified surface distribution of the Boring Lava of Barnes Road.

INAA of sediment samples resulted in the identification of seven groups:

(1) Columbia River source sediments, (2) lower Troutdale Formation, (3) Reed Island ashes, (4) young Columbia River sediments, (5) high- alumina basalt sediments, (6) episodic Cascadian volcanic sediments, and (7) Columbia River Basalt Group (CRBG) sediments.

Only the CRBG sediments group was identified in the Tualatin basin, while all seven groups were identified in the Portland basin. This appears to demonstrate that the sediment packages in the two basins are different.

Finally, each sediment group can be placed into one of three broad geochemical categories:

Columbia River source sediments and lower Troutdale Formation represent a Columbia River or continental source; Reed Island ashes, young Columbia River sediments, high-alumina basalt sediments, and episodic Cascadian volcanic sediments represent a Cascadian or local source; and CRBG sediments represent residual soils or sediments overlying Columbia River basalt flows.

The volcanic stratigraphy of the Juntura region, eastern Oregon, by George B. Binger (M.S., Washington State University, 1997), 206 p.

Major- and trace-element concentrations were determined on 433 samples of the diverse volcanic units along the western margin of the Vale and Mahogany Mountain 1:100,000 sheets in an attempt to refine stratigraphic correlations in a structurally complex area of Basin and Range extension in east-central Oregon. Analyzed samples included 197 collected by J. Evans, H. Brooks, M. Ferns, M. Francis, and J. Johnson from 12 7½-minute quadrangles and 73 collected from a continuous section of Steens Basalt by J. Johnson and C.J. Hawkesworth. These were supplemented by 138 samples collected for this study and compared to earlier analyses of samples mainly collected from the north and northeast of the study area by K. Lees (24 samples).

The data are used to more fully characterize units identified in the original mapping and to recognize 12 additional units. Significant modifications of the stratigraphic framework are suggested and related to the chronology established by Lees (1994). Detailed correlations between basalt sections have established the relationship between the Steens Basalt and tholeiitic basalts progressively farther north, which can be correlated with the Imnaha and Grande Ronde basalts of the Columbia River Basalt Group. The stratigraphy of the volcanic units demonstrates the change from the mantle-plume-related lower tholeiites, through calc-alkaline sequences and finally alkali basalts related to the active extension. The extension-related younger units are low volume, geographically and chemically distinct flows, unlike the higher volume, relatively homogeneous lower tholeiites.

Paleoseismic deformation in behind-arc lacustrine settings: Acambay, Mexico, and Ana River, Oregon, by Robert M. Langridge (Ph.D., University of Oregon, 1998), 188 p.

Paleoseismic techniques offer the means to study fault activity in "behind-arc" tectonic settings where rates of deformation and historic seismicity are low. This dissertation presents geologic evidence of large earthquakes in the behind-arc, and establishes this setting as one that generates large (M~7) and damaging earthquakes. Developing criteria for the recognition and characterization of subaqueous paleoseismic events is central to this study.

The 1912 MW 7.0 Acambay earthquake in Mexico is used as a model for behind-arc extensional faulting. This event's rupture is ana-

(Continued on next page)

Simonton appointed as new Governing Board member

Vera E. Simonton of Pendleton has been appointed by Governor John Kitzhaber and confirmed by the Oregon Senate for a four-year term as member of the Governing Board of the Oregon Department of Geology and Mineral Industries. She succeeds Jacki Hagerty of Enterprise, whose term expired in July.

Ms. Simonton is a real-estate agent with Garton and Associates Realtors in Pendleton and has a 20-year history as an educator with community colleges in eastern Washington and Oregon. She has long been involved in civic organizations in the Pendleton area and in 1993 was inducted into the Pendleton Round-Up Hall of Fame. In 1995, she was appointed to the site selection committee for the Pendleton County Jail and Work Release Center. Most recently, Simonton has been volunteering with the local Cancer Society, Festival of Trees, and St. Anthony Hospital Hospice.

Serving with Simonton on the three-member board are Don Christensen of Depoe Bay, Chair, and Arleen Barnett of Portland.

(Continued from previous page)
lyzed to assess the prehistoric record of earthquakes on the Acambay-Tixmadejé fault, and to test whether the size and geology of this earthquake are typical for this setting. Trenches at four sites along the 1912 ground rupture revealed evidence of repeated latest Pleistocene and Holocene earthquakes with equivalent offset, and by inference magnitude, to the 1912 event. The recurrence interval for events is 3-5,000 years and the slip rate across the Acambay graben totals ~0.25 mm/year. These results probably apply to geomorphically similar deformation along active faults in both central Mexico and Oregon and therefore have implications for the contemporary seismicity predicted for these regions.

