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Main Office: Suite 965, 800 NE Oregon Street # 28, Portland 97232, phone (503) 731-4100, FAX (503) 731-4066.
Internet: http://sarvis.dogami.state.or.us
Baker City Field Office: 1831 First Street, Baker City 97814, phone (541) 523-3133, FAX (541) 523-5992.
Mark L. Ferns, Regional Geologist.
Grants Pass Field Office: 5375 Monument Drive, Grants Pass 97526, phone (541) 476-2496, FAX (541) 474-3158.
Thomas J. Wiley, Regional Geologist.
Mined Land Reclamation Program: 1536 Queen Ave. SE, Albany 97321, phone (541) 967-2039, FAX (541) 967-2075.
Gary W. Lynch, Supervisor.
Internet: http://www.proaxis.com/~dogami/mlrweb.shtml
The Nature of the Northwest Information Center: Suite 177, 800 NE Oregon St. # 5, Portland, OR 97232-2162, phone (503) 872-2750, FAX (503) 731-4066, Donald J. Haines, Manager.
Internet: http://www.naturenw.org

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

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Cover photo

View to the east of Lower Table Rock (foreground), Upper Table Rock (middle), and Mount McLoughlin (distant background) in Jackson County. Article beginning on page 81 presents the first comprehensive geologic description of the Table Rocks and the andesite of Table Rock that created their caps.

Innovation and creativity highlighted at annual mined land reclamation awards

A logger-turned-miner has been named one of Oregon's **Reclamationists of the Year**. Vern Perry spent a lifetime working in the forests of Oregon. As a student he planted trees for a Toledo lumber company, then as an adult his company, Gem Logging Inc., harvested those trees for Georgia Pacific. Perry retired from logging in 1989 but decided to try a new career – working for Dalton Rock, a new aggregate producer in the Dallas area. As equipment operator, Perry has been instrumental in getting this venture off the ground. His knowledge of facilities and plant layout allowed the Dalton operation to develop into a major aggregate resource. His lifelong love of the outdoors is evident in his dedication to completing the reclamation at Dalton Quarry and Perry was recognized for his commitment to developing natural resources in an environmentally sound manner.

Walter Matschkowsky of Glenbrook Nickel Company was also named as a **Reclamationist of the Year**. Matschkowsky was highly regarded for his leadership and initiative in creating environmentally sound mining practices. He spent his long career on Nickel Mountain in southern Douglas County near Riddle, first with Hannah Mining, then with Glenbrook. During his years at Glenbrook, Walter supervised the mining activities along with annual grass and tree planting efforts. He also assisted with ideas and efforts to maintain good water quality from the many permitted discharge points. A significant accomplishment of Matschkowsky's was his lead role in the Thompson Creek reclamation project. He supervised the process that turned an area affected by mining into a green, healthy part of the forest indistinguishable from unaffected land. Matschkowsky was recognized for a career of responsible mining and reclamation. He passed away in September 1997, but his work will always be a part of Nickel Mountain.

Six other businesses and two government agencies were also recognized at the annual awards event. Winners were chosen by the Oregon Department of Geology and Mineral Industries (DOGAMI) for their exemplary efforts to reclaim sites creatively and for their commitment to enhance the environment. "These companies are being recognized because they go above and beyond the standards required by the law in their reclamation efforts," said Gary Lynch, Supervisor of DOGAMI's Mined Land Reclamation (MLR) Office. "They lead the industry by their good example."

The mining awards were developed by the MLR program of DOGAMI to recognize environmentally conscious miners. The seven-person staff, based in Albany, regulates mining operations throughout the state of

*(Continued on page 91, **MLR**)*

A new approach to earthquake hazard identification in Oregon

Creating a map of Oregon UBC soils

by Yumei Wang, Oregon Department of Geology and Mineral Industries, Portland, Oregon 97223, and Ray J. Weldon and Dennis Fletcher, Department of Geological Sciences, University of Oregon, Eugene, Oregon 97403

INTRODUCTION

In the mid-1990s, the Oregon Department of Geology and Mineral Industries (DOGAMI) encountered a number of questions regarding earthquake hazard mapping methods in several of its projects throughout the state. One particular question was whether hazard ratings based on established methods really meant the same for different areas of the state. What was needed was to provide a uniform, statewide basis to judge regional earthquake hazards.

For seismic engineering design and construction purposes, site characterization of soil properties is a necessary step in determining ground motions. The 1996 edition of *Recommended Lateral Force Requirements* by the Structural Engineers Association of California (SEAOC)(Shea, 1996) introduced improved descriptions of soil types and became a model for the 1997 Uniform Building Code (UBC) (International Conference of Building Officials, 1997). Initially, DOGAMI scientists used the 1996 SEAOC soil profile types to determine the statewide earthquake hazards. These soil types are identical to the 1997 UBC soil profile types, which will go into effect for Oregon's building codes in October of 1998 and serve as the basis of the map described in this paper.

The 1997 Uniform Building Code, Chapter 16, Division V, defines six soil profile types (hereafter referred to as UBC soils) that are to be used in the determination of earthquake design requirements for building sites. The UBC soils range from hard rock to special soils that require site-specific investigations for characterization, such as thick soft clays. In general, harder UBC soils provide stronger foundation materials, and softer types provide weaker foundation materials. In addition, harder UBC soils transmit earthquake waves faster, which often results in less ground shaking damage than with slower, softer types.

In accordance with the 1997 UBC, the authors of this paper are developing a statewide map that shows Oregon's soil profile types and provides general information on areas with harder and softer UBC soils over a broad region.

This map shows the statewide earthquake hazards and serves to provide a uniform basis of evaluating these hazards from geologic conditions. Its primary use is to identify regions of higher and lower hazards and to understand areas of higher and lower risk. It is also to be used in a statewide earthquake damage and loss estimate. Other uses of the map include regional emergency planning and facility siting.

The map data may be combined with such information as elevations, slope angles, and earthquake ground shaking potential for the evaluation of specific hazards. The map does not have site-specific accuracy and should not be used for site-specific purposes.

The map shows concentrations of high-value (high-hazard) soil types, i.e., soil types S_D, S_E, and S_F in coastal estuaries, the Willamette Valley, and basins in central and eastern Oregon. Areas of highest value soil types are landslides and margins of open water. Western Oregon is made up largely of type S_C (soft rock).

BACKGROUND AND METHODS

The map of Oregon UBC soils was developed on the basis of earlier work by Fumal (1978), Fumal and Tinsley (1985), Joyner and Fumal (1985), Rogers and others (1985), Mabey and Madin (1992 and 1995), Borchert (1994), Wang and Priest (1995), and Wang and Leonard (1996). This previous work had investigated the relationship between shear-wave velocity and surficial geologic units and was based on extensive measurements of shear-wave velocity in a variety of surficial geologic units.

The UBC soil types shown on the map have been derived from evaluations of published, digital, regional geologic and agricultural soil maps: the 1:500,000-scale *Geologic Map of Oregon* (Walker and MacLeod, 1991) and the 1:500,000-scale general soil map of Oregon by the Soil Conservation Service (U.S. Department of Agriculture, 1995; hereafter referred to as "SCS"). Consequently, the accuracy of the UBC soil map is dependent on the accuracy of those maps. For areas of high accuracy, the finest resolution is ±250 m, which is the standard line width on the geologic map used in this study.

For the development of the UBC soil types on the map, we first assigned one of the 1997 UBC soil profile types to each mapped geologic unit. The six UBC soil profile types (S_A through S_F) are listed in Table 1, which is taken from the 1997 UBC, volume 2, Table 16-J and Section 1636.2. Section 1636 also defines average shear-wave velocity, average field standard penetration resistance, and average undrained shear strength. The assignment was based on the previously mapped and measured geologic and soil properties and on shear-wave velocities measured on the unit or on similar units. No new field investigations were performed.

(Continued on page 78)

Preliminary sample of map of Oregon UBC soils.

Table 1. UBC soil profile types. From International Conference of Building Officials (1997), v. 2, p. 23 and 30

SOIL PROFILE TYPE	SOIL PROFILE NAME/GENERIC DESCRIPTION	AVERAGE SOIL PROPERTIES FOR TOP 100 FEET (30 480 mm) OF SOIL PROFILE		
		Shear Wave Velocity, $\bar{v}_s$ feet/second (m/s)	Standard Penetration Test, $\bar{N}$ [or $\bar{N}_{CH}$ for cohesionless soil layers] (blows/foot)	Undrained Shear Strength, $\bar{s}_u$ psf (kPa)
S_A	Hard Rock	> 5,000 (1,500)	—	—
S_B	Rock	2,500 to 5,000 (760 to 1,500)		
S_C	Very Dense Soil and Soft Rock	1,200 to 2,500 (360 to 760)	> 50	> 2,000 (100)
S_D	Stiff Soil Profile	600 to 1,200 (180 to 360)	15 to 50	1,000 to 2,000 (50 to 100)
S_E[1]	Soft Soil Profile	< 600 (180)	< 15	< 1,000 (50)
S_F	Soil Requiring Site-specific Evaluation. See Section 1629.3.1.			

[1] Soil profile type S_E also includes any soil profile with more than 10 ft (3,048 mm) of soft clay defined as soil with a plasticity index $PI > 20$, $w_{mc} \geq 40$ percent and $s_u < 500$ psf (24 kPa). The plasticity index PI and the moisture content w_{mc} shall be determined in accordance with approved national standards.

[2] Soil profile type S_F includes:

1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils.
2. Peats and/or highly organic clays [H > 10 ft. (3,048 mm) of peat and/or highly organic clay where H = thickness of soil].
3. Very high plasticity clays [H > 25 ft. (7,620 mm) with PI > 75].
4. Very thick soft/medium stiff clays [H > 120 ft. (36,580 mm)].

If the site corresponds to any of these criteria, the site shall be classified as Soil Profile Type S_F and a site-specific evaluation shall be conducted.

