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Geology and Mineral Resources Map of the
Grizzly Peak Quadrangle, Jackson County, Oregon
By F.R. Hladky
Text

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INTRODUCTION

The Grizzly Peak 7½-minute quadrangle is located in the Western Cascades subprovince of the Cascade Range. Elevations range from about 590 m (1,900 ft) on the north in Lost Creek and South Fork Little Butte Creek to 1,804 m (5,920 ft) at the summit of Grizzly Peak. The topography of the quadrangle is dominated by the eroded remains of early Miocene volcanoes and spatter cones. The low-lying areas of the north expose the remains of ancient, primarily basaltic andesite shield volcanoes. Grizzly Peak and its unnamed sister butte to the north are the remains of an ancient stratovolcano. Northeast of Grizzly Peak is the Eagle Butte silicic eruptive complex (EBSEC), which is dissected by Deer Creek, Soda Creek, and South Fork Little Butte Creek. Just outside the northeast corner of the quadrangle is Heppsie Mountain, an ancient basaltic andesite center.

The quadrangle contains strata spanning at least 23 million years of volcanism and sedimentation. In earliest Miocene time, basaltic andesite shield volcanoes and small spatter cones developed. Andesitic and dacitic lavas and tuffs were erupted onto the subdued terrain of the shield volcanoes, emanating from sources to the west at and near Chimney Rock. The growth of a substantial stratovolcano through a series of eruptions centered on the current location of the community of Climax produced an edifice comparable in size and composition to modern Mount McLoughlin. Antelope Creek has subsequently dissected the Grizzly Peak volcano. As the Grizzly Peak volcano grew, a new structure emerged: the Eagle Butte silicic eruptive complex (EBSEC). From the EBSEC, successive ash-flow tuffs and silicic lavas were erupted. Foundering and resurgence within the EBSEC produced radiating and concentric fracture and eruption patterns. The EBSEC, active from 23 to 21 Ma, expired and was immediately inundated by basaltic andesite lavas of the Heppsie Formation from sources outside the quadrangle to the north and east. The last 20 million years have seen erosion and, in particular, mass wasting shape the landscape. In Quaternary time, large-scale, gravity-induced faulting in the Sharon Fen[1] area in the southeast corner of the quadrangle produced extension, subsidence, and landsliding. The resulting topography includes many closed depressions and fens—nutrient-rich, peat-forming wetlands. An ancient landslide impounded Lost Creek to make Lost Lake.

The extent of groundwater resources is unknown. Water quality, however, is a concern. Some springs, seeps, and domestic water wells yield high levels of arsenic and other metals. Mineralization related to the EBSEC is particularly conducive to the metallization of groundwater.

Presently, the principal economic mineral is crushed rock, which is used on the local unpaved roads. Manganese was produced at the Tyrrell Mine prior to 1920. Oil shale prospected at Shale City has never been found in commercial quantities. There are no records of mercury production, but prospects locally contain highly anomalous levels of mercury. Very little copper mineralization was discovered during this study. In addition, the mineralization and alteration patterns found in the EBSEC show similarities to those found in producing silicic volcanic-hosted Au-Ag districts in the western United States, including the Western Cascades.

This report presents a detailed geologic map produced from extensive field examinations and photogrammetric plotting from aerial photographs. Field and aerial data were compared and rechecked in the field to draw unit contacts. A potassium-argon age has been plotted from data reported by Fiebelkorn and others (1983), and together with three new $^{40}Ar/^{39}Ar$ ages, helps bracket the Wasson Formation.

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[1] Sharon Fen is the name chosen for a new Nature Conservancy preserve and describes an area with a series of unnamed lakes in and around sec. 13, T. 38 S., R. 2 E., which includes the new preserve.

EXPLANATION OF MAP UNITS

Surficial Deposits

Qya **Young alluvium (Holocene)**—Gravel, sand, and silt deposited along modern stream channels. Thickness varies, maximum about 8 m (25 ft)

Qaf **Alluvial fan deposits (Holocene and Pleistocene)**—Poorly sorted, gravel, sand, and silt deposited in lobes at the mouths of tributaries to South Fork Little Butte Creek. Thickness varies, maximum about 9 m (30 ft)

Qc **Colluvium (Holocene and Pleistocene)**—Angular to subrounded, unconsolidated gravel, sand, and silt forming slope-mantling aprons. Mapped where thickness exceeds about 6 m (20 ft)

Qls **Landslide deposits (Holocene and Pleistocene)**—Unconsolidated, poorly sorted fragments of bedrock displaced downslope by gravity sliding. Hummocky topography. No distinction made between active and inactive slides. Impounds Lost Creek to form Lost Lake in NW¼NW¼ sec. 35, T. 37 S., R. 2 E. Deposits mantle Sharon Fen area in southern part of quadrangle and produce numerous small closed basins. Thickness varies. Mapped where thickness greater than about 3 m (10 ft)

Tertiary Volcanic Rocks

Th **Heppsie Formation of Hladky (1995), undivided (lower Miocene)**—Medium-gray to dark-gray, fine-grained to very fine grained basaltic andesite, basalt, and platy andesite. Rubbly and vesicular interflow zones common. In Wasson Canyon in adjacent Lakecreek quadrangle, an andesite has a K-Ar age of 22.7±1 Ma, which compares with a basaltic andesite in sec. 31, T. 37 S., R. 3 E. that has a K-Ar age of 22.8±0.8 Ma (Fiebelkorn and others, 1983)(Table 2, map no. 25). Maximum thickness 670 m (2,200 ft)

Thu **Upper part**—Orange- and tan-weathering, medium dark gray, fine-grained to very fine grained basaltic andesite. Formed typically of phenocrysts of black pyroxene 1–2 mm, less than 10 percent; locally in glomeroporphyritic clots as large as 5 mm; plagioclase smaller than 1 mm, less than 10 percent; and dark-reddish-brown iddingsite smaller than 1 mm, less than 5 percent, in a groundmass of microlites, dark-brownish-gray glass, and magnetite. Locally platy. At Heppsie Mountain in adjacent Lakecreek quadrangle, a basaltic andesite has a K-Ar age of 21.9±1 Ma (Fiebelkorn and others, 1983). Maximum thickness about 335 m (1,100 ft)

Thl **Lower part**—Brown-weathering, medium- to dark-gray, fine-grained to very fine grained basaltic andesite. Massive to irregularly jointed. Prominent ridge-forming unit on the south flanks of Heppsie Mountain. Locally rubbly and brecciated. Thickness exceeds 150 m (500 ft)

