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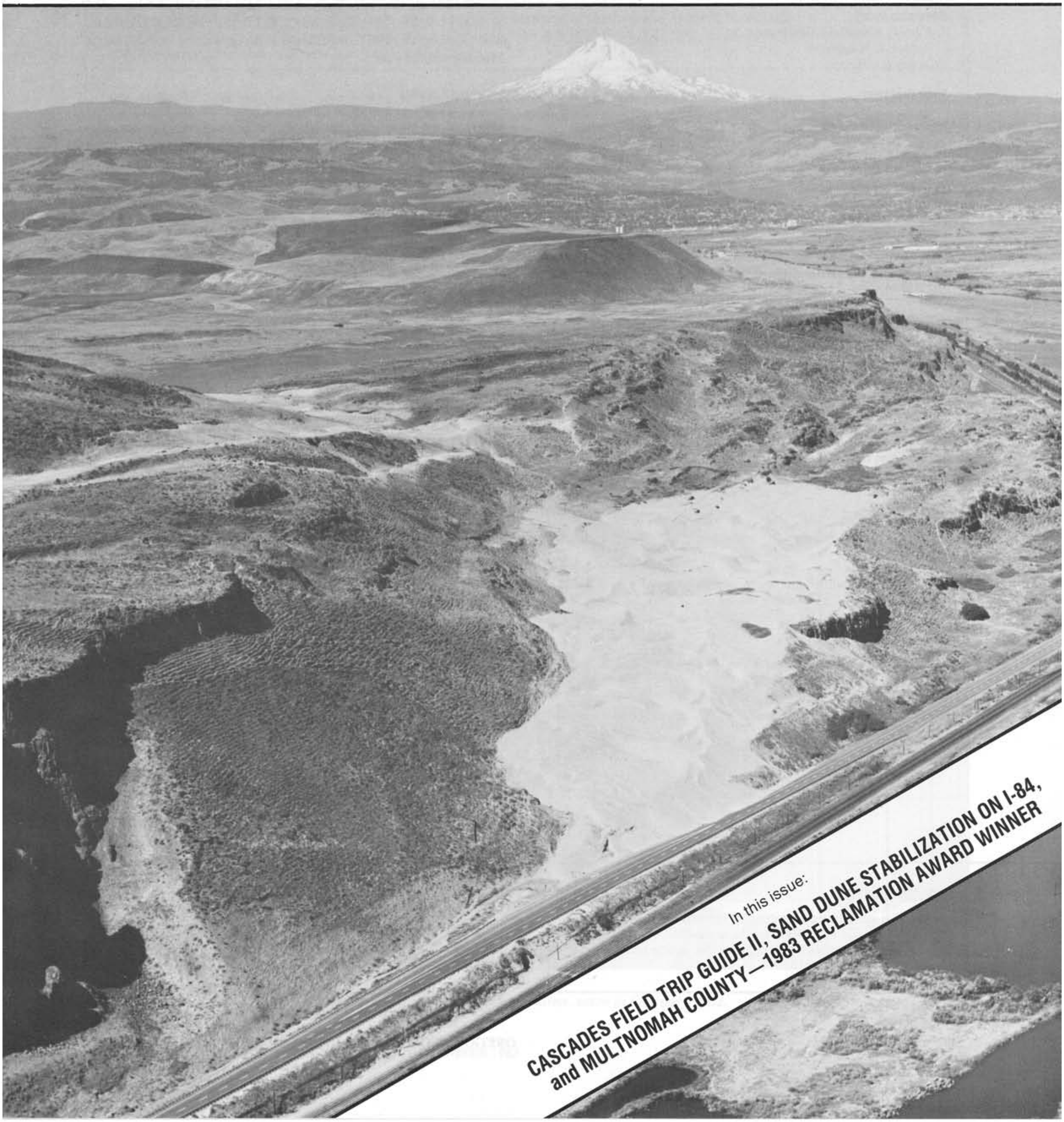

In this issue:

CASCADES FIELD TRIP GUIDE II, SAND DUNE STABILIZATION ON I-84, and MULTNOMAH COUNTY—1983 RECLAMATION AWARD WINNER

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COVER PHOTO

Active sand dune encroaching on Interstate Highway 84. This mid-1981 view is from northeast to southwest; The Dalles and Mount Hood are visible in background. See article on recent stabilization efforts on page 131.

OIL AND GAS NEWS

Clackamas County

RH Exploration, Rose 1, located in sec. 20, T. 5 S., R. 1 E., was abandoned as a dry hole on October 24, 1983. RH has given no indication that it plans to drill Rose 2, permit 242.

Mist Gas Field

Reichhold Energy Corporation has drilled and suspended Wilson 11-5. The total depth was 2,827 ft, and the suspension date was October 14, 1983. Additional drilling will be carried out at Mist later in the year.

Douglas County

Drilling has begun in Douglas County on the Hutchins and Marrs Glory Hole 1 in sec. 10, T. 27 S., R. 7 W. The operator spudded the well on October 28, 1983, with a proposed total depth of 4,500 ft and has plans for four additional wells in the immediate area.

Lane County

Leavitt Exploration and Drilling is preparing to spud its Maurice Brooks 1 well in sec. 34, T. 19 S., R. 3 W. The well has a proposed total depth of 3,000 ft.

Recent permits

Permit no.	Operator, well API number	Location	Status, proposed total depth (ft)
253	Reichhold Energy Corp. Adams 32-34 009-00122	NE¼ sec. 34 T. 7 N., R. 5 W. Columbia County	Application; 2,800

□

GSOC luncheon meetings announced

The **Geological Society of the Oregon Country** (GSOC) holds noon meetings in the Standard Plaza Building, 1100 SW Sixth Ave., Portland, OR, in Room A adjacent to the third-floor cafeteria. Upcoming meetings, topics, and speakers:

December 16–*The German Village Passion Play, Oberammergau*, by Robert L. and Louise Gamer.

January 6–*The Geology of the Lake Oswego and West Lynn Area*, by Donald D. Barr, past president of GSOC.

January 20–*Antiques* (Bring one for identification!), by Harvey Steele, import specialist for U.S. Customs.

February 3–*Xian to Hong Kong and Home (Part II)*, by Frank Dennis, railroad engineer inspector, retired.

February 17–*Yellow Knife and the Canadian Shield*, by Phyllis Bonebrake, member GSOC.

March 2–*Geology of the Owyhee*, by Donald D. Barr, past president of GSOC.

March 16–*Indian Ruins of the Southwest*, by Lloyd A. Wilcox, past president of GSOC, active member of the Archaeologic Society, participant in dig at the Calico Man site.

For additional information, contact Viola L. Oberson, Luncheon Program Chairwoman, phone (503) 282-3685. □

CONTENTS

Stabilization of the I-84 sand dune

Many of our readers will have heard of the active sand dune encroaching on Interstate Highway 84 along the Columbia River, just east of The Dalles, Oregon. Some may have experienced directly the hazard the blowing sand can pose to highway traffic. So far, only the tip of the wandering dune has reached the highway, while the main body of sand is still upwind, waiting to be blown toward the river. The State Highway Department has estimated that by the year 1995 the annual cost of removing the sand from the highway will be $100,000.