Trenches and exposures across and near the Ana River fault, Oregon, reveal evidence of multiple late Pleistocene and Holocene earthquakes from a well-exposed and dated sequence of tephra-bearing lacustrine sediments of pluvial Lake Chewaucan. Near- to far-field correlation of event horizons has helped establish a long paleoseismic record for the Ana River fault. Large earthquakes recur every 10–20,000 years on this structure, with a slip rate of ~0.1 mm/year.

Many of the paleoseismic events on the Huapango Plain, Mexico, and at the Ana River occurred underwater during Pleistocene pluvial periods. Seismically-deformed thizotropic sedimentary packages are defined by the presence of low-angle faulting, folding, slumping with section stacking, subtle bevel unconformities, addition or removal of section, liquefaction, and boudinage structures. Detailed mapping of seismites has resulted in a tectonic model for submerged normal faults, based on shaking-related failure and gravity-driven block transport on gentle slopes.

Structure and seismic hazards evolution of the of the offshore Cascadia forearc and Neogene forearc basin, by Lisa C. McNeill (Ph.D., Oregon State University, 1998), 178 p.

The Cascadia subduction zone has been characterized as a typical Chilean-type subduction zone based on qualitative comparisons of plate age and convergence rate, with simple forearc structure. However, the discovery of unusual structural styles of deformation, variations in the morphology of the forearc, and its absence of seismic activity suggest differences from the Chilean analog. The manuscripts presented here illustrate this complexity and provide examples of contrasting deformation throughout the offshore forearc. The Washington and northern Oregon shelf and upper slope are characterized by extension in the form of listric normal faults. These faults have been active since the late Miocene and are driven by detachment and extension of the underlying overpressured melange and broken formation. This region of the forearc is partly to wholly decoupled from convergence-driven compression which dominates deformation elsewhere in the forearc. One exception to convergence-driven compression is a region of N-S compression of the inner shelf and coastal region, which reflects the regional stress field. N-S compressional structures apparently influence the positions of coastal lowlands and uplands and may contribute to the record of coastal marsh burials interepreted as the result of coseismic subsidence during subduction zone earthquakes. Modeling of subduction zone earthquake characteristics based on marsh stratigraphy is likely to be inaccurate in terms of rupture zone position, magnitude, and recurrence interval. The Cascadia shelf and upper slope are underlain by a sequence of deformed basinal strata which reflects the tectonic evolution of the margin. The surface of a regional late Miocene angular unconformity (7.5-6 Ma: a global hiatus) indicates deformation by uplifted submarine banks and subsided synclines (coincident with low recent uplift onshore), which control the current shelf break position. The basin is currently filled behind a N-S-trending outer-arc high, which uplifted in the early-middle Pliocene following truncation and erosion of the seaward edge of the basin. Breaching of the outer-arc high occurred in the early Pleistocene leading to the formation of the Astoria Submarine Fan and increased growth rates of the accretion ary wedge.

DOGAMI PUBLICATIONS

Released October 21, 1999:

Tsunami Hazard Map of the Astoria Area, Clatsop County, Oregon, by George R. Priest, Edward Myers, Antonio Baptista, Garnet Erdakos, and Robert A. Kamphaus. Interpretive Map Series map IMS-11, scale 1:24,000, 4 p. text, $10.

Tsunami Hazard Map of the Warrenton Area, Clatsop County, Oregon, by George R. Priest, Edward Myers, Antonio Baptista, Garnet Erdakos, and Robert A. Kamphaus. Interpretive Map Series map IMS-12, scale 1:24,000, 5 p. text, $10.

These map shows how three different tsunamis might affect the area. A tsunami is a series of waves generated by undersea earthquakes, so the authors used computers to simulate three different local earthquakes and the tsunamis they might cause. The simulations were used in conjunction with field observations to produce the maps.

Great (magnitude 8 to 9) undersea earthquakes off the Oregon coast cause devastating tsunamis to strike every 300–600 years. The earthquake itself might last up to four minutes; then, within about 30 minutes after the start of the earthquake, the first of several large high-velocity tsunami waves hits this part of the coast. It is important that people know the safest way to go to high ground or at least go as far inland as possible. The new maps and similar maps will help find evacuation routes that will be least affected by tsunamis.

