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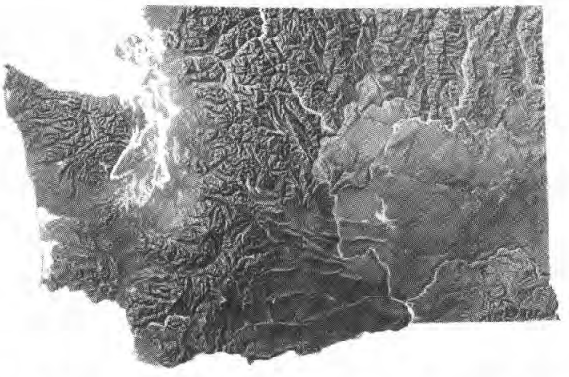

WASHINGTON GEOLOGY

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WASHINGTON STATE DEPARTMENT OF
Natural Resources
Jennifer M. Belcher - Commissioner of Public Lands
Kaleen Cottingham - Supervisor

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Cover Photo: Randomly oriented snags protruding from the surface of Lake Sammamish, King County, Washington, may be evidence of an earthquake-induced landslide about 1,000 years ago. Approximately 70 snags were counted off the north shore of Greenwood Point, which is near the south end of Lake Sammamish. See article, p. 3.

National Geologic Mapping Act Mapping Advisory Committee

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It is anticipated that increased funding will be made available to the states in federal Fiscal Year (FY) 96 under the National Geologic Mapping Act. Section 4(d)3 of the Act requires that a "multirepresentational" mapping advisory panel be established by a state that wishes to qualify for a federal grant. Section 6(3)C further specifies that "for the state geologic mapping component, a priority-setting mechanism" is to determine mapping needs. Competitive grant requests prepared by the State Geologist, with the advice of the state advisory committee, would then be submitted to a national peer review group consisting of geologists from the U.S. Geological Survey and state geologists.

During September, nine members were appointed to the Washington State committee by myself as State Geologist and Jennifer M. Belcher, Commissioner of Public Lands. The committee members and their affiliations are:

Derek Booth
King County Department of Public Works

Ned Brown
Western Washington University

Marsha A. Davis
National Park Service

Richard Galster
consulting engineering geologist

Krystyna Kowalik
Washington Department of Ecology

Raymond Lasmanis
State Geologist

Grant Newport
Weyerhaeuser Co., Mineral Resources Div.

Steve Reidel
Westinghouse Hanford Co.

Virginia Stern
Washington Department of Health

Don Swanson
U.S. Geological Survey

The first meeting of the state committee was held October 20 in the Natural Resources Building, Olympia. Members were briefed on the National Geologic Mapping Act and our state geologic mapping program and evaluated our geologic mapping grant proposals for FY-96 (that had to be submitted to the U.S. Geological Survey by November 3, 1995). Donald Hull, Director and State Geologist of Oregon, reviewed the history of the National Geologic Mapping Act, its management structure, and the intricacies of the national advisory committee. ■

Evidence for a Large Prehistoric Seismically Induced Landslide into Lake Sammamish

by Robert L. Logan and Timothy J. Walsh
Washington State Department of Natural Resources
Division of Geology and Earth Resources
PO Box 47007, Olympia, WA 98504-7007

Local residents and boaters on Lake Sammamish east of Seattle have long been aware of the many large snags (cover) that protrude from the lake near Greenwood Point (Fig. 1). In 1897, in his discussion of geologic features of the Puget Sound area, Kimball reported the location of the snags as a landslide. The snags are indeed the remnants of a prehistoric forest that may have been drowned when the southwest shore of Lake Sammamish collapsed into the lake. This may have happened during a large earthquake focused along what was recognized as a late Quaternary fault by Gower and others (1985) and is commonly referred to as the Seattle fault (Yount and Holmes, 1992) (Figs. 1 and 2).

Evidence for a large seismic event or events occurring about 1,000 years ago is widespread throughout the Puget Sound region (Bucknam and others, 1992; Atwater and Moore, 1992; Karlin and Abella, 1992; Schuster and others, 1992; Jacoby and others, 1992). Radiocarbon dates on snags from the lake support this possibility. The Lake Sammamish sunken forest could extend the area affected by seismic activity eastward along the projection of the Seattle fault if all of these potentially seismogenic features are synchronous.

Greenwood Point is underlain by alluvium attributed to the partial redistribution of glacial deposits from the slopes of Cougar Mountain to the southwest (Booth and Minard, 1992). As the continental ice withdrew from the Sammamish trough, deposition of Greenwood Point alluvium must have been fairly rapid, leaving a steep and relatively unstable delta front, a prime locus for failure during seismic loading.

Wood samples from the Lake Sammamish sunken forest were collected by Jim Doolittle of Issaquah and forwarded to us by Brian Atwater of the USGS. In the spring of 1995, we obtained radiocarbon dates on these samples that confirm the landslide's antiquity and are close enough to the ages of other seismogenic features in the Puget Lowland (Figs. 2 and 3) to suggest a seismic trigger from the same earthquake source. Our investigations have been limited to about ten minutes of photography and note-taking during a quick boat ride to the eastern end of the snag field in May of 1995 and about three hours of snag mapping during another short boat trip in July 1995.

The distribution of the snags that make up the sunken forest is shown in Figure 1. We mapped the snag locations using global positioning system (GPS) technology. A GPS uses satellite signals to precisely locate objects on the Earth's surface. The GPS data were differentially corrected to give a horizontal precision of about 3 feet.

Our mapping reveals that the sunken forest is composed of two clusters of snags. This distribution indicates that either two separate landslides moved the trees into the lake or some snags may have been removed in the gap between the clusters. The adjacent shoreline morphology consists of two embayments that could be headwall scarps of landslides that carried the ancient trees into the lake off of the tip of Greenwood Point. We took measurements on about a third of the approximately 70 snags. A good portion of those snags point shoreward, as if they had been rotated into that position on slump blocks.

Although we have precise GPS locations on many of the snags in the lake, we do not know from exactly which snags the radiocarbon-dated wood came or whether the wood was from inner or outer rings of the snag.

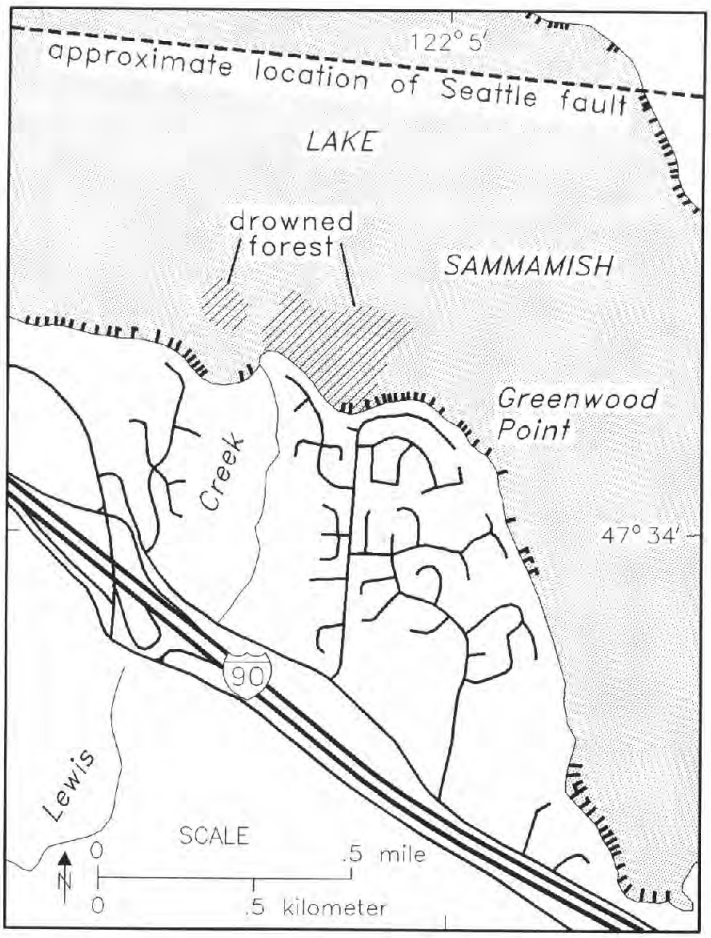

Figure 1. Patterned area shows location of snag clusters north of Greenwood Point on Lake Sammamish. (See Fig. 2 for lake location.) The two associated embayments in the shoreline south of the clusters suggests that at least two landslides may have transported the ancient forest into the lake.

One of the analyzed samples, Beta 80713, was saturated with pitch and had annual growth rings as wide as 4 mm. These characteristics suggest that this wood is from near the heart of the tree and that the tree may have died several hundred years later (than the age of the heart wood) when it rode the landslide into the lake. The date of 1,450 ± 40 yr B.P. on this heartwood is consistent with the possibility that the tree was drowned about 1,000 to 1,100 years ago. The other sample, Beta 80917, had narrower rings, up to 1.5 mm, and was not laden with pitch, indicating that it may have come from farther away from the heart of the tree. The radiocarbon age of 1,330 ± 50 yr B.P. that was obtained for this sample is also consistent with that supposition.

We know from experience with other ancient drowned forests in western Washington that the outermost (that is, the youngest) wood is typically removed or eroded away by exposure to oxidation and (or) biological agents and (or) abrasion. Neither Sammamish sample is likely to represent the true age of the forest when it was drowned. Figures 3 and 4 illustrate just how extensive erosion has been on trees of similar age from elsewhere in the region. Indeed, some trees have been reported to be at least 6 ft in diameter at depth in Lake Sammamish. The snags probably represent the narrowing tips of large trees, and it is likely that some erosion of the trunks has produced the smaller diameter of snags observed at the lake surface.