Table 2. *Sample of table for UBC Soil Profile Types. After Walker and MacLeod (1991) and U.S. Department of Agriculture, 1975*

Geologic units[1] 1 = with, 0 = without influence from SCS soils		Base value[3]	SCS soil units.[2] 1 = with, 0 = without influence on UBC soil type designation																								
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
			1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Coast Range and Klamath Mountains																											
Qal	**0**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Qls	**0**	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Qt	**1**	3	4	4	4	3	3	3	3	3	4	4	4	3	3	3	3	3	3	4	4	3	3	3	3	3	3
Tc	**0**	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Tms	**1**	3	4	4	4	3	3	3	3	3	4	4	4	3	3	3	3	3	3	4	4	3	3	3	3	3	3
Cascade Range																											
Qyb	**1**	2	3	3	3	2	2	2	2	2	3	3	3	2	2	2	2	2	2	3	3	2	2	2	2	2	2
Qmp	**1**	3	4	4	4	3	3	3	3	3	4	4	4	3	3	3	3	3	3	4	4	3	3	3	3	3	3
Qs	**0**	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Tn	**1**	2	3	3	3	2	2	2	2	2	3	3	3	2	2	2	2	2	2	3	3	2	2	2	2	2	2
Thi	**1**	1	2	2	2	1	1	1	1	1	2	2	2	1	1	1	1	1	1	2	2	1	1	1	1	1	1
Eastern Oregon (northern Basin and Range, Blue Mountains, and Deschutes Plateau)																											
Qpl	**0**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Ql	**0**	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Ts	**1**	3	4	4	4	3	3	3	3	3	4	4	4	3	3	3	3	3	3	4	4	3	3	3	3	3	3
Tbas	**0**	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
KJi	**0**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

[1] Refer to Table 3 for geologic unit descriptions.
[2] Refer to Table 4 for SCS soil unit descriptions.
[3] Assigned UBC soil type based on geologic unit only.

(Continued from page 75)

In using surficial geologic units to assign the UBC soil types, we assumed that for each geologic unit and assigned UBC soil type the range of shear-wave velocities falls within the range of defined velocities for that UBC soil type. In some cases, this assumption will be erroneous due to the mixed nature of the geologic unit. For example, a single alluvial unit may consist of point bar gravels (producing higher velocities), crevasse splay sands (producing intermediate velocities), and overbank fines (producing slower velocities) and could have several UBC soil types assigned to it. However, the map scale we were using did not allow work to be conducted at this level of detail. Furthermore, while it is possible for a thin unit to overlie a unit with much different characteristics, it was considered to be outside the scope of this project to address the thickness dimension to this degree of detail.

In cases where the properties of a geologic unit fell on the boundary between two UBC soil types, we used the SCS agricultural soil map to further differentiate the unit. Geologic units overlain by a mantle of thick, deeply weathered, clay-rich soils were assigned a value one step higher than the same geologic units with poorly developed soil horizons.

For example, geologic unit Qt (Holocene and Pleistocene terrace gravels) is variable enough to span the boundary between two UBC soils—in this case, S_C (soft rock and very dense soil) and S_D (stiff soil). In an attempt to make this distinction, we used the SCS agricultural soil map to assign a higher value if the deposit occurred in an area associated with thick, deeply weathered soils, such as are common in the wetter and higher parts of the state, and a lower value in regions characterized by poorly developed soils, such as deserts.

To define the UBC soil profile type, we constructed a table (sample portion in Table 2). The (horizontal) rows of the table list all surficial geologic units as represented on the *Geologic Map of Oregon* (Walker and MacLeod, 1991) but simplified to show each unit only once (abbreviated descriptions of these geologic units in Table 3). The columns of the table represent the major SCS soil groups (A through Y) as mapped on the *General Soil Map, State of Oregon* (U.S. Department of Agriculture, 1995) (descriptions in Table 4). They are preceded by a column indicating the basic UBC soil designation that is derived from an evaluation of the geologic unit before including SCS soil designations in that evaluation. The numbers "1" and "0" adjacent to the geologic units (rows) and agricultural soil types (columns) represent, respectively, "influence" and "no influence" of the SCS soil designations on the UBC soil designations of the geologic units.

The matrix of the table presents the numerical results of the UBC soil assignment, with 1 = S_A, 2 = S_B, and so on, down to 6 = S_F For example, unit Qd (Holocene sand dune deposits) typically consists of well-sorted, slightly indurated sand with a shear-wave velocity of about 250 m/s. This places the unit in UBC soil category 4 = S_D (stiff soil). By contrast, unit Tc (Miocene Columbia River Basalt Group and related flows) has a shear-wave velocity of about 1,110 m/s, which places it in UBC soil profile type 2 = S_B (rock).

How to read the table matrix is demonstrated in the following example of unit Qt (terrace deposits), which occupies row 4. The "1" adjacent to the unit designation indicates that certain SCS agricultural soil types affect the basic UBC soil type designation. The "3" in the next column indicates that UBC soil type S_C was initially assigned to the unit as basic designation. As you read across the row, you will find that the number is changed to "4" in those columns referring to SCS soils whose presence influences the UBC soil profile type designation—as indicated by the "1" adjacent to the SCS soils column headings. In contrast, columns with the number "3" in this row mean that the basic UBC soil type designation remained unaffected by the presence of SCS agricultural soils—as indicated by the "0" adjacent to the column headings.

All occurrences of unit Qls (Holocene and Pleistocene landslide and debris flow material) were designated as UBC soil type 6 = S_F While many landslides may not meet the stated description of S_F ("soils vulnerable to potential failure or collapse under seismic loading, such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils"), we feel that mapped landslides require site-specific studies due to potential reactivation of the landslide mass.

UBC soil type 5 = S_E (soft soil) was assigned to all occurrences of unit Qal (Quaternary alluvium). This choice is appropriate in most places, but in some cases, the active alluvium is probably more properly classified as S_F S_D, or even S_C.

For one unit in south-central Oregon, we chose to change the UBC soil type designation in a nonsystematic way: Geologic unit Qs (Pleistocene lacustrine and fluvial sediments) is designated in the table as 4 = S_D (stiff soil), which is consistent with its average character throughout the state. However, in the large closed basins of south-central Oregon, the unit contains large amounts of fine-grained, water-saturated lacustrine sediments and thus should be 5 = S_E (soft soil). Consequently, we selectively changed unit Qs outcrops from S_D to S_E in places around the Klamath and Harney basins. Because these outcrops of unit Qs are quite large and contain a wide variety of material, this choice probably overstates the amount of S_E in the area. At the scale of the existing 1:500,000 geologic map, it is not possible to define each location separately. In this single case, however, it was considered prudent to override the systematic approach and change the individual units.

Finally, a 1-km-wide S_F zone was placed around all

Table 3. *Oregon geologic units and abbreviated descriptions from Walker and MacLeod (1991) for selection of geologic units listed in Table 2*

	Coast Range and Klamath Mountains
Qal	**Alluvial deposits (Holocene)**—Sand, gravel, and silt forming flood plains and filling channels of present streams. In places includes talus and slope wash. Locally includes soils containing abundant organic material, and thin peat beds
Qls	**Landslide and debris-flow deposits (Holocene and Pleistocene)**—Unstratified mixtures of fragments of adjacent bedrock. Locally includes slope wash and colluvium. May include some deposits of late Pliocene age
Qt	**Terrace, pediment, and lag gravels (Holocene and Pleistocene)**—Unconsolidated deposits of gravel, cobbles, and boulders intermixed and locally interlayered with clay, silt, and sand. Mostly on terraces and pediments above present flood plains.
Tc	**Columbia River Basalt Group and related flows (Miocene)**—Subaerial basalt and minor andesite lava flows and flow breccia; locally includes invasive basalt flows. Flows locally grade laterally into subaqueous pillow-palagonite complexes and bedded palagonitic tuff and breccia. In places, includes tuffaceous sedimentary interbeds. Joints commonly coated with nontronite and other clayey alteration products. Occurs principally in the Willamette Valley from Salem north to the Columbia River, and in the northern Coast Range
Tms	**Marine sedimentary rocks (middle and lower Miocene)**—Fine- to medium-grained marine siltstone and sandstone that commonly contains tuff beds. Includes the Astoria Formation, which is mostly micaceous and carbonaceous sandstone and the middle Miocene Gnat Creek Formation, which overlies Frenchman Springs Member of the Wanapum Basalt east of Astoria
	Cascade Range
Qyb	**Youngest basalt and basaltic andesite (Holocene)**—Little-modified flows and associated breccia of basaltic andesite and some basalt in both central part of Cascade Range and on slopes of Newberry volcano
Qmp	**Mazama pumice deposits (Holocene)**—Primary and reworked air-fall rhyodacite pumice related to climactic eruptions of Mount Mazama
Qs	**Lacustrine and fluvial sedimentary rocks (Pleistocene)**—Unconsolidated to semiconsolidated lacustrine clay, silt, sand, and gravel; in places includes mudflow and fluvial deposits and discontinuous layers of peat.
Tn	**Nonmarine sedimentary rocks (Eocene)**—Continentally derived conglomerate, pebble conglomerate, sandstone, siltstone, and mudstone containing abundant biotite and muscovite. Dominantly nonvolcanic; clastic material derived from underlying older rocks
Thi	**Hypabyssal intrusive rocks (Miocene and Miocene?)**—Hypabyssal, medium-grained, hornblende diorite and quartz diorite in small stocks and large dikes; includes intrusions of medium- to fine-grained gabbro and plugs and small stocks of medium-grained, holocrystalline, olivine andesite. Also includes medium-grained, commonly porphyritic biotite quartz monzonite and leucocratic granodiorite. Many of these intrusive bodies are moderately to intensely propylitized, as are wallrocks they intrude; locally, along shears, the rocks also are sericitized
	Eastern Oregon (northern Basin and Range, Blue Mountains, and Deschutes Plateau)
Qpl	**Playa deposits (Holocene)**—Clay, silt, sand, and some evaporites
Ql	**Loess (Holocene and Pleistocene)**—Windblown clayey silt and fine sand. Includes the Pleistocene Palouse Formation and deposits derived mostly from reworking of Palouse Formation. Contains local interbedded layers of soil, caliche, and some water-laid silt and gravel
Ts	**Tuffaceous sedimentary rocks and tuff (Pliocene and Miocene)**—Semiconsolidated to well-consolidated mostly lacustrine tuffaceous sandstone, siltstone, mudstone, concretionary claystone, pumicite, diatomite, air-fall and water-deposited vitric ash, palagonitic tuff and tuff breccia, and fluvial sandstone and conglomerate. In places, includes layers of fluvial conglomerate and, in parts of the Deschutes-Umatilla Plateau, extensive deposits of fanglomerate composed mostly of Miocene basalt debris and silt. Also includes thin, welded and nonwelded ash-flow tuffs
Tbas	**Andesitic and basaltic rocks on Steens Mountain (Miocene)**—Lava flows and breccia of aphyric and plagioclase porphyritic basalt and aphyric andesite
KJi	**Intrusive rocks (Cretaceous and Jurassic)**—Hornblende and biotite quartz diorite (tonalite), trondhjemite, granodiorite, and small amounts of norite, in batholithic masses and large dikelike bodies

bodies of water large enough to be shown on the 1:500,000-scale map. In many places, this is reasonable because swampy, organic-rich material often occurs on the edge of bodies of water, and such material is categorized as S_F However, some bodies of water, especially west of the Cascade Range, are bounded by firm materials (such as bedrock) with only a thin soil veneer. Such is also the case with most reservoirs.