The maps, which show city streets and tsunami flooding areas, were produced by DOGAMI in partnership with a community advisory committee. The Oregon Graduate Institute of Science and Technology and the National Oceanic and Atmospheric Administration (NOAA) provided scientific research to produce the maps. NOAA and the Federal Emergency Management Agency (FEMA) funded the project.

Released October 25, 1999:

Relative Earthquake Hazard Maps for Selected Urban Areas in Western Oregon, by Ian P. Madin and Zhenming Wang. Interpretive Map Series map IMS-10, 9 maps on 2 sheets (scale 1:24,000), 4 p. text, one CD-ROM disk, $20.

The relative earthquake hazard maps for nine coastal communities—Astoria-Warrenton, Brookings, Coquille, Florence-Dunes City, Lincoln City, Newport, Reedsport-Winchester Bay, Seaside-Gearhart-Cannon Beach, and Tillamook—combine the effects of ground shaking amplification, liquefaction, and earthquake-induced landsliding (included on CD-ROM) to show the earthquake hazards relative to the geologic conditions.

The maps were produced with funding by the State of Oregon and the U.S. Geological Survey.

Important uses of these new maps include the following:

- Emergency response and hazard mitigation

Planning for disaster response will be enhanced by the use of these maps to identify which resources and transportation routes are likely to be damaged.

- Land use planning and seismic retrofit

Efforts and funds for both urban renewal and strengthening or replacing older and weaker buildings can be focused on the areas where the effects of earthquakes will be the greatest. Requirements placed on a development could be based on the hazard zone in which it lies.

- Lifelines

Lifelines include road and access systems including railroads, airports and runways, bridges, and over- and underpasses, as well as utilities and distribution systems. These hazard maps allow assessing vulnerability and setting priorities for mitigation.

Additional earthquake hazard maps for western Oregon communities will be released January 26, 2000, the 300th anniversary of the last great Cascadia subduction zone earthquake.

Released September 7, 1999:

Geology and Mineral Resources Map of the Brownsboro Quadrangle, Jackson County, Oregon, by Frank R. Hladky. Geological Map Series map GMS-109, scale 1:24,000, 12 p. text, $10.

The Brownsboro quadrangle, is located northeast of Medford and just east of Eagle Point in Jackson County. The new map includes areas around Antelope Creek and Little Butte Creek in the foothills of the Cascade Range. The accompanying text outlines groundwater and mineral resources and the geologic history of the area.

The oldest rocks identified in the area were erupted about 30 million years ago. On top of this bedrock, the dominant factor in shaping the landscape has been landsliding. Large-scale landslides may have been induced by earthquakes. As streams have drained the area and changed their channels, gravel terraces have been preserved. These gravels reach a maximum thickness in the quadrangle of 50 ft.

Crushed rock is the primary mineral resource of the quadrangle. Clay, mercury, and copper have been prospected, but there has been little or no production.

Groundwater resources are affected by the variety among volcanic rocks. Volcanic lava flows tend to produce large quantities of water , often of good quality. Tuffaceous rocks tend to restrict ground water movement. Areas of silicic rocks, especially near old volcanic vents, often produce water with high levels of metals, including arsenic and mercury, so these resources must be carefully analyzed before use.

The publications are available from the Nature of the Northwest Information Center, 800 NE Oregon Street #5, Portland, 97232, (503) 872-2750; and the DOGAMI field offices: 1831 First Street, Baker City, 97814, (541) 523-3133; and 5375 Monument Drive, Grants Pass, 97526, (541) 476-2496.

How many earthquakes occur in Oregon over a year, and where?

The answers to both questions might surprise you.

by Lou Clark, DOGAMI Earth Science Information Officer

The Pacific Northwest Seismograph Network at the University of Washington tracks earthquakes in the Pacific Northwest and notifies DOGAMI through RACE, Rapid Alert for Cascadia Earthquakes. The following earthquake highlights come from that system.

These are only earthquakes over magnitude (M) 1.5, but thousands of smaller quakes happen throughout the year that we cannot measure and record. In much of Oregon, population density is so low, and damaging earthquakes happen so infrequently that seismometers are not installed in many places. While they give us valuable data, seismic instruments are so expensive to place and maintain that we can't afford and justify enough of them to truly understand Oregon's earthquake context.