So, what is the true age of the landslide, and how did it happen? Answers to these and other questions are pending investigation of the site when time and resources permit. Additional sampling for precision radiocarbon dating of wood and coring of the lake floor for possible stratigraphic dating of the landslide should help us better understand the prehistoric seismicity of our region and thereby help us plan for the future.

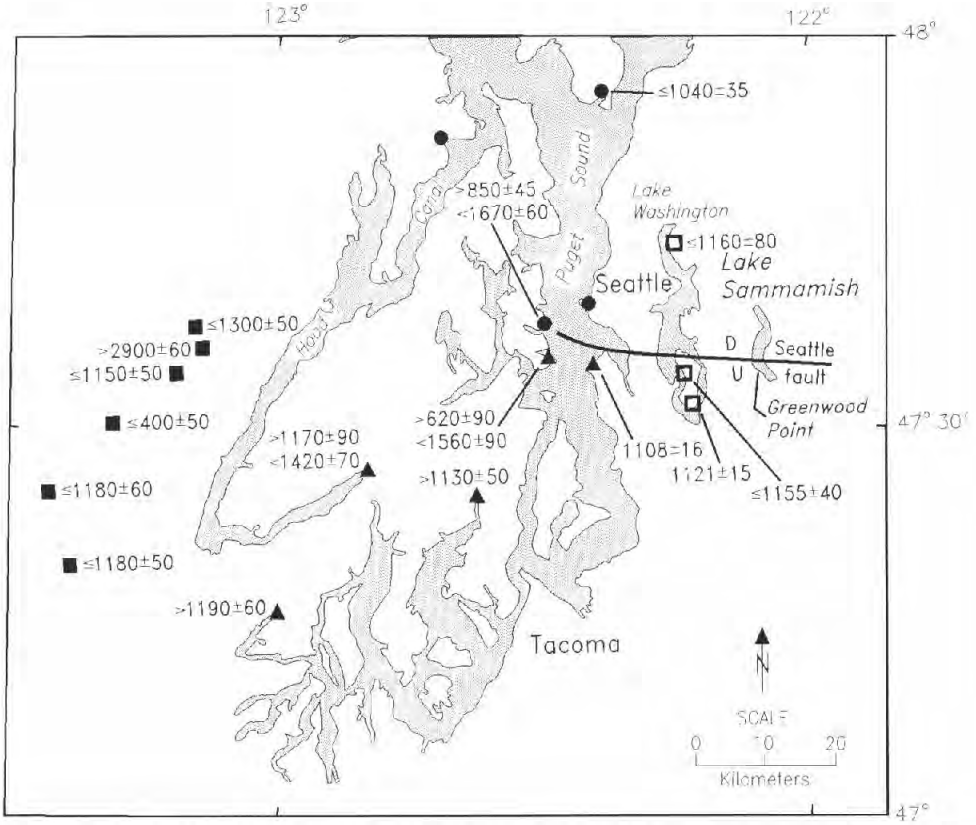

Figure 2. Location and radiocarbon age of features bearing on seismic events in the Puget Sound region of Washington between 500 and 1,700 years ago. The age of the Greenwood Point material averages about 1,400 yr B.P., but the timing of the drowning could be consistent with local radiocarbon ages. ▲, uplifted tidal flat or wave-cut marine platform; ●, tidal-marsh deposit showing little or no abrupt change in level in the past 2,000 years; ■, rock avalanche; □, landslide. Radiocarbon ages in ^{14}C years before A.D. 1950, with 1 standard error quoted by laboratory. No prefix, age of feature relative to average age of dated material; ≥, older or, ≤, younger by as much as decades; >, older or, <, younger by as much as centuries. Modified from Bucknam and others (1992).

Figure 3. Eroded snag in growth position on the shore of Spider Lake, southeast Olympic Peninsula. The outside layers of ancient trees are commonly damaged or missing if they are exposed to air or erosive elements such as wave action. Note the pocket knife for scale. Approximately 5 inches of the outer part of this tree is missing where it protruded above the protective lake bottom. This tree was killed about 1,000–1,180 years ago by drowning in a landslide-dammed lake.

Acknowledgments

Thanks to Jim Doolittle for collecting and forwarding the wood samples to DGER and the USGS and to Brian Atwater of the USGS for funding radiometric dating of sample Beta 80917. We thank Pete and Cathy Melchior and their children of Fall City, Washington, for providing a boat ride to the site.

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Figure 4. Spider Lake in the southeastern foothills of the Olympic Mountains. Snags in this landslide-dammed lake have been radiocarbon dated at 1,180 ± 60 yr B.P. and are nearly indistinguishable in age from many other seismogenic features associated with the Seattle fault (see Fig. 2).

Mineral Collectors' Resources

The Division library recently received from the author copies of the three books listed below.

Claude, Ray, 1995, Mineral sites of Island, San Juan, and Skagit Counties, Washington: GeoTrek, 58 p., $8.95.

Claude, Ray, 1995, Mineral sites of King County, Washington: GeoTrek, 78 p., $10.95.

Claude, Ray, 1995, Mineral sites of Snohomish County, Washington: GeoTrek, 82 p., $12.95.

Ray indicates that volumes for other counties are in preparation. Rockhounds may wish to obtain copies of those now in print. Please send orders to:

GeoTrek
623 Fruitdale Road
Sedro Woolley, WA 98264

Washington residents should add 7.8% sales tax. Add $2.00 to each order for shipping and handling (USPO; book rate). If you prefer USPO parcel post, the charge is $2.80; for UPS, the charge is $5.00.

USGS Closes Offices

With the recent staff reductions, the Minerals Information Offices (MIO) of this federal agency have been closed. The Mineral Resources Data System, formerly accessed through the MIOs, is slated to be made available on CD-ROM and will be sold at the Earth Science Information Centers (ESIC). The Washington ESIC is at West 904 Riverside Ave, Rm 135, in Spokane, in the Post Office Building. The ESIC can be reached at 509-353-2524.

Erosion Control Conference
February 27–March 1, 1996

The International Erosion Control Association is holding its 27th annual conference and trade exposition at the Sheraton Seattle Hotel and the Washington State Convention and Trade Center. For more information about this meeting, contact the IECA at PO Box 774904, Steamboat Springs, CO 80477-4904. *Phone:* 1-800-455-4322 or 970-879-3010, *Fax:* 970-879-8563.

Richard Galster Honored

The Engineering Geology Division of the Geological Society of America gave their Distinguished Practice Award to Richard W. Galster at the 1995 annual meeting in New Orleans. Galster has also been active for many years with the Association of Engineering Geologists nationally and in Washington State. He is a member of the mapping advisory committee for the Division of Geology and Earth Resources

Implications of Middle Eocene Feathers and Crayfish from Republic, Washington

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The beautifully preserved 50-million-year-old leaves, flowers, insects, and fish found at Republic (Fig. 1) have been well known to scientists and collectors since early in this century. Recently two fossil feathers have been added to the list of finds—firsts for both Republic and Washington State. The earlier discovery (Fig. 2A) was made in 1992 at the 'Boot Hill' site at the north end of town by Steve Hines of Seattle. The second feather (Fig. 2B) was found this year by Bill Richards' North Idaho College class from Coeur d'Alene, Idaho, at the same locality. Mr. Hines and Mr. Richards have generously donated these rare fossils to the Stonerose Interpretive Center collection in Republic. The counterpart impressions are deposited with the Thomas Burke Memorial Washington State Museum collection in Seattle. Museum visitors on both sides of the state will be able to see these fossils.

Katja Hinrichsen recently found a nearly complete fossil crayfish (Decapoda) (Fig. 3) at the McAbee site (Eocene) near Cache Creek, BC, in Canada. This fossil complements a partial crayfish from Republic (Fig. 4) and expands our information about Eocene freshwater crustaceans.

These fossils are important clues to Eocene life. Taken by themselves, they are unusual, and thus interesting additions to faunas. But viewed in the context of all the other fossil and geologic information coming from the Okanogan Highlands, there is a much broader perspective to be gained.

GEOLOGIC HISTORY OF BIRDS

Modern birds are a diverse and widespread group. For example, at least 5,000 passerine bird species (songbirds, from titmice to ravens in size) are known, and they are found on all continents except Antarctica. Today, about 800 species of birds breed in North America (National Geographic Society, 1983).

Fossil birds have been extensively studied. Nearly all the living orders of birds have a fossil record, but it is far from complete, and interrelationships are poorly known (Carroll, 1988). Paleontological research shows that birds were varied and widespread in the later Mesozoic, but these older forms would look quite strange to us today. Some Mesozoic land birds were large and flightless, others inhabited damp environments—or even deserts. Beak morphology suggests that some of these early birds were carnivores (eating fish or other animals)—but at least one family was omnivorous. Water birds are comparatively ancient (that is, they evolved early in avian history) and apparently developed from land birds during the Late Mesozoic (Carroll, 1988).

With the extinction of dinosaurs, a major segment of terrestrial faunas was removed. The early Tertiary mammals and presumably the birds became the major herbivores, and both rapidly evolved from stocks of small stature. Modern birds are opportunistic—that is, they switch food sources when necessary (seasonally or areally) (Ehrlich and others, 1988, p. 589)—and it is likely that their ancestors were also.