The following article describes attempts to avert this threat by stabilizing the dune. In the latest, recently completed effort, the final decisions were based in part on consultation with the Oregon Department of Geology and Mineral Industries.

The article is reprinted here with permission from Pacific Builder & Engineer, *July 4, 1983, p. 18–19, where it appeared under the title "Migrating Sand Dune Taking Over Interstate 84." (ed.)*

Wind-blown sand originating from a 50-acre sand dune is encroaching upon the travel lanes of Interstate 84 east of The Dalles, Oregon. This sand has been creating a safety hazard to vehicles on I-84 and trains on the adjacent Union Pacific tracks. Annual costs to both agencies have increased significantly in recent years and will continue to increase as the dune moves at a rate of about 250 ft every 10 years.

A combination mineral blanket/vegetative stabilization of the sand dune was undertaken in January and February 1983. The stabilization should create vegetative growth over the sand. Before describing this recent stabilization process, following is a description of the area and other attempts at stopping or slowing movement of this dune.

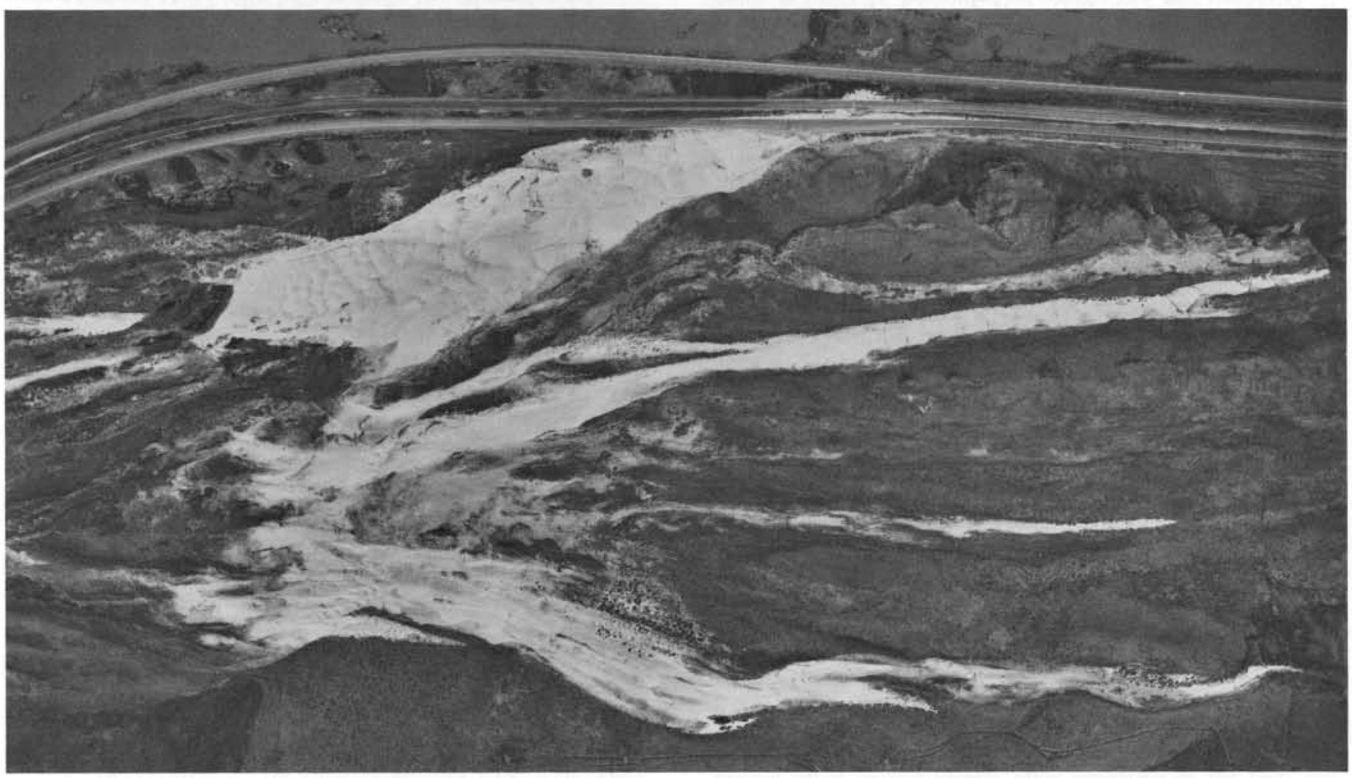
Numerous alternative treatments for physical stabilization of sand dunes have been attempted. The list includes (1) mineral blankets; (2) snow/wind fences; (3) covering with tires; (4) spraying with asphalt and other commercial stabilizing agents; (5) spraying with water and/or water with sewage sludge; (6) mixing agents into surface including cement, straw paper mulch, and bark mulch; (7) planting trees for wind breaks; (8) seeding and mulching; and (9) using straw bales as wind breaks.

The surface area of the dune – believed to be the largest active sand dune in the Northwest – includes an estimated 1.5 million to 2 million cu yd of sand. Relief of the dune varies from 200 ft elevation at the highway (I-84) to 350 ft at its southwestern end. Mobile heaps of sand on the dune have an asymmetrical form, with a nearly equal streamlined gentle slope to the windward side and a steeper slope over the crest on the leeward side. The leeward slope assumes the angle of repose for loose sand.

Dune movement is related to wind velocity, constancy of wind direction, rainfall, sand source supplying the dune, and grain size. The direction of the wind in the dune area is from 270 to 280 degrees from the north over 50 percent of the time, which is nearly along the axis of the dune. Semiarid climate in the area limits the rainfall to 14.5 in annually. During the winter and spring months when the sand is wet, little movement occurs.

The active dune will continue migrating toward the Columbia River. At its current rate, and on level ground, this dune could move across the highway in about 130 years.

Over the years, many attempts have been made to halt or slow the dune. In the 1940's, Union Pacific Railroad, then adjacent to the dune, sprayed crude oil over a large portion of the foredune. This



Vertical aerial view of sand dune area, taken in February 1982.

was a common treatment in the 1920's–1940's and provided short-term control. Again, in the 1940's and 1950's, Union Pacific attempted to control the area with snow fences over large portions, with no success. The fences slowed the sand movement until the weight of the sand tipped them over or buried the fence. In 1966, a suggested method of control was to place several hundred old tires on the dune. The local kids had a field day rolling these down and onto the highway, increasing the hazard and not controlling the dune. Then in 1972, State forces seeded and mulched six to seven acres on the dune face. This involved covering this area with straw, seeding, and punching the straw into the dune. Snow fences were also placed across the dune in front of the covered area. While growth was established, most of the treatment area was covered with blown sand within few months.

Late in 1981, an agreement was reached for developing a stabilization plan through the Oregon State Highway Division, Warm Springs Agency, Wasco County Soil and Water Conservation District, and Union Pacific Railroad.

The contract involved several phases, with completion scheduled for February 1983. First was the development of access roads within the dune followed by rounding the steep faces. Producing the aggregate for the mineral blanket and reclaiming the site was followed by placing the mineral blanket and reseeding. The crushed aggregate had a maximum size of 1½ in and was placed in a thin layer. The selected vegetation procedures involved six different types of treatment according to wind exposure, steepness of slopes, moisture conditions, livestock exposure, accessibility to area, and visual impact.

