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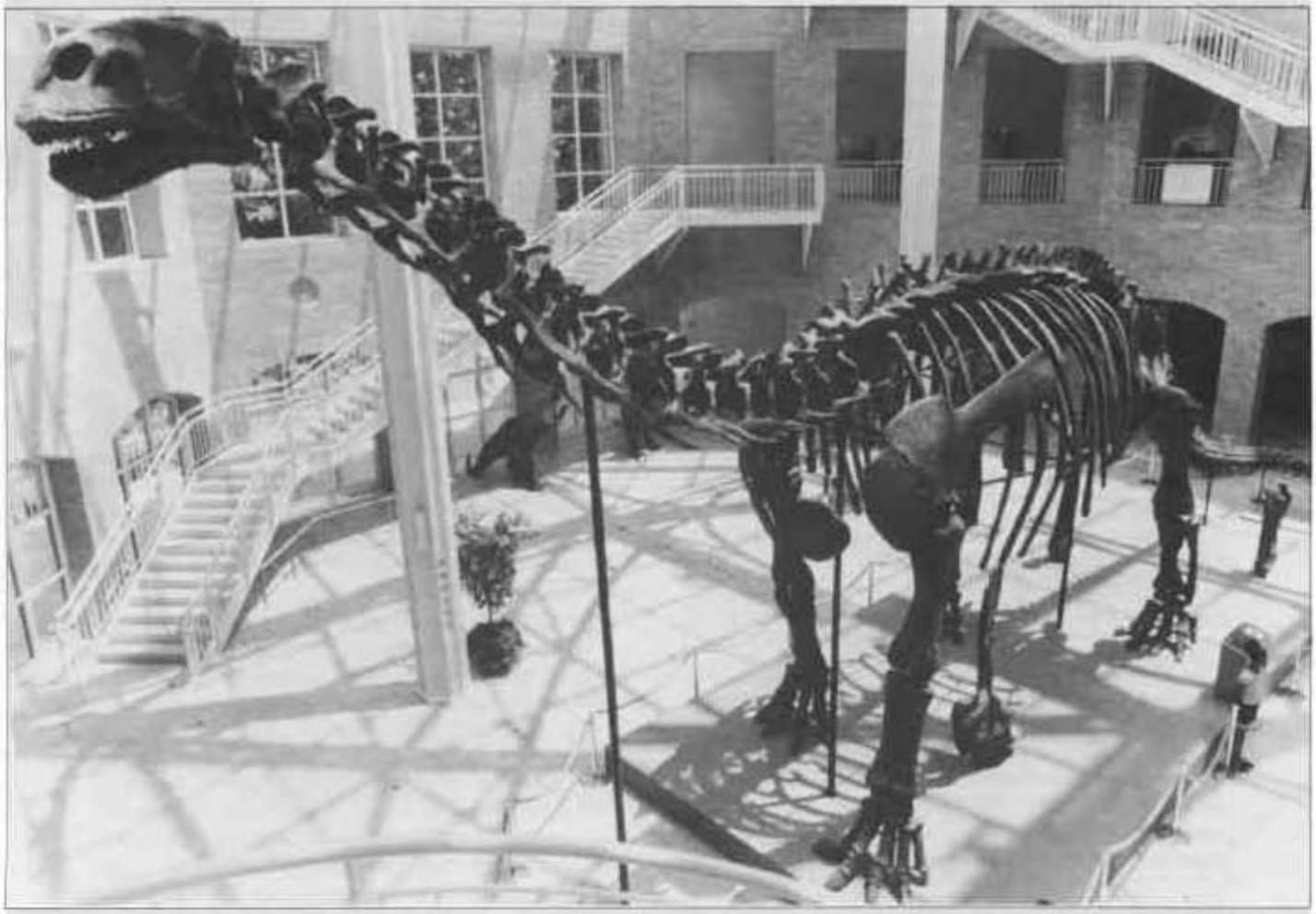
March to September in Portland at OMSI: *Nurosaurus qaganensis*



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Oregon Geology is designed to reach a wide spectrum of readers interested in the geology and mineral industry of Oregon. Manuscript contributions are invited on both technical and general-interest subjects relating to Oregon geology. Two copies of the manuscript should be submitted. If manuscript was prepared on common word-processing equipment, a file copy on diskette should be submitted in place of one paper copy (from Macintosh systems, high-density diskette only). Graphics should be camera ready; photographs should be black-and-white glossies. All figures should be clearly marked; figure captions should be together at the end of the text.

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

Authors will receive 20 complimentary copies of the issue containing their contribution. Manuscripts, letters, notices, and meeting announcements should be sent to Beverly F. Vogt, Publications Manager, at the Portland office (address above).

Cover photo

This giant sauropod is the largest complete fossil dinosaur currently on exhibit at the Oregon Museum of Science and Industry in Portland. It is the most impressive specimen of a collection on loan from the Inner Mongolian Museum of Natural History, China. On display are fossils collected in the Gobi desert mostly during the 1980s. See description of the exhibit on page 41 of this issue.

April is National Earthquake Awareness Month

April is again being observed as National Earthquake Awareness Month in Oregon through a partnership including the Oregon Department of Geology and Mineral Industries (DOGAMI), the Office of Emergency Management, and local American Red Cross chapters. The following major events are planned:

- Oregon Governor John Kitzhaber will proclaim April as Earthquake Awareness Month.
- DOGAMI will set up an earthquake display on seismic rehabilitation on April 1 and 2 at the State Capitol in Salem.
- Free information materials will be provided through the Nature of the Northwest Information Center in Portland and DOGAMI field offices in Grants Pass and Baker City. Materials will provide resources to homeowners on how to protect their homes and families from earthquake damage.
- DOGAMI Earthquake hazard maps and related materials will be sold at a 20-percent discount at the Nature of the Northwest Information Center during April. That includes relative hazard maps of the Portland, Mount Tabor, Beaverton, Lake Oswego, Gladstone, Linnton, and Salem East/Salem West quadrangles and of the Siletz Bay area and a statewide probabilistic map. (A list is available from the Center and can also be found on the DOGAMI homepage under http://sarvis.dogami.state.or.us/eq/eqpblst5.htm–*ed.*)
- The free booklet, "Before Disaster Strikes" is offered through the Oregon Trail Chapter of the American Red Cross. This complete guide highlights preparedness measures for most emergencies, with heavy emphasis on earthquakes.
- In the Portland area, the Oregon Trail Chapter of the American Red Cross and local emergency managers will distribute earthquake education kits to elementary schools.

Last year's biennial "QuakeEx" earthquake simulation was cancelled because emergency responders were busy with the floods. The exercise is planned for April 1998. □

Corrections

With apologies to authors and readers, we have to correct two errors that slipped into the last two issues: In the November 1996 issue, volume 58, number 6, on page 148, the right-hand column in Table 3 lists "Average expected value of losses" in **thousands** (not millions) of dollars—as is apparent from other places in Bob Whelan's article. And in the January 1997 issue, volume 59, number 1, page 2, the "In memoriam" column for John Eliot Allen should have said that Allen died **December** (not November) 17, 1996. □

Preparing for earthquakes in Oregon

by Yumei Wang, Oregon Department of Geology and Mineral Industries

This article is a slightly modified version of a paper by Yumei Wang, Geotechnical Engineer and Director of Earthquake Programs of the Oregon Department of Geology and Mineral Industries. The paper will be included in *Engineering and Environmental Geology of Oregon: Case Histories*, an upcoming publication sponsored by the Oregon Section of the Association of Engineering Geologists. The paper is presented here because April is Earthquake Awareness Month—an appropriate time to examine what has been and is being done in the State of Oregon to prepare for earthquakes and to consider what other steps need to be taken to protect Oregonians and their property from earthquakes. *—ed.*

ABSTRACT

This paper traces the changes in the understanding of Oregon's earthquake hazards and provides an overview of how Oregon addresses reducing earthquake risks. The threat of a great Cascadia subduction zone earthquake identified during the last decade and the occurrence of two relatively minor yet damaging "wake-up calls" with the Scotts Mills and Klamath Falls earthquakes of 1993 have underscored the reality of earthquake hazards in Oregon. While periodic earthquake shaking has been reported in Oregon for over the last century and a half, modern earthquake monitoring has been possible only for the past few decades. Most of the earthquake hazard assessment and mitigation efforts made to date have been accomplished within the last decade, and public awareness has risen remarkably during that same period. Major federal, state, and local government agencies and private organizations support earthquake risk reduction and have made significant contributions. Despite the progress, Oregon still remains underprepared. Many structures and lifelines, such as buildings, bridges, and water systems, need to be strengthened, and land use planning needs to be improved.

INTRODUCTION

Some people who used to live in Oregon believed so strongly that earthquakes pose a tremendous threat that they have packed their belongings and moved out of the state. Others have sought refuge from earthquake hazards by moving to Oregon after the 1989 Loma Prieta earthquake in California. These extreme cases illustrate the range of problems that people are having in understanding and responding to earthquake hazards in Oregon.

Earth scientists now believe that all parts of Oregon can be shaken by earthquakes. Oregon lies where two tectonic plates, the North American plate and the Juan de Fuca plate, are colliding, and the Juan de Fuca plate is being forced to dive under the North American plate along a large active fault called the Cascadia subduction zone. Earthquakes can occur within the Juan de Fuca plate (such earthquakes are called intraplate earthquakes), in the overriding North American plate (called crustal earthquakes), or along the Cascadia subduction zone, which is the interface between the two plates (called subduction zone earthquakes). All three possible earthquake types (intraplate, crustal, and subduction zone) (Figure 1) can severely impact the state. Active volcanoes in the Cascade Range present another earthquake source.

Although the number of earthquakes in Oregon's recorded history is limited compared to that of California or Washington, earthquakes have occurred in every Oregon county. Surface expressions of faults capable of producing earthquakes are sparse, but young faults (defined here as active within the Quaternary Period, the last 1.6 million years) have been mapped in almost every county in Oregon (Figure 2). These facts show Oregon's earthquake potential despite its moderate level of seismicity and suggest the existence of a significant seismic threat to the inhabitants.

EARTHQUAKE SOURCES AND THEIR SIGNIFICANCE

The western part of the Pacific Northwest lies in an actively converging plate-tectonic setting. The scenic topography along the coast, throughout the Willamette Valley, and in the Cascades, was essentially created by plate tectonic activity related to the Cascadia subduction zone, the active fault zone separating the Juan de Fuca and North American plates. The Juan de Fuca plate extends from northern California to British Columbia and lies just off Oregon's coastline. This plate is continually being "subducted" or forced under the North American plate (Figure 1). As a result, the highly publicized Cascadia subduction zone "megathrust" earthquake is expected to occur sometime in the future along the boundaries of these plates. Although no significant Cascadia subduction zone earthquake has occurred in historic times, several large-magnitude subduction zone earthquakes are thought to have occurred during the past few thousand years, with the last event about 300 years before the present (Atwater and others, 1995). The maximum magnitude of Cascadia subduction zone earthquakes, for both past and future events, is estimated to be about 8.5–9.0.