Much of what we know about Eocene birds is based on remains found at two localities: the early to middle Eocene Green River Formation sites in Wyoming, Utah, and Colorado, and the middle Eocene Messel deposit near Darmstadt, Germany. More complete or nearly complete articulated bird fossils have come from the Green River Formation than from any other pre-Pliocene locality in North America. Many of these birds are not aquatic; they somehow fell or were carried into

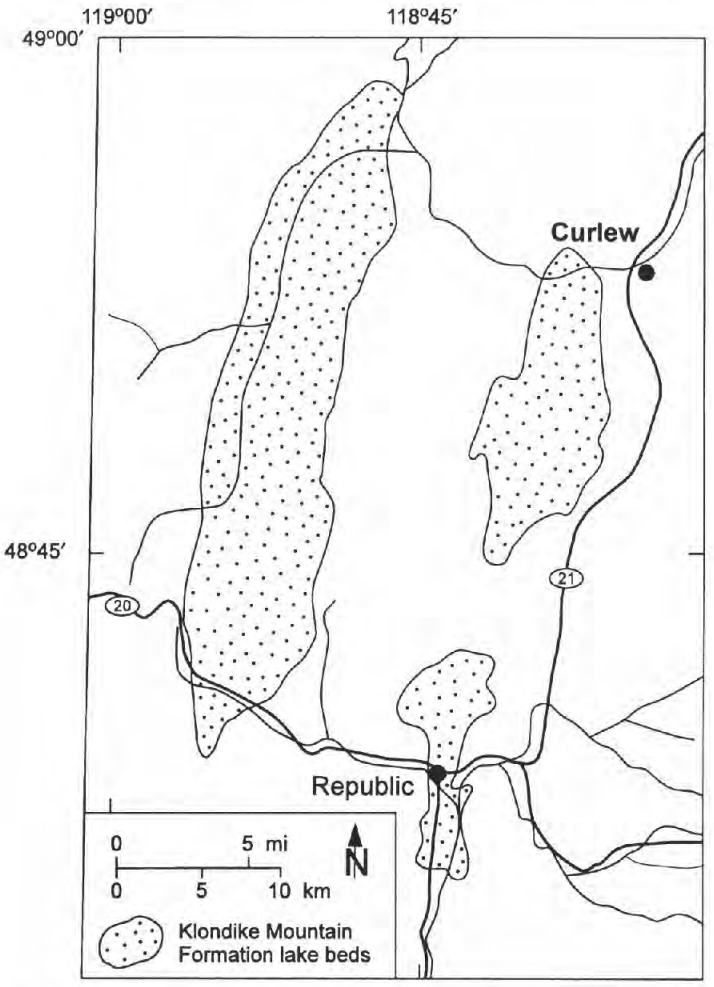

Figure 1. Location of middle Eocene lake beds near Republic in which the feathers and crayfish were found. Modified from Wolfe and Wehr (1987).

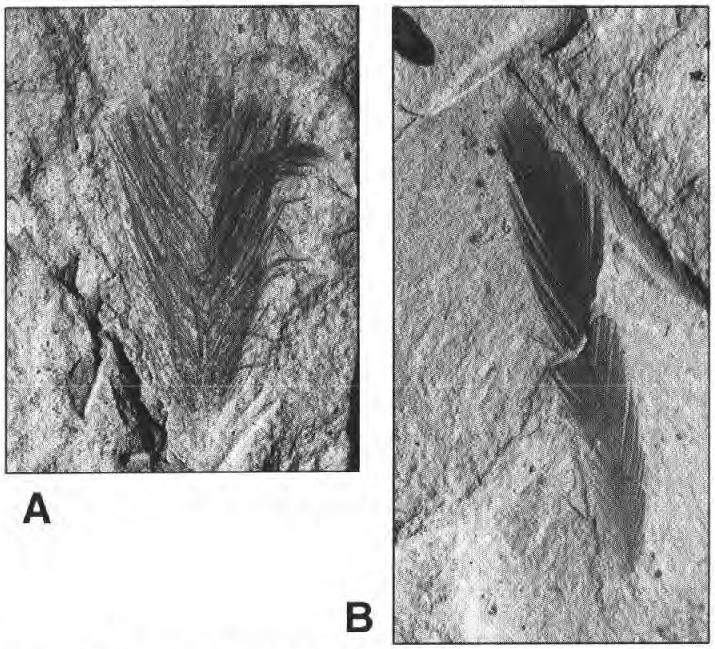

Figure 2. A, Feather, SR 92-17-58, x 1.7, loc. B4131, Republic, Stonerose Interpretive Center collection. B, Feather, SR-95-28-01, x 1.3, loc. B4131, Republic, Stonerose Interpretive Center collection.

the Green River lake environment and were fossilized in the same manner as the well-known fish from that formation. Many of the world's fossil bird remains are associated with inland waters and may be "derived from terrestrial environments immediately proximal to them" (Davis and Briggs, 1995, p. 786).

Even in the early Tertiary, we find birds much more similar to modern types (see, for example, Schaal and Ziegler, 1992) than are the Mesozoic varieties. Representatives of living bird families appear in the late Eocene or Oligocene (40–35 million years ago). In North America and Europe, most of the early Tertiary arboreal birds are related to the Coraciiformes (roller-like birds, with their main North American representatives the kingfishers).

The Messel deposit also contains representatives of orders that include birds resembling rails, cranes, plovers, ostriches, ibises, and flamingos, even owls, but no passerine birds. In view of their relative abundance, primobucconids may have been the 'typical' perching birds of the Eocene. Primobucconids were small perching birds, members of the Coraciiformes. Two genera and four species have been described from the Green River Formation, and several more species are known from the overlying Eocene Bridger Formation and at Messel. However, it was not until the mid-Tertiary that passerine birds became the dominant perching birds in North America (Grande, 1980).

Pacific Northwest Record of Birds

Prior to the discovery of the Republic feathers, the only evidence of Early Tertiary birds in Washington was nine fossil bird tracks found east of Bellingham in the sandstone and finer grained rocks (flood-plain environment) of the Slide Mountain Member of the Eocene Chuckanut Formation sandstone. These tracks have been compared to those of *Ardea herodias*, the modern great blue heron (Mustoe, 1993).

Eocene bird remains from Oregon include an auklet from near Coos Bay (Miller, 1931) and a late Eocene species of giant pelican from the Keasey Formation northwest of Portland (Goedert, 1988, 1989).

Fossil bird remains from the early middle Eocene rocks of the Okanogan Highlands of British Columbia include an almost complete skeleton collected by Dave Langevin of Kamloops at the McAbee site near Cache Creek. This bird, on display at the Kelowna Museum (Kelowna, BC), has been tentatively placed in a new order, Sandcoleiformes, by Storrs Olson (D. Bruce, Kelowna Museum, written commun., 1995). A skeleton of *Primobucco* lacking only the head has been found at the early middle Eocene Driftwood Creek site near Smithers. There are also nearly a dozen feathers and several bird bones known from the McAbee, Driftwood Creek, and Quilchena sites in British Columbia (K. W. Pugh, Sardis, BC, written commun., Oct. 1995).

What kind of birds might the Republic feathers have come from? It is not yet possible to identify the birds from these kinds of feathers, but we can speculate about Eocene bird life of the time near the lake in which the feathers were 'deposited' and about the interactions of plants and birds.

FOREST PALEOECOLOGY

The size of seeds (not the fruits) can be used as a rough guide to the structure of a plant community (Tiffney, 1984). A fruit/seed flora dominated by small seeds suggests an open, well-lighted habitat, perhaps one that is frequently disturbed. Small seeds typically require more sunlight to establish the plant. Small seeds can be broadcast more easily than large seeds, and seeds that can be moved by several agents (wind, birds, terrestrial animals) are more likely to reach suitable environments than are many larger seeds. They are also more common in the light gaps caused by fallen trees. Modern swamp willow (*Decodon*) lives in marshes and swamps (no forest canopy), and a single plant produces as many as 2 million tiny seeds. *Princetonia*, an extinct genus from Princeton, BC, has (like *Decodon*) small seeds, which might suggest that this plant also lived at the open edge of aquatic environments.

The geologic setting of Republic contains multiple evidences of volcanic activity (such as ashfall deposits) that might well have occasionally destroyed the landscape in much the same way that Mount St. Helens cleaned the local slate in 1980. Recovery there has been rapid, and there is a lot of evidence for immigration of small-seeded plants into the disturbed area.

In contrast, a flora dominated by large seeds suggests a fairly stable, shaded interior forest community (Tiffney, 1984). The large seeds are typically produced in closed canopy forests, where the seed includes more food for the plant that must grow in less light. Some large seeds come in 'packages' preferred by animals. For example, in the Eocene Clarno nut beds of Oregon, there are more large fruits than at Republic. Manchester (1994, p. 21) notes that the "overwhelming majority of Nut Beds species represent fleshy fruits, of the kind dispersed by birds."

How Do Birds and Plants Cooperate?

The physiology of small warm-blooded animals demands high-energy nutrition, a role nicely filled by fruits and seeds.

These predators probably increased pressure on angiosperms and trees, and as a defense many developed large seeds or fruits with tough outer coatings. Or, in taking advantage of mammals, birds, and even insects that assist reproduction and dispersal, many developed attractive flowers or seeds. For example, butterflies and bees seem to prefer red, yellow, or blue, bright-colored flowers; moths choose paler colors. Birds also are attracted to bright colors. Plants with these characteristics are pollinated by these agents far better than would be the rarer green flowers. Color perception is more complex than we indicate here; insects, for example, may select flowers more by ultraviolet light reflection than by color alone, and some insects are red-blind.

Seeds and fruits have also evolved in ways that attract birds (and mammals). Plants that have odorless, bright-colored berries or fruits have likely co-evolved in concert with the finely honed visual systems of birds. In contrast, the dull-colored fruits have more appeal to mammals, many of which are colorblind. Many mammals have a good sense of smell, and fruits with distinctive odors would be good candidates for mammalian dispersal (van der Pijl, 1972).

To obtain nutrition from seeds and fruits, birds have adopted several tactics. Few birds can selectively remove the skin and thin layers of flesh around large seeds, so they tend to swallow the whole fruit. To do so they have evolved large gapes—and digestive tracts that can easily dissolve the nutritious flesh; they then pass the seeds in their feces (see Ehrlich and others, 1988), likely at some distance (one digestive-cycle worth of travel) from the fruit source.