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DISCLAIMER

The views and conclusions contained in this map are those of the authors and should not be interpreted as necessarily representing official state policies. The map serves as a tool for regional applications. The map does not have site-specific accuracy and should not be used for site-specific purposes.

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Table 4. – SCS soil units from U.S. Department of Agriculture (1975)

A	Udic isomesic soils of the coastal fog belt
B	Udic mesic soils on terraces and flood plains of western Oregon
C	Udic mesic soils on forested uplands of the coastal and Cascade mountains
D	Udic frigid and cryic soils on forested uplands of the coastal and Western Cascade mountains
E	Udic cryic soils of the High Cascade and Wallowa mountains
F	Xeric cryic soils of the high plateaus and mountains in south-central and southeastern Oregon
G	Xeric cryic soils on pumice-mantled, forested plateaus
H	Aquic frigid and cryic soils of basins and valleys in eastern Oregon
I	Xeric mesic soils on terraces and flood plains of western Oregon interior valleys
J	Xeric mesic soils on forested uplands of western Oregon
K	Xeric mesic soils on forested mountains and hills of southwestern Oregon
L	Xeric mesic soils on flood plains and terraces of eastern Oregon valleys
M	Xeric mesic soils on grass-shrub uplands of eastern Oregon
N	Xeric frigid soils on forested mountains of southwestern Oregon
O	Xeric frigid soils on forested mountains and plateaus of eastern Oregon
P	Xeric frigid soils on terraces and flood plains of eastern Oregon
Q	Xeric frigid soils on grass-shrub uplands of eastern Oregon
R	Xeric/aridic mesic soils on terraces and flood plains of eastern Oregon
S	Xeric/aridic mesic soils on grass-shrub uplands of eastern Oregon
T	Xeric/aridic frigid soils on grass-shrub uplands of eastern Oregon
U	Aridic/xeric mesic soils on flood plains and terraces of eastern Oregon
V	Aridic/xeric mesic soils on grass-shrub uplands of eastern Oregon
W	Aridic/xeric frigid soils on terraces and in basins of eastern Oregon
X	Aridic/xeric frigid soils on plateaus and uplands of eastern Oregon
Y	Lava flows

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OCAPA honors Gary Lynch

The Oregon Concrete and Aggregate Producers Association (OCAPA) thanked DOGAMI Mined Land Reclamation (MLR) Program Supervisor Gary Lynch by presenting him with the association's President's Award. The OCAPA award is given to someone who has helped the association greatly. It is usually awarded to an association member.

MLR program supervisor Lynch was chosen this year because of his work in helping the association with a number of difficult issues, including key legislative bills, projects involving the confluence of the McKenzie and Willamette Rivers, and issues concerning Goal 5 of the Land Conservation and Development Commission.

Association President Rich Angstrom presented Lynch with the award and said that Lynch's style of rewarding good work was a great help in raising standards in the industry. A good example of that, he added, were the MLR awards for outstanding mining practices and reclamation.

Lynch was surprised by the recognition, saying he was just doing his job. He credited the entire MLR staff for developing a positive working relationship with the industry while maintaining Oregon's high standards for mining and reclamation. □

Age, chemistry, and origin of capping lava at Upper Table Rock and Lower Table Rock, Jackson County, Oregon

by Frank R. Hladky, Oregon Department of Geology and Mineral Industries, 5375 Monument Drive, Grants Pass, Oregon 9797526

ABSTRACT

Upper Table Rock and Lower Table Rock, prominent landmarks in southern Oregon, are capped by the upper Miocene andesite of Table Rock. This capping lava is lithologically and chemically distinct from other lavas in the Cascade Range of southern Oregon. In particular, the lava is more alkaline. The unit varies in thickness, from a maximum of 220 m (730 ft) at Lost Creek Lake, to about 30–60 m (100–200 ft) at the buttes north of Medford. Isotopic ages indicate that the lava was erupted most likely about 7 Ma. It spread over terrain of variable relief. The lava flow was not confined to the channel of the ancestral Rogue River, but spread like a sheet over much of the ancient valley of the Rogue River and its tributaries. The present shape of the two buttes is the result of erosion. Since the andesite of Table Rock was emplaced, faulting is known to have displaced the unit west of Lower Table Rock. Source vents for the andesite of Table Rock have not been discovered. They are most likely covered by younger lavas. Chemical data indicate a compositional link with younger alkaline lavas at Olson Mountain, a broad, extinct shield volcano near Lost Creek Lake. The andesite of Table Rock is more similar to lavas at Olson Mountain than to lavas from stratovolcanoes of the High Cascades, formerly considered to be the source for the andesite of Table Rock.

INTRODUCTION

North of Medford in southern Oregon are two prominent, horseshoe-shaped, flat-topped buttes: Upper Table Rock and Lower Table Rock (Figure 1). Southern Oregon residents often refer collectively to the buttes as the Table Rocks. The buttes are located near the Rogue River between Sams Valley and Central Point. The unincorporated community of Table Rock is located between the two buttes. Unlike the surrounding rounded hills, the buttes have vertical cliff faces in their upper portions that change abruptly to flat tops at their summits. The buttes stand more than 240 m (800 ft) above the valley floor and owe their distinctive morphology to a cliff-forming cap of upper Miocene lava that overlies sandstone, conglomerate, and mudstone of the upper Eocene Payne Cliffs Formation. The capping trachyandesitic lava is exposed at Upper Table Rock, Lower Table Rock, Castle Rock, and at several places near the Rogue River upstream from Upper Table Rock. Collectively, these exposures compose the andesite of Table Rock. The andesite of Table Rock was erupted from vents in

Figure 1. View to the southeast showing Upper Table Rock (left) and Lower Table Rock (right). Sams Valley is in the foreground.

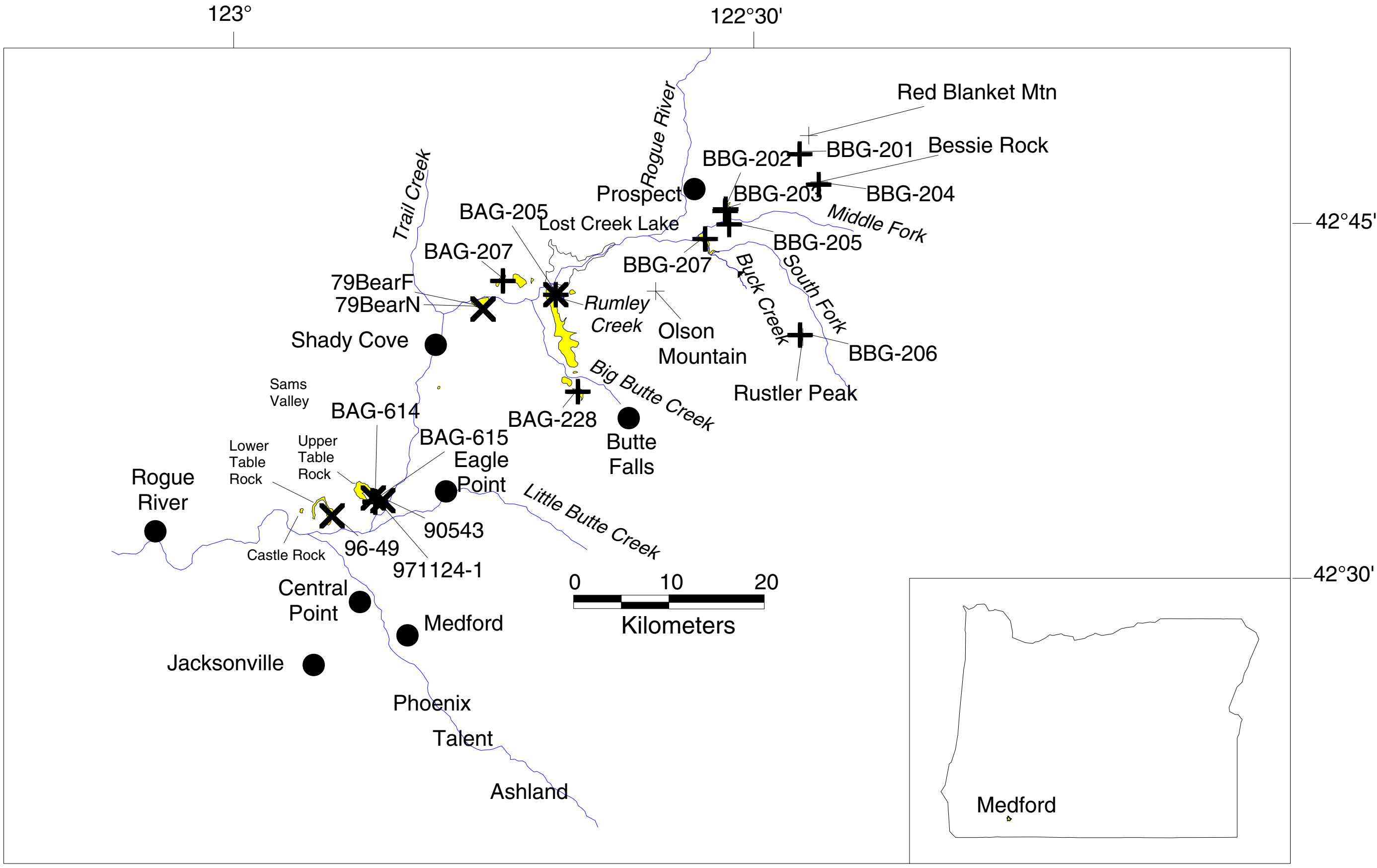

Figure 2. Sketch map showing location of the study area, outcrops of the andesite of Table Rock (stippled areas), whole-rock samples (marked by "+"; analyses in Tables 1–3), and samples used for isotopic age determinations(marked by "×"; analyses in Table 4.

the Cascade Range of southern Oregon probably about 7 Ma. The source is thought to lie near Olson Mountain, a large extinct shield volcano southeast of Lost Creek Lake and south-southwest of Prospect, Oregon.