Intraplate earthquakes occur within the subducting Juan de Fuca plate at depths of 40–60 km. The maximum magnitude of an intraplate earthquake is estimated to be about 7.5. Although numerous microearthquakes have been identified as intraplate events in Oregon, none has been of significant magnitude. The Puget Sound region in Washington has experienced two significant intraplate events in modern

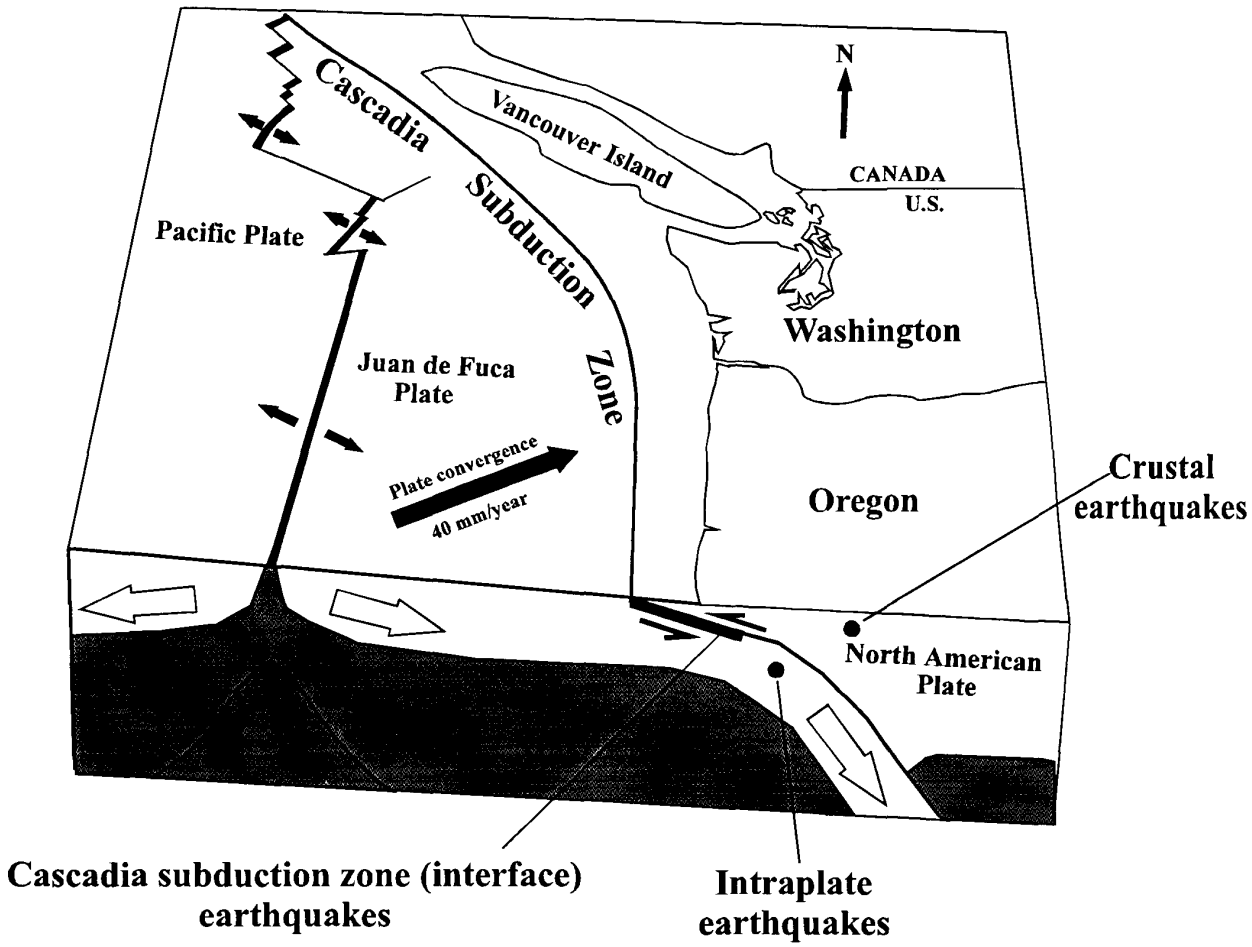

Figure 1. Map and cross section showing the North American plate, the Juan de Fuca plate, the Cascadia subduction zone, and typical locations for the three earthquake types discussed in the text. Figure modified from Anthony Qamar, University of Washington (written communication, 1996).

times, in 1949 and 1965, with magnitudes of 7.1 and 6.5, respectively. Both events caused serious local damage and were felt in Portland and as far away as Montana.

Shallow crustal earthquakes typically occur within the overriding North American plate at depths of 10–25 km. The 1993 M 5.6 Scotts Mills earthquake (Figure 3) centered northeast of Salem was a crustal event, as were the 1993 Klamath Falls earthquakes (M 5.9 and M 6.0). The maximum estimated magnitude of a crustal earthquake ranges from 6.5 to over 7.0. In 1962, a M 5.5 event with a maximum intensity of MM VII (Bott and Wong, 1993) that occurred in the Portland area was felt a distance of 150 mi away (Dehlinger and Berg, 1962; Dehlinger and others, 1963).

Volcanic earthquake sources, such as at the Mount St. Helens seismic zone in Washington and the less active Mount Hood area in Oregon, generally pose a lesser threat than the other types of earthquake sources. Seismic volcanologists limit the maximum magnitude of volcanic earthquakes to about 5¼. Two volcanic earthquakes of M 4.9 and M 5.1 occurred in May 1980 at the time of the Mount St. Helens volcanic eruption (Steve Malone, University of Washington, personal communication, 1996).

A recent statewide seismic study commissioned by the Oregon Department of Transportation (ODOT) includes a map onto which the locations of all known Quaternary-active faults and earthquake epicenters since 1827 were compiled. The report, which also includes probabilistic ground motion maps, provides the most current and comprehensive data available for the state (Geomatrix Consultants, Inc., 1995). This information is being used by ODOT to provide ground motion parameters necessary for design, construction, and earthquake mitigation of the state-owned road system.

A recent study of historic earthquakes in the greater Portland area indicates that several earthquakes larger than M 5 have occurred in the Willamette basin over the last 150 years and gives descriptive accounts of each earthquake (Bott and Wong, 1993).

THE GROWING UNDERSTANDING

Earthquakes were felt in Oregon as early as 1877 (Algermissen, 1983). Human recollections of earthquakes tend to fade quickly, however, and the general sentiment has been that "Oregon is not earthquake country." As early as 1912, geologists recognized and documented the fact that Oregon was seismically active (Smith, 1919). Despite early scientific recognition, the public failed to understand and appreciate the seismic risk for many decades. During the past decade, however, there has been increasing acknowledgment that earthquakes pose a real threat to the state's inhabitants.

In reality, the seismic risk is getting more severe, not because the level of seismicity is increasing, but because the population is increasing. With more people, more buildings, more infrastructure, and more businesses and industries in the state, more is at stake. It is fortunate that the awareness of Oregon's seismic threat has grown from "almost nil by most" to "well recognized by many." Furthermore, awareness of Oregon's vulnerability to earthquakes has even reached the national level, and several significant Portland-based seismic projects that will be discussed later in this paper were federally supported.

The first major earthquake risk studies in the Pacific Northwest, however, were related to siting of nuclear power plants. In 1970, when the siting of the Trojan nuclear power plant near Rainier in Columbia County was under consideration, the realization of the need for considering earthquake risk for the siting of this facility led to an investigation of earthquake potential and risk within the state (see appendix of Oregon Department of Geology and Mineral Industries, 1978).

The question of seismic hazards at Trojan was later revisited. In 1978, the Oregon Department of Geology and Mineral Industries (DOGAMI) conducted an independent geologic hazard review of the site, including earthquake hazards (Oregon Department of Geology and Mineral Industries, 1978). In 1981, following the May 1980 Mount St. Helens volcanic eruption, DOGAMI geologists conducted a seismic and volcanic hazard evaluation of the Trojan site (Beaulieu and Peterson, 1981). The 1981 study indicated that the maximum possible earthquake in the source region was in the range of M 5.2 to M 6.2. This report also described the plate tectonic setting off the coast of Oregon and presented the seismic potential associated with the Cascadia subduction zone as an unresolved question.

The first notable regional seismic study was performed in 1972. It was conducted to assess ground motion characteristics in the federal Bonneville Power Administration service area (Shannon and Wilson, Inc., 1972), which includes Oregon, Washington, Idaho, and western Montana. At that time, the still relatively new theory of plate tectonics, which helped to explain the nature of earthquakes, was gaining broad acceptance. The report's findings alluded to the existence of the Cascadia subduction zone and stated that "it is generally recognized . . . that the Pacific Northwest is not the site of major tectonic thrusting, nor is it as inactive as the central area of a tectonic plate." The study surveyed historic earthquakes and considered an earthquake of "magnitude $m_b = 6.5$ as the likely maximum for Portland and vicinity" (Shannon and Wilson, Inc., 1972).

Among many important studies on the Cascadia subduction zone, the following three played a key role in leading toward the current mainstream understanding that the Cascadia subduction zone is an active subduction zone: First, in 1981, findings from a study on geodetic strain measurements in Washington indicated that, in the vicinity of the Olympic Peninsula, measurable horizontal strain parallel to the direction of plate-convergence had accumulated over a 10-year observation period (Savage and others, 1981). This manifestation of crustal shortening indicated that active convergence was taking place on the Cascadia subduction zone and supported a history of subduction zone earthquakes. Second, in 1984, a study that compared the Cascadia subduction zone with many other subduction zones around the world was published (Heaton and Kanamori, 1984). The authors noted the low level of seismicity associated with the Cascadia subduction zone and provided three possible explanations: "(1) The North American and Juan de Fuca plates are no longer converging; (2) the plates are converging, but slip is accommodated aseismically; or (3) the northwestern United States is a major seismic gap that is locked and presently seismically quiescent but that will fail in great earthquakes in the future." The authors concluded that the plate convergence rate appeared to be 3–4 cm/yr and "that there was sufficient evidence to warrant further study of the possibility of a great subduction zone earthquake in the Pacific Northwest." Finally, a 1987 paper by B.F. Atwater (1987) presented paleoseismic evidence (buried peat soils) for great Holocene earthquakes along the outer coast of Washington. These three studies have fundamentally shaped the way earth scientists currently view the Cascadia subduction zone and its potential impact on Oregon.

In 1987, the Oregon State University Geology Department and DOGAMI hosted a landmark professional gathering at the Oregon Academy of Science in Monmouth, Oregon. For the first time, earth scientists gathered together to discuss the potential of a Cascadia subduction zone earthquake. Later that same year, DOGAMI hosted a "cluster" meeting of regional state surveys with U.S. Geological Survey (USGS) scientists to discuss earthquake hazards in the Pacific Northwest. With the added momentum generated by these scientific enthusiasts, the USGS was convinced that the Portland, Oregon, area was vulnerable to major earthquakes. This led to a Cooperative Agreement between the USGS and DOGAMI that involved collecting earthquake-related geologic data in the greater Portland area and educating the public on earthquake hazards. These initial meetings directed DOGAMI to assist in leading many of the present-day statewide earthquake efforts.

CURRENT STATE OF UNDERSTANDING

Since 1987, voluminous research findings support the fact that the Cascadia subduction zone is active and a threat. These research data are from three primary sources: (1) prehistoric earthquakes, (2) instrument-recorded earthquakes, and (3) geologic records from old earthquakes. More specifically, data on prehistoric earthquakes include Native American legends and Japanese historic documents. Instrument-recorded earthquake data include geophysical and seismicity analyses, geodetic (including global positioning system [GPS]) analyses, and heat-flow analyses. The geologic evidence of old earthquakes (paleoseismic data) comprises the most compelling evidence and includes earthquake-induced landslides (in Washington State), marsh soils buried and forests drowned by coseismic subsidence, tsunami sand deposits, liquefaction features, turbidites, and offshore submarine landslide features possibly related to past Cascadia subduction zone events.

By the early 1990s, the idea of the threat of a Cascadia subduction zone earthquake in the Pacific Northwest was accepted by many in the scientific community; by the mid-1990s, the idea was much more widely accepted. In April 1996, at the Geological Society of American Cordilleran Section conference in Portland, a straw poll of some 150 earth scientists attending a session on Cascadia subduction zone earthquake issues indicated they all believed that the Cascadia subduction zone could experience a M 8 or larger earthquake.