The avian fossil record would suggest that birds were not important in angiosperm dispersal until the early Tertiary. From then on, they have become increasingly important as seed-distributing agents (Tiffney, 1984).

Possible Middle Eocene Interactions Between Birds and Plants

If we can't know precisely which fruits and seeds the Republic birds were eating in the middle Eocene, we know what kinds of fruit-bearing trees and shrubs were available to them. Many of the fossil plants have modern descendants whose seeds and fruits are commonly eaten and dispersed by birds, especially upland gamebirds and songbirds.

For instance, outstanding sources of wildlife food today include the oak and pine families. The oldest record of oaks, based on leaves, is at Republic, and the oldest known acorns come from the middle Eocene Clarno Formation in Oregon. The Republic forest also contained spruce (*Picea*), hemlock (*Tsuga*), true fir (*Abies*), Chinese golden larch (*Pseudolarix*), and several pine species (Wehr and Schorn, 1992). These conifers produce winged seeds now commonly eaten by passerines. Many members of the rose family have their first records in the Republic flora and are now major sources of food for birds: wild cherries (*Prunus*), blackberries and raspberries (*Rubus*), mountain ash (*Sorbus*), Saskatoon berry or service berry (*Amelanchier*), photinia, and apple (*Malus*). Other fruits that birds enjoy have their earliest known fossil records in the Okanogan Highlands: elderberries (*Sambucus*), mulberries (*Morus*), buckthorns (Rhamnaceae), madrona (*Arbutus*), wild currants and gooseberries (Grossulariaceae), holly (*Ilex*), and mistletoe (Loranthaceae). Other Republic trees and shrubs whose fruits and seeds have become important food sources for modern upland game- and songbirds include elm (*Ulmus*), sumac (*Rhus*), dogwood (*Cornus*), maple (*Acer*), sassafras, hazelnut (*Corylus*) and sweetgum (*Liquidambar*) (Wehr and Hopkins, 1994). Snow and Snow (1986) note that "most members of the Rosaceae...are very prone to exploitation by seed predators."

Although most of these genera are unrelated, they often have in common bird-attracting colored fruits (red, yellow, orange, blue; birds generally pay less attention to white or green fruits). Together, these plants offered birds a varied menu.

But is there any evidence that Eocene birds or mammals actually ate these seeds or fruits? The superbly preserved fauna at Messel has several fine examples. *Propalaeotherium parvulum*, an early horse, has fossil plant remains in its gastrointestinal tract, mainly grape seeds; other horse fossils contained walnuts and representatives of at least five plant families. Fossil grape seeds were also found in the stomach of a member of the woodpecker family (Picidae). Entire or chewed seeds are also found in other birds and rodents (Schaal and Ziegler, 1992).

Birds[1] probably had the potential to expand seed distribution significantly, particularly the smaller seeds. Tiffney (1984) has observed that dispersal mechanisms for Tertiary fruits and seeds can be inferred from their morphology and from their living relatives. He cautions (p. 56), however, that

> ...many morphological features are not preserved, and present day dispersal adaptations of a genus or family are no guarantee of past mechanisms. However, both lines of evidence suggest that a wide range of fruits and seeds adapted to animal dispersal were present by the Eocene...

In some fossil deposits, fruits and seeds have been found, but no leaf traces of the plants that bore them. For example, Manchester (1994) pointed out that while grape seeds are common in the Clarno nut beds, no grape leaves have been unearthed. The vitaceous seeds found in the Princeton chert are abraded, and they could suggest transport (Cevallos-Ferriz and Stockey, 1990); the Princeton chert environment (aquatic, near a lake shore) is not one in which we would look for grape leaves. Cevallos-Ferriz and others (1991, p. 179-181) note:

> The abundance of organs of a particular plant may give some indication of the distance plants were transported from their growth site to the basin of deposition. Fossil seeds of plants with affinities to known aquatics occur in the [Princeton] chert by the thousands (e.g., *Decodon, Allenbya, Keratosperma*), while other seed and fruit remains are considerably rarer (e.g., Vitaceae, Rosaceae). Related extant taxa of these rarer forms are usually transported by animals (e.g., *Prunus* fruits, *Ampelocissus* seeds) and may be dropped into basins from nearby environments.

[1] While the history of bat evolution is not yet clear, bats were already highly specialized in the early Eocene (Carroll, 1988). Six families are known from deposits of that age, and four of those are extant. A bat has been found in the Oligocene John Day Formation at Fossil, Oregon (Brown, 1959). Bats are also important dispersers of seeds and fruits, particularly in warmer regions where fruiting occurs nearly year-round. Bats typically disperse large, odoriferous fruits with a large stone (van de Pijl, 1972).

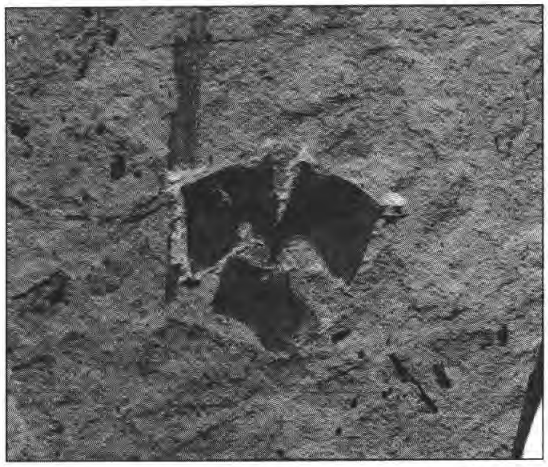

Figure 3. Crayfish parts, UWBM 77546A, approx. x 2, loc. A0307, Republic. Washington State Thomas Burke Memorial Washington State Museum collection.

Figure 4. A crayfish from near Cache Creek, British Columbia. The left claw (with the leg elements) in this specimen is about 2.1 cm long. Photo by Trevor Wick, reprinted from Archibald (1995) with the permission of The Vancouver Paleontological Society. Rolf Ludwigsen (Denman Island, BC, written commun., Oct. 1995) reports this specimen has been assigned to *Procambarus* Ortman; the genus also occurs in the Green River Formation of Wyoming (Feldman and others, 1981).

GEOLOGIC HISTORY OF CRAYFISH

Although the Republic fauna contains several kinds of fish (for example, suckers, mooneyes, and the earliest recorded salmonids [Wilson, 1977]), the only record of crustaceans at that site is two parts of a crayfish (molt?)—the rostrum and an abdominal plate (Fig. 3) found by Wehr in the 1980s. The fossil crayfish from the approximately coeval McAbee site near Cache Creek, BC, is shown in Figure 4 for comparison.

The oldest known freshwater crayfish is from Lower Cretaceous rocks of Australia. Whole decapods (crabs and their relatives) are very rare in nonmarine deposits of North America; more common are parts of molted 'shells'. Two crayfish are known from the Green River Formation (Grande, 1980), and one comes from the Miocene Payette Formation of Oregon and Idaho (Rathbun, 1926). Their marine relatives are considerably more common—and larger. At least one modern Alaskan crab can have an 11-foot 'leg-span'.

Crayfish are relished by snakes, salamanders, raccoons, otters, alligators, and birds, such as the great blue heron. The Chuckanut "heron" becomes a candidate for both bearer of one of the feathers and a predator on crayfish. In addition, modern *Amia* (bowfin fish) are known to eat crayfish, and a species of *Amia* was present at Republic.

CONCLUSIONS

The flora of Republic suggests a warm temperate to subtropical climate (Wolfe and Wehr, 1987) and a wealth of food resources. The rarity of Eocene bird remains almost certainly leads to an underestimation of their importance in influencing the rates of plant and forest diversification. Howe (1986, p. 127) observed

> A perception of either an ancient or modern forest must be a warped shadow of reality unless the means and consequences of seed-dispersal by fruit-eating birds and mammals are understood.

A survey of seed size by Tiffney (1984) suggests that most Cretaceous angiosperm seeds were small. In Paleogene deposits, we have the first records of large seeds. The abundance of larger seeds coincides with a period of rapid bird and mammal adaptive radiations.

Based on modern examples, we can surmise that early Tertiary birds may have played an important role in establishing microfloras, such as thickets and forest-edge communities. While wind and insects may have been important pollinating agents, birds (and bats) were likely the long-distance movers of the time.

Even without the whole-body fossils, bones, teeth, or tracks, we can begin to piece together life in and along the Eocene lake as we continue to unearth the flora and fauna buried in the lake sediments. Together the plants, feathers, and crayfish fragments also help us understand the relations of eater and eaten. We should be more alert for traces of both.

Acknowledgments

Emmett Evenoff, Estella Leopold, Steve Manchester, Bastiaan Meeuse, John Rensberger, Ruth Stockey, Bruce Tiffney, and Chris Thompson reviewed parts or all of this article. We are grateful for their sharp eyes and constructive suggestions.

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Erratum:

In plate 5 of the article *Early Tertiary flowers, fruits, and seeds of Washington State and adjacent areas*, the numeral 5 in the upper right part of the plate should be deleted. Figure 5 is the flower on the left side of the plate.

Northwest Paleontological Association Schedules 1996 Lectures

January 13: Ted Fremd, Paleontologist at John Day National Monument, will speak on the geology and fossils of the monument.

March 9: Don Grayson, Archaeologist, University of Washington, will talk about the significance of vertebrate fossils in archaeological sites.

Lectures are at 1:00 p.m. in the Burke Rooms of the Thomas Burke Memorial Washington State Museum on the University of Washington campus, just off 45th Avenue in Seattle. Anyone interested is welcome to attend.

Topographic Map Scales and the General Land Office Grid System

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Maps. We have all used them at one time or another. They are sometimes stuffed into glove compartments, backpacks, and pockets. Maps get folded, crumpled, torn, and written on. I have even heard of maps going through the laundry. These used and abused sheets of paper are fairly important. Sometimes the only way we know how to "get there" is when we have a map as our guide. Maps, however, are only useful to us when we understand their language.

