WASHINGTON GEOLOGY

Washington Department of Natural Resources, Division of Geology and Earth Resources Vol. 20, No. 4, December 1992

Some effects of the April 1992 earthquakes in northern California. The photo above shows one of the many homes in Ferndale, CA, knocked from its foundation. The photo on the left shows the distinct line between live (dark color) and dead (light color) seaweed in an area near Cape Mendocino that experienced a meter or more of uplift. The tide now reaches only to the top of the dark area. One or more of these earthquakes may have occurred along the Cascadia Subduction Zone, which is also present off the coast of Washington. See article, p. 10.

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WASHINGTON GEOLOGY

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Evolving Priorities in Applied Geology

by Raymond Lasmanis

The Geological Survey of Canada (GSC) celebrated its 150th anniversary on April 14, 1992. In commemoration of this milestone, the GSC convened an international conference of geological surveys to discuss the state and status of applied geological studies. The Association of American State Geologists was invited to participate in this program. From these discussions it became clear that some common themes are evolving in nearly all countries as well as in the surveys in the United States. These themes are:

- The economic slow-down is worldwide and is creating budgetary constraints.
- The need for applied geological information is increasing. The gap between what is available and what is needed is being bridged by high-tech equipment and streamlined procedures.
- Except for third-world countries, there is a shift in emphasis from mineral resource information to issues in environmental geology.

Here in Washington, as the Division of Geology and Earth Resources faces continuing funding reductions, we are finding a significant demand for information relating to geological hazards, to ground-water management, and to toxic waste cleanup efforts. Agencies and institutions needing this information have funds available for some of this work. It is only natural, therefore, that our mission priorities have been adjusted to attend to these more immediate needs and at the same time to alleviate the budgetary pressures.

We in Washington are in step with the national and international trends to focusing on applications of geological data and techniques that have relevance to immediate problems, but we retain our interest in the long-term need for resource information, in particular industrial minerals. ■

Staff News

Jack Powell has recently been hired by the Division as a reclamation geologist for the Southeast Region. Powell has a B.A. in geology from Central Washington University and an M.S. in geology from the University of Idaho. For the last 20 years, he has worked mapping and studying the Columbia River basalts, in mineral exploration in the western United States and Alaska, and as a geology instructor for Yakima Valley Community College. Projects he has worked on for the Division of Geology include the geologic maps of the Bluelight, Poisel Butte, and Logy Creek 15-minute quadrangles.

Joan Casteneda started with the Division on November 16th, replacing Kelli Ristine as clerk typist/receptionist. Joan was a temporary clerk typist with the Attorney General's Office prior to joining DNR as a permanent employee. She and her family have recently moved back to the Olympia area from Texas, where they have been living for the past year and a half.

Reclamation of Quarries

by David K. Norman

Quarried rock is consolidated material mined by blasting, ripping, or cutting. Rock types commonly quarried in Washington include basalt, andesite, granodiorite, limestone, dolomite, and, in the past, sandstone. When operations cease, unreclaimed working faces and engineered benches can be obtrusive, unsafe, liable to erode, and aesthetically unpleasant. However, reclaimed quarries can create spectacular landscapes and add to the variety of landforms in an area.

Washington's Surface Mining Act (Chapter 78.44 RCW), which is administered by the Department of Natural Resources, defines reclamation as "the reasonable protection of all surface resources subject to disruption from surface mining and rehabilitation of the surface resources affected by surface mining including the area under stockpiled materials. Although both the need for and the practicability of reclamation will control the type and degree of reclamation in any specific instance, the basic objective will be to *reestablish on a continuing basis the vegetative cover, soil stability, water conditions, and safety conditions* appropriate to the intended subsequent use of the area." [emphasis added]. RCW 78.44 also states that "the slopes of quarry walls in rock or other consolidated materials shall have no prescribed angle of slope, but where a hazardous condition is created that is not indigenous to the immediate area, the quarry shall be either graded or backfilled to a slope of one foot horizontal to one foot vertical or other precautions must be taken to provide adequate safety" (RCW 78.44.090 (4)).

Figure 1. A reclaimed quarry in mountainous terrain. Naturally hazardous conditions (cliffs) are present in the immediate area. Chutes, spurs, scree slopes, and soil on the scree have created a natural appearance. Trees now grow on the slope where soil is located and complete the reclamation. The site will be used for forestry in the future. Note person (midslope) for scale. Photo by M. A. Shawver.

The goal of RCW 78.44 is that reclamation create stable, usable land at a mined site. The reclaimed quarry should appear natural, that is, slopes should be sinuous and right-angle corners should be rounded. The height and angle of some working quarry faces need not be reduced if there were tall cliffs in the area prior to mining (Fig. 1). Subsequent uses of a quarry will be constrained by its post-mining topography. For example, cliffs are appropriate if the subsequent use of the pit floor is forestry or grazing and it is in a mountainous area.

Several methods of reclamation can be used to convert a quarry into a stable site that blends with surrounding landforms at a minimum cost. This article introduces some of these methods. It is a companion to "Reclamation of sand and gravel mines" (Norman and Lingley, 1992), which discusses strategies for topsoil replacement, revegetation, and various subsequent uses that will be applicable in many quarries. As with sand and gravel pits, the strategy of choice for quarries is segmental reclamation. These similarities notwithstanding, the differences in approach to reclaiming sand and gravel pits and quarries are distinct enough to warrant this separate discussion.

RECLAMATION PLANS

Quarry operators should prepare and follow a detailed and effective operating and reclamation plan. This plan should be simple, practical, and easy to implement. The plan should also be flexible and take into account both market changes and the potential for unanticipated changes in geologic conditions that will affect reclamation. In addition, the plan should make provision for high-quality reclamation, even if mining to depletion does not occur. Managers and senior equipment operators must be familiar with the reclamation plan and the obligations to which the permit holder has committed.

A typical operation and reclamation plan might include:

- A map showing existing topography, hydrology, and details on how the site will be mined and whether it will be left wet or dry
- Information about subsequent use of the land, appropriate for the location of the quarry
- An indication of the sequence of topsoil stripping, storing, and replacement on mined segments
- A map showing direction and sequence of excavation for prompt reclamation after mining on any segment and within the constraints of economically efficient mining

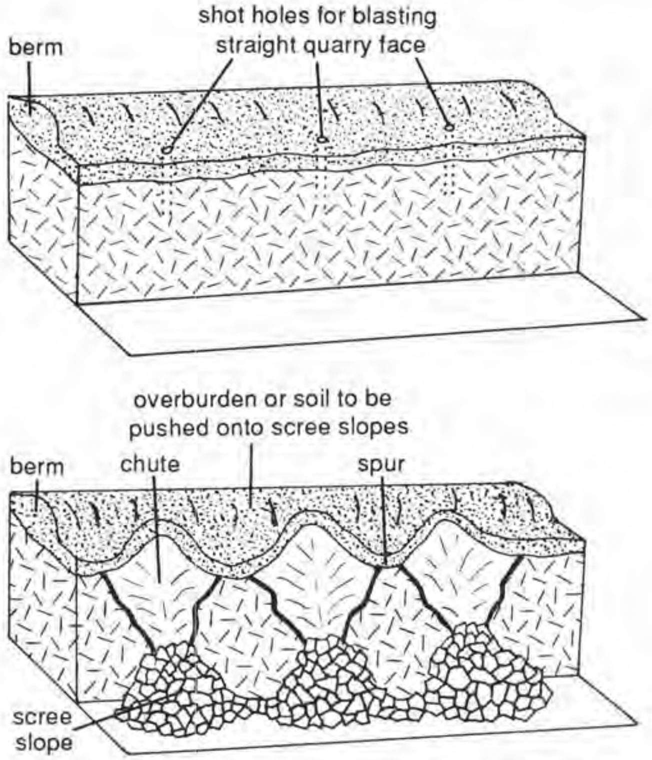

Figure 2. Selective blasting (top) can produce a natural appearance by eliminating right-angle corners, straight lines, and flat surfaces. The resulting scree slopes (bottom) provide a suitable medium for revegetation when soil is pushed onto them.

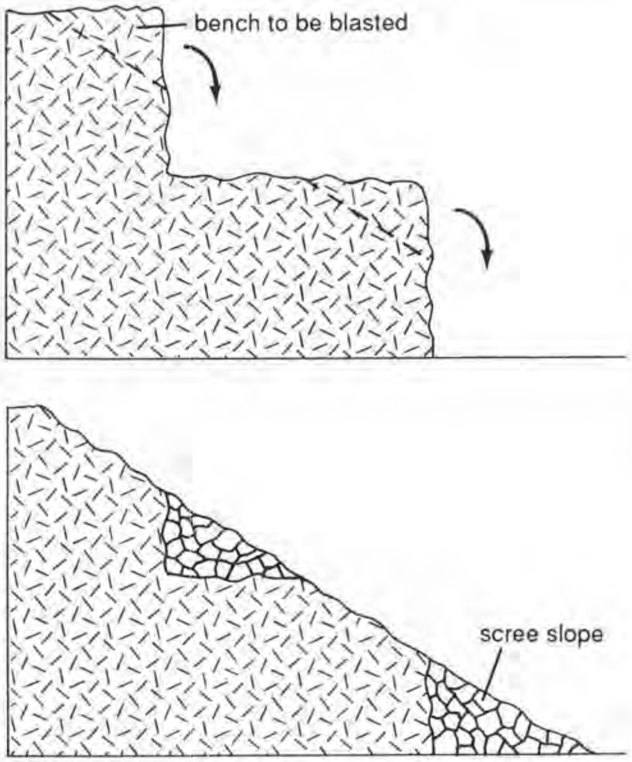

Figure 3. Blasting (top) can reduce or remove benches and create scree slopes (bottom) that can be further stabilized by plantings.

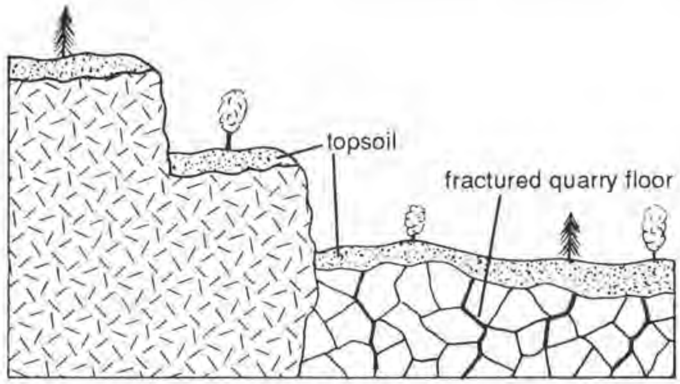

Figure 4. Topsoil placed on benches and on a fractured quarry floor will make the site look natural and prepare it for revegetation.