The most pressing unresolved problem that remains for most scientists is not whether a Cascadia subduction zone event will occur but rather how big it can be and how often it will occur. Some scientists believe that M 8 is the upper magnitude limit, while others believe that an event even greater than M 9 is possible. One can assert, based on presumed rupture zone, paleoseismic evidence, and historic Japanese tsunami records, that it is possible for the Cascadia subduction zone to generate an earthquake greater than M 9. One counterargument is that major offshore strike-slip faults, such as the offshore Wecoma fault located west of Siletz Bay in Lincoln County (Goldfinger

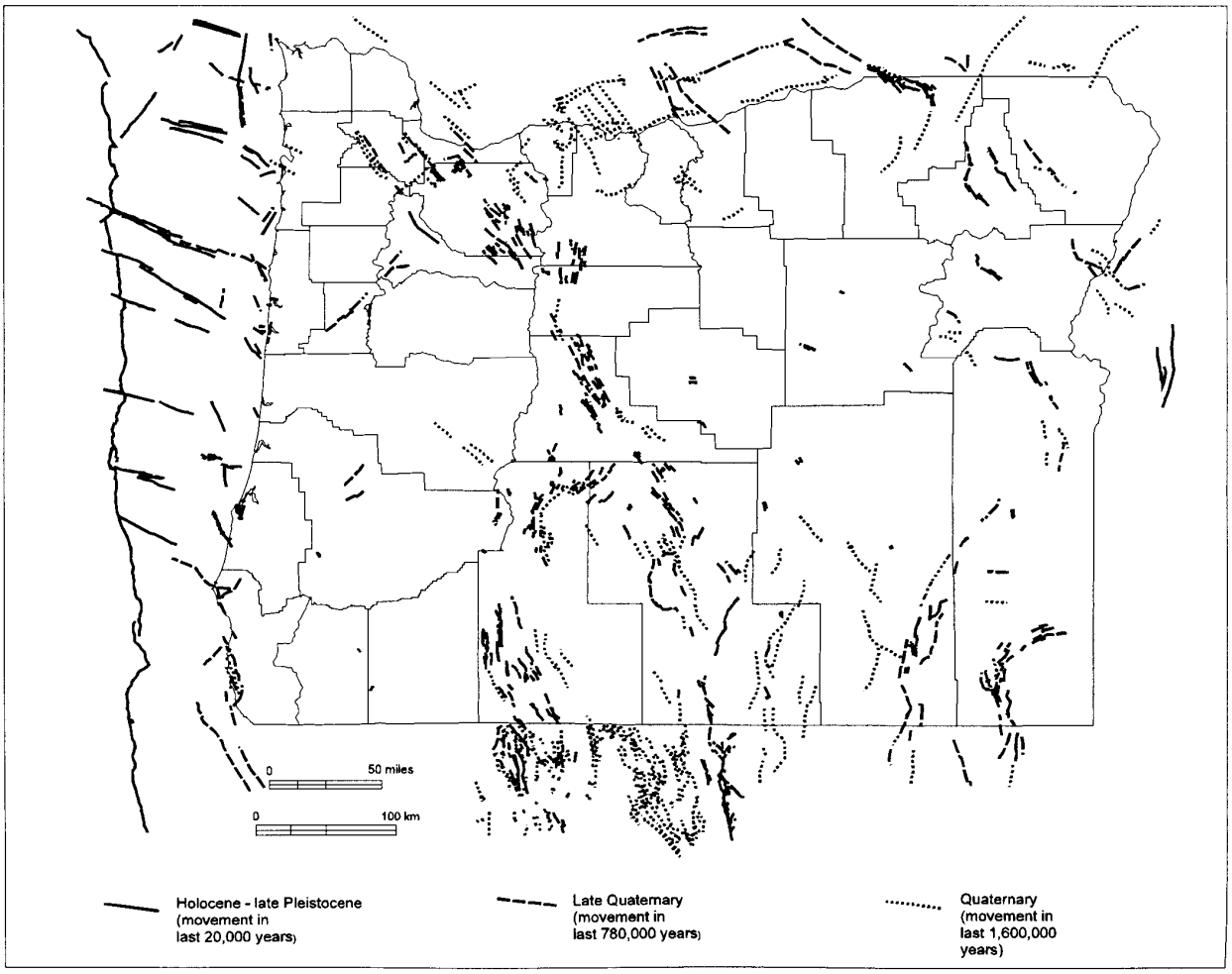

Figure 2. Map showing young faults in Oregon. Map from Geomatrix Consultants, Inc. (1995).

and others, 1992), may divide the Cascadia subduction zone into "segments" and limit the size of the maximum possible earthquake to M 8 or so. Although the possible maximum magnitude question needs to be pursued, clearly, even a M 8 event would be ominously large and would impact a widespread region.

How often do these great subduction zone earthquakes occur? Current thinking limits the range for the average recurrence interval (the time between earthquakes) to between 400 and 600 years (Atwater and others, 1995). The recent Geomatrix Consultants, Inc. (1995) study narrows the estimate of the recurrence interval to 450±150 years. Japanese historic documents describing a tsunami not preceded by a local earthquake suggest that the most recent Cascadia subduction zone event occurred on January 26, 1700 (Satake and others, 1996).

Although these questions of magnitude and frequency of a Cascadia subduction zone earthquake cannot be definitively answered at this time, our understanding of earthquake hazards is at the level where we can say, "There is consensus in the scientific community that in Oregon strong ground shaking from earthquakes is inevitable and poses a significant threat."

NEED FOR ACTION

Giving society a better chance to function in personal and economic safety and with minimal disruption after an earthquake involves a concentrated effort among many people. It is no easy task to convey to the community at large the importance of being well prepared and the necessity of taking concrete steps to get prepared. For instance, many who purchase earthquake insurance do not realize that being insured does not equate with being adequately prepared. Having insurance does not prevent fatalities, strengthen facilities, or stave off damage in any way—being prepared does.

Therefore, the next fundamental steps are to define the "hazards" associated with ground shaking and to identify the "risks" associated with the hazards. "Hazards" are important only when there are "risks," and the level of risk depends not only on the hazards present but also the amount of exposure (population and buildings). Therefore, the higher the hazard and the greater the exposure (such as vulnerable populations or weak buildings), the higher the risk. Risk includes not only fatalities, injuries, and property damage, which are immediate impacts, but also lifeline interruption, business interruption, worker displacement, homelessness, and other effects that can have a serious long-term impact on recovery from an earthquake.

The next steps are to identify ways to reduce these risks, mitigate the unacceptable risks to acceptable levels, and develop policies to reduce risk. The following discussion reviews how reduction of earthquake risks has been addressed through state legislation and organized efforts in Oregon.

STATE LEGISLATION

A broad array of earthquake-related state legislation has been introduced over the last decade, and many laws have been passed to help improve earthquake preparedness in Oregon. Listed below are the more important items of legislation that have been passed and written into the Oregon Revised Statutes (ORS).

In mid-1989, the Oregon legislature expanded the scope of DOGAMI's responsibilities, thereby requiring the agency not only to develop an understanding of hazards, including earthquakes, landslides, tsunamis, and floods, but also to mitigate the loss of life and property these hazards can cause (ORS 516.030[3]).

Following the October 1989 Loma Prieta earthquake, then Governor Goldschmidt created a task force to evaluate Oregon's seismic vulnerability. In response to the task force findings that indicated the general vulnerability of the state, the Governor issued an Executive Order (EO–90–02) to form a eight-member commission. In 1991 legislation, this commission was formally established as the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) (ORS 401.337 to 401.353). OSSPAC's mission is to reduce exposure to earthquake hazards through education, research, mitigation, and response preparation. In 1995, four more members were added to OSSPAC.

Also in 1991, DOGAMI introduced State Senate Bill 96, which involved several seismic issues and became law. It required site-specific seismic hazard investigations for essential facilities, major structures, hazardous facilities, and special-occupancy structures (e.g., schools and hospitals); the filing of the hazard investigation reports with DOGAMI; and a program for the installation of strong-motion accelerographs in or near selected major buildings (ORS 455.447). It also required "duck, cover, and hold" drills to be conducted for grades K–8 in public schools (ORS 336.071).

By 1992, there was substantial support of seismic mitigation by State Legislators and executive leaders. The Oregon Legislative Emergency Board increased DOGAMI's base budget to cover the salary of an earthquake geologist (initially funded by the previously mentioned USGS Cooperative Agreement).

In 1993, the Building Codes Division (BCD) of the Department of Consumer and Business Services adopted a zone change from Seismic Zone 2B to Seismic Zone 3 in western Oregon (Figure 4). This change meant that new buildings were required to meet a higher standard of seismic strength. That same year, the State Senate adopted Senate Joint Memorial (SJM) 12, which asked Congress to retain existing earthquake funding levels and encouraged federal agencies to assist Oregon, California, Alaska, and Washington in earthquake hazard mitigation efforts.

In 1993, Senate Bill 81 designated $4.3 million in lottery funds for reinforcing the poorly constructed State Capitol dome, which was damaged from low levels of shaking during the 1993 Scotts Mills earthquake. The Legislative Administrative Committee oversaw this retrofit work and is

pursuing additional seismic strengthening of the remainder of the State Capitol Building.

Most recently, in 1995, 14 earthquake-related bills were introduced into the legislature. Passage of several of them resulted in new or changed Oregon Revised Statutes (ORS). Included among the new statutes were a requirement for tsunami drills and education in schools (ORS 336.071), a requirement that essential and special occupancy structures be built outside the tsunami zone (ORS 455.446), the creation of a Seismic Rehabilitation Task Force to make recommendations to the legislature for the seismic rehabilitation of existing buildings (ORS 455.395[4]), provisions for entering and inspecting earthquake-damaged buildings (ORS 455.448), and provisions for the abatement of unsafe buildings (ORS 455.449).

The Seismic Rehabilitation Task Force was created in 1995 by the legislature and appointed by the Governor in consultation with the State Geologist. This 13-member Task Force convened to examine the safety of buildings that were built under prior building code criteria and to make recommendations to the 1997 Legislature for any seismic rehabilitation that should be required in those existing buildings to protect the public from seismic risk. The identification of existing buildings that require mitigation and the implementation of mitigation measures are highly complex and controversial issues. A report containing the recommendations of the Task Force was submitted to the legislature in September 1996 and developed into 1997 House Bill 2139.

House Bill 2139 proposes a survey over the next six years that will determine the type of construction and degree of safety of each building in the state, except for one- and two-family homes and other exempt structures. House Bill 2139 also proposes that seismic rehabilitation be performed in a three-stage time frame, dating from notification that results from the survey: (1) within 15 years, for unreinforced masonry (URM) buildings with parapets, signs, and other appendages, except for cornices and nonstructural cladding, that may constitute a falling hazard during an earthquake; (2) within 30 years, for the remainder of the URM buildings; and (3) within 70 years, for all other unsafe buildings. The upgrading may be stimulated by tax credits, property tax abatements, and public education.

LEADING ORGANIZATIONS

Experience has shown that public expenditures for mitigation (e.g., risk reduction of loss of life and property) are dramatically less than the costs of reconstruction following a disaster. The potential billions of dollars that will be spent in Oregon on reconstruction and business interruption losses by governments, private insurers, and the public can be minimized by mitigation expenditures to an amount on the order of only millions. The benefit-to-cost ratio is generally estimated to be somewhere between 10:1 and 100:1. More importantly, many needless fatalities can be avoided.

Several organizations have led the effort on reducing earthquake risks. These organizations included DOGAMI, Metro (Metropolitan Portland area regional government), Oregon Seismic Safety Policy Advisory Commission, Building Codes Division, Seismic Rehabilitation Task Force, Oregon Department of Transportation, and Oregon Emergency Management. Their most significant contributions are described below.

Oregon Department of Geology and Mineral Industries

In addition to its other responsibilities, DOGAMI has the legislature's mandate to better understand and mitigate earthquake hazards. Part of the agency's mission is to "reduce the future loss of life and property due to potentially devastating earthquakes." Realizing that the state is currently underprepared to suffer a destructive earthquake, the agency applies its earthquake efforts in three broad areas: (1) earthquake hazard identification, (2) mitigation of earthquake hazards, and (3) increasing earthquake hazard awareness. Although the agency provides technical information, it also encourages policy applications associated with its efforts.

Earthquake hazard identification: Since the year 1987, DOGAMI has incorporated earthquake hazard identification into the agency's scope of work. DOGAMI concluded that hazard identification was best approached by evaluating ground response from source-independent earthquakes, rather than by attempting to determine the locations of all active faults. The agency further concluded that the geology-related hazards that contribute to most of the damage are strong ground shaking (including amplification of peak ground accelerations), landsliding, and liquefaction.

DOGAMI has focused on earthquake hazard identification by developing geology-based earthquake hazard maps that indicate susceptibility to ground shaking amplification of peak ground accelerations, landsliding, and liquefaction susceptibility. Also, a general hazard composite map was produced by combining these three hazards with geographic information system (GIS) tools. Information on expected ground response from these regional maps can be used for a variety of purposes and applications. For example, in the case of new buildings, consideration of the siting of facilities may be based on expected ground response, and the level of the geotechnical investigation, design, and construction may be scaled according to the expected hazards. For existing buildings, the maps can be used to conduct a systematic risk assessment, so that property owners have the information needed to prioritize retrofit of their structures. The maps can also help facilitate prudent regional land use planning and emergency response planning both before and during an earthquake disaster.

Hazard mapping is under way in several urban areas, including the outer reaches of the greater Portland area and the greater Eugene and Springfield area. Mapping has been completed for most of Portland, for Salem, and for the Siletz Bay area in coastal Lincoln County. Continued mapping efforts are projected for Klamath Falls and 24 small-

Figure 3. Damage to Molalla High School, Molalla, Oregon, from the Scotts Mills earthquake of 1993. Bricks from the unreinforced masonry gable over the doorway fell to the steps and sidewalk (left photo) during the earthquake, illustrating the need for seismic rehabilitation. The damage to the steps (right photo) that was revealed when the debris was removed can serve as a vivid reminder of an important rule for response during an earthquake: Do not run out of a building! Rather, "duck, cover, and hold"!

to moderate-sized cities in western Oregon (including communities such as Albany, Corvallis, Newberg, Medford, Coos Bay, and Newport).