Since the Utah Geological Survey (UGS) began selling topographic maps in January 1994, map-related questions are a daily occurrence. Some people are curious about various map symbols and others need help with map orientation. Most of the questions we receive regarding topographic maps are about the difference in map scales, and what are "township, range, and section", technically referred to as the [General] Land Office Grid System.

Map Scale

Map scale is the relationship between distance on a map and the corresponding distance on the ground. Scale is expressed as a ratio, such as 1:24,000, and shown graphically by bar scales marked in feet and miles, or in meters and kilometers. The table below shows the various scales of topographic maps available....

[Maps on which the bar scale covers a short distance], for example 7.5-minute maps, are often called large-scale maps because they show more detail (by covering less area) than [those where the bar scale covers a longer distance, for example 30- x 60-minute maps. To put it another way, the larger the denominator, the smaller the scale; 1:24,000 (1/24,000) is a larger scale map than one at 1:100,000 (1/100,000).]

7.5-minute Series

The 7.5-minute map series is the most detailed available.... This series is useful because topographic features are easy to identify, which allows for accurately determining location. Also, the clarity of the topographic features makes route-finding easier. For these reasons, the 7.5-minute series is very popular and is typically used for hiking, hunting, geologic prospecting, locating real estate—the number of uses is endless. The main drawback of this map series is that several maps may be needed to provide coverage for a large area. One map covers approximately nine miles in a north–south direction and approximately 6.5 miles east–west. [The width in Washington is slightly less because the state is farther north than Utah.]

15-minute Map Series

Also suitable for recreational and other activities is the 15-minute map series, which provides enough detail to determine location with good accuracy. These maps cover [exactly] four times the area of one 7.5-minute map. The U.S. Geological Survey has discontinued publishing and distributing this map series....

30- x 60-minute Map Series

The 30- x 60-minute map series is useful for four-wheeling, hunting and other activities for which coverage of a large area, rather than detail, is required. [Thirty-two] 7.5-minute maps cover the area of one 30- x 60-minute map. This is a multipurpose map series which shows most of the same features (for example, railroads, powerlines, unimproved roads, and highways) on larger scale maps, but with much less detail.

U.S. 1:250,000 Map Series

This map series is the smallest scale [readily] available.... These maps show a large area; only 13 1:250,000 maps are needed to cover the state of Utah (full state coverage using 7.5-minute maps requires 1,512 maps). The 1:250,000 map series is useful for an overall view of an area but is not recommended for back-county use because of the lack of topographic detail.

[Utah covers 82,186 square miles. Washington covers 66,582 square miles. Eighteen 1:250,000 maps cover Washington, though only small parts of the state are shown on half of these maps. Simplified topographic maps of the southwest and northeast quadrants of the state at this scale are available from the Division of Geology and Earth Resources; the south-

Map series	Scale	1 inch represents approximately	1 centimeter approximately	Size (latitude x longitude)	Minimum area† covered (square miles)
7.5 minute*	1:24,000	2,000 feet (exact)	240 meters	7.5 x 7.5 minutes	49
15 minute	1:62,500	1 mile	625 meters	15 x 15 minutes	197
30 x 60 minute	1:100,000	1.6 miles	1 kilometer	30 x 60 minutes	1,568
U.S. 1:250,000	1:250,000	4 miles	2.5 kilometers	1 x 2 degrees	4,580

(*Minute refers to one minute of latitude and longitude. A 7.5-minute map covers 7.5 minutes of latitude and 7.5 minutes of longitude)

†[The minimum areas are smaller for Washington.]

east quadrant is in preparation. Fifty maps at 1:100,000 scale (30 x 60 minute) cover the state.]

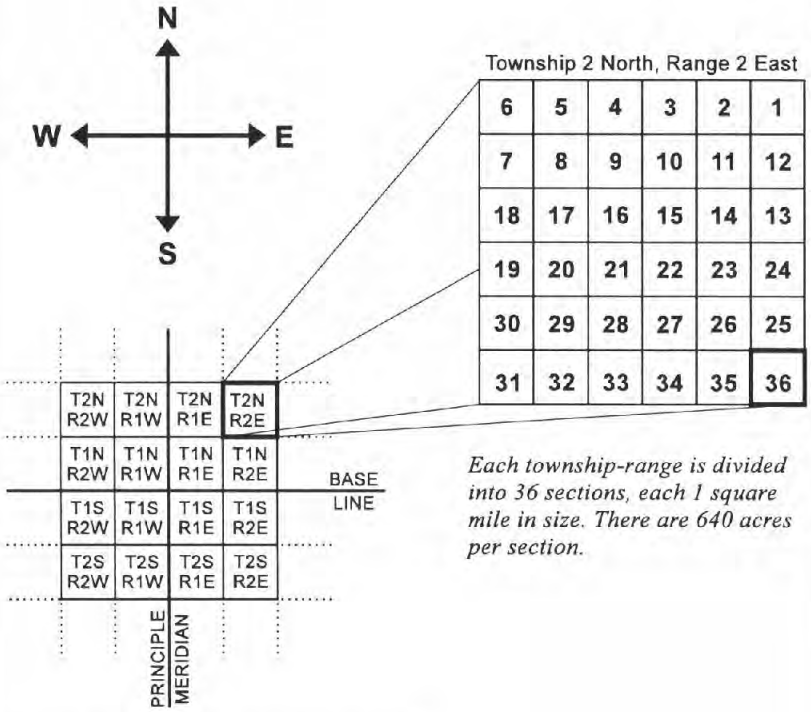
Township, Range, and Section

In 1812, the U.S. Government formed the General Land Office (renamed the Bureau of Land Management in 1946) to create a standardized system to more accurately define a given U.S. location. This system was initiated in response to the acquisition of large tracts of land, like the Louisiana Purchase, during the 1800s. The system developed by the Government Land Office is called the [*General Land Office Grid System*] and is used in states west of Ohio [as well as part of Ohio]. The system divides land into 36-square-mile units called *townships*. Each township has a township and range designation [shown in red print as, for example, T. 20 N., or R. 4 E. along the edge of the 1:24,000 topographic map] to define its 36-square-mile area. Township is numbered north and south from a selected parallel of latitude called a *base line*, and range is numbered west or east of a selected meridian of longitude called a *principal meridian*.

Townships are sub-divided into 36 1-by-1-mile parcels called sections. Sections are numbered from 1 to 36 for identification. Sections are broken into quarters, which are further quartered to describe a property location. The figure [to the right] shows the numbering systems for township-range, sections, and quarter sections.

The [land] office grid system is used for legal land descriptions.... [In Washington, for example, the west end of Grand Coulee Dam is in the SW1/4NW1/4 sec. 1, T. 28 N., R. 30 E. The Willamette principal meridian divides west and east ranges in Washington. It runs north–south from near Blaine, just west of Woodland, and on south. The baseline, which divides north and south townships, is actually in Oregon; it runs east–west through Portland. It is called the Willamette base line.]

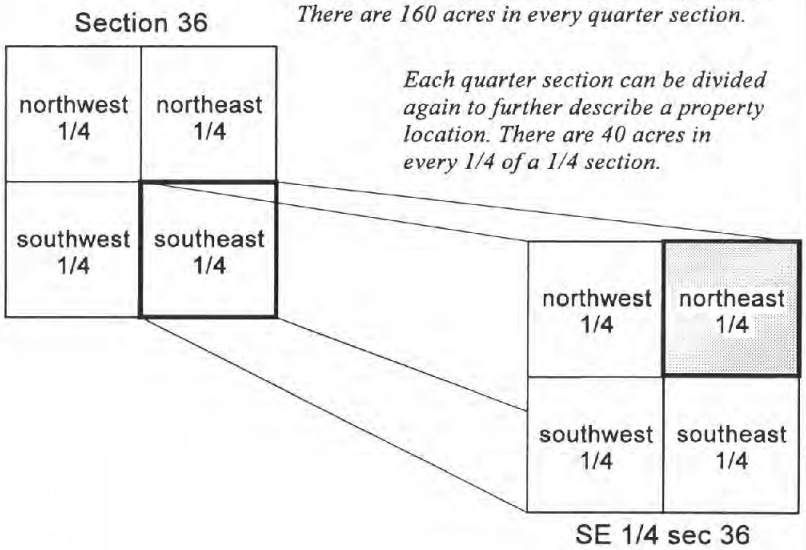
USGS and other maps can be purchased from the Photo and Map Sales section in the Natural Resources Building, 1111 Washington St. SE, Olympia; phone 360-902-1234, and from the U.S. Geological Survey, U.S. Post Office Building, Rm 135, W. 904 Riverside Ave., Spokane; phone 509-353-2524, as well as several sporting good stores around the state. Some 15-minute maps may still be available at these locations.



Each township-range is divided into 36 sections, each 1 square mile in size. There are 640 acres per section.

General Land Office Grid System defined as Township and Range. Each Township is 36 square miles in size or 6 miles square.

Sections can be subdivided into four quarters to better describe the location of a given property. There are 160 acres in every quarter section.



Each quarter section can be divided again to further describe a property location. There are 40 acres in every 1/4 of a 1/4 section.

This complete legal description for the shaded area above is: NE 1/4, SE 1/4, section 36, T. 2 N., R. 2 E.

Editor's Note:
This article is taken verbatim, with thanks, from Survey Notes, published by the Utah Geological Survey. Only references to places in Utah and items for sale at the Survey's bookstore are left out of this article. We have made changes and added some information specific to Washington in [ ]s and slightly modified the figure.

Summary of Mount St. Helens Seismic Activity, January through September 1995

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and

Staff, Geophysics Program
University of Washington
Seattle, Washington

Mount St. Helens was quiet between January 1 and September 30 of this year. No explosion or emission of gas and ash occurred from the lava dome. Seismic activity is still low, but the number of small magnitude (less than magnitude 1) earthquakes beneath the crater has increased slowly but steadily from less than 10 events per month in January to about 100 events in September (Fig. 1).