The major type of treatment involved placing a thin layer of crushed aggregate over the sand followed by seeding and fertilizing. The second largest treatment type was used on that area immediately adjacent to the highway. This area was seeded and fertilized, covered with straw mulch which was punched into the sand by a special roller, and reseeded. The natural terrain protects this area from the direct wind force, and it is further protected from livestock grazing by the right-of-way fencing. The remaining treatment types addressed special problems of access or took advantage of moisture or existing growth on the dune perimeter.

A commercial fertilizer was applied at the rate of 275 lb per acre. Areas too steep to apply a mineral blanket satisfactorily were mulched with a straw mulch at the rate of 2½ tons per acre. The straw was then punched into the sand with a sheepsfoot roller especially designed for this work. In some areas, the straw was covered with netting to prevent it from blowing away.

Some of the area was seeded and fertilized by helicopter to prevent equipment from disturbing the mineral blanket after it had been placed. Treatment areas where straw mulch was applied were seeded with a hydro-seeder. Half of the seed was applied prior to application of the mulch and the other half of the seed and all of the fertilizer were applied after the straw had been planted in or covered with netting. Some areas required hand planting.

Spot reseeding and refertilization may be required in some areas to establish a satisfactory stand of grass. After two years, a second treatment with fertilizer will take place to promote good root development so the vegetative cover will be better able to withstand drought.

The Soil Conservation Service will be monitoring the establishment of the grass cover and will control livestock grazing access to ensure that the livestock grazing does not damage the vegetative cover.

The Oregon State Highway Division and Union Pacific Railroad will be watching, too, to see if this stabilization attempt will at last hold off this 50-acre mountain of sand. □

Fireballs sighted

A fireball that was sighted on September 3, 1983, at 10:05 p.m. PDT, was reported by two different sets of observers: (1) Christie Galen and Marshall Gannett, at lat. 44°51′ N., long. 121°22′ W. at Sparks Lake in Deschutes County, were looking straight up in the sky and first sighted the fireball 15° east of north at an altitude of 60°. The fireball was last seen 15° east of south at an altitude of 40°. The angle of descent was 20°, and the duration of flight was four seconds. The blue-colored fireball was one-tenth the size of the full moon, had a short yellow-white tail, and cast a shadow. Although there was no sound or breakup, a very bright blue flash shot out in front of the fireball at the end of its flight. (2) Two other observers, Bert and Davis Vollans, saw the same fireball at the same time from west of China Hat, also in Deschutes County. They first saw the fireball due north at an altitude of 75° in the sky and watched it descend at an angle of 20° until it disappeared to the south at an altitude of 40°. The duration of the flight was three seconds. The blue-yellow-white fireball was one-third the size of a full moon and had a yellow-white tail that covered 40° of the sky. There was no sound, but the fireball broke up into five or six fragments. The fireball cast a shadow and left a glowing train for one second. According to the observers, the fireball "increased in size and ended like an exploding skyrocket."

Four different observers in the Portland area observed a daylight fireball on September 15, 1983, at 4:15 p.m. PDT. The observers, Anthony Covington, Ron Eilers, Richard Giusti, and Paul Owenby, were at lat. 45°29′ N., long. 122°40′ W. looking to the south. The fireball was first seen 15° west of south at an altitude of 45° and was last seen 15° west of south at an altitude of 35°. The angle of descent was straight down, apparently toward the observers, and the flight lasted for four seconds. The white fireball was one-fourth the size of a full moon and had a white tail that was five times the size of the fireball. There was no sound or breakup. The fireball, which appeared to be falling very slowly, left a vapor trail that lasted several seconds.

On September 30, 1983, at 5:55 a.m. PDT, Gordon Bolton saw a fireball at lat. 45°34′ N., long. 123°9′ W., just south of Banks in Washington County. He first saw the fireball in the north sky at an altitude of 70°. The fireball was last seen at an altitude of 10°, still in the north sky, and appeared to be coming straight down. The duration of the flight was two seconds. The white fireball was one-fifteenth the size of a full moon and had a short white tail. There was no sound and no breakup. The fireball cast a shadow.

A fireball reported by Jason Matthews was observed October 26, 1983, 6:20 a.m. PDT, at lat. 45°33′ N., long. 122°35′ W., in Gresham, Multnomah County. Observer was facing north and first saw the fireball 2° west of north at an altitude of 15°. The fireball was last seen 10° east of north at an altitude of 5°. The angle of descent was 10°, the duration of the flight two seconds. The blue fireball was one-fourth the size of a full moon and had a blue-white tail that covered 40° of the sky. It broke into three or four fragments. No sound, shadow, or train were observed.

These sightings have been reported to the Scientific Event Alert Network, Smithsonian Institution. Anyone with any additional information about these or other meteorite sightings should contact Dick Pugh, Cleveland High School, 3400 SE 26th Ave., Portland, OR 97202, phone (503) 233-6441. □

Available Again

The popular geologic map of the western half of Oregon, out of print for some time, is now available again as a reprint for 1983. It is the *Geologic map of Oregon west of the 121st meridian*, Miscellaneous Geologic Investigations Map I-325 of the U.S. Geological Survey, scale 1:500,000.

The map is available for purchase at the Oregon Department of Geology and Mineral Industries Portland office. The price is $5. □

A field trip guide to the central Oregon Cascades

This field trip to the central Oregon Cascades was offered as part of the annual meeting of the Geothermal Resources Council on October 24-27, 1983, in Portland, Oregon. The trip began in Portland on October 28 and ended back in Portland on October 29, after an overnight stay in Bend, Oregon.

The second part of the trip is presented in this issue; the trip of the first day, from Government Camp at Mount Hood to Bend, was published in the last (November) issue. The trip route is indicated by trip stop numbers in Figure 1, with the numbering error of the previous issue corrected. Note that, because of the correction, there is no trip stop number 8.

The main purpose of the trip was to examine the structure of the central Oregon Cascades, particularly the evidence for a central High Cascade graben.

We thank the Geothermal Resources Council for the permission to reprint the field trip guide here.

Second day: Santiam Pass—Belknap Hot Springs—Breitenbush Hot Springs

by George R. Priest, Oregon Department of Geology and Mineral Industries

INTRODUCTION

This portion of the trip is aimed at showing the evidence for down-to-the-east faulting on the eastern margin of the Western Cascade Range. Although brief descriptions of High Cascade volcanic features are given in the guide, most of the following discussion centers on the stratigraphy and structure at Belknap Hot Springs, Cougar Reservoir, and the North Santiam area. The trip begins in Bend, proceeds across Santiam Pass to Belknap Hot Springs, Cougar Reservoir, north to Breitenbush Hot Springs, and back to Portland.

Central Oregon Cascades

The central Oregon Cascade Range consists of the mature, deeply dissected Western Cascade Range and youthful, undissected volcanic terrane of the High Cascade Range. The two ranges are separated by a topographic low in most areas, causing the headwaters of many of the major streams such as the McKenzie and North Santiam Rivers to swing into a north-south trend where they are deflected by the escarpment of the Western Cascade Range (Figure 1).