The Oregon coast is the focus of substantial risk from Cascadia subduction zone earthquakes and accompanying tsunamis, which have estimated first-wave arrival times of about 5 to 30 minutes after the onset of ground shaking. Regional tsunami-inundation zone maps have been completed for the entire Oregon coast. Also, detailed mapping has been completed for the greater Siletz Bay area; mapping is being conducted in Seaside and Newport; and future mapping in other areas (including Gold Beach and Coos Bay) is in preparation. In addition, large historical markers describing tsunamis have been erected at Seaside, Newport, and Reedsport; tsunami hazard zone and evacuation route signs have been installed in several coastal towns and communities; and informational tsunami brochures and bookmarks have been distributed all along the coast.

Mitigation of earthquake hazards: In 1989, DOGAMI was charged with the additional duties of mitigating earthquake hazards, that is, reducing the loss of life and property from earthquakes. Four main areas are targeted: new buildings, existing buildings, uses of the DOGAMI hazard maps, and earthquake damage and loss studies.

Since 1993, the Building Codes Division has required construction of safer new buildings (discussed below under "Building Codes Division"). For existing buildings, efforts are underway to develop a prioritized strategy for reduction of future losses by identifying steps that can provide for greatly enhanced safety at reasonable and justifiable expense. The goal is to establish policies that will help identify and strengthen vulnerable existing buildings (discussed below in "Seismic Rehabilitation Task Force").

DOGAMI collaborates with Metro on the Portland earthquake hazard mapping project, with DOGAMI developing the maps and Metro focusing on the application of the maps in its jurisdiction over the greater Portland area (see discussion below under "Metro"). DOGAMI's and Metro's efforts can help guide the use of hazard maps in other areas of the state as well as other parts of the country.

Another element of mitigation is conducting damage and loss assessments to estimate the loss of life and property from expected future earthquakes. With this information, strategic retrofit programs can be developed. DOGAMI has been involved in several earthquake damage and loss assessments. In 1993, a hazard map of the Portland 7½-minute quadrangle was accompanied by an earthquake damage and loss estimate for an area of 60 city blocks (Metro/Oregon Department of Geology and Mineral Industries, 1993). Initiated in 1995, a federally funded National Institute of Building Sciences (NIBS) damage and loss study of the greater Portland area is under way. Results are projected to be available to the public in early 1997 (discussed below in "National Institute of Building Sciences"). In 1996, DOGAMI completed an economic impact

evaluation from a design earthquake for each county. The study led to the result that over the next 55 years, the estimated average annual loss in Oregon would total over $100 million (Whelan and Mabey, 1996).

The agency encourages local partnerships and cooperation with communities, so that a systematic evaluation of risk can be better understood and mitigation efforts can be prioritized. An additional element is cooperation with local officials, such as land use and emergency planners and building officials, to incorporate the understanding of the mapped hazards and risks into everyday practices, plans, and policies.

Increasing earthquake hazard awareness: Earthquake risk can be reduced by increasing hazard awareness in the public. DOGAMI engages in technology transfer and public education by leading and participating in committees, conferences, workshops, and applied sessions with targeted audiences, including planners and building officials, and by developing and distributing fact sheets and brochures. Some outreach includes disseminating information through media, schools, and universities and supporting continuing education and studies for organizations such as the Oregon Building Officials Association, Oregon Planning Institute, American Society of Safety Engineers, Oregon Occupational Safety and Health Division of the Department of Consumer and Business Services, Oregon League of Women Voters, Northwest Power Pool (lifeline managers), and insurers. DOGAMI also assists with preparedness efforts of the American Red Cross.

Metro

Metro is authorized through its charter to address natural-disaster planning and response coordination in the greater Portland area. The agency's focus to date is on collection and dissemination of seismic risk information and on interaction with federal, state, and local governments, businesses, utilities, and special-interest groups in developing a regional earthquake preparedness program.

Metro was a key player in the Regional Planning Group that created the Regional Emergency Management Workplan, with the stated goal "to determine the emergency management issues and needs of the region and propose methods of coordinating, improving, and maintaining the emergency services system in the region." A geographic information system (GIS) database with regional infrastructure and building inventory is about half completed and has been shared with those who are conducting the National Institute of Building Sciences (NIBS) damage and loss assessment of the greater Portland area.

In early 1994, Metro formed the Metro Advisory Committee for Mitigating Earthquake Damage (MACMED) to support cooperative efforts among community members and to address regional policy issues regarding uses of the DOGAMI earthquake hazard maps. In May 1996, MACMED completed its efforts to tie earthquake hazard maps to land use planning and building practices and issued a report titled "Using Earthquake Hazard Maps for Land Use Planning and Building Permit Application." Metro plans to present the recommendations in the report to the Metro Policy Advisory Committee and Metro Council for future action.

Since 1993, Metro has sponsored several regional conferences that addressed earthquake hazards and emergency response. Metro is involved in several ongoing projects, including the NIBS-funded damage and loss study for the Metro area.

Oregon Seismic Safety Policy Advisory Commission (OSSPAC)

OSSPAC serves to reduce earthquake exposure and advises the legislature and government agencies on earthquake policy issues. OSSPAC includes representatives from the Building Codes Division, DOGAMI, the Department of Human Resources, Department of Land Conservation and Development, Department of Transportation, Oregon Emergency Management, Department of Water Resources, legislature, school districts, structural engineers, city governments, and county governments.

While OSSPAC functions as a forum and is still in developmental stages, it has identified the potential risk from existing buildings and bridges as the greatest earthquake-related risk the state now faces. OSSPAC played a vital role in presenting legislation that upgraded Oregon's building requirements from Zone 2B to Zone 3 for western Oregon. Currently, OSSPAC is evaluating the policy issues surrounding a possible change of seismic zone ratings along the Oregon coast for the Building Codes Division.

Department of Consumer and Business Services, Building Codes Division (BCD)

BCD sets state requirements of the minimum design and construction standards for new buildings. In 1993, BCD upgraded the Oregon Structural Specialty Code (OSSC) seismic zonation rating for western Oregon and Hood River and Klamath Counties from Zone 2B to Zone 3, which requires that new buildings be built to higher seismic standards.

Also since 1993, BCD requires that site-specific seismic hazard investigations be performed for new essential facilities, major structures, hazardous facilities, and special-occupancy structures such as hospitals, schools, and emergency response facilities. BCD is currently evaluating the merits of changing the requirements of coastal Oregon, such as possibly upgrading to a Uniform Building Code Zone 4 rating, and is active on several earthquake committees and continuing education programs.

Oregon Department of Transportation (ODOT)

ODOT has focused on reducing seismic risks by placing an emphasis on strengthening future construction and by developing a priority list for retrofitting existing structures. Starting in 1991, ODOT began seismic retrofit of high-priority bridges, a screening of all state-owned bridges for seismic retrofit prioritization, and installation of a statewide seismic strong-motion instrumentation network. By 1995, ODOT had concluded its seismic hazard mapping project

for the state. The agency is continuing its aggressive search for funding alternatives for seismic strengthening of bridges and is moving forward as well on other mitigation efforts.

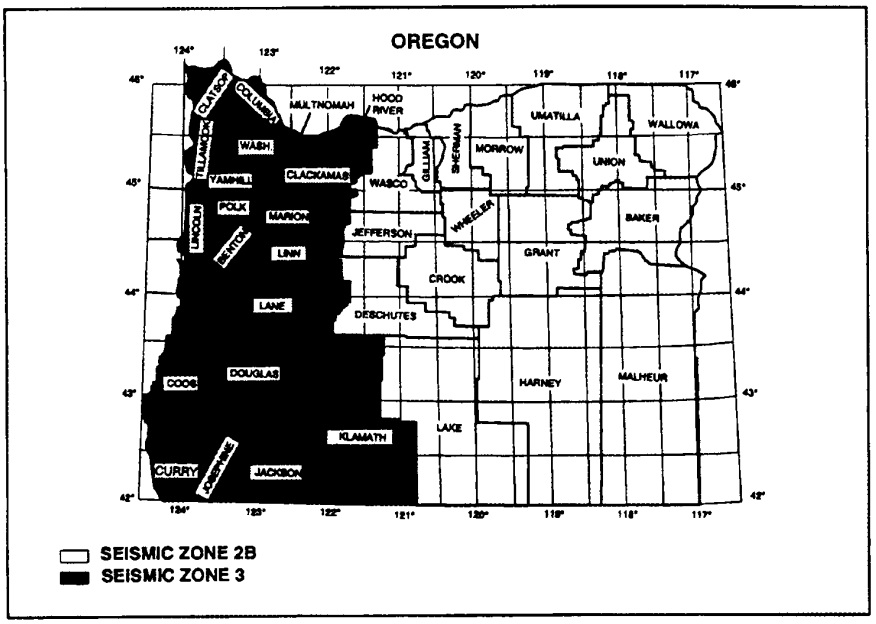

Figure 4. Seismic zone map of Oregon. Prior to the 1993 change of the Oregon Structural Specialty Code, all of Oregon was Seismic Zone 2B.

Department of State Police, Oregon Emergency Management (OEM)

OEM is charged with applying for and administering disaster and other grants related to emergency program management and emergency services for the state. OEM coordinates the activities of all public and private organizations providing emergency services within the state. Most of the coordination efforts are related to planning for and conducting emergency response. OEM coordinates the response to an earthquake, which includes providing inspectors to assess damage. OEM led its first biannual statewide emergency response exercise for a Cascadia subduction zone earthquake scenario (QuakEx) in 1994 and continues scheduling the exercise on a biannual basis, involving many public and private organizations and sponsoring conferences and education focused on mitigation.

OTHER GOVERNMENT ORGANIZATIONS

Other organized efforts by agencies on the federal, state, and local government levels, some of which some are partnerships among various governmental agencies and private groups, are listed below. For the purposes of this paper, information about partnership efforts is generally provided under the section of the leading organization.

Federal Emergency Management Administration (FEMA)

FEMA is charged with mitigating the effects of natural disasters and responding to needs that develop after a disaster. FEMA provides disaster relief funds following an emergency and works most closely with OEM (for example, in response to the 1993 Scotts Mills and Klamath Falls earthquakes). FEMA has helped elevate the awareness of Oregon's seismic risk to the national level and has been a strong financial supporter of earthquake mitigation projects in the Portland area, including the Portland area earthquake hazard mapping project.

U.S. Geological Survey (USGS)

The USGS actively engages in earthquake research and also strongly supports research by others by providing funds and professional involvement through a variety of means. Recent USGS research includes paleoseismic investigations along the Columbia River, aeromagnetic surveys of the Portland area and the northern Willamette Valley, recordings of the 1993 Scotts Mills and Klamath Falls earthquake aftershocks by deployment of temporary seismometers, evaluation of landslides induced by the 1993 Klamath Falls earthquake and of slopes in the greater Eugene and Springfield area that are prone to fail in earthquakes, and evaluation of crustal strain related to the Juan de Fuca plate subduction zone through a global positioning system (GPS) network.

In addition, the USGS funds the Pacific Northwest Regional Network, with headquarters at the University of Washington (UW), which provides earthquake recording coverage of much of Oregon. Other parts of Oregon are covered by Boise State University. The USGS, UW, and DOGAMI are currently initiating a system that allows for real-time monitoring of earthquakes. The USGS participates in partnership efforts (FEMA, DOGAMI, and California Division of Mines and Geology) to develop standardized methods of making earthquake hazard maps.

National Earthquake Hazards Reduction Program (NEHRP)

NEHRP was established by act of Congress in 1977 and is charged with providing long-term, nationwide earthquake risk reduction. NEHRP consists of federal agencies-FEMA, USGS, National Science Foundation (NSF), and National Institute of Standards and Technology (NIST) and awards grants on a competitive basis. NEHRP has funded such studies in Oregon as the evaluation of the 1993 Scotts Mills and 1993 Klamath Falls earthquakes, publication of

liquefaction maps in the greater Portland area, Portland area basin studies, Portland area probabilistic ground motion studies, and Coos Bay area fault maps.

National Earthquake Loss Reduction Program (NEP)

NEP, which was formed in 1996 to focus on earthquake loss reduction by complementing NEHRP activities, is led by FEMA and involves many agencies in addition to those that make up NEHRP. The stated goals are to provide leadership and coordination for federal earthquake research, improve technology transfer and outreach, improve engineering of the built environment, improve data for construction standards and codes, continue the development of assessment tools for seismic hazards and risks, analyze seismic hazard mitigation incentives, develop understanding of societal impacts and responses to earthquake hazard mitigation, and continue documentation of earthquakes and their effects.