Previous investigators noted the capping lava at Upper Table Rock and Lower Table Rock and recognized that its source lay in the Cascade Range (Winchell, 1914; Wells, 1939; 1956; Williams, 1942; Beaulieu and Hughes, 1977;. Smith and others, 1982; Hladky, 1993; Wiley and Smith, 1993). Exposures of trachyandesite crop out intermittently along the valley and canyon of the Rogue River and overlie older rocks of the Western Cascades. The easternmost exposures of andesite of Table Rock are east of Prospect in the High Cascades, a geomorphic subprovince of the Cascade Range dominated by slightly to moderately eroded shield and stratovolcanoes that are mostly less than 2 million years old (Sherrod and Smith, 1989). The westernmost bedrock exposure is found on top of a small hill, known locally as Castle Rock, west of Lower Table Rock (Figure 2). Northwest of Castle Rock residual cobbles of andesite of Table Rock are found as far west as the western edge of Sams Valley along State Highway 234.

LITHOLOGY AND PETROGRAPHY

The andesite of Table Rock is a distinctive, plagioclase-speckled, dark-gray to black, glassy rock that typically crops out as poorly shaped pseudo-hexagonal columns. The conspicuous tabular feldspar, as large as 0.5 by 6 mm, has been determined petrographically to be mostly oligoclase, a variety of plagioclase. It varies in abundance from 10 to 30 percent, although its abundance decreases virtually to zero near chilled margins. The normative plagioclase composition, or theoretical composition based upon chemical analyses of the whole rock, is An_{32-38} (andesine). Olivine and augite phenocrysts are typically small (up to 1 mm) and usually each comprise less than 2 or 3 percent of the rock. The olivine is often iddingsitized either partially or completely. Phenocrysts of equant alkali feldspar (up to 3 mm), most easily identifiable in thin section, are also present. The groundmass comprises brown to black glass, and tiny andesine and labradorite laths, magnetite and hematite, hexagonal apatite, and orthopyroxene.

There is little petrographic variability in the unit except near chilled margins, where the lava cooled against adjacent soil and bedrock. Hand samples and thin sections of the unaltered rock are comparable, whether taken from the Table Rocks or from the canyon of the South Fork Rogue River in the High Cascades. Plagioclase phenocrysts can be white or nearly translucent, depending upon local weathering, but they characteristically stand out against the black, glassy groundmass. As might be expected, the abundance of phenocrysts of all types decreases near chilled margins. The rock commonly contains as much as 5 percent vesicles as large as 1 cm near chilled margins.

As the andesite of Table Rock cooled, it contracted to produce two distinct patterns of columnar jointing. Columnar jointing in solidified lavas consists of parallel, prismatic columns, either hexagonal or pentagonal in cross section. Two zones of jointing occur in the andesite of Table Rock: the colonnade and the entablature. Columns in the colonnade, the zone of jointing that has thicker, more regular columns than the entablature, are typically 30–45 cm (12–18 in.) across. In the canyon of the South Fork Rogue River, however, the colonnade contains some moderately well-formed columns slightly more than 200 cm (80 in.) across (Figure 3). Columns in the colonnade are observed to be mostly perpendicular to the ancient land surface. The colonnade is typically in the middle of the unit; however, at the Table Rocks, the colonnade is intermittently found near the bottom. The entablature is the most common jointing pattern of the andesite of Table Rock. In the entablature, columns are poorly formed and typically about 15 cm (6 in.) across. They are also more chaotically oriented than in the colonnade. The unit shows vesiculation locally near its top and bottom and commonly where entablature meets colonnade.

In a roadcut exposure along Highway 62 in NW¼ sec. 35, T. 35 S., R. 1 E., south of Lost Creek Dam, is what is interpreted to be an autoclastic flow breccia. It is up to 8 m (25 ft) thick. Autoclastic flow breecia develops when chunks of solid and semi-molten lava calve off the edges of the lava flow; the advancing flow then overrides its breccia. In some places at Upper Table Rock the basal 2 m (6 ft) of the flow is commonly partially palagonitized and scoriaceous, having been in contact with water when the rock was molten. Similar palagonitized scoria is found in some basal outcrops between Shady Cove and Lost Creek Lake.

The thickness of the andesite of Table Rock varies from place to place. The maximum cumulative thickness the unit attains is about 220 m (730 ft) on the south bank of Lost Creek Lake. Paleosols and other indicators of depositional breaks indicating multiple flows have not been found. Because of talus and soil cover, no more than about 40 m (130 ft) of continuously uncovered section is exposed—except at Lost Creek Dam quarry, where about 60 m (200 ft) is exposed. The typical thickness of the andesite of Table Rock between Shady Cove and Olson Mountain ranges between 130 and

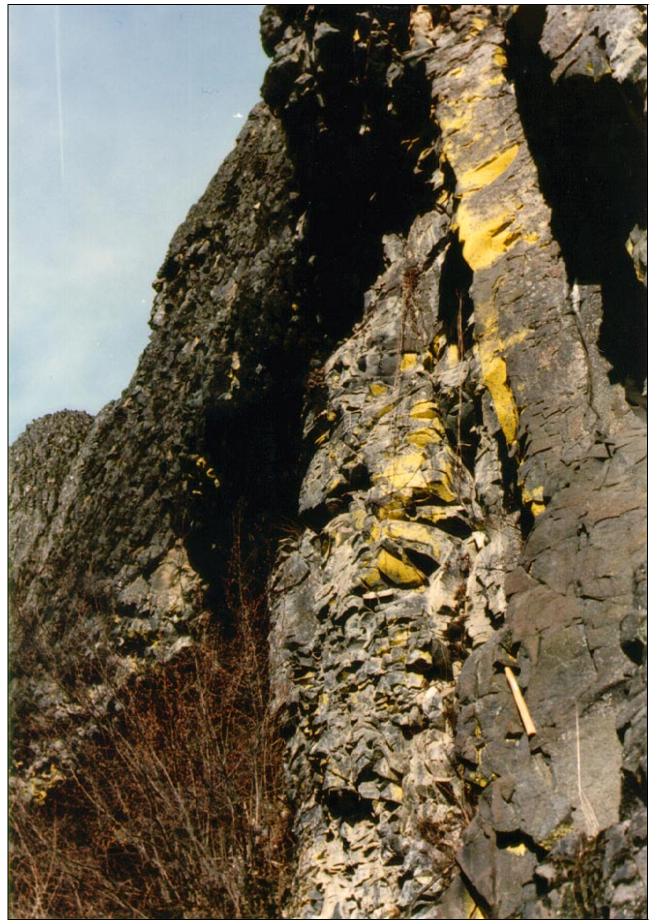

Figure 3. As the andesite of Table Rock cooled, joints produced the smaller, poorly formed columns of the entablature (top and left sides of photo) and the larger columns of the colonnade (right and lower parts of photo). Hammer at lower right is approximately 40 cm long.

180 m (400 and 600 ft). In this area, outcrops of the andesite of Table Rock occur at and near the top of the canyon on either side of the present Rogue River, and the unit is thickest toward the river (inferred center of the flow). Near the course of present-day Big Butte Creek, the unit averages about 130 m (400 ft) in thickness and crops out over a wide area. More than 80 m (260 ft) of andesite of Table Rock was measured in the canyon of the South Fork Rogue River east of Olson Mountain; however, the base is not exposed there. About 50 percent of the section in the South Fork is covered by soil or talus. The maximum thickness at Upper Table Rock and Lower Table Rock is about 60 m (200 ft), but talus typically covers about 20 m (65 ft) of section. In general, the unit is thought to be thickest near its source and thinnest nea flow margins and north of Medford, where it is most distant from its source.

DISTRIBUTION

Today, outcrops, boulder trails, and monoliths of the andesite of Table Rock extend from east of Prospect in

Table 1. *Whole-rock analyses from the andesite of Table Rock, Jackson County, Oregon. Unless otherwise noted, all data are new. Samples BAG-205 and BAG-207 originally reported in Hladky (1993). Samples BAG-614 and BAG-615 originally reported in Wiley and Smith (1993).* (Continued on opposite page ➤)

Sample number	¼	¼	Sec.	T. (S.)	R.	UTM coordinates	Elev. (ft)	Location description	Lithology
BAG-205	SE	NE	35	33	1 E.	4723081N 527706E	2,480	Lost Creek Dam quarry	Trachyandesite
BAG-207	SE	NW	29	33	1 E.	4724497N 522173E	2,560	Schoolhouse Rock/Elk Ridge	Trachyandesite
BAG-228	NW	SW	31	34	2 E.	4712985N 530046E	2,220	Butte Falls Highway	Basaltic trachyandesite
BAG-614	NW	SW	1	36	2 W.	4701445N 508860E	2,030	Top of Upper Table Rock	Trachyandesite
BAG-615	NW	SW	1	36	2 W.	4701412N 508872E	1,920	Flow base, Upper Table Rock	Trachyandesite
BBG-202	NW	SE	34	32	3 E.	4732080N 545405E	2,680	Borrow Pit	Weathered trachyandesite
BBG-203	NW	SE	34	32	3 E.	4731895N 545345E	2,620	Middle Fork Rogue River	Trachyandesite
BBG-207	NE	SW	9	33	3 E.	4728975N 543265E	2,560	South Fork Rogue River	Trachyandesite
971124-1	SE	SE	2	36	2 W.	4701830N 508650E	2,020	Near top, Upper Table Rock	Trachyandesite
96-49	NE	SW	9	36	2 W.	4699960N 504340E	2,045	Top of Lower Table Rock	Trachyandesite

Table 2. *Whole-rock analyses of rocks taken from selected ancient High Cascade volcanoes that were mapped by Smith and others (1982) as the same unit as the andesite of Table Rock but, in fact, overlie the andesite of Table Rock. These areas were formerly thought to be possible sources.* (Continued on opposite page ➤)

Sample number	¼	¼	Sec.	T. (S.)	R.	UTM coordinates	Elev. (ft)	Location description	Lithology
BBG-201	NW	NE	16	32	4 E.	4737885N 553080E	4,980	Red Blanket Mountain quarry	Andesite
BBG-204	NE	NE	27	32	4 E.	4734710N 555075E	5,690	Bessie Rock	Basaltic andesite
BBG-205	NE	SE	3	33	3 E.	4730495N 545775E	2,750	Middle Fork quarry	Basaltic andesite
BBG-206	SW	SE	9	34	4 E.	4719025N 553265E	5,490	Rustler Peak	Andesite

Table 3. *Whole-rock analyses of rocks taken from Olson Mountain that overlie the andesite of Table Rock. Originally reported in Hladky (1993).* (Continued on opposite page ➤)

Sample number	¼	¼	Sec.	T. (S.)	R.	UTM coordinates	Elev. (ft)	Location description	Lithology
BAG-224	NE	NW	36	33	1 E.	4723203N 528711E	2,200	Andesite along HWY 62	Trachybasalt
BAG-229	NW	SE	1	34	1 E.	4720853N 528853E	2,600	Andesite of Olson Mtn	Basaltic trachyandesite

the High Cascades to the east edge of the Klamath Mountains at Sams Valley, a distance of approximately 70 km (44 mi). The andesite of Table Rock overlies rocks of late Miocene, Oligocene, Eocene, and Mesozoic age (Hladky, 1993; Wiley and Smith, 1993)—a result of having traversed the course of the ancestral Rogue River during Miocene time. The andesite of Table Rock probably emanated from near Prospect and Olson Mountain and was subsequently buried beneath lavas of Olson Mountain and High Cascades volcanoes. The easternmost exposures crop out above the confluence of the Middle and South Forks of the Rogue River. In both forks the base is covered and the thickness exceeds 80 m (265 ft).