The High Cascade Range is composed primarily of a low platform of 4-m.y.-old and younger basalt and basaltic andesite, overlain by much smaller quantities of more silicic volcanic rock. Many of the more fluid basalt flows have flowed west into drainages of the uplifted Western Cascade Range. The major composite cones are a relatively small part of the total volcanic pile and are composed of basaltic andesite to rhyodacite lavas and pyroclastic rocks. The greatest quantity of silicic volcanic rocks occurs in the vicinity of the South Sister, where a silicic highland 15 mi wide has developed (Taylor, 1978).

Some of the most recent eruptions in the central High Cascade Range have been from the mafic platform west of the North and Middle Sisters. Vents in the vicinity of Four-in-One-Cone, South Belknap Cone, Belknap Crater, Nash Crater, Collier Cone, and Yapoah Cone were active between about 1,500 and 2,900 years ago (Taylor, 1980, 1981). Spectacular outcrops of these young basalt and basaltic andesite flows can be seen along the roads near Santiam Junction.

The central Western Cascade Range consists of a thick pile of late Eocene to late Miocene volcanic rocks with minor Pliocene to Pleistocene intracanyon lavas derived from the High Cascades or rare local vents. From oldest to youngest, the Western Cascade Range consists of four main units:

1. 18- to 40-m.y.-old silicic tuffs and lavas with black tholeiitic lavas interbedded in the upper part.
2. 9- to 18-m.y.-old calc-alkaline basalt, basaltic andesite, and andesite lavas with subordinate dacite tuffs and lavas.
3. More than 4- to 9-m.y.-old compact to diktytaxitic basalt and basaltic andesite flows with lesser amounts of andesite and dacite. These rocks which cap the highest Western Cascade ridges were erupted prior to uplift and faulting along the east margin of the Western Cascade Range. The basalts reach compositions more mafic than those in basalts of unit 2.
4. 0- to 4-m.y.-old intracanyon diktytaxitic basalt and basaltic andesite flows from the High Cascade Range.

Unit 3 is compositionally identical to unit 4 and other rocks of the High Cascade Range. Unit 3 was probably erupted from vents in and adjacent to the High Cascades. Units 1 and 2 were erupted from many vents west of known High Cascade volcanic centers, although some of these older vents are probably buried beneath the High Cascade Range. Figure 2 shows a schematic summary of the stratigraphic relationships. For a more detailed summary of central Western Cascade stratigraphy, the reader is referred to DOGAMI Special Paper 15 (Priest and others, 1983b).

Horse Creek-McKenzie River fault

A major north-south fault system with down-to-the-east displacement bounds the Western Cascade Range and controls the north-south trends of parts of the upper McKenzie River and Horse Creek. An east-facing topographic scarp extends along the fault zone and is, in places, breached by drainages (Figure 1). The McKenzie River has cut through the scarp near McKenzie Bridge at Foley Ridge, and unfaulted High Cascade basalt flows, dated at 2.0 to about 4.0 m.y. B.P. (Sutter, 1978; Taylor, 1980; Priest and others, 1983b), have flowed westward through the breach in the fault scarp (Taylor, 1980, Flaherty, 1981). Flows dated at about 5.0 m.y. B.P. (Sutter, 1978) cap the highest ridges at the top of the scarp. Offset, therefore, appears to have occurred over a short time span between 5 and 4 m.y. B.P. (Taylor, 1980; 1981). Structural relief on the fault is about 1,970 ft at Horse Creek (Flaherty, 1981). The fault zone has been mapped north to Santiam Junction (see Brown and others, 1980b; Avramenko, 1981). Belknap Hot Springs is located on this fault zone.

Topographic relief in the area is about 3,300 ft, which is characteristic of the eastern part of the Western Cascade Range. The base of the oldest Foley Ridge flows lies at about the same elevation as the present McKenzie River, indicating that all of the present relief existed shortly after formation of the fault zone (Flaherty, 1981). This leads to the speculation that much of the

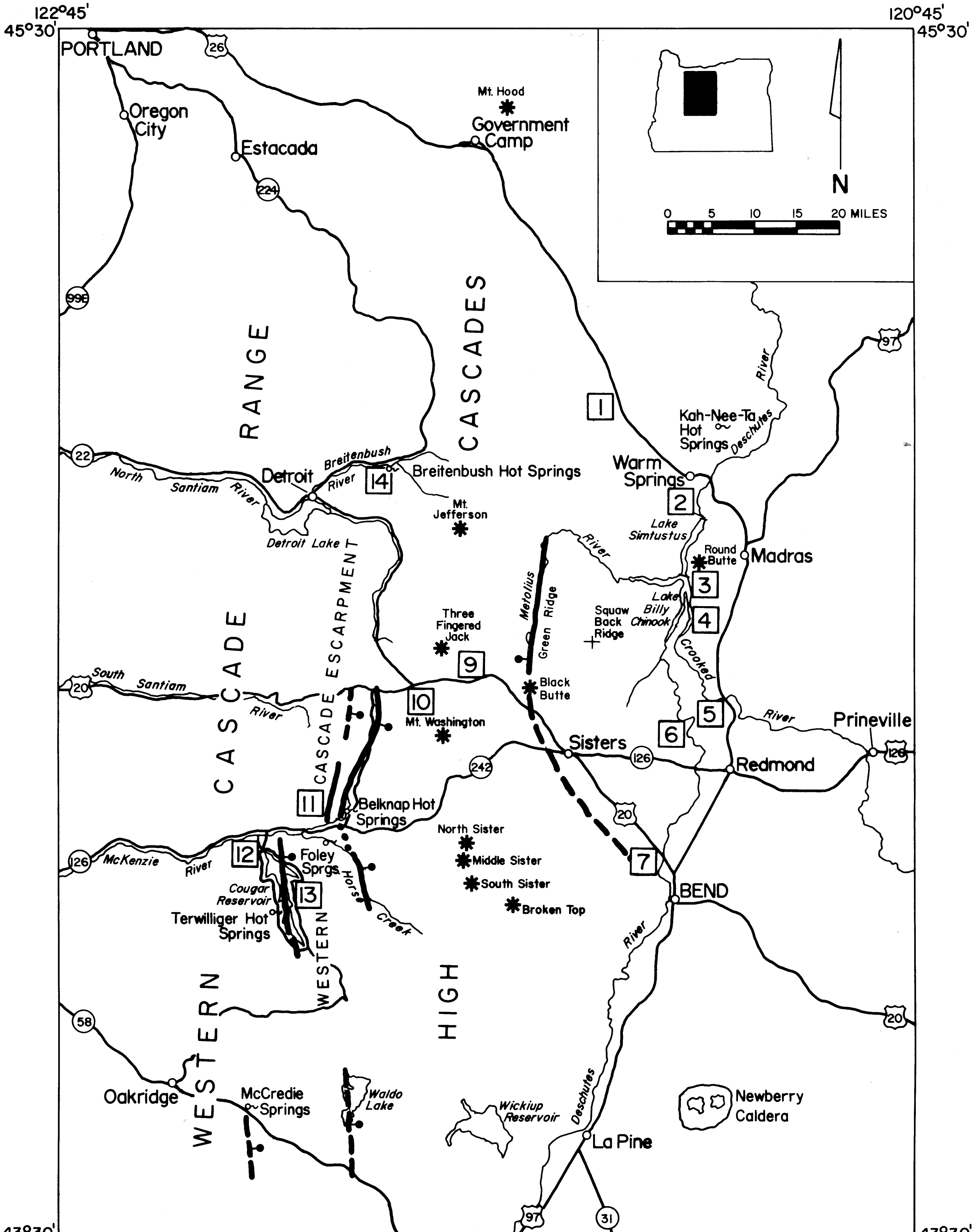


Figure 1 (corrected version of map printed in November issue). Location map for the central Oregon Cascade field trip. Numbers surrounded by squares are the field trip stops. Because of the map correction mentioned above, there is no stop number 8.