National Institute of Building Sciences (NIBS)

FEMA has sponsored NIBS to develop for NEHRP a risk assessment tool that estimates earthquake losses and that should be available in early 1997. Ultimately, local officials responsible for planning and stimulating mitigation efforts can utilize this methodology to reduce losses and better prepare for emergency responses and recovery following and earthquake. With results thus obtained by a consistent method, NEHRP can better determine the level of resources needed on a nationwide basis and more accurately allocate those resources to appropriate regions.

At this time, three pilot studies to test the developmental software (HAZUS) produced by NIBS are being conducted. The greater Portland area was selected as the western U.S. site.

Cascadia Region Earthquake Workgroup (CREW)

CREW is a private-public coalition formed in 1995 that works to reduce the risk of Cascadia-region earthquake hazards by linking regional mitigation resources and encouraging regional mitigation projects. CREW consists of a broad spectrum of Northwest-based members, including representatives of government, corporate, medical, financial, manufacturing, utility, and transportation groups. CREW plans to develop earthquake scenarios of Cascadia subduction zone and Portland earthquakes to identify areas of high risk.

Western States Seismic Policy Council (WSSPC)

WSSPC is a policy consortium of 18 governmental bodies from 13 western states represented by their emergency managers and State Geologists, whose mission includes the sharing of information among the states for earthquake mitigation purposes.

Oregon Department of Land Conservation and Development (DLCD)

DLCD supports earthquake hazard planning relating to its Comprehensive Plan Goal 7 on natural hazards and encourages prudent land use planning according to the MACMED report recommendations (see "Metro," above). DLCD participates in earthquake efforts together with OSSPAC and MACMED.

Oregon State System of Higher Education

All three of the state's major public universities, University of Oregon, Oregon State University, and Portland State University, are involved with earthquakes and earthquake hazards in some capacity. At these institutions, the federally funded work conducted tends to be oriented towards basic research, whereas the state-funded work typically has more practical application.

Some of this work has included the analysis of the Scotts Mills and Klamath Falls earthquakes, studies of offshore faults and geology, studies of paleoseismic evidence along the coast and the Columbia River, installation and operation of a limited seismic network in cooperation with the Pacific Northwest Regional Network, geologic modeling and geophysical studies for supporting DOGAMI earthquake hazard mapping, and course offerings and seminar lectures on earthquake engineering issues.

Oregon Department of Education

The Department of Education is generally concerned with seismic safety in schools. It supports the required monthly earthquake drills mandated in the Oregon Revised Statutes (ORS 336.072). The Department does not have authorization to mandate seismic safety efforts in schools but can make recommendations to local school districts on such issues. For example, it encourages use of a curriculum produced by FEMA that focuses on mitigating nonstructural hazards in schools and assists schools in obtaining funds for these purposes.

Oregon Department of Administrative Services (DAS)

DAS is responsible for all state government buildings and has taken a leading role in applying the new earthquake awareness to the safety of structures. The new state office building in Portland was built to Zone 3 standards in 1991/1992—before Zone 3 was adopted by BCD. Existing structures, such as the Public Service building and the Public Utility Commission building in Salem, have been rehabilitated for increased seismic resistance.

Oregon Department of Water Resources (DWR)

DWR safeguards many of the existing dams in the state. The agency has recently begun to consider earthquake safety of dams, for instance, as part of the dam relicensing process and has recommended installing seismic instrumentation on dam sites.

Oregon Boards of Geologist Examiners and Engineering Examiners

In late 1996, the Boards jointly adopted guidelines for the preparation of reports on seismic hazard investigations

required for new essential facilities, major structures, hazardous facilities, and special-occupancy structures.

Local governments

Implementation of earthquake preparedness policy often takes place at the local government level, in cities, counties, water districts, and on school boards. For example, many decisions regarding planning, building, strengthening of structures, and post-disaster response are made at the local level.

In August 1993, the City of Portland formed the Portland Seismic Task Force to address the City of Portland Dangerous Building Code, which was substantially affected by the 1993 state building code changes. In order to determine which existing Portland buildings need to undergo seismic rehabilitation, the task force initiated a risk study to determine acceptable levels of risk within its jurisdiction. The ultimate goal of the task force is to develop public policies encompassing acceptable seismic practices involving the Portland Dangerous Building code and existing vulnerable structures. The history of the building codes for Portland can be found in Kennedy (1996).

PRIVATE ORGANIZATIONS

Various branches of the professional engineering, earthquake, and earth science communities have been actively involved in Oregon's earthquake issues. The Structural Engineers Association of Oregon (SEAO) has recommended requiring continuing education for structural engineers to better address the increasing level of competence needed to design seismically resistant structures. The Oregon Chapters of the American Society of Civil Engineers (ASCE) and the Association of Engineering Geologists (AEG) have provided input on various proposed earthquake-related items of legislation and have offered numerous lectures on seismic issues. National conferences of ASCE and AEG covering Pacific Northwest earthquake issues are planned in 1997. The Earthquake Engineering Research Institute (EERI) and the Geological Society of America (GSA) have sponsored conferences centered on earthquake issues in the Pacific Northwest.

The growing earthquake awareness and concern over earthquake preparedness and mitigation is reflected in the activities of many more organizations, institutions, media, and individuals. Coverage of earthquake-related issues has increased considerably in the region's public media. Educational facilities have developed instructional programs such as the FEMA-funded "Seismic Sleuths" and "Tremor Troops" teacher workshops presented throughout the Pacific Northwest by the Oregon Museum of Science and Industry. Nonprofit organizations have been active in earthquake awareness activities. For example, the League of Women Voters of Oregon conducted a statewide earthquake hazard and awareness study partially funded by DOGAMI that also raised awareness of earthquake issues at the community level. The American Red Cross focuses on public education, preparedness, and emergency response aimed at families and businesses.

DISCUSSION

The understanding of Oregon's earthquake hazards and the way the state addresses earthquake risks have changed over the years. Periodic earthquake shaking has been felt in Oregon for over a century and a half. The great Cascadia subduction zone earthquake threat was identified in the past decade. The 1993 Scotts Mills and 1993 Klamath Falls "wake-up call" earthquakes confirmed to most people that earthquake hazards are present in Oregon. These recent events have dispelled the notion that Oregon was not earthquake country.

Because earthquakes are low-probability catastrophic events, it is not easy to gain political support and the necessary resources to reduce earthquake risks. However, enough Oregonians have come to realize that the huge costs to society associated with damaging earthquakes can easily exceed the cost of reasonable efforts of preparedness, and attempts are being made to bring the state into a better position before next big earthquake hits.

Progress in identifying hazards and risks, estimating the damage and loss potential, reducing risks, and planning for emergency response has been made mainly in the last decade. In view of the fact that no major earthquakes that would raise public awareness have occurred yet, Oregon has made great strides. Many, in fact, consider Oregon to have created an exemplary framework of proactive steps that may be applied elsewhere in the nation to regions that can benefit from guidance in earthquake preparedness. National and regional awards have been granted to the DOGAMI/Metro hazard-mapping project for the Portland area. The surprising thing about Oregon's remarkable progress is that the earthquake mitigation efforts have been performed in fragments by various organizations without comprehensive oversight, whereas addressing the region as a whole would probably have been more efficient. Perhaps the most noteworthy aspect of the accomplishments is that the professional disciplines, including those within government agencies, have managed to overcome the common communication barriers between each other to the advantage of society and have taken decisive initial steps in the right direction. Still, Oregon remains largely underprepared for a significant earthquake, and much more effort is needed to lower the earthquake risk.

History shows that every earthquake has been a "surprise." The exact timing of an earthquake always contains the element of surprise, because true prediction is not possible at this time, nor does it seem likely to be possible for decades to come. Also, earthquakes are all different in respect to their type, the environment in which they occur, and the built environment they affect. In seismically active regions, the earthquake "surprises" and the associated damages and losses should not really be surprises. For that reason, inhabitants of seismically active regions have the opportunity of being prepared for the next "surprise" earth-

quake. It is possible to understand reasonable bounds of potential earthquakes and earthquake hazards, to approximate them through earthquake scenarios, and to reduce the risks to a reasonable level to the benefit of current populations and future generations.

Many earthquakes around the world have had disastrous consequences. Preliminary estimates from earthquake damage-and-loss studies of the densely populated greater Portland area indicate that many hundreds of lives could be lost and that property loss could be on the order of tens of billions of dollars in such an event. Quantifying potential losses is one step in getting closer to the difficult question: "How much can we invest prudently in safer living?"

Since 1993, a higher standard for the seismic safety of new buildings and seismic investigations of building sites for certain new structures, such as hospitals, schools, or emergency response facilities, have been mandated in Oregon. To achieve safer conditions for the entire community, however, more than just the safety of its new buildings must be assured. All buildings and the vulnerability of lifelines such as roads and water, waste-water, electricity, gas, and communication systems need to be addressed. Many need seismic strengthening. Realistic measures to prioritize seismic strengthening must be taken quickly and prudent land use measures established promptly. In addition, a higher degree of preparedness needs to be attained at many levels, from emergency response at the government level to disaster preparedness at the personal level.

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Although it is not the author's intention, this paper may be biased with general viewpoints of the Oregon Department of Geology and Mineral Industries due to the fact that much of the background was gathered from the agency's staff and files. Significant earthquake research and mitigation efforts by those not mentioned in this paper can be brought to the author's attention for future clarification.

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Oil and gas exploration and development in Oregon, 1996

by Dan E. Wermiel, Petroleum Geologist, Oregon Department of Geology and Mineral Industries

ABSTRACT

Oil and gas leasing activity was about the same during 1996 as it was in 1995. Four U.S. Bureau of Land Management (BLM) lease sales were held during the year, and no offers were received. Federal applications were filed and leases issued on 25,335 acres in Jefferson County. A total of 39,571 federal acres were under lease at year's end. The State of Oregon conducted no lease sales during the year. There were 12 State of Oregon tracts under lease at year's end, comprising 941 acres. Columbia County held no lease sales during the year.

During 1996, Enerfin Resources Company drilled two exploratory wells at the Mist Gas Field, Columbia County. These were the first exploratory wells drilled in Oregon since 1993, when thirteen exploratory wells and three redrills were drilled. Both wells have been temporarily abandoned pending further evaluation. Enerfin Resources plugged two depleted former gas producers at Mist Gas Field during the year.

At Mist Gas Field, 21 wells were productive during 1996. A total of 1.7 Bcf of gas was produced, less than the 2.5 Bcf of gas produced during 1995. The total value of the gas for the year was about $3.4 million, which is higher than the $1.8 million for 1995, because of changes in gas price.

Northwest Natural Gas Company did natural gas injection and withdrawal testing and conducted an extensive 3-D seismic program. Results will be used to develop additional underground natural gas storage at Mist Gas Field.

The final report on DOGAMI's five-year study of the oil, natural gas, and coal resource potential of the Tyee Basin was released during 1996 as Oil and Gas Investigation OGI–19.

One rule change to DOGAMI administrative rules during 1996 provided DOGAMI with the authority to permit temporary underground natural gas storage testing without use of a packer.

LEASING ACTIVITY

Oil and gas leasing activity was low in Oregon during 1996. This is a continuation of a trend of generally inactive leasing activity that began during the early 1990s. Activity included four public sales by the U.S. Bureau of Land Management (BLM) at which no bids were received for any leases on federal lands. Aside from those public sales, applications were filed and leases issued to Robert F. Harrison, Seattle, Washington, for 25,335 federal acres located in Jefferson County, Oregon. Harrison and other individuals have held leases on a block of federal lands comprising about 39,500 acres in this general area since 1977.

At year's end, 39,571 federal acres were under lease, which is an increase over the 11,760 acres at the end of 1995. Total rental income to BLM was $55,313 for 1996.

The State of Oregon held no lease sales during 1996, and no new leases were issued. At year's end, 12 State of Oregon tracts were under lease, comprising 941 acres, which is a decline from the 25,240 acres of State of Oregon tracts under lease during 1995. Total rental income to the State of Oregon was about $950.

Columbia County held no lease sales during the year.

DRILLING

Two exploratory gas wells were drilled in Oregon during 1996. These were the first two exploratory wells drilled since 1993, when thirteen exploratory wells and three redrills were drilled. The wells were drilled by Enerfin Resources Company of Houston, Texas. Both wells, the John Hancock 31–20–54, located in NE¼ sec. 20, T. 5 N., R. 4 W., and drilled to a total depth of 2,436 ft, and the

Shallow seismic shot hole drilled as part of the Northwest Natural Gas Company 3-D seismic program at the Mist Gas Field during 1996. The seismic data will be used to develop more underground storage for natural gas.