This increase in seismic activity is very small compared to the activity that preceded each of the explosive and dome-building eruptions between 1980 and 1986. During these eruptions, earthquake activity was clearly associated with the rise of molten rock, or magma, into the volcano and its eruption at the surface. The dome-building eruptions were preceded and accompanied by intense shallow earthquake activity, located less than 2 miles beneath the crater. In contrast, recent earthquakes were smaller and originated at depths between about 1 and 6 miles. There is no evidence to suggest that they indicate an upward rise of magma.

The current seismic activity closely resembles seismicity that began in late 1987 and occurred before and during a series of small gas explosions from the dome in 1989–1991. These explosions, though relative small, were large enough to hurl dome rocks as large as 1 foot in diameter at least 0.5 mile from the dome and produce ash plumes as high as about 20,000 feet above sea level. Because the 1989–1991 steam explosions were not preceded by any specific short-term warning, the similarity of the current seismicity to that of the earlier episode raises our concern that small explosions from the dome could again occur without additional warning.

Our experience with the 1989–1991 series of gas explosions from the dome, as well as explosions during the years of dome growth, suggests that they would produce hazards primarily within the crater, to a lesser degree in the stream channels leading from the crater, and to an even smaller degree on the upper flanks of the volcano. These hazards could include the impact of dome rocks ejected from the dome and rapidly moving hot-rock avalanches (pyroclastic flows) sweeping the crater floor. During the explosion on February 5, 1991, a small pyroclastic flow reached the north edge of the crater. Heat from a rock avalanche or pyroclastic flow could also generate a lahar, a mixture of rock, mud, and water, in the crater and channels leading from the crater. Also, gas explosions could generate dilute but visible ash plumes perhaps as high as 20,000 feet above the volcano and light ashfall as far as 100 miles downwind from the volcano.

Likely Explanation of Recent Earthquake Activity

The recent earthquakes originate at depth about 1 to 6 miles below the crater (Fig. 2). This same zone of seismic activity

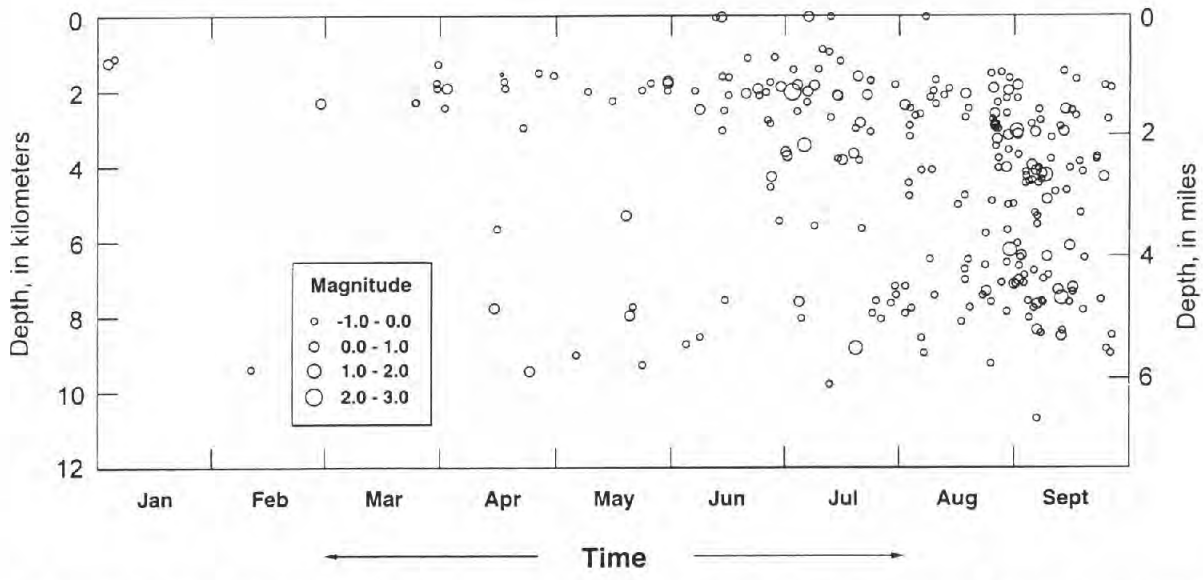

Figure 1. This graph shows the increase in seismic activity at Mount St Helens during the first nine months of 1995. Many of these earthquakes are less than magnitude 1. The largest earthquake (magnitude 2.3) occurred on July 4.

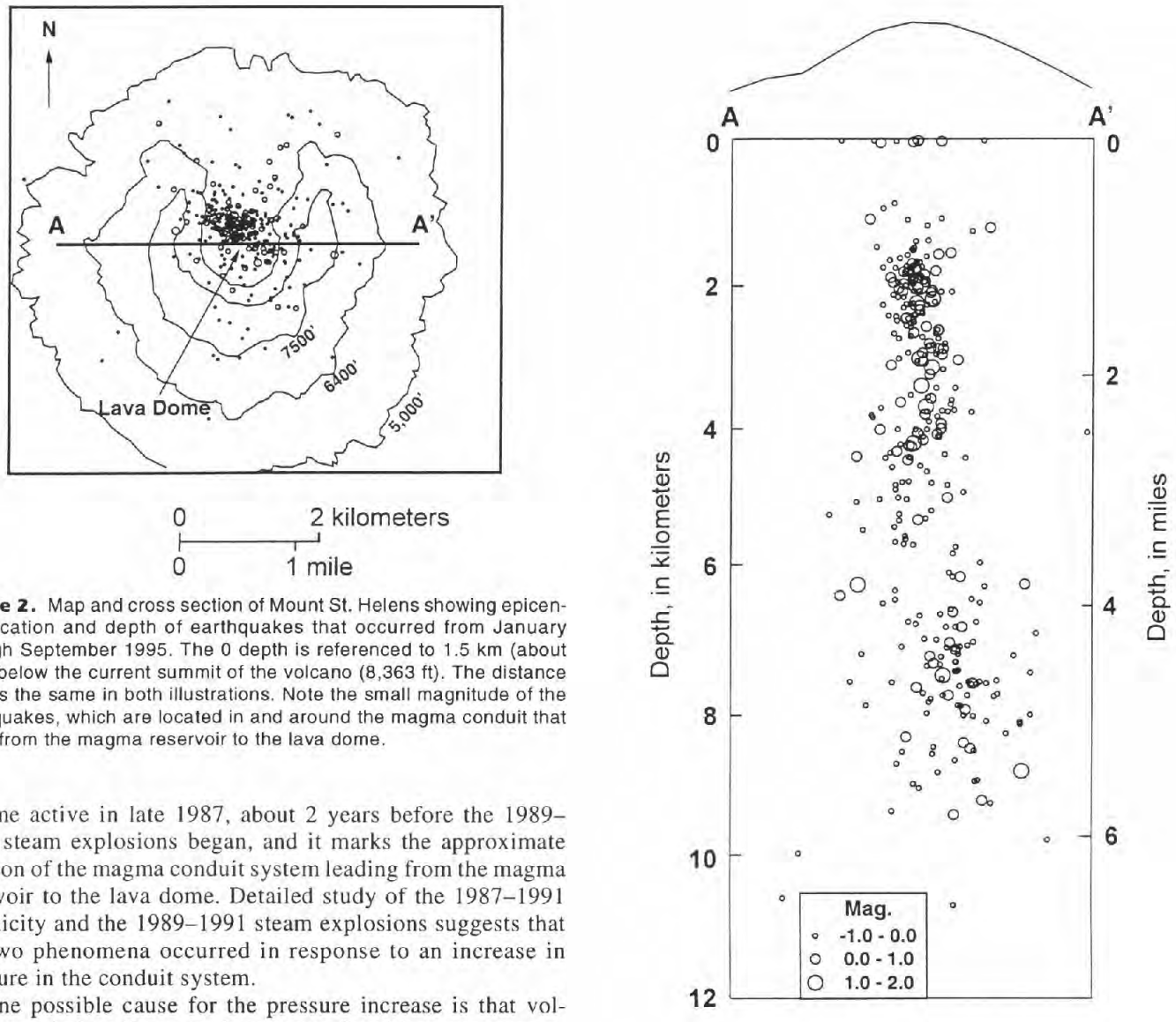

Figure 2. Map and cross section of Mount St. Helens showing epicentral location and depth of earthquakes that occurred from January through September 1995. The 0 depth is referenced to 1.5 km (about 1 mi) below the current summit of the volcano (8,363 ft). The distance A–A′ is the same in both illustrations. Note the small magnitude of the earthquakes, which are located in and around the magma conduit that leads from the magma reservoir to the lava dome.

became active in late 1987, about 2 years before the 1989–1991 steam explosions began, and it marks the approximate location of the magma conduit system leading from the magma reservoir to the lava dome. Detailed study of the 1987–1991 seismicity and the 1989–1991 steam explosions suggests that the two phenomena occurred in response to an increase in pressure in the conduit system.

One possible cause for the pressure increase is that volcanic gas (primarily water in gaseous form) became concentrated along the volcano's conduit system. The concentration of gas along the conduit was likely a consequence of the progressive cooling and crystallization of the magma in the magma reservoir. As magma cools, mineral crystals grow, and gas in the remaining molten rock becomes concentrated. If the gas cannot escape easily to the surface, it accumulates along the conduit, which leads to increased pressure. This pressure would likely lead to increased fracturing of rock immediately surrounding the conduit system, causing increased seismicity, as well as to intermittent sudden release of gas at the dome's surface. In addition, downward growth of cracks and fractures in the dome during and just after periods of heavy rainfall could trigger gas explosions when fractures intersect pressurized areas in or below the dome. Many, but not all of the explosions in 1989–1991 followed heavy rains.