Wasson Formation (lower Miocene)—Divided in this report into two newly defined (informal) members, Eagle Butte-Shale City and Heppsie Mountain, and a lower unit, the buff tuff of Wells (1956) (his unit Twbt). The two new members have a definite stratigraphic sequence within a geographic area. The buff tuff of Wells (1956) is a recognized regional marker (in most places) at the base of the Wasson Formation. Direct correlations between individual subunits of the two new members remain uncertain. Correlations between specific vent and distal facies of all the members also remain uncertain

Eagle Butte-Shale City member—A complex collage of primarily silicic volcanic rocks that were erupted from numerous vents in and near the Eagle Butte silicic eruptive complex (EBSEC) and associated sedimentary facies. The EBSEC is located approximately south of Heppsie Mountain, east of Lost Creek, north of Shale City, and west of the eastern edge of the Soda Creek basin

Twd **Dacite, undivided**—Massive, lavender-gray and gray dacite lavas and hypabyssal rocks. Includes undivided lavas east of Soda Creek. Exposed thickness in quadrangle about 60 m (100 ft)

Twdv **Dacite vent deposits, undivided**—Olive-gray and reddish-brown, partly altered, welded, dacitic, crystal-vitric tuff, ash tuff breccia (less than 25 percent ash and less than 75 percent blocks) (Dietrich and Skinner, 1979) and vent agglutinate. Matrix comprised typically of phenocrysts of magnetite smaller than 0.25 mm, about 2 percent; chloritized pyroxene smaller than 1 mm, 1 percent; and feldspar smaller than 2 mm, 14 percent; in a brown groundmass, 83 percent, of partially devitrified glass, tridymite, and calcite. Commonly consists of a poorly sorted monolithologic ash tuff breccia comprised of clasts, 50 percent, ranging in size from a few millimeters to 0.5 m in diameter and welded in a fine-ash matrix. Clast-matrix boundaries are often indistinct. In sec. 3, T. 38 S., R. 2 E., unit Twdv contains both monolithic ash tuff breccia and poorly sorted, faintly stratified, nonwelded, polylithic ash tuff breccia containing clasts of welded tuff, vitrophyre, and andesite 5–30 cm across. In sec. 19, T. 37 S., R. 3 E., unit is dark gray, fine grained, and brecciated with extensive chalcedony and quartz veins up to 0.3 m wide. Unit Twdv represents source unit for various dacitic units, although precise relationships with individual dacitic tuffs and lavas often uncertain. Exposed thickness exceeds 60 m (200 ft)

Twd3 **Dacite unit 3**—Orange-weathering, pinkish-gray, medium-grained dacite to rhyolite lava. Smooth and platy to rough and jagged (aa texture). Mafic minerals typically argillized, plagioclase phenocrysts are sparse, groundmass is cryptocrystalline. Overlies dacite tuff unit Twt2 north of South Fork Little Butte Creek. Includes exposures northeast of Lost Lake. Late-stage lavas of EBSEC. Exposed thickness exceeds 427 m (1,400 ft)

Twda **Dacite**—Pink, orange, red, and cream, fine- to coarse-grained, argillized and locally silicified dacite. Typically massive and internally textureless except for local Liesegang rings. Crops out between Deer Creek and Soda Creek. Viscous, extrusive lavas probably related to resurgent doming in the interior of EBSEC. May include related, unmapped intrusive rocks. Maximum thickness may exceed 550 m (1,800 ft)

Twr **Rhyolite**—Tan to lavender-brown, partially altered, flow-banded, aphanitic rhyolite (Table 3, map no. 8). Weathers into nonfriable, irregular plates. Viscous lava flows. Weathering has produced an arch 5–6 m high 120 m due east of map no. 8 in sec. 18, T. 37 S., R. 3 E. Thickness in quadrangle may exceed 365 m (1,200 ft)

Tuff of Eagle Butte—Divided in this report into:

Twen **Nonwelded facies, undivided**—Light-gray to white, coarse-ash to lapilli-ash, moderately well sorted, partially altered (to clay), nonwelded to incipiently welded, dacitic, lithic-vitric ash-flow tuff. Very light gray to white, Salt-and-pepper appearance. Poorly sorted. Faintly stratified in some intervals. Pumice lapilli, as large as 4 cm, inversely graded. Up to 20 percent normally graded accidental and accessory lithics of gray basaltic andesite, as large as 4 cm. Maximum thickness about 90 m (300 ft)

Twew **Welded facies, undivided**—Pink to lavender-brown, coarse-ash, welded, dacitic to rhyolitic, crystal-vitric ash-flow tuff. Feldspar phenocrysts up to 2 mm comprise 10 percent; fine-grained yellow clay or zeolite up to 20 percent; subhedral quartz up to 2 mm, 5 percent; very fine grained magnetite up to 2 percent in a partly devitrified cryptocrystalline groundmass that is lavender-gray to reddish-brown. Contains up to 5 percent pale greenish yellow subspherical clots up to 8 cm of vapor-phase minerals; including very fine grained (smaller than 0.5 mm) magnetite, clay or zeolite, acicular tridymite, and feldspar. Sparse lithic fragments comprise less than 1 percent of the unit. $^{40}Ar/^{39}Ar$ age of 21.43±0.76 Ma from sample at map no. 20 in sec. 36, T. 37 S., R. 2 E. Maximum thickness about 150 m (500 ft)

In the Sharon Fen area of the southeast corner of the quadrangle, the tuff of Eagle Butte can be subdivided into the following succession of nonwelded and welded facies. The inferred basal welded facies is not exposed there:

Twen5 **Nonwelded tuff**

Twew4 **Welded tuff**

Twen3 **Nonwelded tuff**

Twew2 **Welded tuff**

Twen1 **Nonwelded tuff**

Twey **Vitrophyre**—Black, glassy, porphyritic, coarse-ash, densely welded, dacitic to rhyolitic crystal-vitric ash-flow tuff vitrophyre. Phenocrysts of feldspar and quartz, as large as 3 mm, up to 30 percent, in a groundmass of dark-gray or black, fine-grained magnetite and hematite and green clay. Subrounded accidental lithics of mafic lava 1–3 cm in diameter, about 10 percent. Devitrified pumice clasts now comprised of quartz and magnetite phenocrysts in greenish-yellow clay and hematite, usually smaller than 1 cm but as large as 7 cm, about 10 percent. Unit exposed as lensoidal bodies, interpreted to be zones of maximum welding of an ignimbrite deposited on irregular paleotopography. Locally exposed at the base of the tuff of Eagle Butte. Maximum thickness about 12 m (40 ft)