Table 1. *Oil and gas permit activity in Oregon, 1996*

Permit number	Operator, well, API number	Location	Permit activity (TD=total depth)
500	Enerfin Resources Co. Columbia Co. 22-26-65 36-009-00320	NW¼ sec. 26 T. 6 N., R. 5 W. Columbia County	Permit issued; Proposed TD 1,730 ft.
501	Enerfin Resources Co. John Hancock 31-20-54 36-009-00321	NE¼ sec. 20 T. 5 N., R. 4 W. Columbia County	Temporarily suspended; TD 2,436 ft.
502	Enerfin Resources Co. Columbia Co. 32-27-65 36-009-00322	NE¼ sec. 27 T. 6 N., R. 5 W. Columbia County	Temporarily suspended; TD 2,084 ft.

Columbia County 32–27–65, located in NE¼ sec. 27, T. 6. N., R. 5 W., and drilled to total depth of 2,084 ft, are located at the Mist Gas Field, Columbia County, and are temporarily abandoned pending further evaluation.

Enerfin Resources abandoned two depleted former producing gas wells at Mist Gas Field during 1996. These are the Columbia County 34–28–65, located in the SE¼ sec. 28, T. 6 N., R. 5 W., and the Columbia County 12–19–65, located in the NW¼ sec. 19, T. 6 N., R. 5 W.

During 1996, DOGAMI issued three permits to drill, while no permits were withdrawn or canceled during the year. Permit activity is listed in Table 1.

PRODUCTION

The Mist Gas Field was operated by Enerfin Resources and Northwest Natural Gas during 1996. During the year, 21 natural gas wells were productive at Mist Gas Field, 14 operated by Enerfin Resources and 7 by Northwest Natural Gas. This is about the same number of wells productive during 1995. Gas production for the year totaled 1.7 Bcf, which is lower than the production during 1995, when the Mist Gas Field produced 2.5 Bcf of gas.

Most of the decrease in production can be attributed to normal decline in the production from the existing wells with no new wells brought on to production during the year. The gas price during 1996 was about 20 cents per therm, an increase over the 1995 price that ranged from between four cents to eleven cents per therm until December, when the price rose to 22 cents per therm. The total value of the gas produced at Mist Gas Field was about $3.4 million, which is higher than the $1.8 million during 1995 because of the higher gas price. Cumulatively, the Mist Gas Field has produced about 60.0 Bcf of gas with a total value of $116.2 million since it was discovered in 1979.

GAS STORAGE

The Mist Gas Storage Project remained fully operational during 1996. The gas storage project has nine injection-withdrawal service wells, five in the Bruer Pool and four in the Flora Pool, and 13 observation-monitor service wells. The two pools have a combined storage capacity of 10 Bcf of gas. This allows for the cycling of about 6 Bcf of gas in the reservoirs at pressures between approximately 400 and 1,000 psi and will provide for an annual delivery of 1 million therms of gas per day for 100 days. During 1996, about 4,813,386 cubic feet of gas was injected and 5,188,835 cubic feet of gas was withdrawn at the Mist Storage Project.

Northwest Natural Gas Company began work during 1996 to develop additional underground natural gas storage at the Mist Gas Field. This included natural gas injection and withdrawal testing of three former producing wells. The three wells were evaluated for injection and withdrawal rates from which data will be used to design and develop the additional underground natural gas storage. The wells that were evaluated were the Busch 14–15, located in the SW¼ sec. 15, T. 6 N., R. 5 W.; the Columbia County 14–23, located in SW¼ sec. 23, T. 6 N., R. 5 W.; and the Columbia County 23–22, located in NW¼ sec. 22, T. 6 N., R. 5 W. In addition, Northwest Natural Gas conducted an extensive 3-D seismic program whose results will be used to develop the underground storage project. The seismic program was primarily located in four sections at Mist Gas Field: secs. 22, 23, 26, and 27, T. 6 N., R. 5 W.

OTHER ACTIVITIES

DOGAMI has completed a five-year study of the oil, gas and coal resource potential of the Tyee Basin located in Douglas and Coos Counties in the southern Coast Range. DOGAMI Oil and Gas Investigation OGI–19, *Oil and Gas Potential of the Southern Tyee Basin, Southern Oregon Coast Range*, includes a 141-page report plus maps and support data. The study was funded by landowners in the study area and by county, state, and federal agencies in a public-private partnership. OGI–19 is the final report of an investigation of the source rock, stratigraphy, and structural framework of the Tyee Basin for those characteristics that are needed to generate and trap oil and gas. A series of maps and preliminary reports that presented a revised understanding of the geologic framework of the area had been published previously. The final report now concludes that the area has natural gas potential and presents plays for future exploration. Contact DOGAMI for a complete publication list including those for the Tyee Basin study.

The Northwest Energy Association remained active for the year and has over 100 members. At its regular monthly meetings, speakers give talks that are generally related to energy matters in the Pacific Northwest. The 1996 fall symposium was held at LaConner, Washington, and the 1997 fall symposium will be held in Portland, Oregon. For information, contact the NWEA, P.O. Box 6679, Portland, Oregon 97228.

During 1996, one change was made to DOGAMI administrative rules pertaining to oil and gas operations. The change concerns temporary testing for underground natural gas storage. It gives DOGAMI the authority to permit temporary gas storage testing into an existing well without the use of a packer, a device for separating vertical zones in a well. Copies of current statutes and administrative rules can be obtained from DOGAMI. □

OMSI opens "giant" exhibit

The Oregon Museum of Science and Industry (OMSI) has brought a west coast exclusive blockbuster to Portland. AT&T will be the title sponsor of the exhibit entitled "Giants of the Gobi," which can be seen at OMSI from March 1 through September 1, 1997. The exhibit showcases a rare and important collection of dinosaur and mammal fossils from the Gobi desert of Inner Mongolia. The collection, which contains 75 fossil specimens, including 16 complete creatures, is on loan from the Inner Mongolian Museum in Hohhot, China, and has never been seen before in the western United States.

AT&T's "Giants of the Gobi" is the largest exhibit ever staged by OMSI. The centerpiece of the exhibit, a giant sauropod, measures 25 ft tall and 85 ft long and is considered to be one of the largest assembled dinosaur fossils in the world (see cover photo). Among the other giants are a 17-ft-tall mammoth, wooly rhinoceros, *Protoceratops, Bactrosaurus, Psittacosaurus*, and *Archaeornithomimus.* Other highlights include nests, eggs, dinosaur tracks, turtles, and plants. Several specimens are shown still in matrix.

With fossils dating back from 100 million years ago to 30,000 years ago (mid-Cretaceous to late Pleistocene), the exhibit is designed to take the visitor on a journey through geologic time as well as to an authentic modern "dig" experience, both in the field and at the research laboratory. The setting created by OMSI is that of Gobi desert scenery in which the fossil site was located. The free audio tape guide leads the visitor through the experience as a member of a dig team.

As an additional experience, a working paleonotology laboratory project of the Northwest Museum of Natural History Association can be seen in OMSI's Earth Science Laboratory. As Dave Taylor, director of the Association, describes it, the project shows how work on a dinosaur proceeds once it is brought in from the field. In this case, the object is a *Triceratops* skeleton, which members of the Association recovered from eastern Wyoming.

Admission to "Giants of the Gobi" is $9.50 for adults and $8.00 for seniors (63+) and youths (4–13). It includes an audio tape tour, admission to the museum as well as a planetarium show. Members receive their first visit free; thereafter, they pay $3.50 for the audio tour headset. Members always have free access to all other exhibit halls.

Opening times March 1 to May 23 are 9:30 a.m. to 5:30 p.m., except on Thursdays, when closing time is 8:00 p.m. From May 24 through September 1, times will be 9:30 a.m. to 7:00 p.m. (8:00 p.m. on Thursdays). Tickets to the exhibit will be sold until 1½ hours before closing time; they are also available at Fastixx locations and at phone numbers 1-800-992-8499 or (503) 224-8499. Information on special rates for groups is available at 1-800-955-OMSI or (503) 797-4629.

OMSI can be reached by phone at (503) 797-4000. The World Wide Web address is www.omsi.edu. □

December fireball lights up NW skies

by Richard N. Pugh, Science Department, Cleveland High School, Portland, Oregon

At 6:14 a.m., December 17, 1997, the sky was clear for the first time in many weeks, and thousands of people were going to work, when a brilliant fireball appeared in the morning sky. It was seen in Oregon as far south as Salem, as far west as Clatskanie, and as far east as The Dalles. The northernmost sighting was Port Townsend in northwestern Washington.

The fireball appeared to have formed above the Chehalis/Centralia (Washington) area. It descended toward the west at an angle of about 45°. The observed duration was from three to five seconds. Most observers reported the object to be brighter than a full moon and about the size of a full moon. The head of the fireball had a fairly long tail. Many colors were reported, with most people seeing a white to green object with a yellow tail. Many reports mentioned sparks and flames in the tail. Some observers reported a bright flash as the fireball disappeared.

No sonic booms or rumbling were reported. There is no evidence that this object produced meteorites. Although events like this happen several times a month, our frequent occurrence of cloud cover lets most of them go unnoticed. Perhaps only once or twice a year will a fireball produce meteorites in the Pacific Northwest. □

DOGAMI volunteers honored

Since the Oregon Department of Geology and Mineral Industries (DOGAMI) first began to recceive help through its volunteer program in 1991, volunteers have donated 7,577 hours, or 947 days, to the Department, including 1,605 hours, or 202 days, during the past year 1996.

The volunteers were honored at a recent dinner and are listed below with the hours they had donated through 1996:

Sonya Bruce (46), Esther Kennedy (132), Dorothy Blattner (138), Joan Konner (407), Phyllis Thorne (409), Phil Johnson (417), Charlene Holzwarth (459), Jan Murphy (609), Rosemary Kenney (1,120), and Archie Strong (1,246). □

MineQuest 97 announced

The Columbia Section of the Society of Mining, Metallurgy, and Exploration, Inc. (SME) will host the 1997 Pacific Northwest Metals and Minerals Conference in Spokane, Washington. The conference will be held April 23–25, 1997, at the WestCoast Ridpath Hotel. The conference theme is "MineQuest 97—Technology Updates."

The program will emphasize technology updates in the exploration, mining, processing, and reclamation aspects of the mining industry. Also included are field trips to area mines and processing plants. Get information from Andrew Berg at (509) 747-3659, e-mail:aberg@on-ramp.ior.com. □

BOOK REVIEW

by Beverly F. Vogt

Bin Rock and Dump Rock, by John Eliot Allen. Hells Canyon Publishing, 1997, soft cover, 282 pages, $12.95

John Eliot Allen, Emeritus Professor of Geology at Portland State University, writer, one-time geologist for the Oregon Department of Geology and Mineral Industries (DOGAMI), and frequent contributor to *Oregon Geology*, died last December. Before his death, he had made arrangements to have Hells Canyon Publishing Company print his autobiography, *Bin Rock and Dump Rock*. Unfortunately he died before he saw the final printed version. Had he had seen it, he would have been delighted with it, because it is an attractive and thoroughly enjoyable book. To browse through it is to take a trip back in time to a different world where someone like John, who was willing to put heart and soul into his exciting chosen profession, was able to have a wonderful life. John Allen's love of life, family, and chosen career shines through every line of this delightful book. Reading it will be a pleasure to anyone who knew John Allen, who wants to know more about geology, who wants to learn how old-time geologists thought and acted, or who likes to read about the days when life was simpler and a field geologist could have a great time pursuing fascinating geologic questions.

The title of this autobiography came from an old miner Allen encountered in his early days with DOGAMI. Allen was doing a survey of mines in Baker County. He started to tell an old miner the technical names of all the rocks in his mine but was interrupted by the miner who said, "Confound it, sonny, this here mine has only two kinds of rock—bin rock and dump rock." Allen took the words to heart. He ignored the dump rock of his life and polished the bin rock into the "concentrates" he presents in this autobiography.

John Allen writes directly and honestly about what matters to him—scouting, his family and friends, geology, what he saw, what he did, and what he thought about it all. An inveterate list maker, he lists such details as what he bought, what he ate, what he wrote, where he lived, and what he read. These are not just Allen's lists, however, they are lists that describe the time in which he lived. In the classic diarist's tradition, he has noted the details of his experiences and thereby recreated a world.

A good geologist observes and records many details but keeps enough perspective to perceive the broad picture the details are presenting. And so it is with John Allen—he provides lots of details but also an understanding of what they are telling him about geology, his life, and the world around him. He describes the details of his geologic field adventures, the vehicles that took him out into the field and got him home again, the instruments and other equipment, including maps he used, the routes he took, the characters he met, and the people who accompanied him along the way.