- Designation of overburden storage areas beyond the limit of mining but positioned for the shortest possible downhill transport during reclamation
- Location of waste rock piles and information on how they will be reclaimed and stabilized
- A map showing the final grades and shapes of quarry walls and floor, incorporating sinuous contours
- A description of surface-water drainage, water diversions, and any subsequent restoration of drainage that may be necessary
- Information about the location and construction of permanent drainage and water-control systems
- Specifications and planting schedules for ground-cover plants to minimize erosion and establish conditions that will increase survival rates of other vegetation and trees
- For areas where trees can be planted, planting specifications, and schedules to make use of the new humic layer generated by ground cover
- Other information pertaining to the conditions on the mining permit and required by statute.

Quarries have impermeable surfaces, such as their floors, a characteristic that can lead to rapid runoff rates. Water-control methods must ensure that erosion does not take place in the quarry or where the runoff leaves the site. Water and erosion control is an important aspect of the operation and reclamation of quarries and is discussed widely in the literature (Washington Department of Ecology, 1992; Banks and others, 1981; Amimoto, 1978; Foster, 1991, Goldman and others, 1986; Gray and Leiser, 1982). It will not be discussed in detail in this article.

RECLAMATION TECHNIQUES

Highwalls and Benches

Several methods of reclaiming quarry walls are effective in achieving stable slopes and land that can be used after the quarrying operation ceases. Shaping the tall rock faces and engineered benches created during production blasting can be particularly difficult. Selective blasting is one method of producing the desired natural appearance and stabilizing a site. If cliffs will be part of the final configuration of the reclaimed quarry, then chutes, spurs, scree slopes, and rough cliff faces can be created by blasting in strategically placed holes. The result will be elimination of flat surfaces (Fig. 2) (Coppin and Bradshaw, 1982). Proper blasting of highwalls leaves rough surfaces that can provide habitat for birds such as cliff swallows. However, the remaining rough surface should be free of loose rock.

If highwalls are part of the reclaimed configuration, rounding the top edges of the quarry, creating a 10-foot-high by 15-foot-wide bench, or placing a berm at the top of the quarry (Fig. 2) will improve safety by slowing access and reducing the effective height of the final face.

Selective blasting can also be used to reclaim benches (Fig. 3) that may otherwise be obtrusive and not blend with natural surroundings. However, if blasting of benches is impractical or dangerous, the benches that remain should be about 40 feet wide to accommodate revegetation. The surface of these benches should slope toward the highwall to trap the moisture and fine particles that will enhance revegetation. At least 3 feet of topsoil should be placed on the inside part of the bench to serve as a stable rooting medium. Trees planted on these benches or elsewhere on a highwall will break up the line of the face and conceal rectilinear features (Figs. 1, 4).

Reclamation blasting (also referred to as blast casting) that reduces the entire highwall to a scree slope or an overburden slope is in essence a cut-and-fill method. However, this process can be used only if there is sufficient material remaining in a setback behind the quarry face to create the desired slope. Mining past these setbacks is not permitted by the Department.

Blasting to eliminate an entire highwall uses a pattern of progressively shallower holes—that is, if a highwall is 60 feet high and the desired slope is 3H:1V, the blast holes closest to the highwall face should be drilled 30 feet deep, or half the height of the highwall. The second, third, and fourth rows away from the face should be drilled to depths of 25, 20, and 15 feet, respectively (Fig. 5); the row of holes extends 90 feet back from the highwall. This method of creating slopes is usually more economical than backfilling (Thorne, 1991; Petrunyak, 1986). Blast casting may not work in overburden that has been moved because shot holes may not stay open in unconsolidated materials.

At some quarries, blasting to reduce the exposed highwall is not recommended because the resulting increased surface disturbance may cause unexpected slope failure on adjacent land. Therefore, the impact of blasting the highwall should be carefully considered when preparing the operating and reclamation plan (U.S. Bureau of Land Management, 1992).

Backfilling against a steep quarry wall using either material on the site or imported material is generally not recommended for reclamation. Backfilling will be cost effective only if enough appropriate overburden material is perched above the quarry and can be readily moved into position (Fig. 6). Therefore, plans should ensure that ade-

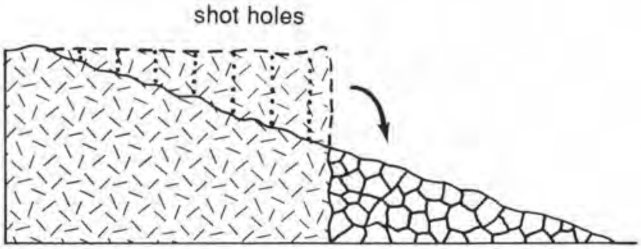

Figure 5. Shot holes drilled to progressively shallower depths provide a blast pattern that will reduce highwall height, create a 3H:1V slope, and prepare the quarry site for revegetation.

Figure 6. In the top photo, overburden is stacked on top of a highwall left by mining, ready to be bulldozed into position. The short push will reduce the cost of reclamation. In the bottom photo, moving of overburden into position for reclamation is nearly complete. Overburden has been pushed over the highwall with a bulldozer. Blast casting was attempted here to reduce costs; however, the shot holes could not be kept open because the overburden is unconsolidated. The final reclaimed slopes allow easy escape from the pond and will be revegetated. Lower photo by M. A. Shawver.

Figure 7. This slope was backfilled using material from the site. Additional material needed could not be taken from adjacent land because it was not part of the permit area. The expense of hauling in material made reclamation costs for this segment higher than the actual value of the rock mined. The belly scraper used to place material compacted the slope to make landsliding less likely. Alder trees, which are nitrogen-fixing plants that enhance soil fertility, will be used in revegetation to complete the reclamation of this segment.

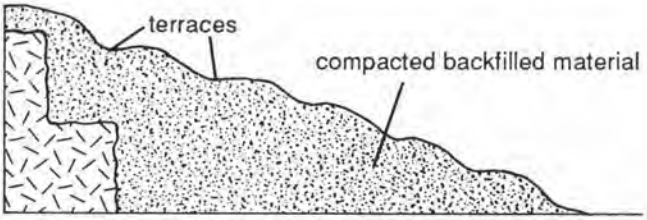

Figure 8. Quarry slopes that are backfilled should be compacted so that the final slope is stable; a 3H:1V slope (with terraces, if it is long) is generally a stable angle. Topsoil should be spread over the compacted slope to make revegetation possible.

quate amounts of material to accomplish reclamation are left in the setback area at the site. If a quarry has been mined to the permit boundary, however, backfilling may be the only way to accomplish reclamation. For a quarry located in a residential or populated area, backfilling is recommended only if no other alternatives exist for creating safe slopes (Fig. 7).

Regardless of the means of creating a slope, topsoil should be pushed onto the slope to promote revegetation.

Slopes

Stability is the first concern for slopes created by either blasting or backfilling during reclamation of the quarry. Once a material is blasted, it is no longer considered consolidated. If reclamation blasting is used to form a slope, a final angle of about 3H:1V is generally required for stability, topsoil application, and revegetation. If no revegetation is necessary, such as on a scree slope of large boulders or where there is sufficient clay content in the backfill material for natural reseeding to be successful, then the slope may be as steep as 1.5H:1V.

Compaction of soil is necessary on many backfilled slopes to enhance stability and lessen the danger of saturating fill with water, which may cause it to liquify and fail. Temporary protection of the slope during the backfill operation may be necessary if backfilling occurs over a long period and planting of permanent vegetation must be delayed. Temporary methods that may be necessary to protect bare soils from rain or snowmelt runoff include seeding the slope with grasses or covering it with plastic sheeting, mulches, or matting.

Slopes backfilled for reclamation can be prone to erosion and gullying if they are smooth, flat, and long. As slope length and steepness increase, runoff velocity increases. This in turn increases the capability of water to detach and transport soil particles. With faster runoff, less infiltration and more erosion will occur. Careful location of drainage and water-control features will enhance slope stability and revegetation potential (Banks and others, 1981; Washington Department of Ecology, 1992).

Slopes longer than 75 feet should be shaped with rounded, natural-appearing terraces or benches to break the slope length and thereby reduce the velocity of water runoff (Fig. 8).

Pit Floors

For most subsequent uses, impermeable pit floors of solid rock should be blasted to fracture the rock (Fig. 4) so that water can drain slowly from the site. In addition, compacted ground and overburden on the floor should be ripped before placing topsoil to create seed beds for revegetation. Before deep ripping or tilling compacted mine wastes or soils, at least one backhoe pit should be dug on the site to determine how deep tilling must penetrate to reach below the compacted zone.

Rippers are mounted on heavy equipment and consist of a vertical shank or shanks that can crack or shatter compacted or hard areas to depths from 2 to 7 feet. Using rippers with longer-than-normal shanks and heavier points will decrease the need for equipment repairs and do a better job of ripping. A rule of thumb: ripper spacing should be less than or equal to the depth of ripping.

If topsoil is replaced using rubber wheeled equipment, ripping may be necessary to loosen this soil before planting either ground cover or trees. The drawback to ripping

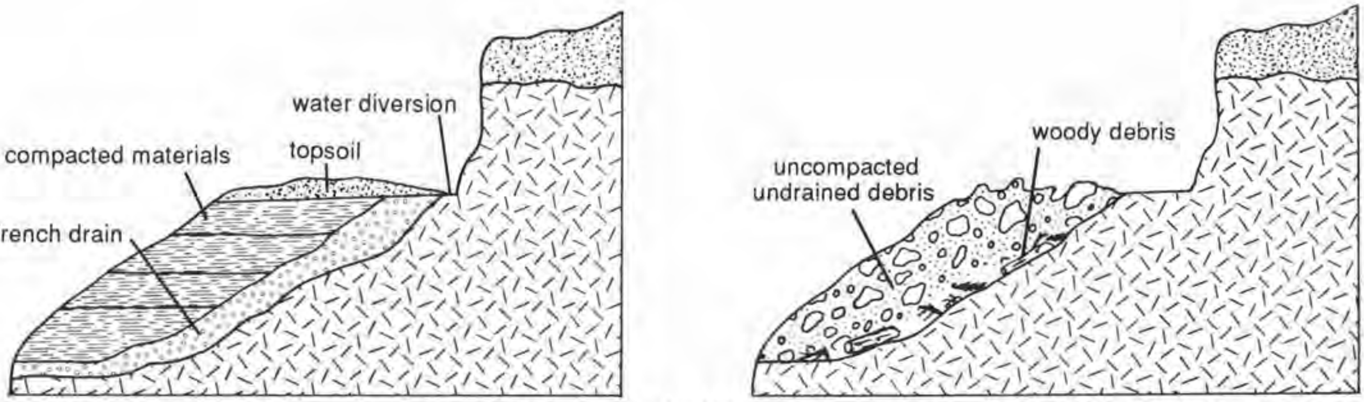

Figure 9. Before overburden waste is placed (left), vegetation should be cleared, and the drainage planned. French drains should be installed beneath the waste piles. Overburden should then be laid down in compacted layers. Water must be diverted away from the fill. Topsoil placed over the compacted fill will promote self-sustaining vegetation. Uncompacted, improper fill (right) with no drainage that is placed over woody material can fail by landslides that may flow onto nearby lands and into water bodies.

slopes is that it can increase instability and erosion on slopes of 3H:1V or steeper. The quality of topsoil should not be degraded by mixing it with subsoils during the ripping process.