Twst **Tuff of Shale City**—White, tan, and pale-yellow, coarse-ash and lapilli-ash, altered, nonwelded to partially welded, dacitic crystal-vitric tuff. Lapilli, where present, are altered to clay. Typically unstratified, but locally contains poorly stratified horizons and shale beds. Along the ridge crest in sec. 9., T. 38 S., R. 2 E., unit is porcelaneous to cherty from silicification and also contains cinnabar in narrow, sub-millimeter-wide veinlets. Maximum thickness about 210 m (700 ft)

Twsl **Lacustrine facies**—Tan, pale-yellow, locally orange-stained, fine-grained, planar laminated tuffaceous shale and claystone. Contains dark-gray to black carbonaceous seams. On brightly colored surfaces, emits an acrid odor when broken. Occurrence is less than about 5 acres (in NE¼ sec. 16, T. 38 S., R. 2 E.). Maximum thickness about 15 m (50 ft). Previous studies by the U.S. Geological Survey and the Oregon Department of Geology and Mineral Industries (Weissenborn, 1969) indicated an oil shale occurrence of 150,000 tons; this occurrence is now mostly mined out

Twp **Mafic pyroclastic rocks**—Brown, coarse-ash, lithic tuff and ash tuff breccia. Clasts of green pyroxene-bearing, mafic lava blocks in a matrix of mud, sand-sized lithics, and broken crystals. Poorly to moderately sorted. Wavy bedded intervals up to 15 cm thick. Exposed in secs. 25 and 36, T. 37 S., R. 2 E. Interpreted to be lahar deposit. Maximum thickness 75 m (250 m)

Twb **Basaltic andesite**—Tan- to orange-weathering, dark-green to blue-gray, fine- to medium-grained, basaltic andesite. Exposed in EBSEC. Brecciated margins and internal vesicles indicate surface emplacement. Unit drapes paleotopography. Maximum thickness 240 m (800 ft)

Twd2 **Dacite unit 2**—Dark-olive to olive-gray and light-gray, fine-grained, tabular, dacite lava flows. Local pipe vesicles up to 5 cm diameter exposed in quarry in NE¼ sec. 3, T. 38 S., R. 2 E. Maximum thickness about 60 m (200 ft)

Twd1 **Dacite unit 1**—Tan-weathering, dark-gray, fine-grained, vitric, platy dacite with subhorizontal partings spaced 2–25 cm. Grades laterally into rough, pinkish-lavender porphyritic dacite with faint subhorizontal foliation; locally near-vertical partings. Locally contains pipe vesicles. Fine-grained, platy facies consists of plagioclase phenocrysts, often glomeroporphyritic but smaller than 1.5 mm, 5 percent; black pyroxene, smaller than 0.5 mm, 5 percent; clear, light green olivine, smaller than 0.5 mm, less than 1 percent; in a groundmass of medium- to dark-gray glass and very fine grained (smaller than 0.1 mm) magnetite. Groundmass glass weathers to tan clay on weathered surfaces, remaining constituents are largely unaffected. ^{40}Ar/^{39}Ar age of 22.87±0.21 Ma from sample at map no. 19, sec. 34, T. 37 S., R. 2 E. Rough facies contains up to 40 percent plagioclase phenocrysts, up to 10 percent pale yellowish green vapor phase alteration clots up to 8 cm across. Maximum thickness about 500 m (1,800 ft)

Heppsie Mountain member—A sequence of lavas and tuffs north of South Fork Little Butte Creek with eruptive sources both in the quadrangle and north of the quadrangle. Correlations between these rocks and the units of the Eagle Butte-Shale City member are tentative

Twt2 **Dacite tuff**—Light-gray, fine-ash, partially altered, nonwelded, dacitic crystal-vitric ash-flow tuff. Exposed north of South Fork Little Butte Creek. Separated from nearly identical unit Twt1 by lava flows of unit Twba2. Maximum thickness about 90 m (300 ft)

Twba2 **Basaltic andesite**—Brown-weathering, medium dark gray to dark-gray, fine-grained basaltic andesite, andesite, and dacite. Different flows may vary in composition from basalt to dacite. Locally includes reddish-brown, limonitically and argillically altered andesitic lapilli breccia. Separated from unit Twba1 by tuff unit Twt1. Maximum thickness about 120 m (400 ft)

Twt1 **Dacite tuff**—Light-gray, fine-ash, partially altered, nonwelded, dacitic crystal-vitric ash-flow tuff. Exposed north of South Fork Little Butte Creek. Separated from nearly identical tuff unit Twt2 by lava flows of unit Twba2. Maximum thickness about 37 m (120 ft)

Twba1 **Basaltic andesite**—Brown-weathering, medium dark gray to dark-gray, fine-grained basaltic andesite. Different flows may vary in composition from basalt to andesite. Separated from basaltic andesite unit Twba2 by tuff unit Twt1. Maximum thickness about 150 m (500 ft)

Twwt **White tuff of Wells (1956)**—Coarse-ash and lapilli-ash, substantially altered (vitric component is virtually all clay), nonwelded to incipiently welded, dacitic, lithic-crystal-vitric ash-flow tuff. Unit generally contains 10–15 percent pumice lapilli. Quartz and feldspar crystals, 2–4 mm, less than 10 percent; magnetite less than 5 percent; biotite, trace. Poorly to moderately sorted; fine-ash vitric component is predominant. Typically unstratified. Unit thickest in Lakecreek quadrangle to north, pinches out north of South Fork Little Butte Creek. Maximum thickness in quadrangle about 15 m (50 ft)

Twf **Lava flows of Wells (1956)**—Brown-weathering, medium dark gray to dark-gray, fine-grained andesite and aphanitic basaltic andesite. Commonly platy. The andesite contains plagioclase less than 2 mm, less than 20 percent; black pyroxene smaller than 1.5 mm, less than 15 percent; green olivine smaller than 1.5 mm, less than 5 percent. Groundmass composed of dark-gray glass with subordinate plagioclase microlites. Includes vesicular and rough-textured zones commonly with argillic and limonitic alteration along vesicles and cracks. K-Ar age of 24.0±1 Ma, reported from sample in Wasson Canyon in Lakecreek quadrangle to the north (Fiebelkorn and others, 1983), superseded by new, more reliable ^{40}Ar/^{39}Ar age of 23.35±0.39 Ma for underlying unit Tub in Grizzly Peak quadrangle (see Geologic Summary). Maximum thickness in quadrangle about 60 m (200 ft).