He loves to find universal truths in his experiences. Take for example, some of his laws of field geology:

- "The more you know, the more you see.
- "You see only what you are looking for.
- "You can't see something you are not looking for.
- "When investigating the unknown, you do not know what you will find.
- "The geology of any area is more complex than you think it is going to be. The key outcrops and fossil localities are usually found at dusk in the most inaccessible part of the area, on the last day of the field season.
- "The weight of a hand specimen is directly proportional to the square of the distance from the car."

He writes like a master musician delighted with the capability of his instrument. No matter what aspect of his life he approaches, he has much to say about it—with flourishes. When he writes about the academic world, he takes time to describe the hierarchy and language of academe. When he describes his first car, a Model T, he lists the 10 steps to follow to get it started. In talking about professional ethics for geologists, he lists the five attributes he believes all professions have in common (a systematic body of knowledge that is consistent, professional authority recognized by clients and based on education and competence, community sanction granted by an authority beyond the client or employer, a professional culture that has common standards, and an ethical code).

The dominant theme presented in his autobiography is optimism and general belief in the essential goodness of humanity. As he says, "My lifelong policy of accepting everyone as honest and reliable *until they prove themselves otherwise* has been especially valuable. This way you don't spend your time and energy doubting and worrying about people." Instead, John took off, studied geology, explored the remote corners of the West, traveled the world, established a family that he loved as dearly as life, made numerous valued friends, started the Portland State University Department of Geology, kept records of everything, and wrote and published books and articles almost until the moment of his death. Although geology was his profession and passion, he had many other interests as well, many of which he discusses in this autobiography.

Sunny and outgoing by nature, Allen was also well disciplined. Until shortly before his death, he went each day to his office at Portland State University to write something on his beloved computer. Unlike so many geologists who love to go out and collect data and resent taking time to write up their conclusions, Allen knew that the only way to share what he had learned and keep it alive long after he had died was to "write it up." When his health was failing, he could no longer go out and observe the external world as a geologist. So he turned his geologist's observational skills inward and observed what was happening to himself. He observed the process, took good notes, described it in clinical

*(Continued on page 45, **Book review**)*

Regional Geologist looks at Newport

The letter below was written in answer to the information request of a student. The writer, George Priest, is the Regional Geologist in the Portland office of the Oregon Department of Geology and Mineral Industries. We believe it deserves sharing with our readers.

Dear Mark:

You asked for information on the geology of the Newport area for your eighth-grade paper. A short summary follows:

The rocks of the area are composed mainly of the Nye Mudstone and overlying sandstones and siltstones of the Astoria Formation. In local areas these 20- to 16-million-year-old sedimentary rocks are overlain by the 16- to 15-million-year-old lava flows of the Columbia River Basalt Group. The hard lavas resist erosion, thus forming most of the headlands (for example, Yaquina Head) and offshore sea stacks (rocks that form little islands like Otter Rock). The lavas were erupted from big fissures near the Idaho border and were of such great volume that they formed vast sheets of lava covering the plateaus of eastern Washington and northern Oregon and even traveled all the way to the ocean. The entire sequence of rocks is tilted westward, which causes some west-facing slopes underlain by weak rocks like mudstones to slide. Big landslides like the Jumpoff Joe landslide at the end of 11th Street in Newport have carried away whole neighborhoods that were built close to the edge of the west-facing cliffs.

During the Pleistocene Ice Age (1.6 million years ago to 10,000 years ago), the sea retreated and advanced as continental glaciers grew or melted during the glacial and interglacial times (we are currently in an interglacial time). Interglacial high sea stands at about 120,000 and 83,000 years ago have left prominent wave-cut platforms that are covered with partially consolidated beach and dune sands called Pleistocene marine terrace deposits. These "almost rocks" crop out at the top of most of the sea cliffs and underlie the flat topography in the main City of Newport. The porous and permeable sand deposits store ground water for water wells in the area. The deposits also erode easily, especially if not vegetated, so one should be careful not to climb on them or carve into them when visiting the beach. Homeowners with houses next to these sea cliffs will not appreciate it!

During the last 16,000 years, the continental ice sheets up in Canada and in the Arctic and Antarctic have been melting off as the climate warmed. Sea level has risen over 400 feet during that time! Just imagine the shoreline being many miles west of where it is today. Yaquina Bay was a river valley with its bottom probably 200 feet below where it is today. By about 10,000 years ago, much of the continental ice sheets had melted, and sea water had returned to the bottom of the old river valley at Newport. Over the last 10,000 years, the river has brought in sediment as sea level continued to rise, filling in the old valley and forming Yaquina Bay. Yaquina Bay is therefore an example of drowned river valley.

The Cascadia subduction zone, a big active fault at the base of the continental slope offshore from British Columbia, Washington, Oregon, and northern California, causes earthquakes of magnitude 8–9 every 200–600 years. These earthquakes deform the sea bottom, causing the sea itself to be deformed so that great tsunamis (tidal waves) roll into the bay 15–20 minutes after these earthquakes. The tsunamis have left behind sandy layers in the marsh deposits around the edges of the Bay. These tsunami sands generally lie on buried black soils called "peat layers," which are the remains of marsh grasses that were killed when the whole area subsided a few feet during the great earthquakes. Buried peats and overlying tsunami sands are some of the main pieces of evidence that make scientists believe that the Oregon coast has experienced these very large earthquakes. The last great earthquake sent a tsunami all the way to Japan, where harbor masters recorded a 6- to 10-ft wave on January 27, A.D. 1700. Scientists hypothesize that the Cascadia subduction zone had a great earthquake at 9 p.m., January 26, A.D. 1700, that probably affected the whole Northwest coast with an earthquake approaching magnitude 9! Indian legends tell of great destruction and loss of life from the tsunami that struck the coast.

The Oregon Department of Geology and Mineral Industries warns people to head to high ground or inland if they feel an earthquake on the coast. The earthquake could mean that a big tsunami will hit within 20–30 minutes on the north coast, 15–20 minutes on the central coast, and 5–10 minutes on the south coast. Waves will continue to strike for several hours after the first one hits; sometimes these waves are nearly as big as the first one, so don't go back to the beach until an official gives you the "all clear."

Best regards,
Dr. George R. Priest
Regional Geologist

Nevada offers symposium in 2000

A symposium entitled "Geology and Ore Deposits 2000—The Great Basin and Beyond" will be held at John Ascuaga's Nugget in Reno/Sparks, Nevada, May 15–18, 2000. It is sponsored by the Geological Society of Nevada, the Nevada Bureau of Mines and Geology, and the U.S. Geological Survey.

The symposium will feature oral and poster presentations, field trips, workshops and short courses, trade exhibits, and social events. The metallogeny and ore deposits of the Great Basin will be the focus of this symposium with contributions from other areas of the American Cordillera.

More information is available from the Geological Society of Nevada at P.O. Box 12021, Reno, NV, 89510-2021, phone (702) 323-3500, FAX (702) 323-3599.

—Geological Society of Nevada news release

DOGAMI library now holds over 100 seismic site hazard reports

On May 1, 1994, an amendment took effect that changed the Oregon Structural Specialty Code, a part of the Oregon Administrative Rules, by ordering that a copy of each legally required "seismic site hazard report" should be "submitted by the applicant to the Department of Geology and Mineral Industries." The Department is thus building a collection of site-specific seismic hazard reports that are on file and accessible to the public for inspection.

This collection has now accumulated over 100 reports. The following abbreviated list is derived from the records in the library's bibliographic database and includes the authors of the reports, the sites investigated, and the 7½-minute quadrangle (Q.) in which the site is located:

AGI Technologies: Grande Ronde Hospital, La Grande. La Grande Q.
—Proposed Sumitomo Sitix site, Newberg. Newberg Q.
—Proposed new fire station, 6600 SE Lake Road, Milwaukie. Gladstone Q.
AGRA Earth & Environmental: Liberty Northwest Insurance Building, Portland. Portland Q.
—Metropolitan Exposition Center expansion, Portland. Portland Q.
—Proposed Siltec silicon facility, Fairview Industrial Park, Salem. Salem West Q.
Bechtel Power Corporation: Hermiston Generating project. Hermiston Q.
—Revised SHAKE analysis report, Umatilla Generating project, Hermiston. Hermiston Q.
Braun Intertec Corporation: Proposed Jesuit High School addition, SW Beaverton-Hillsdale Hwy. and SW Apple Way, Portland. Beaverton Q.
—Proposed new fire station, Tomahawk Island Drive, Hayden Island, Portland. Portland Q.
Carlson Testing: Butte Creek Scout Ranch, 13462 South Butte Creek Road, Clackamas County. Wilhoit Q.
—Crater Schools site, Yamhill County. Newberg Q.
—Far South Middle School site, Liberty and Davis Roads, Marion County. Salem West Q.
—Tigard United Methodist Church, 9845 SW Walnut Place, Tigard. Beaverton Q.
CH2M Hill: Hewlett-Packard Building 9, Corvallis. Riverside Q.
Dames & Moore: Bank parking structure, Eugene. Eugene East Q.
—Central utilities plant expansion, Portland International Airport. Mount Tabor Q.
—City Garage parking structure, Eugene. Eugene East Q.
—Groundwater pump station/interstate facility, Portland. Camas/Portland Qs.
—Hospital addition, Providence Milwaukie Hospital. Lake Oswego Q.
—New police and fire station, Cornelius. Forest Grove Q.
—Pine Grove fire station addition, Hood River. White Salmon Q.
—Planned centers for the humanities and visual arts, Lewis and Clark College, Portland. Lake Oswego Q.
—Proposed Firwood Road fire station, Sandy. Sandy Q.
—Proposed parking structure and helipad, Providence Portland Medical Center. Mount Tabor Q.
Dames & Moore; Fujitani Hilts & Associates: New fueling facilities, Portland International Airport. Mount Tabor Q.
David J. Newton Associates: Impact site for proposed new elementary school, N.E.C. of Monroe and Spruce Street, Cannon Beach. Tillamook Head Q.
—New elementary school, SE 129th Avenue and Masa Lane, Clackamas County. Gladstone Q.
—New Taft High School, High School Drive at SE Spyglass Ridge Drive, Lincoln City. Lincoln City Q.
—Oregon City United Methodist Church, 18955 South End Road, Oregon City. Oregon City Q.
—Proposed Emmanuel Temple Church, North Missouri Avenue at North Sumner Street, Portland. Portland Q.
—Proposed expansion, Terpenning Recreation Center, NW 158th Ave. and SW Walker Road, Beaverton. Linnton Q.
—Proposed Hillsboro Union High School, SW Johnson Street and SW 234th Avenue, Hillsboro. Hillsboro Q.
—Proposed new Newport Middle School. Newport North Q.
—Proposed recreation/aquatic center, Southwest 125th Avenue at Southwest Conestoga Road, Beaverton. Beaverton Q.
—Proposed Waldport Elementary School, Crestline Drive. Waldport Q.
—RV site for proposed new elementary school, 345 Elk Creek Road, Cannon Beach. Tillamook Head Q.
—Silverton Main Fire Station, 819 Railway Drive, Silverton. Silverton Q.
—Springfield High School additions, 7th Street at "G" Street, Springfield. Eugene East Q.
—Springfield Middle School, South 32d Street and Jasper Road, Springfield. Springfield Q.
—Student services building, Portland Community College, Cascade Campus. Portland Q.
—Thurston High School additions, 58th Street at "A" Street, Springfield. Springfield Q.
—Toledo High School additions, 1800 NE Sturdevant Road, Toledo. Toledo North Q.
—Waldport High School Gymnasium, Waldport Q.
Ebasco: Seismic hazards evaluation, Coyote Springs power generation project, Boardman. Boardman Q.
—Site densification report, Coyote Springs cogeneration facility, Boardman. Boardman Q.
Foundation Engineering: Dallas ambulance facility. Dallas Q.
Fujitani Hilts and Associates, Inc.: Ambulance Service Building, NW 6th and Coast Streets, Newport. Newport North Q.
—New East Precinct, Portland. Mount Tabor Q.
—Proposed Inverness Jail expansion, Portland. Mount Tabor Q.
GeoEngineers: Geotechnical and seismic services, Proposed Asahi [Glass] and Tokai [Carbon] developments, Hillsboro. Hillsboro Q.
—Milwaukie, Oregon, Stake Center, Cason Road, Gladstone, Oregon. Gladstone Q.
—Proposed John's Landing office building, Portland. Lake Oswego Q.
—Seismic hazard report, Asahi [Glass] and Tokai [Carbon] sites, Hillsboro. Hillsboro Q.
Geotechnical Resources, Inc.: Act III theaters, Division Street Cinema, Portland. Camas Q.
—Fujitsu facility additions, Gresham. Camas Q.
—Horton Reservoir No. 2, S Day Road, West Linn. Canby Q.
—IDT facility, Hillsboro. Hillsboro Q.
—Intel D1B-Site X, Hillsboro. Hillsboro Q.
—Proposed BOC industrial gas facility, Hillsboro. Hillsboro Q.
—Proposed Dawson Creek Development electronics manufacturing facility, Hillsboro. Hillsboro Q.
—Proposed DYNIC USA Corp. facility, Hillsboro. Hillsboro Q.
—Reed College Auditorium, Portland. Lake Oswego Q.
—Revised report, Broadway and Washington parking structure and hotel, Portland. Portland Q.
Golder Associates, Inc.: Klamath Cogeneration Project, Klamath Falls. Klamath Falls Q.
HongWest & Associates: Molalla United Methodist Church. Molalla Q.
Kleinfelder, Inc.: Phase I geotechnical study, Oregon Department of Corrections, BLM site, Mitchell. Mitchell Q.
—Boeing site, Boardman. Crow Butte Q.
—Bootsma site, Baker City. Baker City Q.
—Collins site, Lakeview. Lakeview NW Q.
—Dammasch site #CK-WS-1, Wilsonville. Sherwood Q.
—Dammasch site #CK-WS-2, Wilsonville. Sherwood Q.
—Dover Lane site, Madras. Culver Q.
—Hay Field site, Salem. Salem East Q.
—Klamath Hills site, Klamath Falls. Lost River Q.
—Martin Dairy site, Cave Junction. Cave Junction Q.
—Meadow View site, Eugene. Junction City Q.
—Orchard site, Medford. Gold Hill Q.
—Pasture (Kunze Road) site, Boardman. Boardman Q.
—Port of Tillamook site. Tillamook Q.
—Port of Umatilla site. Umatilla Q.
—Rigdon site, Oakridge. Oakridge Q.
—Roseburg Resources site, Medford. Sams Valley Q.
—Steel Bridge site, Willamina. Grand Ronde Q.
—Wilsonville Tract, Wilsonville. Sherwood Q.
—Zemke site, Madras. Buck Butte Q.
Mark V. Herbert and Associates, Inc.: Deschutes County Public Safety Center, N. Hwy 97 adjacent to existing Criminal Justice Center, Bend. Bend Q.
—New Gymnasium, Dufur School, Wasco County. Dufur East Q.
Marquess and Associates, Inc.: Additions to Hedrick and McLoughlin Middle Schools, Medford 549C School District. Medford East/Medford West Qs.