present relief in the larger stream valleys of the central Western Cascade Range may also have developed during uplift in the interval of 5-4 m.y. B.P. A topographic escarpment similar to, and on strike with, the scarp of the McKenzie River-Horse Creek fault continues to the north-south segment of the upper North Santiam River (Figure 1). Geologic mapping in the North Santiam area has, however, thus far failed to show stratigraphic evidence for offset along that part of the escarpment (e.g., Rollins, 1976; Hammond and others, 1980, 1982). If down-to-the-east displacement along the North Santiam portion of the escarpment can be proven, the associated north-south faults would form the western boundary of a major graben bounded by the Green Ridge fault zone on the east.

The north-south topographic escarpment of the Western Cascade Range ends at the elbow of the North Santiam River. North of the elbow, preliminary mapping by this author indicates that an andesite ash-flow sheet older than 6.3 m.y. crops out at high elevations (about 4,800 ft above sea level) from the Outerson Mountain area (2.5 mi north of the elbow) to within 3 mi northwest of the flank of Mount Jefferson. Therefore, an essentially unbroken block of rocks older than the McKenzie River-Horse Creek faulting forms a roughly east-west trending highland north of the Western Cascade escarpment.

Cougar fault

The Cougar fault is a major north-south fault with down-to-the-east displacement and controls the north-south trend of the South Fork of the McKenzie River at Cougar Reservoir. This fault has no obvious topographic scarp but does juxtapose Oligocene (?) tuffaceous rocks against middle Miocene andesite lavas. Terwilliger Hot Springs is 0.7 mi west of the fault.

The Cougar fault definitely cuts rocks dated at 13.2$\pm$0.7 m.y. B.P. and is overlain by unfaulted Pleistocene gravels (Priest and Woller, 1982, 1983). The fault has a minimum dip-slip offset of 500 ft, based on drill-hole data, and probably has more than 1,400 ft of displacement, based on stratigraphic arguments (Priest and Woller, 1982; 1983). According to Priest and Woller (1983) there is some evidence that the Cougar fault may be older than the Horse Creek fault, and they speculated that much of the fault offset may have occurred between 13.2 and 9 m.y. B.P.

Probable southerly extent of the faults

Faults roughly on strike with the Cougar fault and Horse Creek-McKenzie River fault zone have been tentatively identified in the McCredie Hot Springs and Waldo Lake areas, respectively (Woller and Black, 1983). Continuity of distinctive gravity anomalies from the Horse Creek area to the Waldo Lake area and from the Cougar Reservoir area to the McCredie Hot Springs area (Couch and others, 1982a, 1982b) suggests that the faults may be regional structures extending well beyond present map areas (Priest and others, 1983a,b; Woller and Black, 1983).

Discussion

Priest and others (1983a,b) speculated that the Cougar faulting may have been caused by an extensional event earlier than, but analogous to, the event which caused the McKenzie River-Horse Creek faulting. They concluded that the two faulting events, one about 8-10 and the other about 4-5 m.y. ago, may have occurred during two accelerations in Basin and Range spreading which caused a microplate of western Oregon lithosphere to rotate toward the west. They postulated that faulting during the two events may have been localized where the relatively cool microplate was in contact with the more plastic, hotter crust underlying the Cascade volcanic arc. Where the microplate was in contact with the subducting Juan de Fuca Plate, an acceleration in the rate of subduction should have accompanied the two faulting events. A 10-m.y.-B.P. acceleration of underthrusting of the Juan de Fuca Plate has been documented (see the summary of Drake, 1982). Magmatic withdrawal and loading of the crust by the volcanic rocks generated over

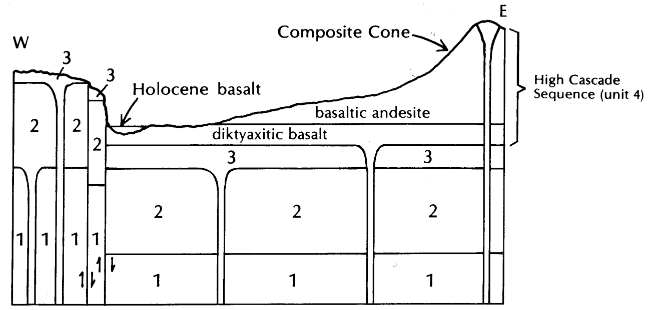


Figure 2. Schematic cross section across the eastern margin of the central Western Cascade Range, Oregon. See text for explanation of units. Modified after Taylor (1980b, 1981).

the subduction zone probably caused increased downfaulting under the Cascade arc relative to adjacent areas.

Geothermal exploration aimed at high-temperature hydrothermal systems should be focused on areas at, and east of, the youngest microplate boundary at the McKenzie River-Horse Creek zone of faulting. Areas of young silicic volcanism, as at the South Sister, are particularly attractive exploration targets for shallow magmatic heat sources.

ROAD LOG

(Start from Bend, going north on U.S. Highway 20/97. Mileage count begins just north of Bend city limit.)

Miles	Comments
0	Junction; U.S. 20 and 97 separate. *Take U.S. 20 to Sisters.* From north to south, Mount Jefferson, Three Fingered Jack, Mount Washington, the Three Sisters, and Broken Top volcano are Pleistocene composite cones which can be seen on the skyline to the west while you are traveling from Bend toward the High Cascades. The composite cones have the following compositions (Taylor, 1968, 1981; Sutton, 1974; Davie, 1980): **Mount Jefferson**—basaltic andesite with less andesite and dacite **Three Fingered Jack**—basaltic andesite **Mount Washington**—chiefly basaltic andesite **North Sister**—chiefly basaltic andesite **Middle Sister**—basalt and minor basaltic andesite, andesite, dacite and rhyodacite **South Sister**—andesite and minor dacite and rhyodacite **Broken Top**—basaltic andesite and minor dacite, rhyodacite, and ash-flow tuff The Middle Sister and South Sister were active during the late Pleistocene and are much less glaciated than the other, older composite cones. Eruptions of silicic lavas have occurred on the flanks of South Sister as recently as 2,300 to 1,900 years B.P. (Wozniak, 1982).
12.8	Suttle Lake Road. Suttle Lake lies in a basin enclosed by lateral and terminal moraines of the Suttle Lake advance of the Cabot Creek glaciation (less than 30,000 years B.P., according to Scott, 1977).
14.2	**STOP 9.** *Wide turnout on south side of highway.* The north-south-trending Green Ridge fault scarp can be clearly seen to the northeast. Black Butte, a reversely magnetized basaltic composite cone, lies on the south end of the fault (Taylor, 1981). The Green Ridge fault formed

approximately 4.5 m.y. B.P., when the High Cascade block subsided (Taylor, 1981).