Another possible cause for the pressure increase is intrusion of new magma into the lower depths of the conduit system. There is no evidence, however, that any new magma has moved to near the surface.

Regardless of the cause, it seems likely that the recent small change in seismicity reflects a renewed increase in pressure along the conduit system.

Volcano Monitoring

The U.S. Geological Survey and the University of Washington Geophysics Program continue to monitor the volcano and maintain a seismic alarm system. (See Washington Division of Geology and Earth Resources Information Circular 89; Part 2 describes the operation of the regional seismograph network.) Information of an emergency character is distributed through the U.S. Forest Service Emergency Coordination Center in Vancouver, Washington. ■

(This article is slightly modified from a report received in October.)

Sand and Gravel Update

According to an article in the August issues of *Rock Products*, CalMat's Sun Valley, ID, facility is now the largest producer of sand and gravel in the nation. Lone Star Northwest's Steilacoom operation is now the second largest.

Selected Internet Resources in the Geosciences and Related Fields, with an Emphasis on the Pacific Northwest

compiled by Rebecca A. Christie
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PO Box 47007, Olympia, WA 98504-7007

The Internet is a network of computer networks that connect computers, from individual personal computers to supercomputers. A vast amount of information is already accessible through the Internet, and more organizations, businesses, schools, and individuals are contributing daily.

The Washington State Department of Natural Resources is currently planning to develop a World Wide Web home page. The Division of Geology and Earth Resources staff is eager to distribute information to an even broader audience. We hope to be online sometime in 1996, and we'll certainly announce the URL (see the glossary) and the Division's contributions in *Washington Geology*.

The following list contains selected Internet sites that provide information of interest to the geologic community. The list emphasizes World Wide Web sites, but there are also gopher, ftp, telnet, and e-mail addresses included. A short glossary appears at the end of the article. For additional information on the Internet, there is no shortage of information available at libraries, in journals, in books, and electronically on the Internet itself. This list *cannot*, by the nature of the Internet, be comprehensive, but it will certainly get you started.

The Internet address (URL) is given as:

protocol://host/path/filename.

COMPREHENSIVE GEOSCIENCE RESOURCES

Online Resources for Earth Scientists (ORES)
by Bill Thoen & Ted Smith
http://www.gisnet.com/gis/ores/

Internet Resources in the Earth Sciences
http://www.lib.berkeley.edu/EART/EarthLinks.html

Netscape Directory for Geology and Geophysics
http://www.yahoo.com/Science/Geology_and_geophysics

CIESIN (Consortium for International Earth Science Information Network)
http://www.ciesin.org

CERN (Virtual Library Earth Sciences Home Page)
http://www.geo.ucalgary.ca/VL-EarthSciences.html

PACIFIC NORTHWEST GOVERNMENT AGENCIES

(See also specific subject areas listed below.)

State of Washington home page
http://olympus.dis.wa.gov/

Washington State Department of Ecology
http://olympus.dis.wa.gov/www/access/ecology/ecyhome.html

Washington State Department of Transportation
http://www.wsdot.wa.gov

Washington State Department of Transportation Research Page
http://www.wsdot.wa.gov/ppsc/research/rpage.htm

Oregon Department of Geology and Mineral Industries (DOGAMI)
http://www.state.or.us
[Select 'Government'; select 'State of Oregon government agencies on Oregon OnLine gopher';
Select 'Geology and Mineral Industries, Dept. of'.]
(A DOGAMI WWW home page is under construction.)

California Division of Mines and Geology
http://www.consrv.ca.gov/dmg/

Idaho Geological Survey
http://www.uidaho.edu/~stanford/index.html

British Columbia Ministry of Energy, Mines and Petroleum Resources
http://www.empr.gov.bc.ca

Battelle Pacific Northwest Laboratories
[See both 'Environmental Technologies Division' and 'Environmental and Energy Sciences Division'.]
http://www.pnl.gov:2080/

U.S. Army Corps of Engineers, Seattle District
http://www.nps.usace.army.mil/cenps/html

U.S. Forest Service, Park and Forest Information
http://www.fs.fed.us/
[Select 'Other Forest Service information on the Internet';
Select 'Oregon–Washington National Forest information'.]

HYDROLOGY, OCEANOGRAPHY, COASTAL STUDIES

U.S. Geological Survey Washington State District, Water Resources Division
http://wwwdwatcm.wr.usgs.gov/wrd-home.html
e-mail: <pubinfo@maildwatcm.wr.usgs.gov>

U.S. Geological Survey Western Region Water Resources Information
http://wwwrcamnl.wr.usgs.gov/

U.S. Geological Survey Water Resources Information
http://h2o.usgs.gov

U.S. Geological Survey Ice and Climate Project
http://orcapaktcm.wr.usgs.gov/

Battelle Pacific Northwest Laboratory Earth and Environmental Sciences Center's Hydrology-related Internet resources
http://etd.pnl.gov:2080/hydroweb.html

Washington Water Research Center
http://www.ce.wsu.edu/wwrc/wwrc.html

Washington Sea Grant
http://wsg.washington.edu

Oregon Sea Grant
http://seagrant.orst.edu

NOAA Northwest Region
http://www.nnic.noaa.gov/WEST.html

Groundwater Modeling Links Page
http://www.et.byu.edu/~asce-gw/

Universities Water Information Network (UWIN) Gopher
http://www.uwin.siu.edu

EARTHQUAKES AND SEISMOLOGY

Seismosurfing the Internet
http://www.geophys.washington.edu/seismosurfing.html

Earthquake information, U.S. Geological Survey, Menlo Park, CA
http://quake.wr.usgs.gov/

National Earthquake Information Center, Golden, CO
http://gldfs.cr.usgs.gov

Tsunami! A WWW Tsunami Information Resource
http://tsunami.cc.washington.edu/tsunami/counter.acgi?view

Earthquake Engineering Research Center (EERC)
http://nisee.ce.berkeley.edu/

National Center for Earthquake Engineering Research (NCEER)
http://www.nceer.buffalo.edu

VOLCANISM

Cascade Volcano Observatory
http://vulcan.wr.usgs.gov

Volcano Systems Center, University of Washington
http://www.vsc.washington.edu/

SOILS, FORESTRY, DENDROCHRONOLOGY

U.S. Natural Resources Conservation Service
(formerly the Soil Conservation Service)
http://www.ncg.nrcs.usda.gov/

British Columbia Ministry of Forests
http://mofwww.for.gov.bc.ca

[Soon changing to: http://www.for.gov.bc.ca]

Laboratory of Tree-Ring Research, University of Arizona
http://www.LTRR.Arizona.EDU/

MINING

INFO-MINE, Mining industry information
http://www.info-mine.com/

International Archive of Economic Geology, University of Wyoming
http://www.uwyo.edu/legal/ahc/iaeg/iaeg.htm

GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Geographic Information Systems—Information Sites
ftp://gis.queensu.ca/pub/gis/docs/gissites.html

PACIFIC NORTHWEST UNIVERSITIES

Eastern Washington University Department of Geology
http://146.187.32.49/csmt/geol/geoldept.HTM

University of Washington Department of Geological Sciences
http://weber.u.washington.edu/~geology/

University of Washington Geophysics Program
http://www.geophys.washington.edu/

University of Washington School of Oceanography
http://www.ocean.washington.edu/

Washington State University Department of Geology
http://www.geol.wsu.edu

Portland State University Department of Geology
http://131.252.71.35

[Note: The geology departments at Central Washington University and Western Washington University are in developmental stages for WWW sites.]

U.S. AND CANADIAN GOVERNMENT AGENCIES

U.S. Geological Survey (USGS)
http://www.usgs.gov

Geological Survey of Canada (GSC)
http://www.emr.ca/gsc/

National Oceanic and Atmospheric Administration (NOAA)
http://www.noaa.gov/

Geophysical On-Line Data (GOLD)
http://www.ngdc.noaa.gov/ngdc.html

National Geodetic Survey
http://www.ngs.noaa.gov/

U.S. Bureau of Land Management (BLM)
http://www.blm.gov

U.S. Environmental Protection Agency (EPA)
http://www.epa.gov

U.S. Federal Emergency Management Agency (FEMA)
http://www.fema.gov

U.S. Fish and Wildlife Service
http://www.fws.gov

PROFESSIONAL ORGANIZATIONS

American Association of Petroleum Geologists (AAPG)
http://www.Geobyte.com

American Geological Institute (AGI)
http://jei.umd.edu/agi/agi.html

gopher://agi.umd.edu 71

American Geophysical Union (AGU)
http://earth.agu.org/kosmos/homepage.html

Association for Women Geoscientists
http://flint.mines.colorado.edu:4502

COGSnet (Computer Oriented Geological Society)
ftp://ftp.csn.org/COGS

Geological Society of America (GSA)
http://www.aescon.com/geosociety/index.html

Geoscience Information Society (GIS)
http://www.lib.berkeley.edu/GIS

Society of Exploration Geophysicists
http://sepwww.stanford.edu/seg

Soil and Water Conservation Society
http://www.netins.net/showcase/swcs

RESOURCES FOR EDUCATORS

On-line earth science education resources
http://www.ems.psu.edu/RelatedWebSites.html

C&C's Earth Science Emporium Home Page
http://nlu.nl.edu/bthu/nlu/eight/es/Homepage.html

Interactive multimedia educational resources
http://www.ems.psu.edu/Earth2/E2Top.html

Online resources for earth scientists—Geoscience education resources
http://www.calweb.com/~tcsmith/ores/geo-ed/

U.S. Geological Survey Ask-A-Geologist
e-mail: <ask-a-geologist@octopus.wr.usgs.gov>

LIBRARY CATALOGS

U.S. Geological Survey Library
telnet://130.11.54.234

[At PW prompt, type GSL <return>;
At ID prompt, type LS2K <return>;
At Terminal: VT/100 prompt, hit <return>; the next screen displays the opening menu of the online catalog;
To exit, type /EXIT <return>]

Canadian Geoscience Information Centre
telnet://geoinfo.gsc.emr.ca (Login=opac)

National Oceanic and Atmospheric Administration (NOAA) Central Library
http://hpcc1.hpcc.noaa.gov/noaalib/noaalib.html

Mining Environment Database (MEDB)
telnet://laulibr.laurentian.ca (Username=netlib)

U.S. Environmental Protection Agency Online Library
telnet://epaibm.rtpnc.epa.gov

National Agriculture Library
gopher://gopher.nalusda.gov

GLOSSARY

E-mail (electronic mail)—A means of sending messages electronically over a computer network. An e-mail address consists of a name and a computer host (location).