Identification follows descriptive text ("Geology of the Medford Quadrangle, Oregon-California") of Wells (1956), rather than unit label in his map explanation

Twbt **Buff tuff of Wells (1956), undivided**—Brown to pink, coarse-ash and lapilli-ash, nonwelded to welded, dacitic, crystal-vitric ash-flow tuff. Contains scattered lithics as large as 2 cm. Unit is mappable over a broad region and underlies rocks of both the Eagle Butte-Shale City member and the Heppsie Mountain member. Mapped by Wells (1956) as unit Twbt and described as both "buff fine-grained tuff with fragments of flow rock" and "dirty yellow tuff." This report locally breaks out various facies within the unit. Source is from within EBSEC. Maximum thickness about 240 m (800 ft)

Twbf **Fine-grained facies**—Tan, buff, yellow, and locally red, fine- to coarse-ash, altered (to clay), nonwelded, dacitic, vitric ash-flow tuff. Massive; rarely faintly foliated. Thickness may exceed 240 m (800 ft)

Twbc **Coarse-grained facies**—Tan, buff, yellow, pink, and pale-olive, slightly altered, nonwelded to welded, dacitic to rhyolitic, crystal-lithic-vitric ash tuff breccia. Typically 50 percent fine-ash vitric component, 40 percent lithic fragments, and 10 percent broken crystals smaller than 2 mm. Lithics up to 15 cm common; up to 2.5 m rare, although large clasts up to 2.5 m are exposed at Lost Lake in NW¼ sec. 35, T. 37 S., R. 2 E. Poorly sorted, faintly to indistinctly bedded. In NE¼NW¼SW¼ sec. 22, T. 37 S., R. 2 E., unit contains 20 percent large glass fragments including both dark-gray glassy fiamme, 2 cm wide by 13 cm long, and unflattened pumice blocks up to 13 cm in diameter. Maximum thickness about 490 m (1,600 ft)

Twbl **Lacustrine facies**—Light-tan to buff, very fine grained, thinly laminated, tuffaceous shale. Contains leaf imprints and fossil leaves. Small deposits exposed in SE¼ sec. 12, T. 37 S., R. 2 E. and NE¼SE¼NW¼ sec. 19, T. 37 S., R. 3 E. Maximum thickness about 15 m (50 ft)

Twby **Vitrophyre**—Black, glassy, densely welded, rhyolitic, lithic-crystal-vitric ash-flow vitrophyre. Lithics smaller than 1 cm, less than 5 percent; crystals smaller than 2 mm, about 30 percent; black glass about 65 percent. Weathers to a rough, pock-marked, very abrasive surface. Exposed beneath Eagle Butte east of Lost Creek as a discontinuous sheet. Maximum thickness about 90 m (300 ft)

Volcanic rocks of Grizzly Peak (lower Miocene)—Volcanic rocks of mostly basaltic andesite composition, with lesser amounts of more silicic rocks, that erupted in the vicinity of Grizzly Peak, producing a large stratovolcanic complex. Where exposures allow, divided in this report into three main units, an upper unit dominated by basaltic andesite lava flows, a middle unit dominated by pyroclastic rocks, and a lower unit dominated by basaltic andesite lava flows

Tgb **Basaltic andesite, undivided**—Medium dark gray to brownish-gray basaltic andesite lava flows. Mapped where exact stratigraphic position uncertain in secs. 23 and 24, T. 38 S., R. 2 E. Exposed thickness in quadrangle about 60 m (200 ft)

Upper unit—Primarily basaltic andesite lava flows, but also small vent and lahar deposits

Tgub **Basaltic andesite**—Medium dark gray to brownish-gray, medium-grained basaltic andesite. Typically contains 10 percent plagioclase phenocrysts, smaller than 2 mm; and about 5 percent pyroxene, smaller than 1 mm; in a dark-gray to lavender groundmass of glass, subhedral plagioclase microlites and dark-green pyroxene. Vesicular along flow margins. Maximum thickness about 580 m (1,900 ft)

Tgul **Lahar deposits**—Tan to dark-brown, planar-stratified to lenticular with intervals ranging in thickness from several centimeters to several meters, poorly sorted, incipiently welded and nonwelded, basaltic andesitic to andesitic ash-flow tuff. Contains basaltic andesite blocks up to 10 cm, less than 10 percent, in a silty to ashy matrix that is locally welded. Outcrop margins conform to channels in basaltic andesite lava flows. Maximum thickness about 50 m (165 ft)

Tguv **Vent deposits**—Dark-gray weathering, reddish-brown and yellowish-brown, vesicular, basaltic andesite vent agglutinate. Monolithologic; irregularly shaped to semi-spherical, subrounded clasts smaller than 5 cm comprise 50 to 60 percent and lie in a coarse-ash, altered, welded, basaltic andesite matrix. Exposures are small, and outcrop-bounding surfaces with lava flows are irregular. Maximum thickness about 60 m (200 ft)

Tgp **Pyroclastic unit, undivided**—Mostly pyroclastic rocks including brown, poorly and moderately sorted lithic lapilli-ash tuff and ash tuff breccia (including both pyroclastic ash flows and lahars); reddish-brown basaltic andesite vent agglutinate; but includes also thin, intercalated basaltic andesite lava flows. Maximum thickness about 180 m (600 ft). Where exposures allow, divided into:

Tgpt **Tuff**—Tan to yellow, poorly stratified, poorly sorted, coarse-ash, lapilli-ash, and block and ash, nonwelded, dacitic, lithic-vitric ash-flow tuff. Contains up to 10 percent randomly-oriented clasts of basaltic andesite as large as 0.3 m. Yellow, subrounded, altered, lapilli-size pumice fragments, 20 to 25 percent. Light-tan, fine-ash and brown, coarse-ash lithics comprise the matrix. Maximum thickness in quadrangle 140 m (450 ft)

Tgpv **Vent deposits**—Brick-red, vesicular, scoriaceous, lapilli- and coarse-ash basaltic andesite vent agglutinate. About 5 percent vesicular, breadcrust bombs. Maximum thickness near Climax about 365 m (1,200 ft)