Mounds, hills, and boulder piles can be left on the quarry floor to vary the otherwise flat topography of the site. They should be covered with soil and seeded to control erosion and improve the appearance of the site, consistent with the subsequent land use.

Topsoil is placed on the surface as a last step before planting. In general, sloping the pit floor toward a highwall will prevent sheet runoff and retain soils and fine material on the site.

Overburden and Waste Piles

Many quarry operations have large amounts of overburden and create excessive amounts of waste rock. Some operators fail to make provision for storing this material in a stable area. Before the overburden is moved, vegetation should be cleared and drainage planned for the storage site. A properly compacted waste pile with drainage and water diversions is shown in Figure 9 (left). Topsoil should be placed over this compacted fill to promote self-sustaining vegetation. Undrained and uncompacted fill (Fig. 9, right) dumped over vegetation and without drainage is prone to mass wasting and landslides.

Failure to remove overburden before mining will leave the overburden undercut and unstable. It may also result in landslides (Fig. 10).

REVEGETATION

Once the pit floor has been ripped and topsoil replaced on the floor and slopes, revegetation should begin as soon as possible during the next appropriate growing season. Well-planned planting or seeding can contribute to slope stability (Fig. 11). Topsoil replacement and revegetation should follow suggestions given in Norman and Lingley (1992).

For cliffs and highwalls that remain, rock-face texture will determine the potential for later plant growth. Broken and fissured rock faces that retain abundant fine material will eventually support plants. A solid rock face with nothing more than artificial ledges will have plants only on ledges that accumulate enough soil.

In general, most slopes of 3H:1V that have a soil cover can support self-sustaining vegetation. The choice of plants will be dictated by the slope material and climate. Selecting plants that do well on scree slopes or in coarse substrate helps assure successful revegetation.

Soils and fine sediments can be placed in pockets and holes at low spots on the quarry floor. These pockets retain moisture that will enhance the growth of trees planted there. Where coarse rock overlies rocky subsoil on slopes and floors and 2-year-old seedlings are to be planted, rocks should be arranged to make a hole that will hold approximately 5 gallons of high-quality soil. There must be a layer of appropriate subsoil at shallow depth into which roots can

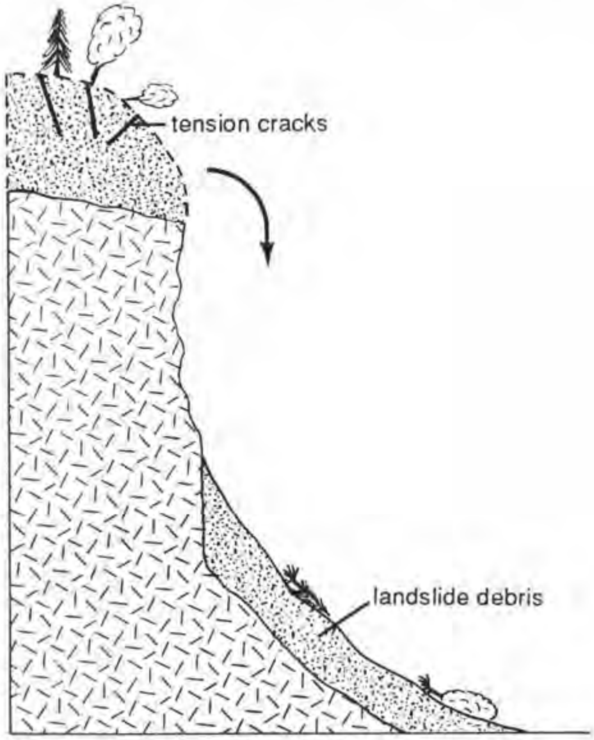

Figure 10. Mining without first removing overburden to a stable site can result in landslides that encroach on an adjacent landowner's property or nearby water resources.

Figure 11. An inspector evaluating the growth of 3-year-old Douglas fir and 4-year-old alder in a reclaimed segment of a quarry. Photo by M. A. Shawver.

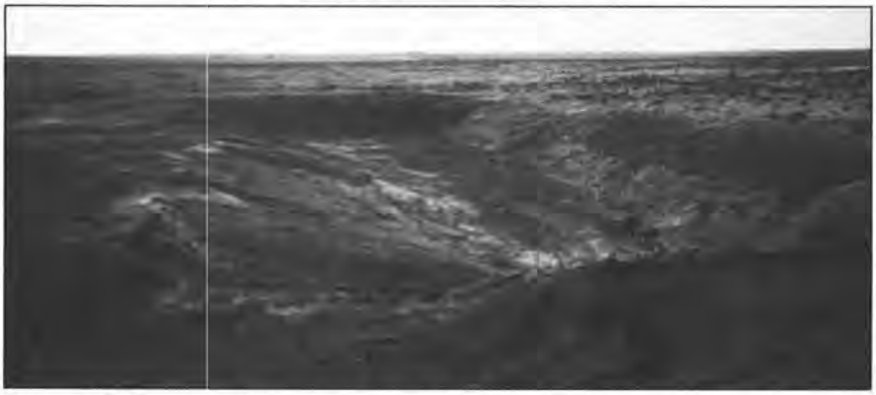

Figure 12. Slopes in this eastern Washington basalt quarry were reduced by moving unused blasted rock and overburden from around the edges of the pit, which is approximately 150 feet by 400 feet. Revegetation has occurred only in areas where soil was present. Photo by Clint Bigger, Adams County Public Works Department.

Figure 13. A wetland has formed on this reclaimed quarry floor. Wetland plant species include cattails and bulrushes; along the wetland margin are alder and cottonwood trees. The highwall in the background is appropriate to this area because there were cliffs here before mining. Spurs and chutes have formed along the highwall, creating a natural appearance.

grow. There should be no air pockets in the soil or materials below it.

Mounds of coarse material left on the pit floor or elsewhere in the quarry will drain quickly. Plants on such mounds will be susceptible to drought. Mature trees growing on mounds may topple in strong winds because of poorly developed root systems. Topsoil placement and choice of plants can avoid some of these problems.

It is more difficult to accomplish reclamation in eastern Washington because that part of the state has less precipitation, as well as lower nutrient availability, coarser grained soils, and higher and lower temperatures than western Washington. Wind erosion, a significant factor in eastern Washington, removes newly formed clay and silt from the soil. In general, conditions are harsher, and successful revegetation requires selection of proper plant species, appropriate timing of planting, adequate fertilization, and the presence of organic matter (Fig. 12).

WET QUARRIES

Quarried areas commonly include a seep or spring. These water sources can be included in the design and construction of a pond or wetland (Fig. 13). Many suggestions for reclamation of mined sites as wetlands and lakes discussed in Norman and Lingley (1992) can be applied to quarry reclamation. For example, quarries reclaimed as lakes (Fig. 14) will provide wildlife habitat. Islands for nesting sites can be made from rock processing waste. A variety of trees and shrubs should be provided for desired habitat diversity.

RCW 78.44 requires that there are places provided for people and animals to get out of deep water at a reclaimed site (RCW 78.44.090 (1b)). Scree slopes, benched steps, or gentle slopes along shorelines create shallow areas that offer easy escape from the water (Fig. 15).

SUMMARY

This article has discussed some ideas, techniques, and guidelines for reclaiming quarries. For a further discussion of reclamation strategies, critical elements of topsoil removal, storing, and replacing, and revegetation, see Norman and Lingley (1992).

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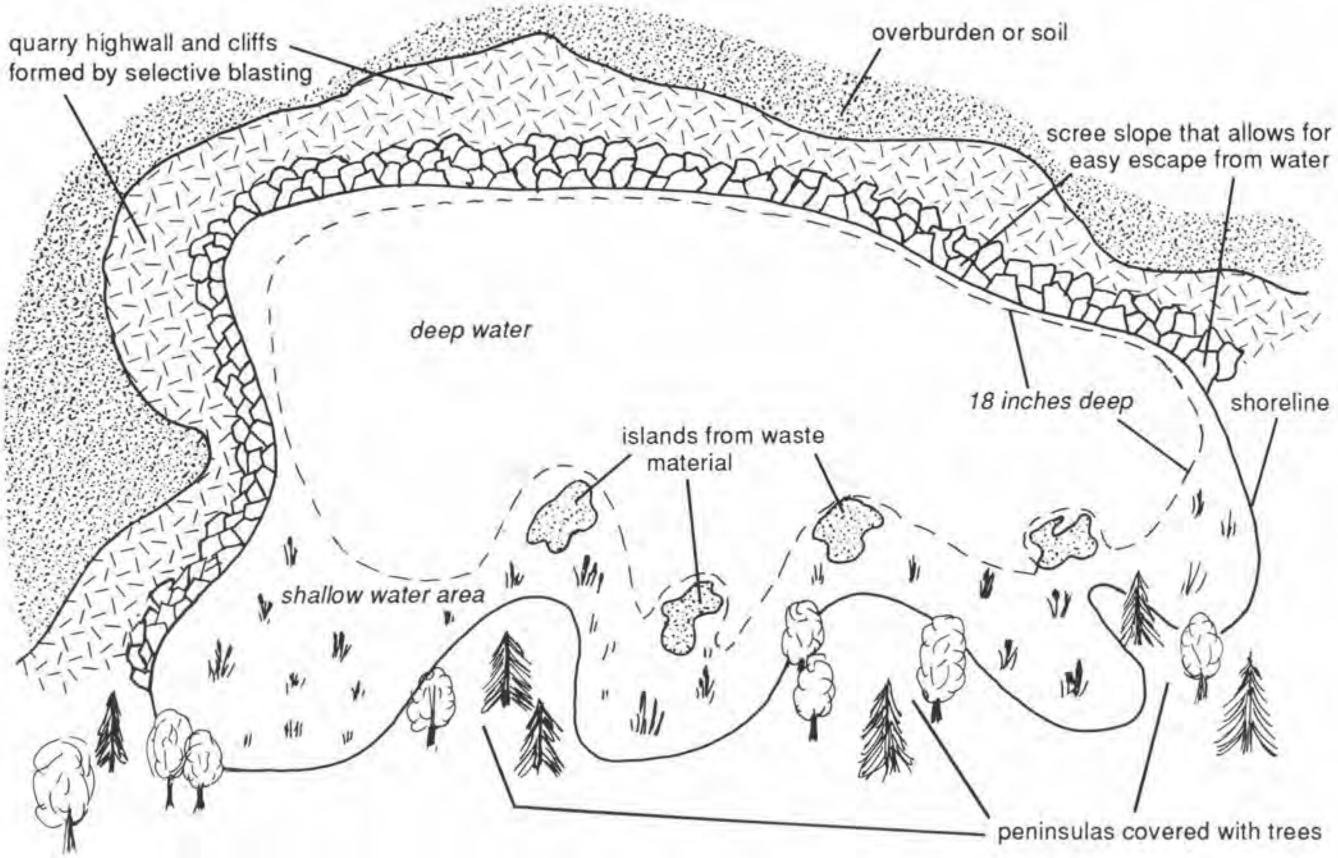

Figure 14. Sketch plan of a wet quarry after final reclamation showing shallow areas, island nesting sites, and a rounded natural appearance. Scree slopes and flat, shallow areas provide access or escape around the entire perimeter of the lake. No scale is implied.