These easternmost exposures of the andesite of Table Rock are overlain by younger basaltic andesite and andesite lavas of Red Blanket Mountain and Bessie Rock; the age of Bessie Rock is about 4.88 Ma (Fiebelkorn and others, 1983). To the west, at Olson Mountain (Figure 2), younger lava flows of light-gray basalt and basaltic trachyandesite overlie the andesite of Table Rock near Lost Creek Lake (Hladky, 1993). At Lost Creek Lake (Figure 2), where thicknesses average 180 m (600 ft), a narrow exposure crops out in Rumley Creek 2 to 8 m (25 ft) below the spillway elevation, about 75 m (250 ft) below where it was mapped by Hladky (1993), making the maximum thickness there about 220 m (730 ft). There, the andesite of Table Rock fills a narrow paleochasm.

Outcrops of the andesite of Table Rock are found as far south as Butte Falls highway west of Butte Falls (Figure 2). The preserved thickness of bedrock exposures of the ancient lava flow near its western terminus at Castle Rock is about 45 m (150 ft) (Figure 2). Near Lost Creek Lake, the andesite of Table Rock unconformably overlies lower Miocene andesite. Between Shady Cove and Lost Creek Dam, flow remnants on either side of the Rogue River canyon walls thicken toward the river. Between Shady Cove and Upper Table Rock, detailed mapping has revealed only one intact outcrop of andesite of Table Rock. In the same stretch, however, a few monoliths of andesite of Table Rock can be found, most of them near Upper Table Rock. The monoliths are typically several meters across and are the residuum of erosion; they are not attached to bedrock. The horse-shaped buttes of Upper Table Rock and Lower Table Rock owe their existence to the resistant capping

Table 1 (continued). *Analyses by X-ray fluorescence (XRF) performed by X-Ray Assay Laboratories (XRAL), Don Mills, Ontario, Canada, except for sample 96*-49, whose data were supplied by Stanley Mertzman (unpublished data, 1998). For sample locations, see Figure 2

	Oxides (weight percent)												Selected trace elements (ppm)						
Sample no.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3T	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	LOI	SUM	Cr	Rb	Sr	Y	Zr	Nb	Ba
BAG-205	57.1	16.5	1.34	7.96	0.15	5.75	2.65	2.28	4.46	0.61	1.05	100.1	16	25	734	29	174	36	796
BAG-207	57.4	16.3	1.34	7.82	0.15	5.29	2.67	2.71	4.20	0.62	0.30	100.0	13	38	698	30	195	27	883
BAG-228	55.0	16.9	1.32	8.56	0.15	6.73	3.7	2.22	4.1	0.61	0.60	100.1	44	41	702	17	164	<10	696
BAG-614	56.7	17.0	1.32	7.67	0.15	5.81	2.71	2.36	0.51	0.62	0.25	100.3	74	35	712	27	172	25	776
BAG-615	56.5	17.1	1.31	7.75	0.14	5.93	2.86	2.17	0.52	0.59	0.50	100.6	76	37	731	33	172	15	782
BBG-202	57.9	17.2	1.14	7.15	0.11	4.86	1.56	2.64	0.59	0.50	0.20	100.1	<10	50	712	33	211	46	928
BBG-203	55.9	16.9	1.25	7.85	0.15	6.14	2.77	2.23	0.18	0.64	0.95	100.2	<10	44	767	14	179	45	907
BBG-207	56.2	16.7	1.25	8.03	0.16	6.05	2.72	2.44	0.98	0.66	0.05	100.5	<10	25	721	28	182	17	880
971124-1	56.5	16.3	1.25	7.73	0.14	6.08	2.84	2.31	4.71	0.62	1.00	99.7	<10	27	698	24	208	<10	815
96-49	57.6	16.8	1.28	7.27	0.14	5.69	2.63	2.46	4.35	0.59	1.32	100.3	25	26	672	29	184	10	866

Table 2 (continued).
For sample locations, see Figure 2

	Oxides (weight percent)												Selected trace elements (ppm)						
Sample no.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3T	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	LOI	SUM	Cr	Rb	Sr	Y	Zr	Nb	Ba
BBG-201	58.4	18.8	0.719	6.57	0.11	5.57	2.67	1.18	3.82	0.17	2.1	100.3	<10	22	872	<10	81	18	409
BBG-204	56.3	16.8	0.627	7.43	0.13	8.06	6.2	0.85	3.63	0.13	0.05	100.4	20	22	829	<10	40	15	284
BBG-205	51.4	17.4	0.956	8.87	0.16	9.12	5.84	0.73	2.98	0.36	2.1	100.1	<10	13	999	12	82	20	350
BBG-206	61.5	18.0	0.517	5.17	0.11	5.42	1.88	1.35	4.57	0.22	1.55	100.5	<10	18	1,050	<10	86	<10	479

Table 3 (continued).
Data indicate compositional similarity to the andesite of Table Rock

	Oxides (weight percent)												Selected trace elements (ppm)						
Sample no.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3T	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	LOI	SUM	Cr	Rb	Sr	Y	Zr	Nb	Ba
BAG-224	50.2	17.6	1.50	11.3	0.18	8.24	4.43	1.44	3.73	0.77	0.75	100.4	94	30	902	29	166	19	627
BAG-229	52.9	17.3	1.31	9.77	0.22	7.46	3.89	1.76	3.97	0.86	0.5	100.2	<10	18	791	38	215	28	939

lava and their shape to erosion. Castle Rock, immediately west of Lower Table Rock, is the westernmost bedrock outcrop. A few large monoliths are located in and near the gravel pits south of Lower Table Rock (Wiley and Smith, 1993). A string of monoliths and cobbles occurs northwest of Castle Rock.

GEOCHEMISTRY

Geochemical data for the andesite of Table Rock and volcanoes that have been suspected as sources are shown in Tables 1, 2, and 3. Whole-rock geochemistry data for andesite of Table Rock are shown in Table 1. Geochemical data from High Cascade volcanoes once mapped as the same unit as the andesite of Table Rock are shown in Table 2. Limited geochemical data from Olson Mountain indicate chemical similarities to the andesite of Table Rock (Table 3).

Previous workers have referred to the distinctive capping lava flow at Upper Table Rock and Lower Table Rock as basalt. Sodic plagioclase, alkali feldspar, pyroxene content, and ratio of alkalis to silica qualify this rock as a trachyandesite (Bates and Jackson, 1987, p. 694; Cox and others, 1979, p. 14). Applying the IUGS classification scheme (Le Bas and Streckeisen, 1991) of silica versus alkali metals to the whole-rock chemical data for rocks in the Cascade Range of southern Oregon shows that the andesite of Table Rock plots conspicuously in the trachyandesite field (Figure 4). One sample is as mafic as basaltic trachyandesite.

The andesite of Table Rock is substantially more alkaline than typical basalt, basaltic andesite, and andesite of the Western Cascades and High Cascades (Figure 4). In addition, the P_2O_5 content of the andesite of Table Rock is substantially higher than in most Cascade rocks of southern Oregon (Figure 5). Chemically similar fine-grained to aphanitic trachybasalt and basaltic trachyandesite lavas at Olson Mountain directly overlie the andesite of Table Rock near Lost Creek Lake and have more P_2O_5. These younger, slightly more mafic, alkaline lavas are only chemically similar. Petrographically, their phenocryst assemblage, when visible, is different. The total alkali-to-silica ratio of the andesite of Table Rock is more similar to lava flows at Olson Mountain than to lava flows in the High Cascades or the Western Cascades (Figure 4). Analyses from High Cas-

(Continued on page 87)

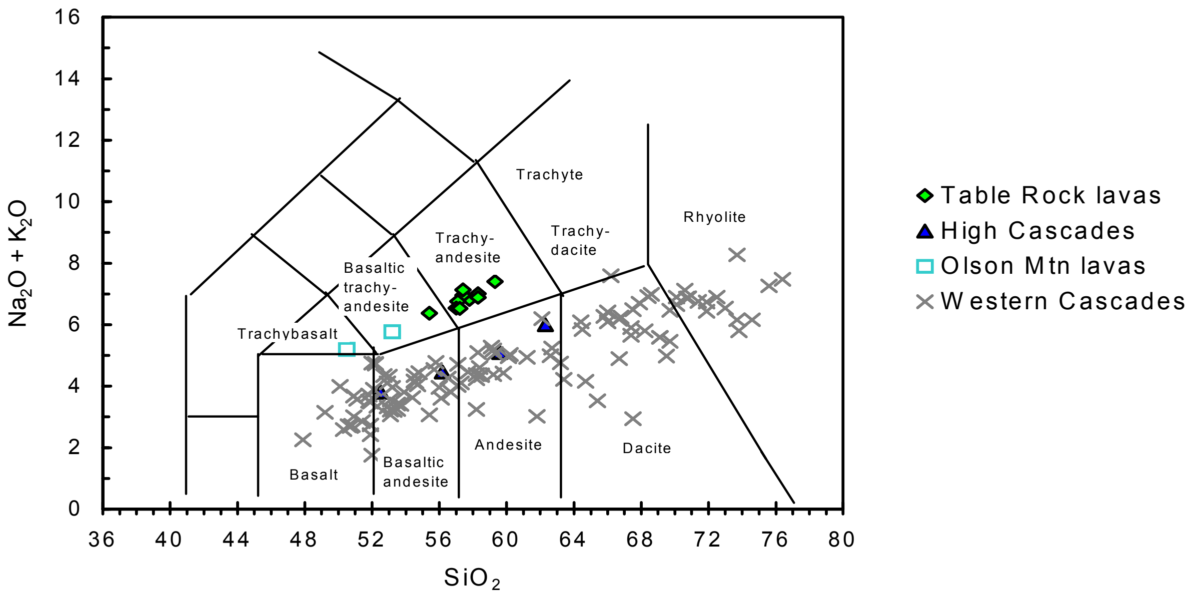

Figure 4. Diagram showing total alkali vs. silica of volcanic rocks of the Cascade Range of southern Oregon. Data from geologic maps of the Shady Cove, McLeod, Lakecreek, Grizzly Peak, Cleveland Ridge, Boswell Mountain, Medford East, Medford West, Eagle Point, and Sams Valley 7½-minute quadrangles, (Hladky, 1992; 1993; 1995, 1996; Wiley and Hladky, 1991; Wiley, 1993; and Wiley and Smith, 1993) and Tables 1–3 of this report. Major oxides were recalculated anhydrous to 100 percent according to the IUGS recommendation of Le Bas and Streckeisen, (1991). Divisions on diagram after Le Bas and others (1986).