14.6 *Narrow turnout on south side of highway.* A better view of Black Butte and Green Ridge to the east (not suitable for a large bus).

15.2 View of Cache Mountain and Mount Washington to the south.

22.5 Highly jointed aphyric andesite dome of Hogg Rock (Taylor, 1981). Three Fingered Jack, a heavily glaciated basaltic andesite composite cone, is visible to the north. To the south is the Hoodoo Butte cinder cone and the Hayrick Butte andesite dome; to the northwest is Maxwell Butte and to the west the Lost Lake chain of cinder cones. Davie (1980) determined that Three Fingered Jack is normally polarized but older than the Abbott Butte Glaciation (200,000-120,000 years B.P.) and that Maxwell Butte is composed of basaltic andesite which erupted between the Abbott Butte Glaciation and the Jack Creek Glaciation (80,000-40,000 years B.P.). The Lost Lake chain of basaltic cinder cones has a C^{14} age of 1,950$\pm$150 years (Taylor, 1967).

23.5 On the north side of the road is Lost Lake and one of the young cinder cones which dammed up the lake on its west end.

25.4 **STOP 10.** Santiam Junction, highways U.S. 20 and Oregon 22. Nash Crater can be seen to the south, and Little Nash Crater is the low hill to the west. Basaltic andesite flows erupted from the base of these cinder cones about 3,000 C^{14} years ago (Taylor, 1981). These volcanic centers are part of a larger Holocene volcanic field which extends northward from the White Branch of the McKenzie River near North Sister (Taylor, 1967). The field experienced numerous eruptions between about 3,850$\pm$215 C^{14} years and about 1,400$\pm$100 C^{14} years ago (Taylor, 1967). *Continue on U.S. 20 (left).*

28.6 Junction of highways U.S. 20 and Oregon 126. *Turn south onto Highway 126.* From this point on, the road lies east of the heavily dissected Western Cascade escarpment. Avramenko (1981) inferred down-to-the-east faults along the escarpment in this area.

35.5 Highway crosses a basalt flow from Belknap Crater which flowed out of the north base of the cinder cone about 1,500 years ago (Taylor, 1981).

37.8 Kink Creek area. Mafic lavas in the road cuts are from intracanyon flows following canyons cut into the High Cascade platform lavas. Avramenko (1981) inferred that the platform lavas cover a down-to-the-east fault with 426-755 ft of displacement and that the fault was last active between 0.7 and 1.0 m.y. B.P.

39.8 Trailbridge Reservoir parking area. A distinctive basaltic andesite ignimbrite (52-53 percent SiO_2) dated at 5.0 m.y. B.P. crops out along the east side of the highway (Taylor, 1981).

45.9 Frissel-Carpenter Road. [Recommended side trip, but not suitable for large buses. The road leads to the Frissel Point area where Brown and others (1980b) showed extensive down-to-the-east, north-northwest step faulting along the Western Cascade escarpment. The Trailbridge ignimbrite is an important stratigraphic marker for faulting in this area (Taylor, 1981)].

47.5 Sign to Belknap Hot Springs. *Turn west.* **STOP 11.** Belknap Hot Springs. The springs discharge 188° F water (Mariner and others, 1980) at 80 gal/min with a mean calculated reservoir temperature of 235°$\pm$57° F (Brook and others, 1979). These springs and Bigelow Hot Springs to the north are on a major boundary fault along the Western Cascade escarpment (Brown and others, 1980b; Taylor, 1981). The fault continues south to Horse Creek, where Flaherty (1981) documented about 1,970 ft of offset. Faults of this zone offset the Trailbridge ignimbrite (5.0 m.y. B.P.) and do not offset High Cascade platform lavas of Foley Ridge which Taylor (1980) inferred from Sutter's (1978) K-Ar data to be as old as 3.98 m.y. (age recalculated by Fiebelkorn and others, 1982). The faulting thus occurred between about 5 and 4 m.y. B.P. *Continue south on Oregon Highway 126.*

48.6 Junction, McKenzie Pass Highway (Oregon 242). Foley Ridge is visible to the south. It is composed of highly diktytaxitic basalt flows which flowed through a breach in the Horse Creek-McKenzie River fault scarp between about 2 and 4 m.y. B.P. (Taylor, 1980, 1981; Flaherty, 1981; Priest and others, 1983b). The basal flows lie at about the same elevation as the present McKenzie River channel; therefore, all of the present erosional relief on the uplifted Western Cascade block had developed by 4 m.y. B.P. (Flaherty, 1981; Priest and others, 1983b). *Continue west on Oregon 126.*

53.3 McKenzie Bridge. Restrooms, gasoline, and food are available here. Intracanyon, diktytaxitic flows of the Foley Ridge sequence make up the hills to the northwest and southeast.

55.3 Castle Rock, the prominent peak to the south, is an andesite plug (60 percent SiO_2) K-Ar dated at 9.3$\pm$0.4 m.y. B.P. (Priest and Woller, 1982). Lookout Ridge to the north and McLennen Mountain to the southeast are middle Miocene andesitic sequences (lavas of Walker Creek) that are capped by moderately diktytaxitic basaltic lavas (lavas of Tipsoo Butte) with K-Ar dates between about 9.4 and 7.8 m.y. B.P. (Priest and Woller, 1982). As previously explained the uppermost part of the capping sequence (here mostly eroded away) is probably about 5 m.y. old, corresponding to the Trailbridge ignimbrite.

58.3 Rainbow. *Turn south on the Cougar Dam road and proceed south to the upper rim of the dam (take the right-hand road when the road forks).* Outcrops near the road junction are the tuffs of Cougar Reservoir, which are lower Miocene and lower altered ash flows, tuffaceous lahars, and epiclastic rocks.

59.1 The large peak to the west is Deathball Rock, a sequence of middle Miocene two-pyroxene andesite flows of the lavas of Walker Creek.

61.2 Outcrops along the road are a complex mixture of a glassy dacite intrusion (63.6 percent SiO_2) and the tuffs of Cougar Reservoir.