*(Continued on page 45, **Library**)*

Books featured at the Nature of the Northwest Information Center

by Center Manager Don Haines

Introduction to Earthquake Retrofitting—Tools and Techniques, by Building Education Center, 77 pages, $9.95. Many wood frame houses may not be strong enough to withstand a major earthquake. This step-by-step manual illustrates tools and techniques needed to do strengthening projects. The manual is designed for the beginners and do-it-your-selfers. Each step is illustrated with photographs.

Bin Rock and Dump Rock—Recollections of a Geologist, by John Eliot Allen, 282 pages, $12.95, Hells Canyon Publishing (reviewed in this issue). Founder of Portland State University's Geology Department and former geologist for DOGAMI, Allen offers a view of a geologist's life and mind. The book contains poetry and anecdotes, along with some excerpts from his "Time Travel" series in *The Oregonian.*

Northwest Exposures—A Geologic Story of the Northwest, by David Alt and Donald W. Hyndman, 443 pages, $24, Mountain Press. This new book by the authors of *Roadside Geology of Oregon* is not written as a road log the way many of their previous publications were but presents a nontechnical overview of Pacific Northwest geology.

Gold Mining in Oregon, by Bert Weber, 332 pages, $29.95, Webb Research Group. This book reprints most of the text from DOGAMI's *Gold and Silver in Oregon* (Bulletin 61), which is now out of print. The separate maps from Bulletin 61 are not included. *Gold Mining in Oregon* describes the mining activity and many of the historic mines in Oregon.

Hiking Oregon's Geology, By Ellen Morris Bishop and John Eliot Allen, 221 pages, $16.95, The Mountaineers. A new hiking guide that contains 51 hikes to some of the most scenic and geologically interesting places in Oregon.

All publications are available from the Center. VISA and Mastercard orders are accepted. For shipping, include $3.00 per destination. □

AEG calls for technical papers

The Oregon Section of the Association of Engineering Geologists (AEG) will host the national 40th Annual Meeting of the organization September 30 to October 4, 1997, at the Portland Hilton Hotel. For this meeting, which has been titled "Converging at Cascadia," AEG invites submittals for paper and poster presentations.

The list of suggested topics includes seismic hazards, landslides and slope stability, coastal engineering, environmental investigations, field and laboratory testing, groundwater investigations/modeling, water-supply studies, landfill technology, stream restoration, fluvial geomorphology, transportation geology, and general engineering geology topics. Topics other than those suggested will be considered, and presentations based on case histories are encouraged. Presentations will be limited to 20 minutes each.

Abstracts should be no longer than 250 words and must be submitted by May 15, 1997. Submittals via e-mail are preferred and should be addressed to aegjuliek@aol.com; mailed abstracts are to be sent to AEG'97 c/o Julie Keaton, 130 Yucca Drive, Sedona, AZ 86336-3222, whose phone number is (520) 204-1553, FAX (520) 204-5597.

For further information, contact

- Gary Peterson, Chairman, Annual Meeting, inquiries and general information, phone (503) 635-4419, e-mail: garyp@squier.com;
- Ed Stearns, Chairman, Technical Sessions, (503) 661-0462, e-mail: 73564.3251@compuserve.com;
- Dave Michael, Chairman, Exhibitors and Sponsors, (503) 359-7448, e-mail: dave.l.michael@state.or.us.

DOGAMI geotechnical engineer Yumei Wang will chair the theme symposium on October 2 and focus on Pacific Northwest earthquake issues, including earthquake risk, seismicity, earthquake sources, current research on hazards, and an overview of attenuation relationships. Speakers will include Bruce Bolt (University of California at Berkeley), Ivan Wong (Woodward-Clyde Federal Services), and Dave Keefer, Steve Obermeier, Silvio Pezzopane, Kaye Shedlock, and Ray Wells of the U.S. Geological Survey. □

*(**Book review**—continued from page 42)*

detail, including the frustration and methods he used to fight to keep himself functioning. He was not one to give up easily.

To John Allen, life was to be experienced fully. He did his best to do that, and he kept good records along the way, many of which became part of this book. It may be purchased from the Nature of the Northwest Information Center and most other local booksellers. □

*(**Library**—continued from page 44)*

—Ashland Community Hospital additions. Ashland Q.
PacRim Geotechnical, Inc.: Proposed Ronler Acres fire station, 229th Street and Evergreen Road, Hillsboro. Hillsboro Q.
Patrick B. Kelly: Proposed new fire station, NE corner of Sunset and Spruce Streets, Cannon Beach. Tillamook Head Q.
Redmond & Associates: Proposed North Harbor site, NE Marine Drive, Portland. Portland Q.
—Proposed Opengate Church of the Nazarene, Keizer (Marion County). Mission Bottom Q.
Schlicker & Associates: Proposed theater site, West 7th and Snipes, The Dalles. The Dalles South Q.
Siemens & Associates: La Pine Fire Station, La Pine. La Pine Q.
—Spray water tanks, Spray (Wheeler County). Spray Q.
Squier Associates: Airport Embassy Suites Hotel, Portland. Mount Tabor Q.
—Exhibit G *in* Hermiston power project, application for site certificate. Hermiston Q.
West Coast Geotech: New Parkrose community center/high school, Portland. Mount Tabor Q.
Wright/Deacon & Associates: The Blazers Boys and Girls Club, NE MLK Blvd. and Roselawn St., Portland. Portland Q.

The library also contains some site-specific seismic reports dated before the 1994 rule change and other site-specific reports related to landslides and mined land reclamation projects. Part of the library's mission is an increased attention to reports usually referred to as "gray literature"—collecting them and making them accessible to a wider audience. □

DOGAMI PUBLICATIONS AND RELEASES

Released January 22, 1997

Description of economic models that forecast the demand for construction aggregates in Oregon, by Robert M. Whelan. Open-File Report O-96-03, 1 CD-ROM disk, $30.

Former DOGAMI Mineral Economist Whelan, now with ECONorthwest in Portland, has developed an aggregate demand model for each of Oregon's counties with a forecast that extends through the year 2050.

The aggregate model includes forecasts of population, income, and construction of roads, housing, and 23 other categories such as schools, bridges, and airports. Included on the CD-ROM are a text describing use of the model and forecasts of aggregate consumption for 45 end uses such as maintenance of asphalt roads, building of low-rise office buildings, and maintenance of railways. Population data that extend from 1960 to 2050 include population projections broken into age categories and number of households in each county and are based on census data from the U.S. Bureau of the Census, the Portland State University Center for Population Research and Census, and forecasts by the author. Construction statistics came from F.W. Dodge.

Oregon is the first state to use econometric analysis and sophisticated modeling techniques to project aggregate demand. The report is the only source in Oregon of population and construction forecast to 2050 that is available at the county level. It will be useful for planners who need to know future demand for aggregate, for mining companies seeking long-term projections of sales, and for people who need information on outlook for construction in counties. This model can also be used as a template to build a model for aggregate demand in other parts of the United States and other countries.

The model now released as Open-File Report O–96–03 was used earlier by Whelan to prepare DOGAMI Special Paper 27, *An Economic Analysis of Construction Aggregate Markets and the Results of a Long-Term Forecasting Model for Oregon.*

Released March 7, 1997

Mist Gas Field Map, 1997 edition. Open-File Report O–97–01, 1 map sheet, 40 p. text, $8.

The map of the Mist Gas Field in Columbia and Clatsop Counties that has been published since 1981 has been updated over its 1996 edition. The release includes the map and a production summary for 1993 through 1996.

The map shows the field divided into quarter sections. It displays location, status, and depth of all existing wells and serves as a basis for locating any new ones. It also shows the areas and wells that are used for storage of natural gas. The production summary includes well names, revenue generated, pressures, production, and other data. The map and accompanying data are useful tools for administrators and planners, as well as explorers and producers of natural gas.

The Mist Gas Field Map is also available, on request, in digital form (price $25). It is offered in three different CAD formats (.DGN, .DWG, and .DXF), all on one 3½-inch high-density diskette formatted for DOS, for use by different software systems.

A cumulative report of past production at the Mist Gas Field between 1979 and 1992 is available in a separate release under the title *Mist Gas Field Production Figures* as DOGAMI Open-File Report O–94–6 (price $5).

The following releases are available for inspection in the library of the DOGAMI Portland office. They are not published in multiple copies and are not for sale but limited to library access only. Photocopies may be obtained at cost:

Released January 27, 1997

Tsunami Hazard Map of the Siletz Bay Area, Lincoln County, by George R. Priest. Open-File Report O–95–06, scale 1:4,800.

The tsunami hazard map for the Siletz Bay area consists of three map sheets covering the coastal area from D River in the north to Gleneden Beach in the south. On an orthophoto map base, different lines mark four levels of inundation hazard, from negligible/low to low/moderate, to moderate/high to high/extreme.

The hazard map was prepared in a cooperative effort by scientists from DOGAMI, the Oregon Graduate Institute of Science and Technology, and Portland State University. It represents a pilot study of detailed tsunami inundation hazard and aided the work that produced the tsunami hazard zone maps DOGAMI Open-File Reports O–95–09 through O–95–67 for the implementation of Senate Bill 379 of the 1995 Oregon Legislative Session.

Released January 31, 1997

Geologic Map of the Malheur Butte Quadrangle, Malheur County, Oregon, by Ian P. Madin and Mark L. Ferns in cooperation with the Oregon Department of Corrections. Open-File Report O–97–02, scale 1:24,000, 13 p. text.

The new map includes the geologic map and two geologic cross sections as well as a separate, 13-page text. The Malheur Butte quadrangle covers an area near the Idaho border just west of the City of Ontario and includes a portion of the Malheur River at its southern end and Jacobsen Gulch at its northern end The text contains explanations of the rock units presented on the map, the geologic history of the area, geologic structure and seismic hazards, and geologic resources. Sand and gravel, used for aggregate in the local construction industry, are the main mineral resources mined in the quadrangle. Potential energy resources include natural gas and geothermal energy.

The map was prepared specifically to evaluate possible earthquake hazards in the quadrangle. The Malheur fault zone, the major complex of faults in the quadrangle, has probably not been active since the middle Pleistocene and is not currently active. □

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