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Figure 15. Top photo shows post-mining unreclaimed steep slopes. The bottom photo was taken a week later, after soil was pushed down to form slopes and flat areas for escape from the pond.

Effects of Holocene and Modern Earthquakes in Northern California

by Wendy J. Gerstel

On June 5, 1992, approximately 175 Friends of the Pleistocene (FOP) gathered at Patrick's Point State Park in Humboldt County, CA, for a 3-day field trip and meeting. The trip was led by faculty and students from Humboldt State University in Arcata, CA, and other geologists working in the area.

The general focus of the trip was past and recent geomorphic and tectonic processes along the northern coast of California. These processes relate directly to movement along faults associated with the Cascadia Subduction Zone, which also lies west of Washington (Fig. 1). I attended the meeting as a representative of the Division of Geology and Earth Resources. The Division wanted someone to examine the results of this tectonism to improve our understanding of the geologic evidence and hazards associated with the subduction zone and their possible relation to postulated similar events in Washington.

The tectonic regime north of Cape Mendocino in California is dominated by the Mendocino Triple Junction (Fig. 1). Subduction of the Gorda and Juan de Fuca plates under the North American plate has left a record of earthquake-induced coastal subsidence and uplift (Atwater, 1987; Atwater and Yamaguchi, 1991). The Gorda and Juan de Fuca plates converge with the North American plate at a rate of approximately 3–4 cm/yr (Minster and Jordan, 1978). Convergence in northern California is absorbed by crustal shortening of the upper plate, at a rate of approximately 2 cm/yr (Clarke and Carver, 1992), in a series of oblique folds and thrust faults. Displacement of about 1 km in the last one million years has been documented through trenching investigations across several of these faults (Carver, 1987).

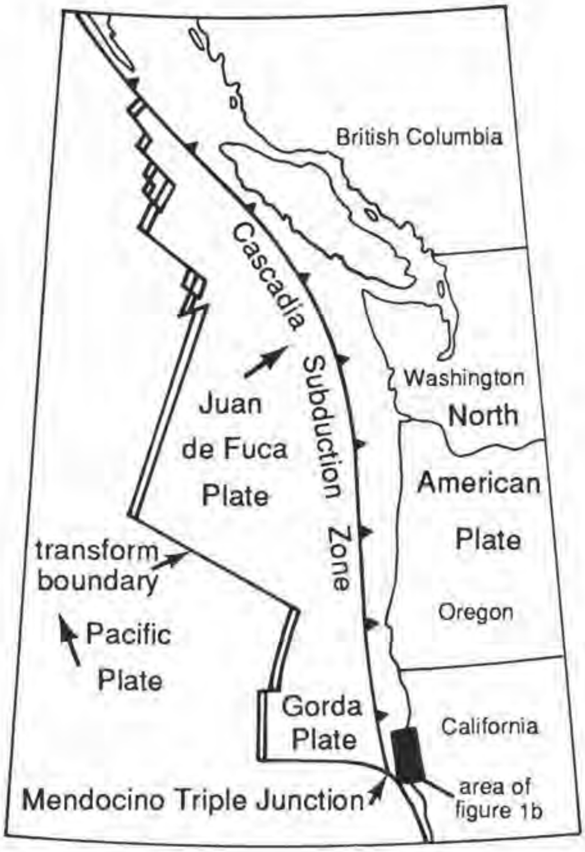

Figure 1. Diagram showing regional tectonics and relation between plates along the coasts of northern California, Oregon, and Washington.

On the first day of the trip, we looked at evidence for faulting associated with the Trinidad, McKinleyville, and Mad River faults, all part of the Mad River Fault Zone (Fig. 2), as well as at ongoing geomorphic processes affecting the coast. A walk from the vista overlook on U.S. Highway 101 (Fig. 2) down to Clam Beach and south to the mouth of the Mad River revealed textbook examples of the tectonic, geologic, and geomorphic processes shaping the coastal area. The recently eroded cliffs along the right (east) bank of the Mad River expose part of the McKinleyville fault in cross section and sediments of the Clam Beach terrace, a raised late Holocene marine terrace.

The mouth of the Mad River has been progressively migrating northward as it erodes the bluffs below the highway. We looked at the attempts of California's highway department to halt this northward progression by placing large volumes of sand and large riprap along the north and east side of the river (Fig. 3). Although the river is temporarily confined to the constructed channel visible in the photo, most geologists on the trip thought it will be just a matter of time before the river re-establishes its northward migration.

The effects of this bluff and bank erosion are both positive and negative. The down side is the high cost of highway maintenance and the possible need for reconstruction of a segment of Highway 101. The benefits are scientific—opportunities to study fluvial processes and to observe fresh exposures of faulting and marine terrace stratigraphy.

Exposed in the eroded banks at the mouth of the Mad River is a sequence of strata that suggests two or three sudden (coseismic) uplift events (Fig. 4). Each of these events elevated the active wave-cut platform and at the same time displaced the shoreline westward. The newly exposed seafloor became the source of sands for the construction of dunes, which are now exposed in the coastal bluffs. The dune sequences created after each uplift event are separated in some places by a buried soil that indicates a period (interseismic) of nondeposition and weathering. The outer wood of fossil trees rooted in the uppermost buried soil layer yielded ^{14}C ages of about 300 yr BP. A landslide deposit near the raised dunes covers a peat that developed behind the dunes. The peat provided a date similar to that of the buried trees. The landslide was therefore probably generated by the same uplift.

A visit to the Mad River Slough, a tributary to Humboldt Bay, west of Arcata (Fig. 2), gave us the opportunity to view evidence for postulated coseismic subsidence events. The northern portion of Humboldt Bay is located in the axis of the Freshwater syncline. Along with the fault zones mentioned earlier, this syncline is one of the large features that make up the Cascadia fold and thrust belt. This relation of areas of subsidence interspersed with areas of uplift is evident all along the Cascadia Subduction Zone, including the coastal areas of Oregon and Washington. (See Shipman, 1990.) At this stop, we looked at a sequence of estuarine muds and interbedded marsh peat deposits (Fig. 5a). The composite stratigraphic column in Figure 5b shows the relation of the peat and mud layers, together with their associated ^{14}C ages. The existence of a peat layer does not necessarily represent a subsidence event; however, those that are overlain by sand and then marine sediments suggest a history similar to that of the down-dropped coastal areas of Washington discussed by Atwater and Yamaguchi (1991).

Subsequent stops provided us with a variety of views of the surface expression and stratigraphy of the fold and thrust fault systems. A highlight of the trip was the visit to the most recently affected coastal area. Here we saw the results of three earthquakes (magnitudes 7.0, 6.0, and 6.5, respectively) that occurred on April 25 and 26, 1992. In the Cape Mendocino area, the earthquakes triggered landslides (Fig. 6) and rockfalls; damaged and destroyed buildings (Fig. 7 and cover photo), roads, and bridges; and caused liquefaction of soils. In addition, the earthquakes created a spectacular stretch of coastline that has been raised by at least 1 m. (See cover photo and Fig. 8.) Analysis of the seismic data from the April 1992 earthquakes has led the trip leaders and other scientists to believe that the first of the April earthquakes might have been the first historic earthquake along the Cascadia Subduc-