61.7 West abutment of Cougar Dam. Outcrops on both the east and west abutments of the dam are the previously mentioned glassy dacite. Note the prominent northwest- to west-trending shear zones, dikes, and breccia dikes which cut the intrusion on the east abutment. The intrusion is a large, north-south-trending dikelike mass forming the ridge to the east. The west abutment appears to be more of a sill-like body. *Turn east and cross the dam.*

62.1 **STOP 12.** East abutment. A K-Ar date of 16.2±1.8 m.y. B.P. was obtained on the intrusion at this locality. The ridge to the west is Katsuk Butte, which is capped by middle Miocene two-pyroxene andesite (andesites of Walker Creek) interfingering with ash-flow, air-fall, and epiclastic tuffs (tuffs of Rush Creek). The basal rocks are the tuffs of Cougar Reservoir and the dacite intrusion. The contact between the tuffs of Cougar Reservoir and the younger rocks can be seen to dip off toward the south. The younger rocks lap onto an old highland of the tuffs of Cougar Reservoir. *Continue south along the lake shore road.*

65.6 South side of the East Fork of the South Fork of the McKenzie River. Observe shear zones associated with the north-south-trending Cougar fault which are here cutting basalts interbedded in the middle Miocene andesite sequence. The fault zone was followed by a Pleistocene channel of the South Fork, but Pleistocene gravels cropping out at this locality are not cut by the fault. The fault zone passes through the north-south lineament formed by the saddle to the north. The fault juxtaposes the tuffs of Cougar Reservoir on the upthrown block to the west with the middle Miocene sequence to the east.

66.6 **STOP 13.** East side of Cougar Reservoir. This locality is the most prominent outcrop of the Cougar fault. Altered breccias of the andesites of Walker Creek and the tuffs of Cougar Reservoir are exposed. Just south of this stop, a 500-ft temperature-gradient well was drilled about 150 ft east of the fault on the downthrown side. The hole encountered only the andesites of Walker Creek. The minimum offset on the fault is thus 500 ft down to the east. With various stratigraphic arguments, Priest and Woller (1982) suggested that the offset is probably more than 1,400 ft.

Several temperature-gradient wells in this area show that the heat flow (80-100 mW/m^2) is transitional to the high heat flow (over 100 mW/m^2) characteristic of the High Cascades (Black and others, 1982). Terwilliger Hot Springs, located on the west side of the reservoir, reflects this lower heat flow by having lower temperature water (111° F) than Belknap Hot Springs (188° F) to the east (temperatures from Mariner and others, 1980). *Turn back north to Santiam Junction (stop 10) and take Oregon Highway 22 to the northwest.*

108.6 At 0.8 mi northwest of Santiam Junction, Highway 22 crosses a spectacular Holocene basaltic andesite flow which was erupted from Little Nash Crater to the south.

121.3 View of Mount Jefferson to the east. Mount Jefferson is a heavily dissected Pleistocene composite cone of basaltic andesite with lesser amounts of andesite and dacite (Sutton, 1974).

121.4 View to the west of middle(?) to late Miocene mafic lavas of Rollins' (1976) Nan Creek volcanics which form much of the north-south topographic escarpment of the Western Cascade Range in this area. To the west, these lavas are capped by late Miocene(?) tuffs and lavas. To the east, the Nan Creek volcanics are capped by Quaternary intracanyon lava flows (the Pigeon Prairie flows). Rollins (1976) and Hammond and others (1982) did not find evidence of any large-scale down-to-the-east faulting along this part of the Western Cascade escarpment.

126.3 Southeast-dipping sequence of middle Miocene(?) mafic lavas and epiclastic rocks of the Grizzly Creek lavas of Rollins (1976). These rocks underlie the Nan Creek volcanics.

126.9 Pamelia Creek. The northernmost end of the Western Cascade escarpment is at Mount Bruno to the west.

127.9 A Quaternary block-and-ash flow which flowed down the Whitewater River from Mount Jefferson (Hammond and others, 1982) crops out on the east side of the highway. Close inspection of the angular blocks reveals some prismatic joints, indicating that the flow was probably quite hot.

128.9 Elbow of the North Santiam River. At this point the river veers sharply toward the west. As explained in the summary, a nearly east-west highland of rocks of late Miocene and older age occurs to the north of the elbow. The Pigeon Prairie flows crop out intermittently along the highway. Most road cuts to the west are composed of altered ash flows of the Breitenbush formation which underlies the Grizzly Creek lavas (Rollins, 1976; Hammond and others, 1982).

139.6 Detroit. Junction with U.S. Forest Service (USFS) Road 4600. *Take USFS Road 4600 to the northeast up the Breitenbush River.* Roadcuts in this area expose the beds at Detroit, a sequence of altered tuffaceous epiclastic sediments older than the ash flows of the Breitenbush tuff (Hammond and others, 1982).

148.7 Junction with USFS Road 2231. Cleator Bend picnic area. Outcrops of green nonwelded ash-flow tuff are visible along the road (Cleator Bend member of the Breitenbush formation of Hammond and others, 1982). *Take USFS Road 2231 to the southeast.*

149.5 Road divides. *Turn left onto USFS Road 2231-890 and follow the signs to Breitenbush Hot Springs (Breitenbush Community).*

150.2 **STOP 14.** Breitenbush Hot Springs. The springs discharge 900 gal/min of water with temperatures up to 198° F and a mean reservoir temperature of 257°±50° F, according to Brook and others (1978). Shallow wells in the area have encountered water up to 230° F with a SiO_2 geothermometric (adiabatic) temperature of 325° F (Mariner and others, 1980). Background heat flow in the area is in excess of 100 mW/m^2 (Black and others, 1982). The springs flow out of highly jointed basaltic lavas probably similar in age to the Grizzly Creek lavas of Rollins (1976). *Return to Oregon Highway 22.*

End of second-day road log.

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Multnomah County: 1983 Mined Land Reclamationist in Oregon

by Paul F. Lawson, Supervisor, Mined Land Reclamation Program, Albany Field Office, Oregon Department of Geology and Mineral Industries

Multnomah County is this year's winner of the award for the Outstanding Mined Land Reclamation Project. The selection committee, composed of the supervisor of the Mined Land Reclamation Program and representatives from a major environmental organization and the mining industry, found it easy to make the final choice unanimously. The county, which received a plaque for its permanent retention, is also temporary custodian of another plaque which lists the annual winners.

Through this accomplishment, Multnomah County has set a commendable example for other mining operators in the county and also for all other county governments. The award was given in recognition of the county's multiple use of land it has reclaimed. The entire operation has been voluntary, since the mining long preceded the reclamation act. It is an emphatic illustration that often reclamation is possible and economically attractive without being mandated.

The award was given for a specific 15-acre parcel located on SE 190th Avenue between Stark and Division Streets, although the county has mined and reclaimed still more land and will continue to mine nearby. In 1940, this was rural land. About 1942, extraction of sand and gravel began. At an average depth of 10 yards, approximately 725,000 cubic bank yards or, conservatively, 870,000 cubic yards as delivered, was harvested. By 1958, mining on this parcel had ceased, and its use as a landfill began. The site was filled

Outstanding Reclamation Project in Oregon for 1983, Multnomah County's energy-efficient operations and maintenance headquarters at 1620 SE 190th Avenue, Portland. Background and foreground show evidence of ongoing and past mining activity here. (State Highway Division air photo)

Dennis O'Meara (left), of Multnomah County Executive's Office, and Tor Lyshaug, Director, Division of Operations and Maintenance, receiving this year's Outstanding Mined Land Reclamation Project Award.