Tgpb **Basaltic andesite**—Medium dark gray to brownish-gray, medium grained basaltic andesite. Vesicular along flow margins. Multiple flows. Unit is sandwiched between pyroclastic units. Thickness about 120 m (400 ft)

Lower unit—Sequences of thick basaltic andesite lava flows, locally interspersed with vent-facies basaltic andesite agglutinate

Tgl **Basaltic andesite**—Medium dark gray to brownish-gray, medium-grained, tabular to massive basaltic andesite. Vesicular along flow margins. Maximum thickness in quadrangle about 150 m (500 ft)

Tglv **Vent deposits**—Brick-red, vesicular, scoriaceous, lapilli-ash and coarse-ash basaltic andesite vent agglutinate. Thickness in quadrangle about 140 m (460 ft)

Volcanic rocks of Chimney Rock (lower Miocene)—Volcanic rocks of andesitic to dacitic composition that were erupted from a volcano and subsidiary cones at and near Chimney Rock. Original volcanic landforms partly exposed in adjacent Rio Canyon quadrangle are now deeply eroded and partially buried beneath volcanic rocks of Grizzly Peak

Tcba **Basaltic andesite to andesite lava flows**—Reddish-brown, brownish-gray, and medium dark gray, tabular, blocky, and platy, medium- to fine-grained lava flows of basaltic andesite to andesite composition. Thickness in quadrangle about 90 m (300 ft)

Tcv **Vent deposits**—Red and brownish-red, altered, vesicular, andesitic to dacitic vent agglutinate and block and ash tuff. Comprised of altered, fine-ash to lapilli-ash vitric fragments containing sparse bombs up to 16 cm. Separate exposures of vent agglutinate occur in secs. 19, 20, 28, and 29, T. 37 S., R. 2 E. Remnants of near-vent block and ash tuff occur as isolated blocks up to 7 m in diameter in SE¼ sec. 18, T. 37 S., R. 2 E. Maximum thickness in quadrangle about 90 m (300 ft)

Tct **Tuff**—Brown, fine-ash to coarse-ash, partially altered (to clay), dacitic vitric tuff; and yellow and red, partially altered, andesitic vitric tuff, ash tuff breccia, and agglutinate. Small, local deposits. Maximum thickness less than 60 m (200 ft)

Basaltic andesite of Lake Creek of Hladky (1995) (lower Miocene)—Sequence of vent rocks and diffuse lava flows with sources near Lake Creek

Tl6 **Basaltic andesite**—Brown-weathering, medium dark gray to dark-gray basaltic andesite. Contains fine-grained pyroxene, less than 20 percent; plagioclase phenocrysts as large as 5 mm, less than 15 percent; and sparse olivine about 1 mm in a groundmass of plagioclase microlites and dark-gray glass. Subhorizontal partings typically spaced 1 m or more. Paleosols, rubbly flow fronts or autoclastic breccias at flow base that is commonly marked by a pronounced break in slope (as viewed in low-level aerial photography). Maximum thickness in quadrangle about 180 m (600 ft)

Tl6v **Basaltic andesite vent deposits**—Red and reddish-brown, basaltic andesite lapilli-ash tuff, block and ash tuff, and scoria. Exposed only in SE¼ sec. 17, T. 37 E., R. 2 E.; however, this unit is undoubtedly buried beneath younger units elsewhere. Exposed thickness less than 6 m (20 ft)

Tl5 **Basaltic andesite**—Brown-weathering, medium dark gray to dark-gray basaltic andesite. Contains fine-grained pyroxene, less than 20 percent; plagioclase phenocrysts as large as 5 mm, less than 15 percent; and sparse olivine about 1 mm in a groundmass of plagioclase microlites and dark-gray glass. Subhorizontal partings typically spaced 1 m or more. Paleosols, rubbly flow fronts, or autoclastic breccias found at flow base, commonly marked by a pronounced break in slope (as viewed in low-level aerial photography). Drapes paleotopography and fills paleodepressions. Mineralized with manganese oxides along fractures and fissures at the contact with basaltic andesite vent deposits (unit Tlv) at the Tyrrell Mine in the W½W½ sec. 10, T. 37 S., R. 2 E. Maximum thickness in quadrangle about 180 m (600 ft)

Tl5v **Basaltic andesite vent deposits**—Red and reddish-brown, lapilli-ash tuff, block and ash tuff, and scoria of basaltic andesite composition. Maximum thickness about 24 m (80 ft)

Tlv **Basaltic andesite vent deposits**—Red and reddish-brown, lapilli-ash, altered, basaltic andesite tuff, ash tuff breccia, and scoria. Mineralized with manganese oxides near the Tyrrell Mine in sec. 10, T. 37 S., R. 2 E. Stratigraphically beneath units Tl6 and Tl5 and associated vent deposits. Maximum thickness about 45 m (150 ft)

Tlt **Tuff**—Yellow and red, significantly altered, lithic lapilli-ash tuffs of andesitic to dacitic composition; volumetrically small; locally derived from covered sources. Typically weathers to yellow and red clay containing poorly preserved angular volcanic clasts. Maximum thickness about 45 m (150 ft)

Tl1 **Basaltic andesite**—Brown-weathering, medium dark gray to dark-gray basaltic andesite. Contains fine-grained pyroxene, less than 20 percent; plagioclase phenocrysts as large as 5 mm, less than 15 percent; and sparse olivine about 1 mm in a groundmass of plagioclase microlites and dark-gray glass. Subhorizontal partings typically spaced 1 m or more. Base not exposed in quadrangle. Thickness at least 60 m (200 ft)

Volcanic rocks of the South Fork Little Butte Creek of Hladky (1995) and basaltic andesite of Lake Creek of Hladky (1995), undifferentiated (lower Miocene)—Divided in this report into:

Tub **Basaltic andesite (lower Miocene)**—Reddish brown weathering, dark-gray, platy, conchoidally fracturing basaltic andesite. Consists of 30 percent pyroxene, mostly smaller than 0.5 mm, although some glomeromorphs attain 3 mm; 65 percent plagioclase smaller than 2 mm with most smaller than 1 mm; 3 percent magnetite smaller than 0.25 mm, and 2 percent chlorite smaller than 0.5 mm. $^{40}Ar/^{39}Ar$ age of 23.35±0.39 Ma from sample at map no. 1 in sec. 10, T. 37 S., R. 2 E. Basalt at outcrop is intermingled with reddish-brown agglutinate in which the clasts are rounded. Base not exposed in quadrangle. Thickness at least 90 m (300 ft)