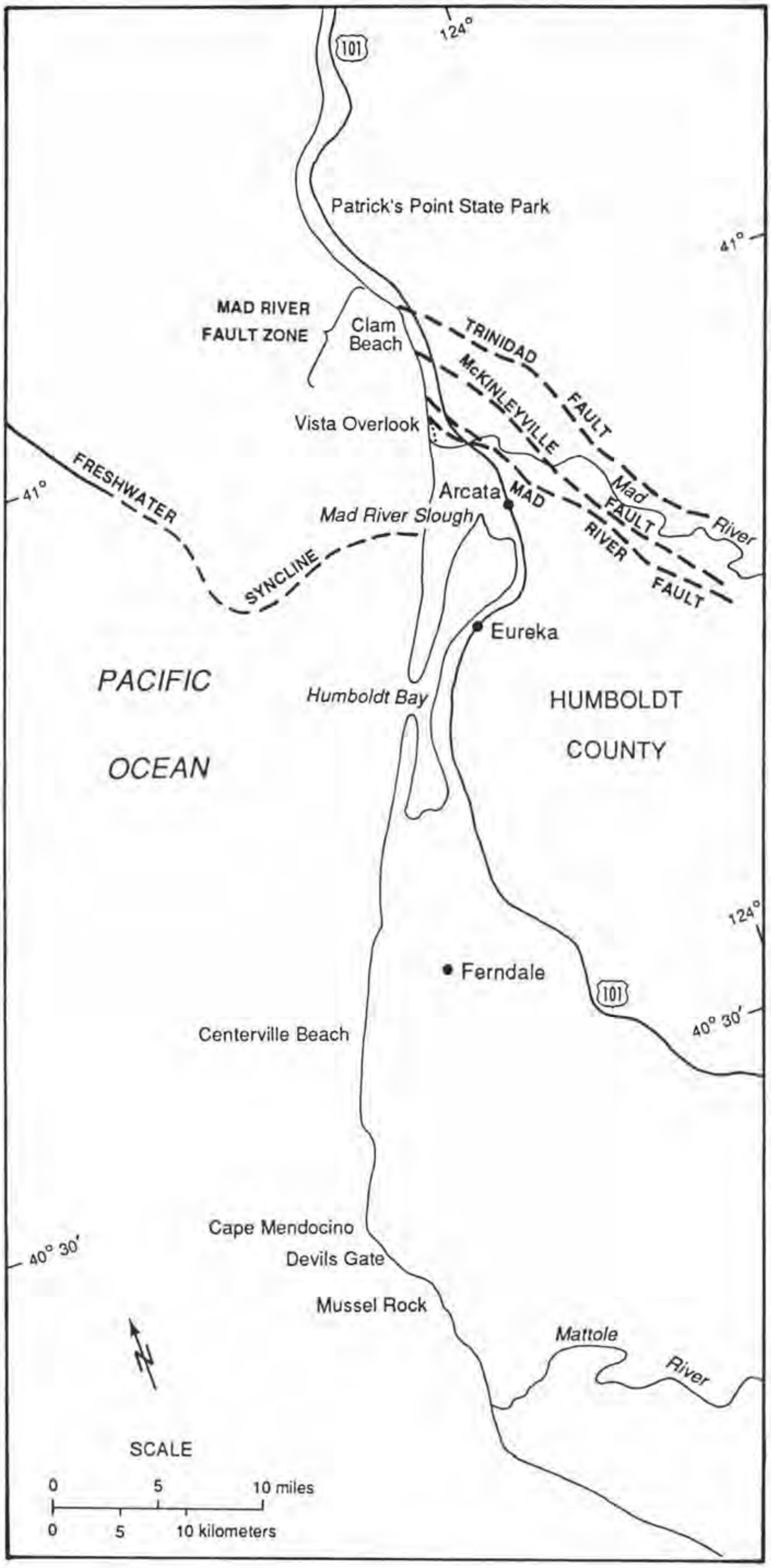

Figure 2. Map of the north coast of California and sites visited during the field trip. Fault zones are shown schematically (dashed lines) as primary active traces. The current position of the migrating channel of the Mad River is indicated by the dotted line just north of its mouth.

tion Zone. The data suggest that slip actually occurred along the boundary between the subducting and overiding plates, rather than being absorbed along faults within the upper (or lower) plate. This would support the argument that the plates are indeed locked during the time between earthquakes and not sliding past each other aseismically. However, the precise location of the earthquakes' epicenters is difficult to determine, and each may, instead, have occurred on any one of the numerous northeast-dipping thrust faults in the area.

The stretch of coastline that experienced maximum uplift during the most recent earthquakes lies between Devils Gate and Mussel Rock, north of the Mattole River (Fig. 2). This stretch of beach offered an opportunity to view the active processes that formed the buried dunes and soils we saw near

Figure 3. View west from a vista overlook on Highway 101, overlooking the mouth of the Mad River. Note the riprap along the north side (right bank) of the river. Since 1989, the river has migrated from a position just south (left) of the area shown in the photo.

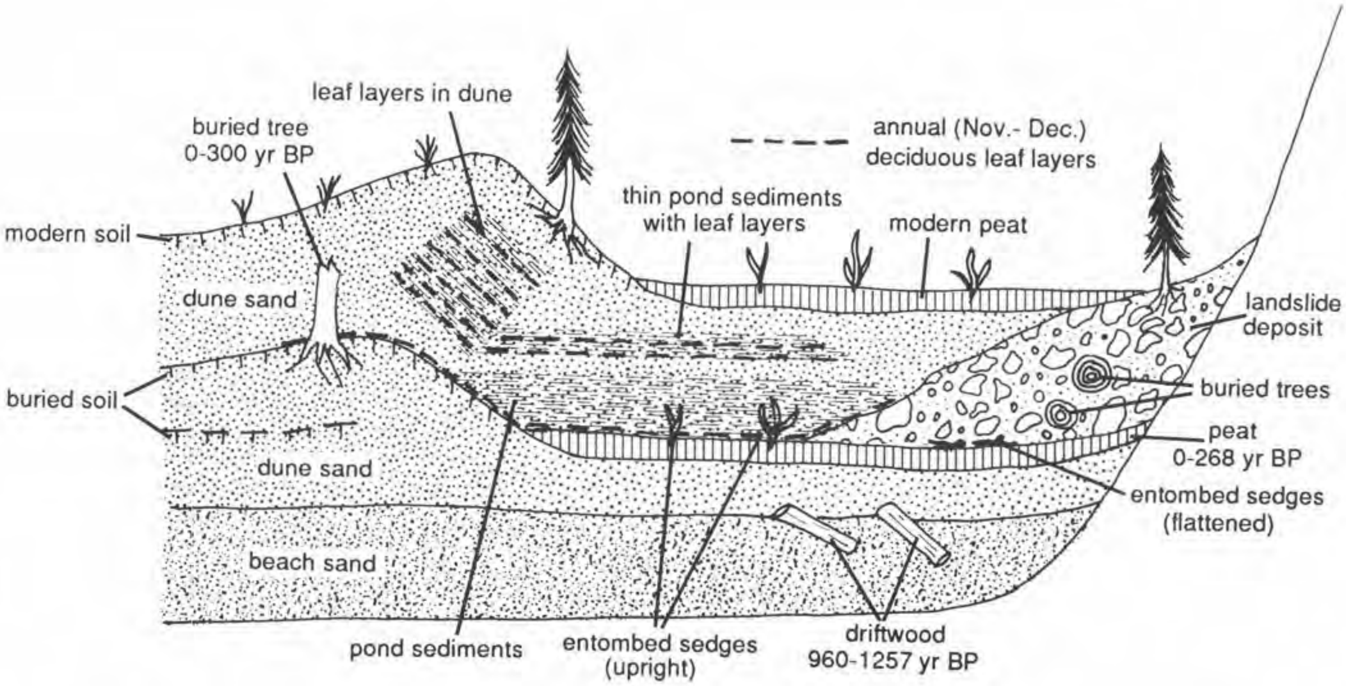

Figure 4. Diagrammatic cross section of cover sediments on the Clam Beach terrace at the mouth of the Mad River in northern California. Uplift events renewed sedimentation above the buried soils and beach sand. Modified from Burke and Carver, 1992, fig. 2, p. 10.

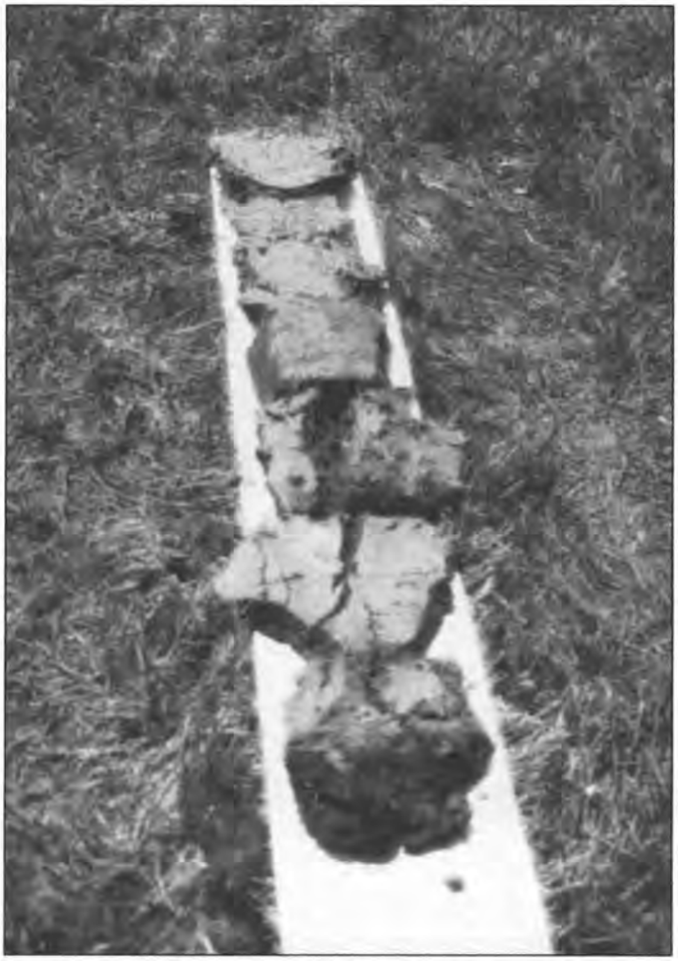

Figure 5a. Estuarine muds interbedded with marsh peats from the Mad River Slough, northern Humboldt Bay. Length of section approximately 2 m.

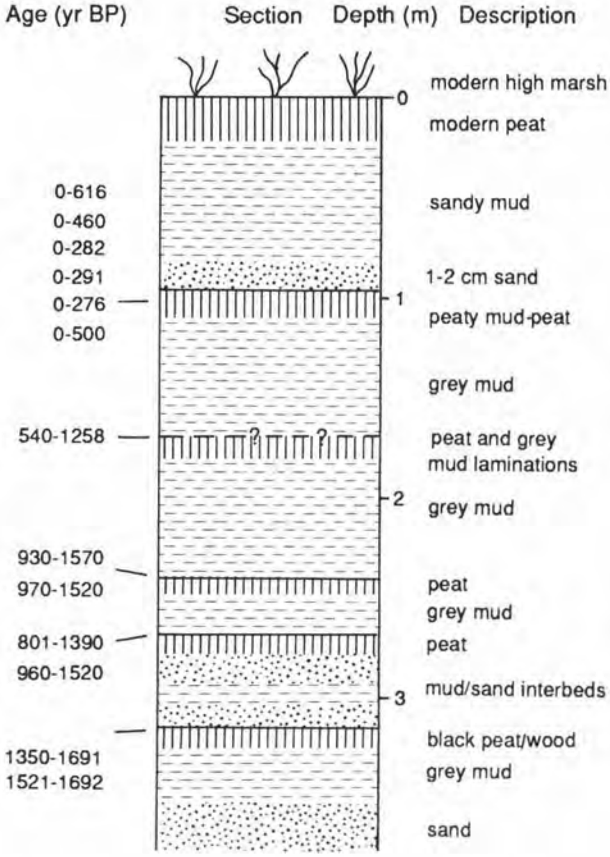

Figure 5b. Composite stratigraphic column for sediments of the Mad River Slough with ^{14}C dates for buried salt-marsh peats. Modified from Burke and Carver, 1992, fig. 6, p. 14.

Figure 6. A walk along the bluffs of Centerville Beach south of Ferndale revealed numerous landslides, soil slumps, and rockfalls. Here the bluff (about 60 ft tall) of sands and clays failed onto the beach where much of the material was subsequently removed by waves.

the mouth of the Mad River. A strong northwest wind was blowing during our visit to the beach site. Coarse sand from the recently exposed swash zone was being transported landward and deposited on top of the pre-existing finer beach sands (Fig. 8). This created the unusual grain-size contrast seen in the photograph.