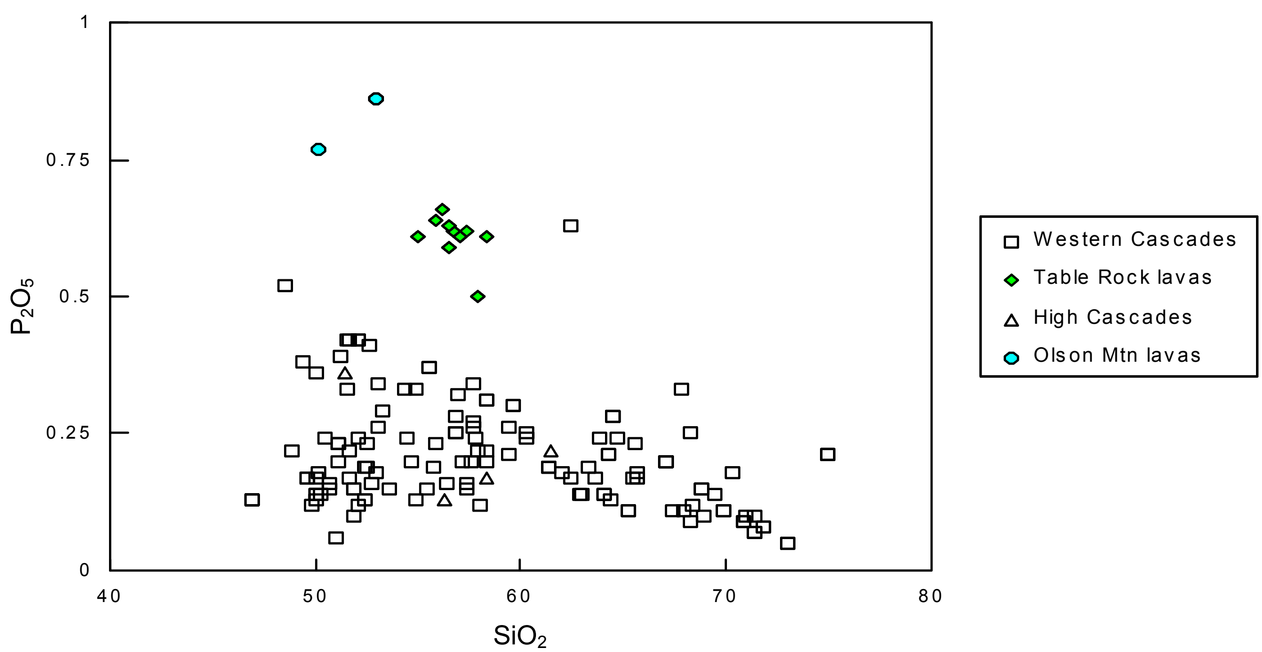

Figure 5. Diagram showing P_2O_5 vs. SiO_2 for volcanic rocks of the Cascade Range of southern Oregon. Data from geologic maps of the Shady Cove, McLeod, Lakecreek, Grizzly Peak, Cleveland Ridge, Boswell Mountain, Medford East, Medford West, Eagle Point, and Sams Valley 7½-minute quadrangles, (Wiley and Hladky, 1991; Hladky, 1992; 1993; 1994, 1996; Wiley, 1993; and Wiley and Smith, 1993) and Tables 1–3 of this report.

(Continued from page 85)

cade volcanoes (Table 2 and Figure 4) are more similar to those from the Western Cascades than to those of the andesite of Table Rock. There is limited trachyandesite in the Western Cascades in the Brownsboro quadrangle southwest of Butte Falls (Hladky, in press a), but these rocks consist of isolated exposures of altered vent agglutinate and tuff and have no petrographic similarity to the andesite of Table Rock.

Trachyandesitic lavas are rare in the Cascade Range of southern Oregon (Figure 4). Rocks with elevated P_2O_5 are also rare in the region. The andesite of Table Rock and alkaline lavas at Olson Mountain contain two to three times as much P_2O_5 as found in most volcanic rocks in the region (Figure 5). The andesite of Table Rock and overlying rocks at Olson Mountain are chemically similar to each other, yet chemically distinct from virtually all other volcanic rocks in the Cascade Range of southern Oregon.

The chemical similarity, stratigraphic relationship, and proximity of alkaline rocks at Olson Mountain to exposures of the andesite of Table Rock indicate that perhaps high-P_2O_5 alkaline lavas were derived from the same or proximally-located magma chambers. If this is so, then the earliest alkaline eruptions at Olson Mountain produced the andesite of Table Rock and later produced slightly more mafic, increasingly P_2O_5-enriched, alkaline lavas.

MAGNETIC POLARITY

The andesite of Table Rock shows normal-polarity magnetization. Numerous determinations were made with the aid of a fluxgate magnetometer at the Lost Creek Dam quarry (Figure 6) and at Upper Table Rock. Results varied greatly near the tops of cliffs at Upper Table Rock, but this is an area where lightning strikes would be expected to modify the thermal remnant magnetic signature of the lava flow. A few meters below the uppermost surface of the butte, both along cliff faces and within crevices, the andesite of Table Rock consistently yielded normal-polarity readings.

AGE

Samples from the andesite of Table Rock have yielded isotopic ages ranging from 6.77 ± 0.2 Ma to 9.6 ± 0.13 Ma (Table 4), i.e., within the late Miocene (Palmer, 1983). The confidence intervals for all of these samples do not overlap, which could indicate the presence of multiple lava flows. An examination of the data, however, shows that one of the analyses is flawed.

Five out of six analyses of the andesite of Table Rock have returned ages of about 7 Ma. Samples 79BearN and 79BearF are two whole-rock analyses from the same site with different ages (Table 4). Fortunately, their confidence intervals overlap. The only difference between the two was in the preparatory treatment of the samples: The thinking was that the glass in the groundmass might be retaining potassium while letting argon slip away, thereby yielding too young an age. For sample 79BearN, the rock was treated in nitric acid only. For sample 79BearF, the rock was treated in nitric acid and hydrofluoric acid which dissolves glass. Investigators thus expected to get an older age from 79BearF which was treated in nitric acid and hydrofluoric acid (Jim Smith, oral communication, 1997). Instead, a slightly younger age was produced. The precision of the results overlap, however, suggesting an age of about 7 Ma.

The age from the Ar-Ar analysis from Lost Creek Dam Quarry (sample BAG-205) is close to that of the samples from Bear Mountain, and overlaps that of sample 79BearN. Even though the Ar-Ar method is newer and supposed to be more accurate, the level of precision is probably overstated. These rocks are probably the same age, and probably from the same flow.

Sample 971124-1 taken recently from Upper Table Rock returned an age of about 7 Ma. The reason for testing this sample was to test the validity of an age obtained several years ago from an Upper Table Rock sample (90643) that yielded an age of 9.6 Ma. Interest-

Figure 6. Looking north at Lost Creek Dam quarry, with Lost Creek Lake in the background. Rock from this quarry was used to construct and face the dam. Magnetic polarity readings here indicated normal magnetization, just as at Upper Table Rock. Sample BAG–205 was obtained from the base of the prominent pinnacle on the left.

Table 4. *Isotopic ages of the andesite of Table Rock, Jackson County, Oregon. All analyses are whole-rock*

Sample number	UTM coordinates[1]	Location description[2]	Method	Reported age (Ma)
90543 [3]	4701560N 509660E [4]	Monolith several meters across near Upper Table Rock, Sams Valley quadrangle	Ar-Ar, incremental heating	9.60 ± 0.13
971124-1	4701830N 508650E	Upper Table Rock, east face, 5 m below top surface, Sams Valley quadrangle	Ar-Ar, incremental heating	7.13± 0.15[5]
BAG-205	4723081N 527706E	Lost Creek Dam quarry, McLeod quadrangle	Ar-Ar, total fusion	7.32 ± 0.08[5]
79BearN	4721570N 520090E [6]	Bear Mountain, Trail quadrangle	K-Ar, whole-rock	7.10 ± 0.2[7]
79BearF	4721570N 520090E [6]	Bear Mountain, Trail quadrangle	K-Ar, whole-rock	6.77 ± 0.2[7]
96-49	4699960N 504340E	Lower Table Rock, top surface	K-Ar, whole-rock	7.7 ± 0.2[8]

[1] UTM coordinates shown for Zone 10, North American datum 1927.

[2] Quadrangles are U.S. Geological Survey 7.5-minute series topographic sheets.

[3] Sample collected by Clifton Mitchell (formerly University of Oregon), analysis by R.A. Duncan (Oregon State University).

[4] Approximate location described by Gerry Capps (BLM, oral communication, 1993) and Wiley and Smith (1993).

[5] New data. Analysis by R. A. Duncan.

[6] Latitude/longitude coordinates from Fiebelkorn and others (1983) plotted to Trail quadrangle map and UTM coordinates extracted. Extracted position accurate to the number of significant figures shown.

[7] Reported in Fiebelkorn and others (1983).

[8] New data (unpublished) from Stanley A. Mertzman, Franklin and Marshall College, Lancaster, Pennsylvania.

ingly, as this report was going to press, it was discovered that Stanley A. Mertzman of Franklin and Marshall College, Lancaster, Pennsylvania, had obtained a whole-rock K-Ar age of 7.7 ± 0.2 Ma from Lower Table Rock (Table 4).