Tuv **Vent deposits (lower Miocene)**—Reddish-brown basaltic andesite vent agglutinate, ash tuff breccia, and scoria. Base not exposed. Thickness about 45 m (150 ft)

Intrusive Rocks

Thi **Hypabyssal rocks of the Heppsie Formation of Hladky (1995) (lower Miocene)**—Purplish medium gray, plagioclase-rich, porphyritic andesite. Plagioclase phenocrysts smaller than 3 mm, nearly 60 percent; quartz smaller than 3 mm, about 5 percent; black pyroxene smaller than 2 mm, about 5 percent; and purplish-gray glass about 30 percent

Intrusive and hypabyssal rocks of the Wasson Formation (lower Miocene)—Divided in this report into:

Twid **Dacitic dikes**—Propylitized dacite dikes. In Deer Creek drainage, dikes consist of 80 to 90 percent apple-green, propylitized very fine grained groundmass with green pyroxene and milky white plagioclase phenocryst up to 3 mm. In Soda Creek drainage, they are typically olive-gray, massive, propylitized, containing very-fine grained, disseminated pyrite, and occasionally iron-stained. Dikes intrude enclosing tuffs and lavas at high angles and are typically nearly vertical

Twib **Basaltic andesite intrusive rocks**—Dark brownish gray to dark-gray, very fine grained to aphanitic basaltic andesite. May form poorly shaped columns. Enclosing tuffs are sintered at contacts. Contacts are steeply dipping to overturned

Twidy **Vitrophyric dacite intrusive rocks**—Tan-weathering, black, glassy dacite. Quartz, feldspar, and rare pyroxene phenocrysts in black glass. Phenocrysts, about 10 percent, 2 mm or smaller. Contains less than 5 percent clots and vesicles of vapor-phase minerals. Poorly-formed columns about 15 cm in diameter or less. Intrudes surrounding tuffaceous rocks

Twhd **Hornblende dacite**—Olive-gray, porphyritic hornblende dacite. Hornblende about 5 percent, smaller than 1 cm; glomeroporphyritic plagioclase about 5 percent, smaller than 4 mm; 25 percent amygdules, most smaller than 1 mm but some up to 5 mm, partially filled with euhedral zeolite minerals; groundmass of cryptofelsite (feldspar and quartz) about 60 percent, and minor, very fine grained magnetite, less than 1 percent. Unit is exposed in NE¼ sec. 24, T. 37 S., R. 2 E., and intrudes domal complex

Twir **Intrusive rhyolite**—Light-gray weathering, medium-gray rhyolite dikes and small stocks. Poorly-shaped columns common. Often coarse-grained, comprised mostly of equigranular plagioclase and quartz phenocrysts 2–3 mm across, set in less than 15 percent glass. In SW¼SW¼ sec. 19, T. 37 S., R. 3 E. exposed in a series of dikes 0.1–0.5 m wide in a zone about 10 m wide. Adjacent to these invading rhyolite dikes the host dacite shows alteration margins a few centimeters wide

Intrusive and hypabyssal rocks related to the volcanic rocks of Grizzly Peak (lower Miocene)—Divided in this report into:

Tgib **Basaltic andesite dikes**—Brown-weathering, dark-gray, fine-grained to aphanitic basaltic andesite dikes. Exemplary exposure on south flank of Grizzly Peak in sec. 20 T. 38 S., R. 2 E. where a dike, 2–4 m wide with poorly-formed, nearly horizontal columns, projects 3 m above surface, invading red, fine-ash, basaltic andesite agglutinate and lithic, lapilli-ash tuff. Similar dikes exposed near Climax and in sec. 21, T. 38 S., R. 2 E., near the Shale City road. Dikes typically straight or slightly arcuate

Tgid **Dacite intrusive rocks**—Medium- to dark-gray, very fine to coarse-grained dacite dikes associated with Grizzly Peak series of volcanic rocks. Distinguished by 30 percent quartz content: groundmass and phenocrysts as large as 3 mm. Also contains 5 percent iddingsitized pyroxene, as large as 1.5 mm; 20 percent feldspar, as large as 2 mm; in a groundmass of dark-gray glass and quartz. Weathers out into tabular blocks. Intrudes surrounding rocks at high angle

Intrusive and hypabyssal rocks related to the volcanic rocks of Chimney Rock (lower Miocene)

Tci **Basaltic andesitic to dacitic intrusive rocks**—Shown in cross section only

STRUCTURE

The main geologic structures of the Grizzly Peak quadrangle are the eroded remains of volcanoes. These volcanoes were constructed from the eruptions of lavas and pyroclasts of basaltic to rhyolitic composition, with basaltic andesite and dacite being the most prevalent compositions. The major volcanic structures in the quadrangle are preserved today as areas of high elevation and high relief. The diffuse morphology of the oldest lava flows indicates that the oldest features were probably shield volcanoes. Upon these shield volcanoes arose small stratovolcanoes such as Chimney Rock in the adjoining Rio Canyon quadrangle to the west. Subsequent volcanic eruptions built a substantial stratovolcano centered over Climax, with a composition and volume comparable to modern Mount McLoughlin. The remains of this edifice, the ancient Grizzly Peak volcano, are Grizzly Peak and its unnamed sister butte to the north. In the Deer Creek and Soda Creek basins east of Eagle Butte, the Eagle Butte silicic eruptive complex (EBSEC) developed. This feature has been deeply incised and reshaped by erosion and partially buried by younger lavas. Its northwestern flank, from which Eagle Butte projects, forms a semicircular arc. Parts of the EBSEC impinge upon the northeasternmost flank of the Grizzly Peak stratovolcano. At least part of EBSEC collapsed, producing a caldera. Radiating faults are preserved in the area of Deer Creek. Concentric ring fractures are not well exposed, but dacite lavas crop out in a semi-circular arc along the ridge that upholds Eagle Butte. These lavas are thought to have been erupted from ring fractures following a catastrophic collapse within the EBSEC (see cross section A-A′). Between Deer Creek and Soda Creek, faults trend radially from a dacitic resurgent extrusive/intrusive dome (units Twda, Twhd). Subsidence of this domal structure induced the semi-arcuate fault in Deer Creek. Numerous intrusive and vent facies rocks crop out within the EBSEC, including dikes, dacitic vent facies agglutinate, and vitrophyric dacitic stocks or domes that intruded surface rocks and may have reached the surface. Late-stage magmatic activity produced dikes and induced propyllitization and argillization of rocks in the EBSEC. Faulting in and near the EBSEC has been primarily a result of constructional volcanic activities and subsequent foundering of some of these structures during early Miocene time.