As previously mentioned, further evidence of the most recent uplift is visible in one of the cover photos and Figure 9. The seaweed in these photographs was killed when it was lifted out of the tidal zone; it has since turned white. The high-tide line (visible in the photos) is now about 1 m lower, relative to the rocks, than its pre-earthquake position. Dead sea urchins, possibly shaken loose from their perches and washed up in a subsequent tsunami or other wave surge, litter the beach at the edge of the waves (Fig. 10). Dead mussel beds have also been recorded in the area.

A final series of stops related the fluvial terraces along the Mattole River to the re-

Figure 7. Many houses in Ferndale, CA, sustained severe damage from the earthquakes of April 1992. This house was one of many that lost chimneys. The house in the cover photo was knocked from its foundation.

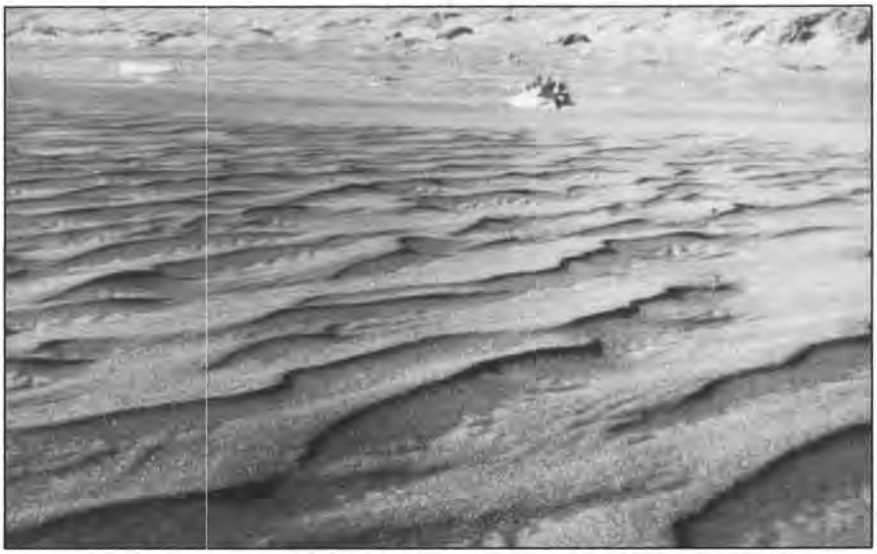

Figure 8. Recently exposed (uplifted) coarse swash zone sands forming ripples (7–10 cm, trough to crest) over pre-existing fine to medium beach sands near Mussel Rock, CA.

Figure 9. Evidence for uplifted coastline near Mussel Rock, CA. The line between dark (live) and bleached (dead) seaweed represents the post-earthquake high tide limit. The bleached seaweed has been raised above of the tidal zone by tectonic uplift.

gion's tectonic activity. Here, Dorothy Merritts, of Franklin and Marshall College in Lancaster, PA, discussed a proposed new model for the intricate relation that exists between stream gradient and tectonically and climatically induced base-level changes occurring in the mouths of coastal rivers. Some of the questions addressed by the model of Merritts and others (1992) include: How are strath terraces, which are cut into bedrock, formed and abandoned? Can terrace remnants be correlated along a river's longitudinal profile? and How far upstream are the effects of base-level changes transmitted?

Basing their model on the results of extensive detailed surveys of channels, bars, floodplains, and terraces of three large rivers near the Mendocino Triple Junction, they concluded that, in contrast to classical fluvial response models, it is incorrect to assume that (1) fluvial terraces merge with marine terraces, (2) strath surfaces form at times of sea-level highstand, and (3) abandonment due to vertical incision must occur during times of falling base level. In general, the model of Merritts and others proposes that the size and power of the river, and consequently the valley width, control the formation and preservation (or lack thereof) of strath and fill terraces.

In the photo in Figure 11, we are in the active river channel looking up at an incised terrace surface dated at approximately 12,000 years. D. S. Merritts used a diagram to illustrate incorrect terrace correlations of previous models compared to the proposed model correlations. The FOP field guide (Burke and Carver, 1992) includes an in-depth discussion of fluvial response to tectonism written by Merritts and others.

For a more detailed discussion of the recent earthquakes in northern California and of the sources of seismicity in that area, see *California Geology* (March/April 1992) and several articles in Burke and Carver (1992).

Although most current studies in Washington focus on evidence for coseismic subsidence (Atwater, 1987; Atwater and Yamaguchi, 1991), areas of coastal uplift are also documented (Shipman, 1990). Viewing first hand the consequences of coseismic uplift, subsidence, and ground shaking in northern California will help Washington geologists interpret the local stratigraphic record and more effectively evaluate and mitigate potential earthquake hazards in the Pacific Northwest.

Figure 10. Dead sea urchins washed ashore near Mussel Rock, CA, following the April 1992 earthquakes.

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Figure 11. Dorothy Merritts, of Franklin and Marshall College in Lancaster, PA, explains a proposed model for fluvial response to tectonic and eustatic sea level changes. The group is gathered on deposits of the active channel and is looking up and toward the south at the approximately 12,000-year-old strath terrace on the horizon.

The Role of the Washington Division of Geology and Earth Resources Library—the 1990s and Beyond

by Connie J. Manson

The library of the Washington Division of Geology and Earth Resources (DGER) is essential to meeting the Division's goals of providing public information, cooperating with other organizations, and performing research. The library staff also deals with the budget, space, preservation, and other issues facing all geoscience libraries in the 1990s, while looking beyond to the future.

Geology is a literature-intensive discipline. Geologists need to know about current research, but they also need access to older materials because most geologic work is cumulative. Geologic reports are issued by different groups in various formats, and some (like theses) have very limited availability. An effective geologic library acquires the new materials, keeps the old, and aggressively tracks down the elusive items.

The Washington state geological survey has existed continuously, under several different names, since 1901. When the Division of Mines and Mining was created in 1935, an important step was taken—the formal establishment of a division library. The library's mandate, as stated in the Revised Code of Washington (Chapter 43.21.070), was to "...collect and assemble a library pertaining to mining, milling and metallurgy of books, reports, drawings, tracings and maps and other information relating to the mineral industry and the arts and sciences of mining and metallurgy" and to "...preserve and maintain such collections and library open to the public for reference and examination..." As with other mandates of our predecessor agencies, the requirement to have a library collection of literature on these subjects, open to the public, has been carried forward to the Division of Geology and Earth Resources.

In order to fulfill these mandates for the DGER library, we try to have copies of *all* reports about the geology or mineral resources of Washington, from every source. The completeness of our library collection makes it a significant resource for all user groups—the public, researchers, consultants, and other agency personnel, as well as DGER staff.

But the DGER library is not unique. Libraries are common assets of state geological surveys. Our neighboring state surveys, the California Division of Mines and Geology, the Oregon Department of Geology and Mineral Industries, and the Idaho Geological Survey, have libraries similar to ours. In contrast, the Montana Bureau of Mines and Geology has its offices on the campus of the Montana College of Mineral Science and Technology and, like other state surveys affiliated with universities, primarily relies on the university library for research materials. These and the other state survey libraries around the country are very similar: they intend to have strong collections of the reports about the geology and mineral resources of their state, and they are open to the public for on-site use. [For a description of state survey libraries, see the *Directory of Geoscience Libraries, United States and Canada*, 4th edition, currently in press by the Geoscience Information Society.]

The information explosion in all the sciences has hit our library, too. The number of citations about Washington appears to be increasing by about 60 percent per decade. At this rate, there will be as many citations about Washington from 1991 through 2000 as there were from 1891 through 1975 (Fig. 1).

Literature about Washington geology falls into three distinct categories:

- monographs (whole works that stand alone), such as books, theses, and separately published maps;
- papers, published in journals, proceedings volumes, or other compilations; and
- abstracts, dominated by the abstracts of papers presented at professional conferences.

The percentages of the total of all Washington citations for these categories for the last 100 years are shown in Figure 2. Some interesting characteristics can be seen in these data:

- State agency monographs (such as DGER publications) constitute only 5 percent of all items about Washington geology, so if users check only our publications list for materials, they will miss about 95 percent of the literature. Even if they search lists of U.S. Geological Survey monographs, they still miss about 85 percent.
- Theses make up 8 percent of the total. They are difficult to find and to obtain. However, they are significant contributions, especially as sources for geologic mapping: 38 percent of all original geologic maps of Washington are

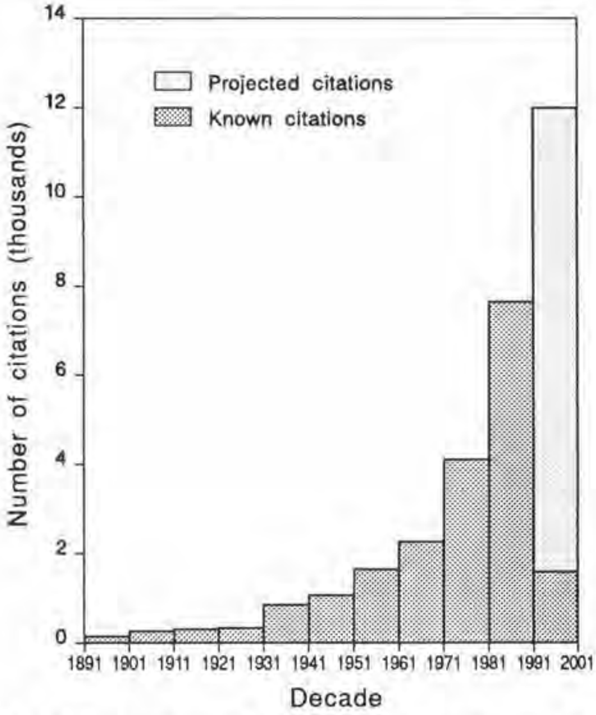

Figure 1. Number of citations about the geology or mineral resources of Washington State, by decade, 1891–1990 and projected to 2000.

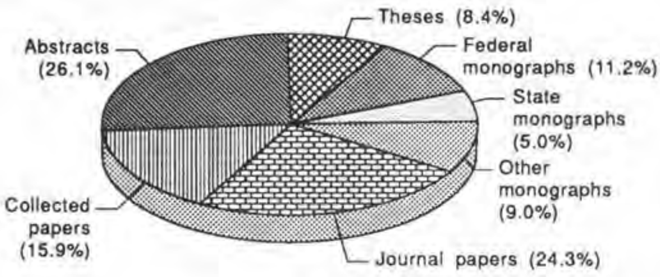

Figure 2. Percentages of items about the geology or mineral resources of Washington State, by category, 1891–1990.

in theses, and theses made up 24 percent of the references cited in the southwest (Walsh and others, 1987) and northeast (Stoffel and others, 1991) quadrants of the state geologic map (Manson, 1992).