Chemical, lithologic, and map data indicate that exposures of the andesite of Table Rock are so similar that they are part of the same flow. The 9.6 Ma age indicated that the trachyandesite at Upper Table Rock was older than trachyandesite above Shady Cove, in other words, a different flow. Newly obtained ages of about 7 Ma from Upper Table Rock and Lower Table Rock accord with ages above Shady Cove, indicating that perhaps the 9.6-Ma age is in error. The original sample that yielded the older age is no longer available, so that it is impossible to determine what caused the age discrepancy. Presuming that the analsis was carefully handled, then perhaps some mineral phase in the rock contained excess argon, thereby skewing the results.

GRADIENT AND TECTONIC DEFORMATION

The gradient of the modern Rogue River and the top and bottom of the andesite of Table Rock are plotted in Figure 7. The method employed was to draw straight lines beginning at a datum point at the intersection of the Rogue River and longitude 123°W. From the datum point, straight lines were drawn with bends at the following upstream confluences with the Rogue River: Little Butte Creek, Trail Creek, Big Butte Creek, South Fork Rogue River, and Middle Fork Rogue River. The gradient chart terminates at the confluence of Buck Creek with the South Fork Rogue River, well above exposures of the base of the andesite of Table Rock. The straight lines were then marked at one-kilometer intervals. Elevations of the modern river and of the andesite of Table Rock were projected perpendicularly to the kilometer ticks on the straight lines. The reasoning for choosing straight lines rather than actual river mile markers is that although the actual course of the ancient river is not known, a plot of the base of the lava might mimic the approximate elevation of the ancient river.

Although plenty of data exist for determining the gradient of the modern Rogue River, the data for the andesite of Table Rock are discontinuous. I hoped that plotting the base of the andesite of Table Rock would yield the approximate, albeit sporadic, trace of the gradient of the ancient Rogue River. The irregular plot of the base of the andesite of Table Rock, indicates that it is not possible to find the thalweg, that is, the deepest centerline, of the ancient river with this method. The irregular gradient plot indicates that the basal measurements are not necessarily near the center of the channel but, in many cases, well up the sides of the retaining channel and away from the thalweg. This situation manifests itself upstream at Lost Creek Lake where pronounced, narrow, deep paleochasms are filled with the andesite of Table Rock (Hladky, 1993)—below the bulk of the flow.

It has been suggested that the horseshoe-shaped outcrop pattern of the andesite of Table Rock at Upper and Lower Table Rocks and the distribution of residual monoliths of andesite of Table Rock represent the inverted topography of an ancient river channel (Gerald Capps, BLM, written communication, 1992). The one-kilometer-spaced gradient plot of the base of the andesite of Table Rock, derived from the geology of Wiley and Smith (1993), however, does not indicate a regular gradient (Figure 7). Furthermore, a map examination of the lower contact of the lava reveals as much as 30 m (100 ft) of undulating elevation relief at both of the two buttes. At Upper Table Rock, this relief is irregular. At Lower Table Rock, the general orientation of the basal contact is higher in the north and lower at the southerly tips, which could indicate that perhaps the butte is gently folded about a north-south axis that plunges south. The lower lava contact at Castle Rock is irregular with a variance of up to 12 m (40 ft), which indicates that the lava flowed onto an uneven surface.

The top surfaces of Upper and Lower Table Rocks also yield insight into the nature of emplacement of the andesite of Table Rock and subsequent tectonic deformation. Although the top surfaces have been modified by erosion, they are still flat enough that they indicate no major structural deformation at the two buttes. At Upper Table Rock, the top surface is lowest at the tips of the horseshoe. This configuration would be expected if the butte were tilted to the southeast. The west arm of the butte, however, is higher that the east arm, suggesting eastward or northeastward rather than southeastward tilting. Erosional relief on the west arm complicates the issue. In addition, although the lower contact varies in elevation by as much as 30 m (100 ft), the top surface varies by only by about 20 m (60 ft). If the butte were folded, we would expect the elevation differences between the top and bottom surfaces to be about the same amount and in the same place, but they are not.

Therefore, the stratum of lava at Upper Table Rock is not only irregular in thickness, but also irregularly shaped along its bottom surface, the result of having molded itself to the irregular topography onto which it was erupted. A small amount of folding cannot be ruled out, but the resolution of the data is not precise enough to discern folding. A similar argument can be made for Lower Table Rock.

Wiley and Smith (1993) show a fault between Castle Rock and Lower Table Rock with as much as 30 m (100 ft) of down-to-the-east offset. This magnitude of offset is also indicated in the gradient chart in Figure 7: Both top surface and bottom contact are offset roughly 30 m (100 ft) across the fault between Castle Rock and Lower Table Rock.

It was thought that plotting the gradient of the andesite of Table Rock would indicate whether more than one lava flow was involved. It was hoped that the gradient data for the lava might display one or more regular gradient curves. The gradient data, however, do not resolve the issue.

PALEOMORPHOLOGY

The andesite of Table Rock was erupted onto terrain of the Western Cascades, a volcanic arc that had developed at least as early as 42 Ma in western Oregon (Fiebelkorn and others, 1983). The Western Cascades were active in southern Oregon from Eocene time through Miocene time (Hladky, 1992, 1993, 1994, 1996, in press a,b; Wiley and Smith, 1993; Smith and others, 1982). Some of the oldest rocks in the region attributed to High Cascade volcanoes were erupted about 6 Ma (Fielbelkorn and others, 1983; Medford Water Commission, 1990), and these rocks overlie rocks of the Western Cascades. The andesite of Table Rock is the oldest known rock exposed in the High Cascades. Its suspected source area at or near Olson Mountain lies in both the High Cascades and the Western Cascades.

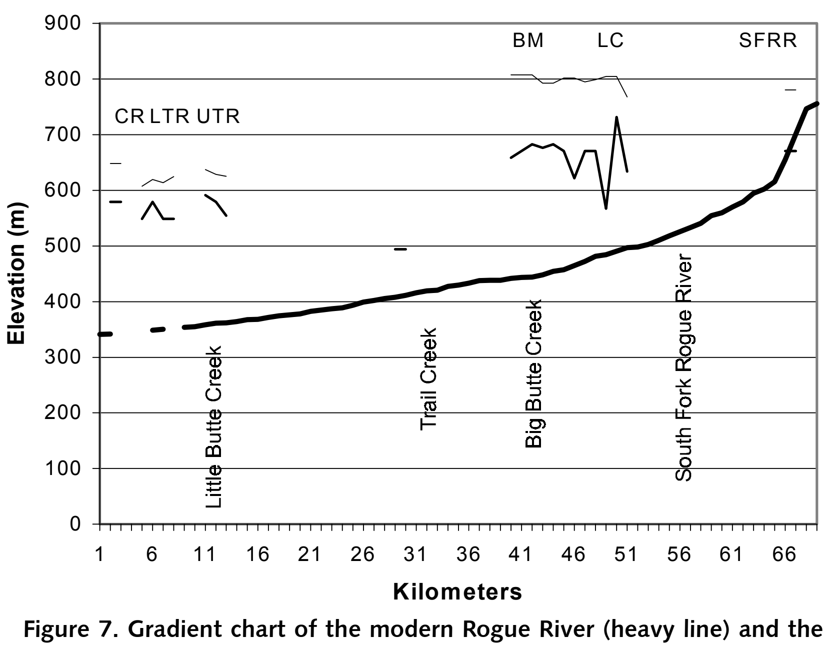

Figure 7. Gradient chart of the modern Rogue River (heavy line) and the top (light line) and bottom (medium heavy line) of outcrops of the andesite of Table Rock. Datum (starting point) is the Rogue River at long 123°W. CR = Castle Rock, LTR = Lower Table Rock, UTR = Upper Table Rock, BM = Bear Mountain, LC = Lost Creek Lake, SFRR = South Fork Rogue River.

It can be inferred from outcrop patterns and thicknesses that the andesite of Table Rock was erupted onto rolling and mountainous terrain. The Rogue River had already established itself between Lost Creek Lake and Castle Rock in approximately its present course. Between Big Butte Creek and Prospect, broad exposures of the andesite of Table Rock indicate that perhaps Olson Mountain did not exist, or that it was far smaller than it is today. The andesite of Table Rock filled in the ancestral Rogue River valley at Lost Creek Dam, Bear Mountain, and the upland areas of what is now Big Butte Creek. The flow conformed to the morphology of the paleovalley between Shady Cove and Lost Creek Lake. Remnants of the unit have a bowl-shaped cross section, being thinner at the margins and thicker toward the center. How far the flow traveled down the ancestral Rogue River remains unknown. Remnants of the flow are found as far west as the western edge of Sams Valley.

Between Shady Cove and Lost Creek Dam and at Upper Table Rock and Lower Table Rock, the present elevation of the base of the flow indicates that at the time the flow was erupted, valley floors were generally about 180–210 m (600-700 ft) higher than at present. Downcutting of the Rogue River and its tributary drainages has generally kept pace with gradual orogenic uplift in the region. At Upper Table Rock, the bed of the Rogue River has lowered itself 210 m (700 ft) in 7 million years.

The ancient Rogue River was displaced to the margins of the flow as lava filled the channel. After the molten lava cooled and solidified, the river cut through it, leaving remnants on both sides of the river above Shady Cove. Downstream from Shady Cove, the river meandered back and forth across the valley and removed most of the flow. The river and its tributaries preferentially cut through softer sedimentary rocks of the Payne Cliffs Formation north of Central Point and stranded remnants of the lava. Continued erosion modified these remnants and the underlying sedimentary rocks to form Upper Table Rock and Lower Table Rock.

It has been suggested that the distribution of sporadic cobbles and monoliths between the west edge of Sams Valley and Lost Creek Lake and the shape of the two buttes indicates the approximate course and shape of the bed and banks of the ancestral Rogue River when it was displaced by the lava flow; however, an evaluation of gradient data at the buttes indicates that it is not possible to define a thalweg that accords with the centerline of the buttes. The andesite of Table Rock probably flowed out over a broad plain north of Medford and was not confined to a river channel. The shape of Upper Table Rock and Lower Table Rock, therefore, is primarily a product of erosion. The many cobble trails and monoliths that have no nearby bedrock source are residual deposits, the erosional remains of a once more extensive lava flow.