MASS WASTING FEATURES

The Sharon Fen area (approximately sec. 13, T. 38 S., R. 2 E.) includes numerous mass-wasting features of Quaternary age, including a number of gravitationally induced normal faults. With many small ponds and closed depressions, Sharon Fen is a new preserve of The Nature Conservancy. A fen is a nutrient-rich, peat-forming wetland that gets most of its nutrients from groundwater or runoff from uplands (Darren Borgias, The Nature Conservancy, Ashland, personal communication, 1996). The area contains some evidence of continued, localized creep and intermittent downslope movement including the occasional curved tree trunk and some fresh but small slump scarps. The main headwall scarps are at least 60 m (200 ft) high. At the base of the main scarps are talus piles 10–20 m (30–60 ft) high of basaltic andesite boulders. In the NW¼ sec. 13, T. 38 S., R. 2 E., a 550-m-long (1,800-ft) chasm up to 20 m (60 ft) deep and 15 m (50 ft) wide is at the base of a 60-m (200-ft) cliff. Throw on individual faults is as much as 120 m (400 ft). The faults intersect the surface at a high angle (greater than 60°). Rotation of individual fault blocks is as much as 15°. The faults are arcuate in plan view. Sharon Fen, essentially a sag pond (Bates and Jackson, 1987), occupies one of the numerous closed depressions in the gently to moderately sloping, undulating terrain. Examination of the fault blocks in the area shows that the faults cut both the overlying basaltic andesites of the Heppsie Formation and at least some of the underlying tuff beds of the tuff of Eagle Butte. It is thought that the faults may be rooted in and flatten out in the relatively ductile rocks of the tuff of Eagle Butte or the tuff of Shale City (cross section B-B′).

The normal faults in the Sharon Fen area have many of the characteristics (Shelton, 1984) that indirectly indicate listric normal faults. The dip of a listric fault shallows with depth. Abundant data on the position of fault surfaces in the subsurface is lacking; however, there is indirect evidence that the faults in the Sharon Fen area are listric. The faults have sharply arcuate patterns. The basin in which Sharon Fen lies is bordered by an arcuate escarpment. The stratigraphic succession consists of brittle rocks (Heppsie Formation) overlying ductile rocks (tuff of Eagle Butte, tuff of Shale City?). Growth chasms at the foot of the large cliffs in the Sharon Fen area indicate that hangingwall material has slipped along a subhorizontal surface. This movement resulted in extension and subsidence in the hangingwall as seen in the many closed depressions. Rotation of individual fault blocks to the northeast toward the fault plane, together with the other evidence, also indicates a listric normal fault geometry. These faults are not true growth faults in the sense that stratigraphic deposition occurs on the downthrown block (Bally and others, 1981; Crans and others, 1980), unless one takes the position of Shelton (1984) that all listric normal faults are growth faults, because their footwalls are sites of sedimentation. Certainly, the Sharon Fen area is a site of talus and lacustrine sedimentation. Although the faults may be shallowly rooted, their downdip termini, if projected to the surface, would be obscured by soil and colluvium (cross section B-B′).

A number of factors have contributed to the development of the landslide feature at Sharon Fen. The area is underlain by ash-flow tuffs that are susceptible to chemical decomposition of their volcanic ash component to clay minerals, producing a ductile unit relative to the overlying basaltic andesites. The area above Sharon Fen receives more precipitation than the valley below. The overlying basaltic andesites have numerous joints, fractures, and rubbly interflow zones that provide routes for water to infiltrate and saturate the underlying tuff. Progressive headward erosion by the creeks below has produced a situation where the area is asymmetrically loaded; there is no mass of rock to the southwest to buttress the Heppsie Formation in its position atop weaker tuff. The high relative relief of the area has produced a high relative potential energy for the higher rock units; there is a tremendous gravitational inducement for the rocks to move downhill. These factors have combined to induce the Sharon Fen area to move to its present position and may induce movements in the future.

NEW GEOLOGIC UNITS

The classification of igneous rocks in this report follows the geochemical method of Le Bas and others (1986). Chemical analyses were recalculated anhydrous (corrected for loss on ignition) to 100 percent to obtain rock names following the convention of the International Union of Geological Sciences (IUGS) (Le Bas and Streckeisen, 1991). Major oxide data are shown in Table 3. Where geochemical analyses were lacking, rock names were applied by visually comparing unanalyzed rocks with analyzed rocks.

This report substantially expands the stratigraphic detail of previous reports (Wells, 1956; Smith and others, 1982) and extends detailed mapping south from the adjoining Lakecreek quadrangle (Hladky, 1995). Wells (1956) mapped three major divisions of Tertiary volcanic rocks in the quadrangle: the Roxy Formation, the Wasson Formation, and the Heppsie andesite. He considered the Roxy Formation to be mostly lava flows with some intercalated tuffs and vent agglutinate and the Wasson Formation as consisting mostly of pyroclastic rocks. These two units he combined as the Little Butte volcanic series. Above this was a great thickness of andesite flows he called the Heppsie andesite. The stratigraphy of Wells (1956) would continue to hold up except for its lack of resolution in areas between Medford and Lakecreek. Smith and others (1982) produced a geologic map on a base map with less resolution than that of Wells, but they added more lithologic detail. Smith and others (1982) dropped the names of the volcanic units of Wells (1956) because of the regional scope of their map and because more lithologic detail could be added. Lithologic units were assigned stratigraphic positions on the basis of known or inferred ages. Several volcanic centers and their associated deposits were identified, a significant step forward from Wells (1956). Hladky (1995) produced a high-resolution map of the Lakecreek quadrangle to the north, which included the type area for the Wasson Formation. He relinquished the usage of the Roxy Formation in the Lakecreek area, largely because Wiley and Smith (1993) had shown that the type area for the Roxy Formation was an intrusive plug and had not applied the nomenclature themselves. Hladky (1995) retained the Wasson Formation because, as defined in Wasson Canyon, the unit withstood careful stratigraphic scrutiny. Several new units of the Wasson Formation were mapped and described because of the possibility to resolve these units at the 1:24,000 scale of mapping (Hladky, 1995). Below the Wasson Formation, Hladky (1995) differentiated and named several new lava flow units. Above the Wasson Formation, Hladky (1995) discovered considerable lithologic and age diversity in the lava flow rocks of the Heppsie andesite. He changed the name to the Heppsie Formation to reflect the lithologic diversity. Volcanic rocks of Miocene-Pliocene and Pliocene-Pleistocene age, formerly in the Heppsie andesite, he set apart as separate units.