Excavation starting in 1980 on former mining-landfill site in preparation for Multnomah County's new operation and maintenance headquarters (center). Note continuing mining-related activities on all sides. (State Highway Division air photo)

Excavation through landfill to base of former mined area for foundation of county headquarters building. (State Highway Division air photo)

by 1970. By the time construction of I-205 forced the relocation of the county's shops from their long-time location at Rocky Butte, this site had ceased to be chemically active and was ready for further use. After considering approximately 200 sites, the county chose this site for the new home of their Division of Operations and Maintenance. In order to obtain stable foundation footing, the fill in the actual area to be occupied by the new building was excavated to the mined pit floor. Removed material was stored securely and neatly on another part of the property.

The building, which was carefully planned by Tor Lyshaug, Director, Division of Operations and Maintenance, Multnomah County, and by the architects, Zimmer Gunsul Frasca Partnership, who, for their contribution, received an award of excellence in 1982 from the Portland Chapter of the American Institute of Architects. The building is especially energy efficient. It is approximately three quarters below grade. Energy is provided by a combination of solar collectors and gas-fired radiant heaters with an oil-fired boiler for backup. Lighting is also special through window design, use of skylights, and incremental lighting utilizing a sophisticated electric eye.

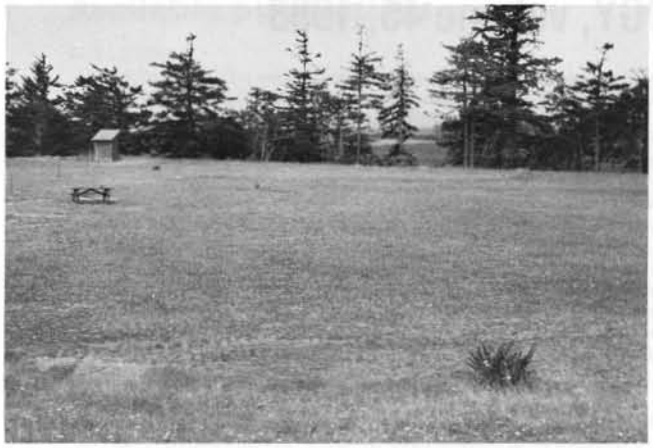
Space is provided within the building for parking of equipment, dispatching and tool rooms for district road crews, service and repairs to county vehicles and equipment (approximately 1,500 pieces), offices, storage rooms, specialty shops, computer room, materials-testing laboratory, training area, and lunch room. Through the use of grassy berms, the landscaping is designed to minimize the visual impact of the building upon future neighbors and of the activities of neighbors upon the building's occupants, a technique used successfully in Japan years ago by Frank Lloyd Wright. A tour of this facility is an exciting and educational experience.

The building is named the John B. Yeon Shops, for Multnomah County's first roadmaster. John Yeon served from 1913 to 1917. It is said he sought the job for $1.00 per year so that he might facilitate the construction of the Columbia River Highway.

Mining continues on other parts of this property and mining and mineral processing continues on other adjacent properties.

There is only one winner, but there are several finalists who are highly deserving of recognition and approbation:

Harold Knapp of Knapp Ranches, Port Orford, has returned approximately five acres of his gravel pit to neatly contoured pasture, while mining continues nearby. A local rifle club also uses the reclaimed area as a rifle range.



Knapp Ranches, Port Orford. Reclaimed mined land now serving as pasture and rifle range.

The Oregon State Highway Division, Department of Transportation, has done a fine job in reclaiming a site 2.7 mi south of Junction City on Pacific Highway West. The site is smoothed and revegetated, and underwater slopes are gentle. The Oregon Department of Fish and Wildlife has stocked the lake for public fishing. This author has watched model seaplane enthusiasts flying their aircraft on it. The reclaimed area, parts of which had been mined at earlier times, totals about 10 acres of water and 10 acres of land; about half of each are from the most recent operation.

Vernon Egge of Egge Sand and Gravel, Eugene, has completed an excellent job in filling, recontouring, and revegetating the Clearwater sand and gravel pit on Clearwater Lane, southeast of Springfield. One acre was reclaimed to wildlife habitat, five acres to agricultural use, and one acre to a solid waste disposal site. The latter is now in use under a permit from another agency.

In making its decision, the selection committee considers these criteria: (1) Compliance with the approved reclamation plan (when reclamation is mandatory), (2) imagination and/or innovativeness in accomplishing the planned reclamation, (3) future value of the site, (4) appropriateness to the local environment, (5) safety, and (6) aesthetics. The purposes of the award program are to (1) recognize and commend the outstanding example of mined land reclamation and the operator performing it, in Oregon each year; (2) acknowledge and praise other operators and their projects which were nominated and considered for the annual award; and (3) encourage and further the goal of sensible mined land reclamation, both mandatory and voluntary.

Oregon State Highway Division reclamation site near Junction City. The 10-acre lake, open to public fishing, has a "drown-proofed" shoreline, i.e., a shallow 3:1 slope extending 18 ft out from water's edge into lake. This also encourages growth of aquatic plants.

The law, ORS 517.750-517.990, with some exemptions, requires lands affected by surface mining after July 1, 1972, to be reclaimed or restored to some "beneficial use." In addition, the Mined Land Reclamation Program tries to insure that a site is left reasonably safe and nonpolluting. Stronger provisions apply to surface mines producing coal and metal-bearing ores which first obtained a permit after August 16, 1981. In October 1983, the law became applicable to the surface impacts of underground mines by amendment of the 1983 legislature. Beyond the limits of the law's applicability, the State of Oregon encourages and assists any operator considering to undertake voluntary reclamation.

Over 3,000 acres of mining lands are currently under performance bond or other security to guarantee reclamation required under the law. To date, over 1,200 acres of mined lands have been reclaimed to agriculture, forestry, wildlife, housing, industrial, recreational, and other uses.

Nominations for the Outstanding Mined Land Reclamation Project Award are invited at any time from anyone with knowledge of a deserving site. Such nominations should be sent to Mined Land Reclamation Program, 1129 SE Santiam Road, Albany, Oregon 97321. □

OAS to meet in February at U of O

The Oregon Academy of Science (OAS) will hold its annual meeting on Saturday, February 25, 1984, at the Erb Memorial Union at the University of Oregon in Eugene. Abstract forms are available from Jay F. Evett, Western Oregon State College, Monmouth, Oregon 97361, until the abstract deadline (January 5, 1984).

Day registration at the meeting is only $2. For $8, one can register for the meeting, become a member of the Academy, and receive a copy of the published proceedings of the meeting. □

PNMMC calls for papers for 1984 meeting

Papers on the regional geology, geophysics, petroleum geology, and economic mineral deposits of the Pacific Northwest are invited for the 1984 Pacific Northwest Metals and Minerals Conference to be held April 30-May 2, 1984, at the Lloyd Center Red Lion Inn. Abstracts are due on January 15, 1984. For more information about the abstracts, contact Mike Cummings, Portland State University, P.O. Box 751, Portland, OR 97207, phone (503) 229-3029. For additional information about the conference, contact Al Rule, Bureau of Mines, P.O. Box 70, Albany, OR 97321, phone (503) 967-5841. □

(References, *continued from page 138)*

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Note: The double issue published for July and August this year is referred to simply as issue number 7.

Available publications (continued)

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4. Heat flow of Oregon, 1978: Blackwell, Hull, Bowen, and Steele	3.00		
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