SOURCE

Little is known about the physical character of the vent or vents that produced the andesite of Table Rock. Today, that area is covered by younger basalt and trachybasalt lava flows of the broad shield volcano of Olson Mountain and by andesitic lava flows from High Cascade volcanoes east of Prospect. Gradient data used in Figure 7 indicate a source in the upper reaches of the present-day Rogue River. Gradient data and mapped exposures indicate that the greatest thicknesses of the andesite of Table Rock are along the western flanks of Olson Mountain. The alkaline lavas that flank Olson Mountain indicate a compositional link to the andesite of Table Rock (Figures 4 and 5). Because alkaline lavas are rare in the Cascade Range of southern Oregon, perhaps the andesite of Table Rock and the basaltic trachyandesite lavas at Olson Mountain are derived from the same parent magma. It is possible that the earliest eruptions of Olson Mountain were those of the andesite of Table Rock. Alternatively, the greatest accumulaions and the fissures or vents that produced the andesite of Table Rock may lie east of Olson Mountain, but are now covered by the younger lavas at Olson Mountain and from the High Cascades, and the chemical similarities with lavas at Olson Mountain are merely fortuitous.

DISCUSSION

Current age data indicate that trachyandesitic lava flowed down the ancestral Rogue River about 7 Ma. This study found, from a new isotopic age, that trachyandesite at Upper Table Rock is about 7 million years old and probably not 9.6 million years, as a previous isotopic age indicated. The reason for the discrepancy has not been discovered; however, the 7-Ma age for Upper Table Rock accords with three ages for the unit upstream from Shady Cove. In addition, an isotopic age from Lower Table Rock also indicates an age of about 7 Ma (Stanley A. Mertzman, Franklin and Marshall College, written communication, 1998). Field mapping has not discovered boundaries between trachyandesitic flows, such as paleosols, that would indicate multiple flows. Gradient data do not resolve whether there are multiple flows or not, but chemical and petrographic data for the andesite of Table Rock, at the current level of examination, are sufficiently similar to argue for a single flow.

ACKNOWLEDGMENTS

The author wishes to acknowledge the thorough and thoughtful reviews of Tom Wiley (DOGAMI) and Dave Sherrod (USGS) and assistance in the field by Tom Wiley, Gerry Capps BLM), and Tom Olive. Dave Sherrod graciously lent a fluxgate magnetometer for magnetic polarity readings. Thanks to Jim Smith (USGS) for his thoughts and recollections of the andesite of Table Rock. I would also like to thank Stanley A. Mertzman (Franklin and Marshall College) who supplied an isotopic age from Lower Table Rock to be included for publication in this report.

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*(**MLR**, continued from page 74)*

Oregon. The MLR is charged with issuing new permits, inspecting current operations and ensuring reclamation of closed sites. An awards selection team composed of an industry consultant, a mine operator, a county planner, a natural resource expert, and a private citizen chose the winners. The awards were presented at the Oregon Concrete and Aggregate Producers Association (OCAPA) annual meeting in June at Salishan.

Other award winners include:

Outstanding Operator – *Westside Rock, Parkin Quarry*

Parkin Quarry, located northwest of Forest Grove, first broke ground in the early 1900s. Westside Rock, owned by John Malnerich, assumed operation in 1996. This site was recognized for efforts that exceed state requirements to protect adjacent natural resources. This basalt quarry, which is a side hill cut, is adjacent to Roderick Creek, a tributary to Gales Creek. Protection of Roderick Creek was a high priority in this project. From the beginning the company worked with neighbors to address concerns with the operation and a proposed expansion. They removed unstable overburden material, reconstructed and seeded a faulty storm water berm, constructed a new sediment retention pond, planted shade trees along Roderick Creek, and monitored storm-water control systems daily. The extensive operating agreement reached with neighbors highlights Westside Rock's commitment to work in harmony with the community.

Westside Rock operation

Outstanding Reclamation – *Rogue Aggregates Inc., Table Rock Site*

Situated on the floodplain 500 feet from the Rogue River, the Table Rock mine provided sand and gravel for the Jackson County Road Department. Rogue Aggregates acquired the operation in 1988 and completed mining in 1995. The proximity to the river presented an opportunity to focus reclamation activities on the construction of ponds for a diverse wetland habitat. Berms were added to separate individual ponds, and complex

Rogue Aggregates reclamation at former Table Rock mine near the Rogue River.

slopes were created and planted with a variety of vegetation. Irregular shorelines and many native plant species make the reclamation a success.

Freeman Rock operation, showing stable, benched highwall. The operator was recognized for outstanding stormwater control and slope stabilization.

Outstanding Small Operator (two winners) —
Ted Freeman, Freeman Rock

The Freeman Rock site is northeast of Brookings in Curry County. Two streams are nearby, the Chetco River and Jack Creek, both containing migrating fish runs. Two primary concerns at this site were control of storm water and erosion. Storm water was handled by the creation of numerous settling ponds around the perimeter rather than concentrating the water in one area. Erosion of a slope near the access road was controlled by the planting of Escallonia bushes on the slope. Freeman also works with the Department of Environmental Quality (DEQ) to control storm water in the winter months. This site was recognized for aggressive efforts to protect the Chetco River and Jack Creek from mine-related effects.

Philip and Connie Johnson

Located north of Myrtle Creek in Douglas County, this quarry has been owned and operated by Philip and Connie Johnson since 1993. This operation is being recognized for its use of Best Management Practices to control storm water. The Johnsons have completely eliminated offsite discharge. A series of settling ponds divided by a vegetated swale screens storm water from the excavation area. Storm water from processing and stockpile areas was diverted to a pasture where it soaks into the ground. The Johnsons were recognized for their unflagging efforts to protect adjacent natural resources.

Rebuilt access road in quarry operation of Coos County Road Department near Myrtle Point, commended for control of erosion and storm water runoff.

Good Neighbor Award – *David A. Peterson, Pacific Rock Products*

Mining at Peterson Rock Pit, a basalt quarry near North Plains in Washington County, began in 1980. During the heavy rains of 1996, a landslide was activated that threatened nearby McKay Creek and Dixie Mountain Road. Pacific Rock Products moved its primary jaw crusher off the slide area to help reduce movement. Moving the crusher and adding a fill slope between it and the county road diminished noise both on and off the site. In an effort to reduce the stockpile of material, the company reprocessed reject material into saleable products. Always concerned with safety, Pacific Rock has also worked with the county and adjacent landowners to widen the county road and provided CB radios to the school buses to avoid potential accidents. Pacific Rock Products was honored for creating an operation that is sensitive to the community.

Outstanding Exploration – *Eagle-Picher Minerals, Inc.*

An exploration permit was issued in 1992 for this site located in the Beede Desert in Harney County. Eagle-Picher Minerals explored the site for diatomite, an organic substance used in industry for filters and absorbents. In order to make reclamation simpler, the company elected not to build any access roads to the drill sites but to drive to them by means of all-wheel-drive vehicles. Ponderosa pines were later added to conceal track marks. A single access road was cut across a hill but was eventually reshaped with a backhoe and successfully replanted with native species. The overall success in replanting in this harsh climate, as well as attention to detail, make this reclamation noteworthy.

Outstanding Reclamation – Agency –*Oregon Department of Transportation – Region IV*

Located west of Bend, this 80-acre site has been used by the Oregon Department of Transportation (ODOT) since the 1960s. The first reclamation attempt failed when the planted grass seed died in the sun. The members of the ODOT Region 4 Geology Crew went to work. On their own time and using their own resources, they rented equipment, then prepared and seeded the surface of the site. Knowing the original seed mixture did not grow, the men developed their own mix of native grass seed. The reclamation proved so successful that now big game frequent the area. The ODOT Region 4 Geology Crew was recognized for using its own initiative and working far beyond legal requirements for this site.

Outstanding Operation – Agency – *Coos County Road Department*

This site is east of Myrtle Point in Coos County and was operated by the Coos County Road Department. To protect water quality the department extensively mulched and seeded bare areas. Because the site is located at the top of a ridge, erosion was a primary concern. To alleviate this, the access road to the site was elevated and completely reconstructed with sloping and ditches to contain storm water. The Coos County Road Department is recognized for its aggressive approach to this project, which implements Best Management Practices to reduce off-site impacts. ☐

DOGAMI PUBLICATIONS

Released June 2, 1998

Mined Land Reclamation Program status map, Clackamas County, Oregon. Oregon Department of Geology and Mineral Industries MLR Status Map 03, scale 1:250,000, $10.

Mined Land Reclamation Program status map, Josephine County, Oregon. Oregon Department of Geology and Mineral Industries MLR Status Map 17, scale 1:250,000, $10.

The MLR status maps show all mining sites within a county that are contained in the database record of the DOGAMI Mined Land Reclamation Program (MLR). This includes open and closed sites, various types of reclamation requirements, nonmetal and metal mining sites, and numbers of acres reclaimed and acres subject to reclamation.

Released June 29, 1998

Map showing faults, bedrock geology, and sediment thickness of the western half of the Oregon City 1:100,000 quadrangle, Washington, Multnomah, Clackamas, and Marion Counties, Oregon, by Scott Burns, Lawrence Growney, Brett Brodersen, Robert S. Yeats, and Thomas Popowski: Oregon Department of Geology and Mineral Industries Interpretive Map Series IMS–4, scale 1:100,000, $10.

The new map outlines potential earthquake hazards for the populated northern Willamette Valley (including much of Portland), covering an area from Aloha and Mount Scott in the north to Brooks, Mount Angel, and Molalla in the south.

Numerous faults in the region are outlined, including the Mount Angel fault that caused the 5.6-magnitude earthquake in 1993. Other potentially active faults on the map include the Portland Hills, Beaverton, Sherwood, Newberg, and Bolton-Marylhurst faults. The area's earthquake history, with the magnitudes of historic earthquakes, is also included.

The map also explains some of the geologic history of the area. "This is not just a map with fault lines on it," said Lou Clark of DOGAMI. "We have incredibly diverse geology in this relatively small area. Whether you're interested in earthquakes, volcanoes, landslides, or floods, we've had them on a big scale around the Willamette Valley.

Various hazards that could occur in future earthquakes are described in the map text. *Liquefaction* is the process when the ground becomes liquid from shaking during an earthquake, causing damage to buildings. *Amplification* occurs in unconsolidated soils where the shaking of an earthquake may feel stronger. *Landslides* can be triggered by earthquakes.

Use the order form on the back page of this issue, or order from the DOGAMI field offices: 1831 First Street, Baker City, 97814, (541) 523-3133; and 5375 Monument Drive, Grants Pass, 97526, (541) 476-2496. ☐

AVAILABLE PUBLICATIONS
OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES (continued)

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GMS-106	Grizzly Peak 7½' quad., Jackson County. 1997	6.00	
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