- Papers, especially those published in professional journals, have high prestige among geoscientists (Bichteler and Ward, 1989) and are normally relatively easy to obtain.
- Abstracts were 26 percent of all citations about Washington for the last hundred years. This is the fastest growing category: they were about 33 percent of all Washington citations from 1986 through 1990. Abstracts, most commonly a description of a paper given at a professional conference, are not ephemeral. Although their citation rate is low (only about 5 percent of the citations on the two state maps were to abstracts), they *are* cited. Abstracts are commonly reports of work in progress, and most abstracts are related, ultimately, to a larger work (a paper or monograph), so they are important links in tracking the progress of a research project.

Geologists rely on all these categories for source materials, but library card catalogs, whether electronic or paper, are only indices to the monographs—only one-third of the total. Furthermore, most of these geologic monographs are theses, state or federal agency reports, or maps, which many large, traditional libraries consider "gray literature". The result is that many libraries delay cataloging them, or they are not cataloged at all (Bichteler, 1991). Citations to individual papers and abstracts are not included in library card catalogs. Only comprehensive databases, like the American Geological Institute's *GeoRef* or DGER's PC-based bibliographic database (and the print products from it, such as Manson, 1990) intentionally include all three types and so provide access to all of these geologic reports. [For a more thorough discussion of these issues, see Manson, 1992.]

In geology, publication date is not a primary indicator of relevance. Old reports, even those published in the 1890s, are still being used. I compared the dates of the 602 references cited in the two state quadrant geologic maps (Walsh and others, 1987; Stoffel and others, 1991) to the number of all reports about Washington, by date, to find the citation rate (Fig. 3). Although, overall, the newer materials are cited more heavily than the older, the older literature is still cited and still being used. For this example, more than 3 percent of the reports about Washington geology issued from 1916 through 1920 were cited in these maps. The maximum use rate was about 5 percent, for the items issued from 1961 through 1970. Clearly, the older materials are still valid. Therefore, in the DGER library, we add the new reports and we keep all the old ones.

Because we keep the older materials, we are concerned with conserving the paper copies or preserving that information in some other medium. Many of the older materials, especially the old federal documents, were printed on highly acidic paper and are rapidly deteriorating. Deacidification would conserve the materials, but its high per-item cost makes it impractical. We recently did archival-level conservation on two sets of the USGS folios about Washington. The eight volumes were taken apart, each of the 90 pages was deacidified and encapsulated, and the volumes reassembled. Those volumes will be usable and their information fully available for hundreds of years, but at an average cost of $48.00 in materials and 12 hours of staff time per volume. Only materials as important as the USGS folios justify that level of investment.

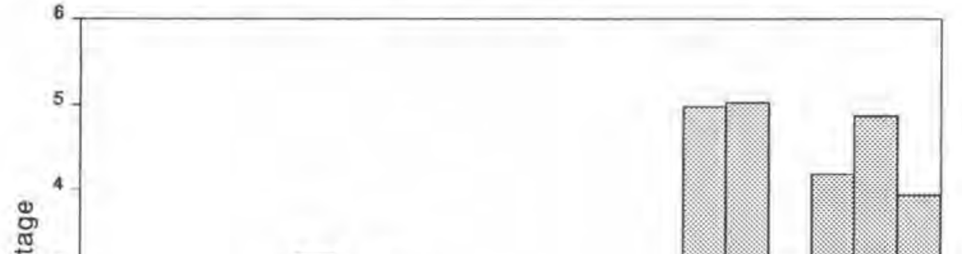

Figure 3. References cited in two geologic maps of Washington (DGER GM-34, -39) by date, as a percentage of all materials on Washington, by date. Total number of references cited = 602.

But what about the rest of the older materials? Procedures such as microfilming, which work well to duplicate materials in other disciplines, have been disappointing for geology. We need high-definition photographs—only the highest quality cameras and film can adequately duplicate the photographs of thin sections, minerals, or fossil specimens. Oversize, colored geologic maps pose additional problems. Electronic preservation, perhaps by scanning onto CD-ROM, is a possibility, or perhaps the newly developed archival-quality, high-definition color microfilm is the answer. These issues are of high concern to geoscience librarians. The Joint Task Force on Text and Image, funded by the Getty Foundation, has been studying these problems (Klimley, 1992), and the Geoscience Information Society's 1992 annual symposium, Preserving Geoscience Imagery, addressed some of these issues.

Another continuing concern for all geology libraries is the recent rapid increase in the cost of many geoscience books and journals. What choices do libraries have when their journal budgets stay the same or decrease, while journal prices increase by 5 or 10 or 15 percent per year? We either find more money or cancel journal titles. Because of our budget limitations this year, the DGER library cancelled over $2600 worth of journals, including *Geochimica et Cosmochimica Acta, Geobyte, Powder Diffraction,* and *Quaternary International*.

The DGER library collection has grown apace with the rapid growth of materials on Washington. From 1980 through 1990, the number of volumes in the DGER library increased by more than 50 percent. The library was near maximum physical capacity at its Lacey location. We have only about 20 percent more space in the Natural Resources Building in Olympia. At the current rate of expansion, we expect to have completely filled our shelves within a few years.

While dealing with present problems, we are also looking to future possibilities. New technologies have brought tremendous changes to libraries in recent years. We will continue to use the known technology while we investigate the new. We will keep using the commercially available CD-ROM indices, and we hope, eventually, to computerize our card catalog, issue the entire bibliography of Washington geology on CD-ROM, and produce our indices to geologic mapping through digital cartography. We are also exploring ways to reach out to our user groups through shared databases and networks.

Meeting the challenges of acquisition, space, and availability will require careful planning and use of funds. Success is critical, both to our own researchers and to the many other people who need full and ready access to the literature about Washington geology.

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The Washington Division of Geology and Earth Resources library has moved into its new quarters, Room 173, across from the Division office on the first floor of the Natural Resources Building.

Progress Report on the State Geologic Map

by J. Eric Schuster

I last reported on the status of the state geologic map in the December 1990 issue of this newsletter (Schuster, 1990). Since then there has been much progress.

The northeast quadrant of the new state geologic map was printed in June 1991 (Stoffel and others, 1991).

Two page-size geologic maps of Washington have grown out of the state geologic map program. The July/August 1991 issue of *Rocks and Minerals* includes a black and white version as a figure (Lasmanis, 1991), and the Division published a colored version in February 1992 (Schuster, 1992).

Meanwhile, preparation of 1:100,000-scale geologic maps for the southeast quadrant of the state has been moving forward. Maps have been compiled for all but the Yakima (east ½) and Hermiston quadrangles, and draft text materials have been prepared for several of the quadrangles. The 1:100,000-scale open-file reports should be ready for distribution by spring or summer 1993. The Wenatchee quadrangle, for which a published 1:100,000-scale geologic map already exists (Tabor and others, 1982b), will not be re-compiled but rather "translated" into the Division's system for representing the geologic units and augmented with more recent geologic data. Table 1 shows compilation assignments.

Cartographic work on the 1:250,000-scale topographic base map for the southeast quadrant has recently been completed. We hope to have the 1:250,000-scale full-color geologic map for the southeast quadrant ready for printing by late calendar 1993 or early 1994.

Work continues on the northwest quadrant. Division geologists are well along on initial compilations of geologic maps for several of the 1:100,000-scale quadrangles. Table 2 shows northwest quadrant compilation assignments. If recent 1:100,000-scale geologic maps already exist (Table 2), these quadrangles will not be re-compiled but rather "translated" and updated.

We hope to release the 1:250,000-scale northwest quadrant geologic map in calendar 1995.

Even though we continue to make progress, the state geologic map program has not been without problems. Budget cuts have affected the program in at least three ways. First, mandated cuts in printing and travel budgets have reduced the amount of field work and eliminated funds that had been earmarked for printing the southeast quadrant geologic map. We are currently seeking printing money. Second, cuts in salaries and benefits have made it necessary for Division geologists to spend considerable time on grants and contracts instead of on the state geologic map program. The good news in this is that some of the grants and contracts are supporting activities that are either compatible with the state geologic map program or actually contribute to it. Third, we have been forced to suspend support for student and faculty mappers. The last projects supported were those in fiscal year 1992. For fiscal years 1985 through 1992 the Division supported 75 student and faculty mapping projects with a total of $127,175. We

Table 1. Compilation assignments for the southeast quadrant of the state geologic map. The southeast quarter of the Wenatchee quadrangle (Tabor and others, 1982b) will be "translated" into the Division's system for representing the geologic units and augmented with more recent geologic data; the other 1:100,000-scale quadrangles referenced below were previously released by the Division. For quadrangles that extend into Idaho or Oregon, only the Washington portions are being compiled

1:100,000-scale quadrangle	**Compiler(s)**
Clarkston and Orofino	Eric Schuster
Connell	Chuck Gulick
Goldendale (east ½)	Eric Schuster
Hermiston	Eric Schuster
Moses Lake (south ½) (Gulick, 1990a)	Chuck Gulick
Priest Rapids	Steve Reidel and Karl Fecht
Pullman	Chuck Gulick
Richland	Steve Reidel and Karl Fecht
Ritzville (south ½) (Gulick, 1990b)	Chuck Gulick
Rosalia (south ½) (Waggoner, 1990)	Stephanie Waggoner
Toppenish (east ½)	Eric Schuster
Walla Walla	Eric Schuster
Wenatchee (southeast ¼) (Tabor and others, 1982b)	Eric Schuster
Yakima (east ½)	Eric Schuster

Table 2. Compilation assignments for the northwest quadrant of the state geologic map. References are to published 1:100,000-scale quadrangles; these will be "translated" into the Division's system for representing the geologic units and updated with more recent geologic data. Tabor and Cady (1978) is an important source of geologic map data for all or parts of the Cape Flattery, Forks, Mount Olympus, Port Angeles, Port Townsend, and Shelton 1:100,000-scale quadrangles

1:100,000-scale quadrangle	**Compiler**
Bellingham	Pat Pringle
Cape Flattery	Hank Schasse
Chelan (west ½) (Tabor and others, 1987)	Joe Dragovich
Copalis Beach (north ½)	Josh Logan
Forks	Wendy Gerstel
Mount Baker	Dave Norman
Mount Olympus	Wendy Gerstel
Port Angeles	Hank Schasse
Port Townsend (Pessl and others, 1989)	Hank Schasse
Robinson Mountain (west ½) (Stoffel and McGroder, 1990)	Joe Dragovich
Roche Harbor	Josh Logan
Sauk River (Tabor and others, 1988)	Hank Schasse
Seattle (Yount and Gower, 1991)	Tim Walsh
Shelton (north ½)	Josh Logan
Skykomish River (Tabor and others, 1982a)	Venice Goetz
Snoqualmie Pass (north ½) (Frizzell and others, 1984)	Venice Goetz
Tacoma (north ½)	Tim Walsh
Twisp (west ½)	Joe Dragovich
Wenatchee (northwest ¼) (Tabor and others, 1982b)	Tim Walsh

hope to resume support for university mappers in the future, because the program encouraged much-needed geologic mapping and fostered closer working relations between Division and university geologists.