In 1999, RACE registered 124 earthquakes between January 1 and October 31—centered in or near Oregon. Few of them were felt: Typically, you don't feel earthquakes below M 3 unless they are very close or you are in a special situation—for example, being in a tall building.

Did you feel the small earthquake on February 24? Thousands of people did. This M 2.7 event was centered between Molalla and Woodburn and cracked plaster at Oregon City High School buildings. What you probably don't know is that within a few miles of that quake, 12 other earthquakes occurred through the year, between M 1.5 and M 2.3!

Another earthquake that people felt was the M 2.1 quake on Sauvie Island in February. That one didn't cause any damage, but was felt by enough people to get some media coverage. There were four other earthquakes around the same spot, (M 2.3 to M 3.2), but they happened in the middle of the night and were not felt.

Of course, the most damaging and widely felt earthquake of 1999 was in July, centered just east of Aberdeen, Washington, and felt throughout northwestern Oregon. The main shock was M 5.7 and caused millions of dollars of damage. There were three small aftershocks within a week (M 1.6 to 2.5).

Several small events were centered in the Coast Range, from south of Astoria to west of Grants Pass.

Occasionally, there are offshore earthquakes. This year, two of these occurred, both in January: a M 2.5 off Rockaway Beach and a M 2.6 off Port Orford.

The Cascade Range had far more earthquakes. In a highly publicized swarm, there were 12 quakes on January 11 on Mount Hood. An additional 11 small quakes shook the mountain in the following months, with only one over M 3. Compare that to Mount St. Helens, which had 13 small earthquakes, with two of them over M 3. This is a very common pattern of small movements on our neighboring volcanoes and does not indicate any movement of magma. There were a few other isolated, very small events in the Cascades.

Northeastern Oregon had a number of quakes. RACE reported nine events north of Umatilla, including a M 3.0 and a M 3.2 in September. Several were located east of Pendleton, the largest being a M 2.6 in March. Two small events were centered near Enterprise.

The area near Condon experienced a number of earthquakes. The largest was a M 3.5 quake on August 31, followed by five more in September.

By far the area with the most earthquakes this year was Christmas Valley: 27 events between April and June (and an "afterthought" in October). One was a M 3.8, but the others were M 1.6 to M 2.4. Fortunately, they were so small that they did not cause damage, and most were not even felt. Even for a geologist, three months of earthquakes might be a little much.

If you're in an area not shaken by an earthquake on this list, don't feel left out. Quakes happen every day, and happen all over the state. For example, in 1993, there were hundreds of aftershocks around Scotts Mills (after a M 5.6 shock) and Klamath Falls (after main shocks of M 5.9 and M 6.0).Last year, there were temblors in various parts of the state where no shaking occurred this year, for instance, two quakes that exceeded M 3 near Halfway in Baker County and a M 2.5 near St. Helens. The two largest quakes of 1998 were offshore: a M 5.1 off Coos Bay and a M 4.1 off Gold Beach.

According to this list, Oregon has experienced one earthquake every other day, on average; however, a great many more earthquakes did actually occur, even if they were not registered by these instruments. We've been fortunate in having little earthquake damage since 1993. But while you're waiting for the earthquake that will make the big headlines, remember that, wherever you are, there's probably an earthquake happening near you today.

Correction

In the last issue (July/August), on page 87, we printed a map that showed the location of Salem a lot closer to the coast than it really is. We apologize for the oversight—as well as for placing an unintended and nameless spot for a town into the state of Washington.

We also thank reader Allen Agnew of Corvallis for letting us know what his sharp eyes had spotted right away!

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Portland, OR 97232-2162

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

Fort Rock State Monument in Lake County, one of six National Natural Landmarks in Oregon

Fort Rock with its steep rock sides is the most striking example of the maars and tuff rings in the young volcanic landscape of the High Lava Plains province. It was formed by a shattering explosion in early Pleistocene time, when rising magma met a shallow lake that covered the Fort Rock and Christmas valleys. The lake water eroded part of the crater ring and left wave-cut benches that can be seen especially near the tips of the horseshoe-shaped "fort."

In the caves cut along the edge of the lake in this vicinity, evidence of early human habitation has been found, including the 10,000-year-old woven sandals that are now thought to be the oldest shoes on record.

Access: From State Highway 31 (Designated Scenic Byway), about 60 mi south of Bend or 100 mi north of Lakeview. The 7-mi side road to Fort Rock is part of the scenic route. Photo contributed by reader Steve Fritz of Portland.