FTP (File Transfer Protocol)—An Internet tool that enables you to transfer files between two computers connected to the Internet.

Gopher—A finding aid to Internet resources, organized as a set of menus.

Hypertext—A nonlinear, nonhierarchical way to organize information. Hypertext allows a user to select highlighted words in a text and be linked to another document or computer system.

html—Hypertext Markup Language.

http—Hypertext Transfer Protocol.

Lynx—A text-based interface to the Internet through the World Wide Web.

Mosaic—A graphical interface to the Internet thrugh the World Wide Web. Mosaic allows the use of a mouse, and has graphical, sound and text display capability.

Telnet—An Internet command that enables your computer to make a direct connection with a remote computer.

URL (Uniform Resource Locator)—The unique address which identifies a document; the URL address defines which protocol to use for a file: http, gopher, or ftp.

World Wide Web (WWW)—The WWW is a hypertext system providing access to the Internet. Two programs that provide access to WWW documents are Mosaic and Lynx. ■

Laurentian University Library's Mining Environment Database

The Mining Environment Database, developed and maintained by the J. N. Desmarais Library at Laurentian University, contains over 13,000 citations on abandoned mines, land reclamation, acid mine drainage, and related topics. A separate entry is created for each journal article, conference paper, or chapter in an edited monograph, with author, title, and source information; most records have a brief abstract. Coverage is international in scope. The Library has a hard copy of most citations.

Citations from two major U.S. bibliographies/collections have recently been integrated into the database:

- *Metal Mining and the Environment: A Bibliography.* Approximately 1,500 titles compiled by Rebecca A. Christie for the Washington State Division of Geology and Earth Resources.
- *Mined Land Reclamation Program Research Library.* A collection of over 9,000 citations on land reclamation, with materials from the 1950s and 60s, at the University of Southern Illinois at Carbondale.

The Library's intent is to serve as a central location for database files from other resource centers with significant holdings on mining and the environment. The Library is also seeking donations of offprints of appropriate articles or conference papers, as well as copies of mining and environmental legislation and regulations from other jurisdictions.

The Library is especially interested in acquiring, with permission, copies of both environmental impact studies and research for decommissioned mine sites, as well as the internal reports of mining companies. These documents form by far the most useful portion of the mining rehabilitation literature. Most companies assume that once a decommissioning and reclamation plan has been approved, the preliminary research and support documentation are of no further use. Research reports are stored briefly and then discarded. The Library has a state-of-the-art archival facility and can provide restricted access to these reports. It has been trying to convince the private sector that these reports would be invaluable to researchers facing similar problems in other jurisdictions or future developers of the same property. Companies and consulting firms would not have to redo research for the same property and could save enormous amounts of money.

The Mining Environment Database is available on CD-ROM for $200 Canadian; upgrades are $100 Canadian. Orders should be sent to the CIMMER Office, Laurentian University; Sudbury, Ontario, CANADA P3E 2C6. *Fax:* 705-673-6508.

The database is also accessible on the Internet, either directly or via the Washington & Lee Law Library Liberty gopher. (See the article on Internet resources above.)

To submit comments or make donations, contact Glen Kelly or Ron Slater, co-editors, Mining Environment Database; Technical Services, J. N. Desmarais Library; Laurentian University; Sudbury, Ontario, CANADA P3E 2C6. *Phone:* 705-675-1151, ext. 3323 or 3329; *Fax:* 705-673-6524; *E-mail:* gkelly @laulibr.laurentian.ca; rslater@laulibr.laurentian.ca.

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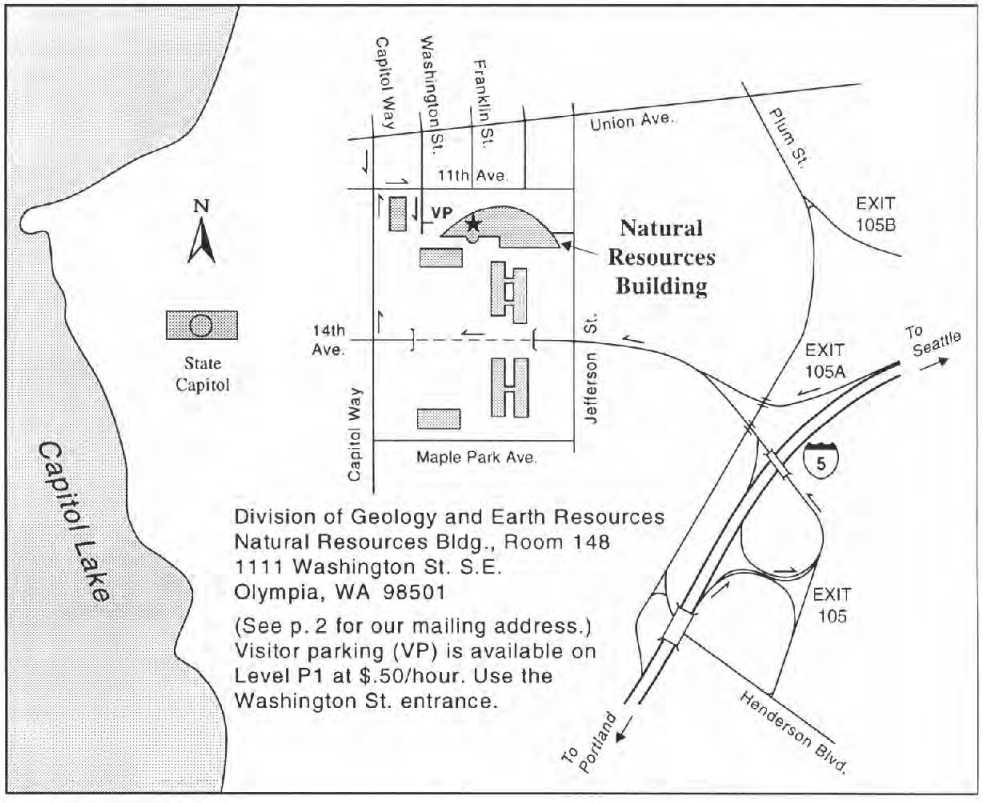

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Oregon State Geologist New Treasurer of AGI

Donald A. Hull, state geologist and director of the Oregon Department of Geology and Mineral Industries, became treasurer of the American Geological Institute (AGI) on Nov. 7, 1995. Hull was sworn into office during the annual meeting of the Geological Society of America being held in New Orleans.

Hull will serve as treasurer for two years, working closely with executive committee members. He will be responsible for general monitoring and review of revenues and disbursement of AGI's funds and will chair AGI's finance committee.

AGI is a nonprofit federation of 28 geoscience and professional organizations that collectively represents more than 80,000 geologists, geophysicists, and other earth scientists.

FAIR USE FORUM

A recent article in *Science* casts new light on some uses of geologic literature. "How does the Texaco case affect photocopying by scientists?" (Science, v. 270, Dec. 1, 1995, p. 1450-1451) reviews some implications and unanswered questions on what constitutes 'fair use'. *Science* invites you to participate in an electronic forum concerning copyright law. Contact Science On-Line (http://science-mag.aaas.org/science.

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Division Releases Liquefaction Susceptibility Maps

A series of maps detailing liquefaction susceptibility for five 7.5-minute topographic quadrangles in the Puget Sound area (Renton and Des Moines, Auburn and Poverty Bay, and Sumner) has recently been completed and published in the Division's Geologic Map (GM) series as GM-41, -43, and -44 respectively.

In each quadrangle, Division geologists assigned geologic deposits to one of three or four susceptibility rankings on the basis of analyses of geotechnical data and historical reports of liquefaction during the 1949 magnitude 7.1 Olympia and 1965 magnitude 6.5 Seattle–Tacoma earthquakes.

These maps are intended to provide land-use planners, emergency-response personnel, geotechnical consultants, building developers and contractors, and private citizens with a qualitative assessment of the likelihood of soil liquefaction during an earthquake. The maps only indicate generalized areas more or less prone to liquefaction and cannot be used to determine the presence or absence of liquefiable soils beneath any specific locality. The data used in the liquefaction susceptibility assessment have been subdivided on the basis of regional geological mapping at the 1:24,000 scale. No estimate of the damage resulting from liquefaction is presented; in many instances liquefaction may occur without causing significant ground displacement and damage to structures.

GM-41 was released earlier this year. The following maps have just been printed:

Liquefaction Susceptibility for the Auburn and Poverty Bay 7.5-minute Quadrangles, Washington, Geologic Map GM-43, by Stephen P. Palmer, Timothy J. Walsh, Robert L. Logan, and Wendy J. Gerstel. 15 p., 2 plates, scale. $4.63 + .37 tax (WA residents only) = $5.00

Liquefaction Susceptibility for the Sumner 7.5-minute Quadrangle, Washington, Geologic Map GM-44, by Joe D. Dragovich and Patrick T. Pringle, with a section on liquefaction by Stephen P. Palmer. 26 p., 1 plate, scale. $2.32 + .18 tax (WA residents only) = $2.50

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