Another recent development will probably have a significant effect on the state geologic map program. In May the National Geologic Mapping Act of 1992 was signed into law (Lasmanis, 1992), and Congress has appropriated funds sufficient to provide an average of approximately $26,000 per state to support geologic mapping in federal fiscal year 1993. With the passage of this act the U.S. Geological Survey has discontinued its COGEOMAP (CO-operative GEOlogic MAPping) program. This program had supported geologic mapping by Rowland Tabor and Ralph Haugerud in the north Cascades for several years—mapping that the Division needs in order to complete the northwest quadrant of the new state geologic map. While we are pleased that federal funds to support state geologic mapping are going to become available, we are concerned that current U.S. Geological Survey mapping in our state remain adequately funded.

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Did You Know . . .

What Is the Value of Nonfuel Minerals?

The U.S. Bureau of Mines valued processed materials made in the United States from nonfuel mineral raw materials at $297 billion in 1991. U.S. mining of raw nonfuel minerals such as iron ore and stone totalled $31 billion, with recycled scrap materials adding $14 billion. Subsequent processing to form iron, steel, and cement resulted in domestic nonfuel mineral products totalling $297 billion. Present in every aspect of our lives, minerals and mineral-based materials are the life-blood of our industrialized economy.

From the Bulletin of the
Northwest Mining Association,
no. 7, October 1992

How Many Minerals Go into Your Computer?

It takes more than 33 elements and minerals to make a computer! Those vital computer ingredients are: aluminum, antimony, barite, beryllium, cobalt, columbium, copper, gallium, germanium, gold, indium, iron, lanthanides, lithium, manganese, mercury, mica, quartz crystals, rhenium, selenium, silver, strontium, tantalum, tellurium, tin, tungsten, vanadium, yttrium, zinc, and zirconium, And we can't forget the petroleum industry's role in the computer—many of the components noted above are housed in plastic!

From the Bulletin of the
Northwest Mining Association,
Fall 1991

New Language Relating to Holding Fees for Unpatented Claims, H.R. 5503, 1993 Appropriations for the U.S. Department of the Interior

Note: The following is an excerpt from the bill.

Provided further, That notwithstanding any other provision of law and effective upon the date of enactment of this Act, for the fiscal year 1993, for each unpatented mining claim, mill or tunnel site on federally owned lands, in lieu of the assessment work requirements contained in the Mining Law of 1872 (30 U. S. C. 28-28e), and filing requirements contained in section 314(a) and (c) of the Federal Land Policy and Management Act of 1976 (FLPMA)(43 U. S. C. 1744(a) and(c)), each claimant shall, except as provided otherwise by this Act, pay a claim rental fee of $100.00 to the Secretary of the Interior or his designee on or before August 31, 1993 in order for the claimant to hold such unpatented mining claim, mill or tunnel site for the assessment year ending at noon on September 1, 1993;

Provided further, That for the fiscal year 1993, each claimant - (i) that is producing under a valid notice or plan of operation not less than $1,500 and not more than $800,000 in gross revenues per year as certified by the claimant from 10 or fewer claims; or - (ii) that is performing exploration work to disclose, expose, or otherwise make known possible valuable mineralization on 10 or fewer claims under a valid notice or plan of operation; and that has less than 10 acres of unreclaimed surface disturbance from such mining activity or such exploration work, may elect to either pay the claim rental fee for such year or in lieu thereof do assessment work required by the Mining Law of 1872 (30 U. S. C. 28-28e), and meet the filing requirements of contained in sections 314(a) and (c) of FLPMA (43 U. S. C. 1744(a) and (c)) on such 10 or fewer claims and certify the performance of such assessment work to the Secretary by August 31, 1993;

Provided further, That for fiscal year 1994, for each unpatented claim, mill or tunnel site on federally owned lands, in lieu of the assessment work requirements contained in the Mining Law of 1872 (30 U. S. C. 28-28e), and the filing requirements of FLPMA (43 U. S. C. 1744(a) and (c)), each claimant shall, except as provided otherwise by this Act, pay a claim rental fee of $100.00 per claim to the Secretary of the Interior or his designee on or before August 31, 1993 in order for the claimant to hold such unpatented mining claim, mill or tunnel site for the following assessment year beginning at noon on September 1.

Provided further, That in the fiscal year 1994 each claimant - (i) that is producing under a valid notice or plan of operation not less than $1,500 and not more than $800,000 in gross revenues per year as certified by the claimant from 10 or fewer claims; - (ii) that is performing exploration work to disclose, expose, or otherwise make known possible valuable mineralization on 10 or fewer claims under a valid notice or plan of operation; and that has less than 10 acres of unreclaimed surface disturbance from such mining activity or such exploration work, may elect to either pay the claim rental fee for such year or in lieu thereof do assessment work required by the Mining Law of 1872 (30 U. S. C. 28-28e), and meet the filing requirements of FLPMA (43 U. S. C. 1744(a) and (c)) on such 10 or fewer claims and certify the performance of such assessment work to the Secretary by August 31, 1993;

Provided further, That for every unpatented mining claim, mill or tunnel site located after the date of enactment of this Act through September 30, 1994, the locator shall pay $100.00 to the Secretary of the Interior or his designee at the time the location notice is recorded with the Bureau of Land Management to hold such claim for the year in which the location was made;

Provided further, That the co-ownership provisions of the Mining Law of 1872 (30 U. S. C. 28-28e) will remain in effect except that the annual claim rental fee, where applicable, shall replace applicable assessment requirements and expenditures through fiscal year 1994;

Provided further, That failure to make the annual payment of the claim rental fee as required by this Act shall conclusively constitute an abandonment of the unpatented mining claim, mill or tunnel site by the claimant;

Provided further, That nothing in the Act shall change or modify the requirements of section 314(b) of FLPMA (43 U. S. C. 1744(b)) or the requirements of section 314(c) of FLPMA (43 U. S. C. 1744(c)) related to filing required by section 314(b), which shall remain in effect;

Provided further, That the Secretary of the Interior shall promulgate rules and regulations to carry out the purposes of this section as soon as practicable after the effective date of this Act;

Provided further, That for the purposes of determining eligibility for the exemption from the claim rental fee required by this Act, any claims held by a husband and wife, either jointly or individually, or their children under age of discretion, shall be counted together toward the ten claim limit;

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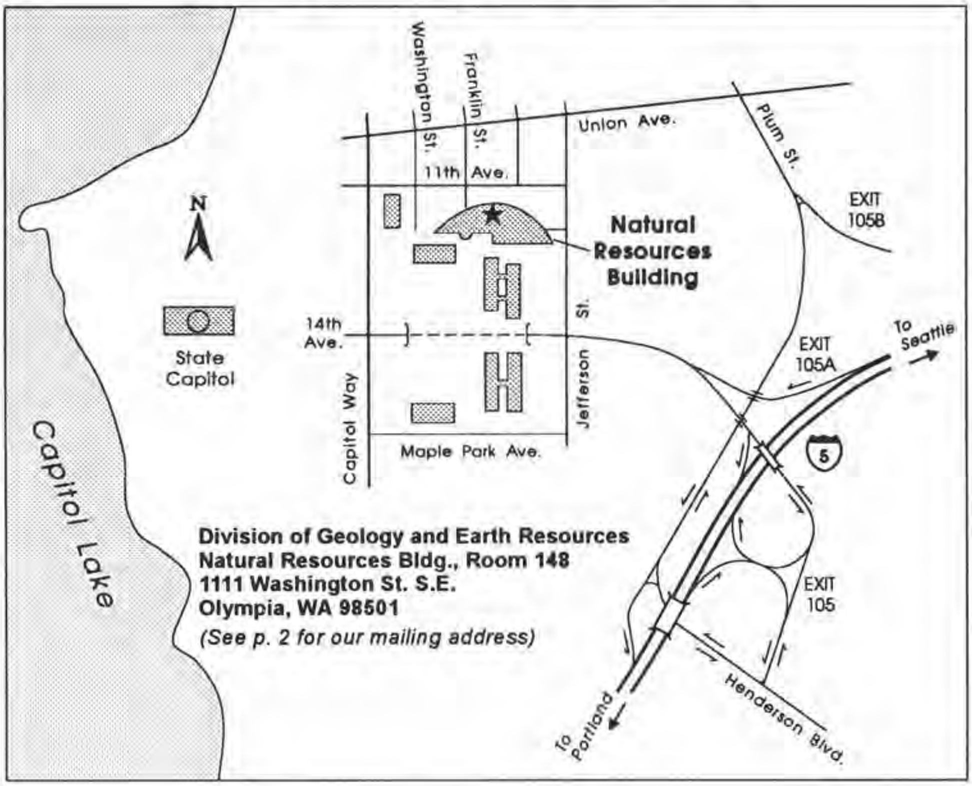

Division of Geology and Earth Resources
Natural Resources Bldg., Room 148
1111 Washington St. S.E.
Olympia, WA 98501
(See p. 2 for our mailing address)

New Division Releases

Directory of Washington mining operations, 1992, Information Circular 87, by William S. Lingley, Jr., and Connie J. Manson. A 76-page report featuring indexes of Washington mining operations by operator, by county, and by commodity and a discussion of 1991 mineral production and mining activities, particularly sand and gravel, in Washington. $2.30 + .20 (tax) = $2.50.

Geologic map of southeastern Asotin County, Washington, Geologic Map 40, by Stephen P. Reidel, Peter R. Hooper, Gary D. Webster, and Victor E. Camp. This map comprises the Anatone, Weissenfels Ridge, Fields Spring, Black Butte, Captain John Rapids, and Limekiln Rapids 7½-minute quadrangles, plus a narrow strip at the north end of the Jim Creek Butte 7½-minute quadrangle in Washington. Includes a table of major element analyses of basalts from southeastern Asotin County. The text accompanies one oversize 1:48,000-scale geologic map, a cross section, and a correlation chart. 22 pages, 1 plate. $.93 + .07 (tax) = $1.00.

Call for Papers

Canadian Dam Safety Association
5th Annual Conference
St. John's, Newfoundland, Canada
September 19–23, 1993

Authors are invited to submit abstracts (up to 1,000 words) of papers relating to the theme of the conference, which is dam safety practices and procedures. Papers on such topics as regulation and legislation; standards, guidelines, and criteria; dam safety review; O & M; technical issues; and case histories are welcome. New ideas and concepts are especially encouraged. Deadline for abstracts: January 31, 1993. Contact: R. D. Barnes; Newfoundland and Labrador Hydro; P.O. Box 12400; St. John's, Newfoundland, A1B 4K7, Canada.
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