In this report, volcanic new map units have been informally named after geographic features interpreted to be in the vicinity of their sources. Newly described units include the volcanic rocks of Chimney Rock and the volcanic rocks of Grizzly Peak. Several new units have been added to the Wasson Formation. Detailed descriptions can be found in the preceding explanation of map units.

The oldest rocks in the Grizzly Peak quadrangle are undifferentiated rocks of the volcanic rocks of South Fork Little Butte Creek and basaltic andesite of Lake Creek, two units defined in Hladky (1995) but not differentiated here because of insufficient exposure. The basaltic andesite of Lake Creek is mapped separately where exposures allow. Overlying these units are the lower Miocene volcanic rocks of Chimney Rock, originally included by Wells (1956) in his Roxy Formation. They obtain their name from a prominent crag in the adjacent Rio Canyon quadrangle that once underpinned a lookout facility. The volcanic rocks of Grizzly Peak overlie the volcanic rocks of Chimney Rock. They were named after Grizzly Peak and are divided into several subunits. The complexity of the Wasson Formation in the Grizzly Peak quadrangle has led to the identification of several new units. The Wasson Formation is divided into three members: the Eagle Butte-Shale City member, the Heppsie Mountain member, and the buff tuff of Wells (1956) whose current nomenclature requires some explanation.

Near Lakecreek, Wells (1956) first mapped a buff-colored tuff and showed that it extended over a broad area at the base of the Wasson Formation. He described it variously as "buff fine-grained tuff with fragments of flow rock" and "massive, dirty-yellow tuff." He mapped the unit as unit Twbt. The extent of unit Twbt at the base of the Wasson Formation was confirmed by subsequent mapping in the Lakecreek quadrangle (Hladky, 1995) and the usage of unit Twbt was retained because significant spatial and lithologic changes were not found, nor had sufficient work been done on the unit in the region to place an adequate geographic name to the unit. Not being able to rely upon additional descriptive and geographic work, Hladky (1995) informally called unit Twbt, the buff tuff of Wells (1956). This report is essentially a continuation of the work done in the Lakecreek quadrangle by Hladky (1995). Although this report reveals additional exposures, the probable source area, and some additional lithologic details, the essential tuffaceous, pyroclastic nature of this unit has not changed, nor has its stratigraphic position. Therefore, the author has chosen to continue to use the "buff tuff of Wells (1956)" to describe a probable regional marker at the base of the Wasson Formation on a interim basis until further work can be done in this complex volcanic terrain.

New units in this report are a result of work that shows that the new units were clearly not recognized previously and lie at newly recognized stratigraphic positions.

Correlations between members of the Wasson Formation and between specific vent and distal facies within members may be uncertain. Units of the Eagle Butte-Shale City member are related to the EBSEC. Units of the Heppsie Mountain member contain rocks from sources both inside and outside the EBSEC and crop out on the south flank of Heppsie Mountain. The buff tuff of Wells (1956) has its source in the EBSEC but is regionally extensive and can be found beneath both the other members of the Wasson Formation. Other notable new subunits to the Wasson Formation include the tuff of Shale City, the tuff of Eagle Butte, and several unnamed extrusive lavas within the EBSEC. New radiometric ages have better defined the Wasson Formation to be lower Miocene.

Intrusive equivalents to various extrusive units are described in this report, some for the first time.

GEOLOGIC SUMMARY

New $^{40}Ar/^{39}Ar$ ages (this report) indicate that the oldest rocks in the Grizzly Peak quadrangle erupted during earliest Miocene time near the Miocene-Oligocene boundary (as defined by Palmer, 1983; Berggren and others, 1985). The stratigraphically lowest rocks in the quadrangle are basaltic andesite lava flows and associated vent deposits of the undifferentiated volcanic rocks of South Fork Little Butte Creek and basaltic andesite of Lake Creek (unit Tub). For unit Tub, a new $^{40}Ar/^{39}Ar$ age (this report) of 23.35±0.39 Ma, comes from a basaltic andesite adjacent to South Fork Little Butte Creek. This higher resolution age revises previous interpretations for the age of the overlying Wasson Formation: For lava flows (unit Twf) in the Lakecreek quadrangle, a K-Ar age of 24.0±1 Ma had been determined (Fiebelkorn and others, 1983; Hladky, 1995). The Wasson Formation is now assigned to the lower Miocene in the Grizzly Peak quadrangle. The oldest rocks in the quadrangle are still poorly understood because of their lack of exposure. The existing field exposure indicates, however, that basaltic andesite was one of the most prevalent rock types being erupted at the beginning of the Miocene and that it probably formed small shield volcanoes.

Rocks of the basaltic andesite of Lake Creek of Hladky (1995) are among the oldest rocks in the quadrangle. These rocks have vents both in the Grizzly Peak quadrangle and in the adjoining Rio Canyon quadrangle to the west. Broad, diffuse lava flows were the principal result of these eruptions. Some dacitic tuffs (unit Tlt) were incorporated into these lava flows.

Eruptions of the basaltic andesite of Lake Creek were followed by a suite of early Miocene eruptions which produced proportionately more andesite and dacite than basaltic andesite. These eruptions produced the volcanic rocks of Chimney Rock (this report). The vent facies are clearly visible at Chimney Rock, where erosion has exposed the interior of a former volcanic cone. Isolated blocks of reddish-brown, altered, dacitic vent agglutinate up to 7 m across in sec. 18, T. 37 S., R. 2 E., are interpreted to be the remains of a block and ash flow which covers about one-eighth of the section. The proportion of Fe_2O_3 to MgO in one of these boulders (map no. 10, Table 3) indicates a tholeiitic lava—the implications warrant future petrologic study. Basaltic andesite lava flows also emanated from the vicinity of Chimney Rock. The remains of other subsidiary cones are exposed as isolated vent deposits and tuffs (units Tcv and Tct) in the Grizzly Peak quadrangle.

Subsequently, a large stratovolcano arose in the area of Grizzly Peak. Although concentrated geochemical sampling is lacking, Grizzly Peak appears to be comprised mainly of basaltic andesite. Substantial volumes of mafic pyroclastic material allowed a steep-sided structure that was subsequently reinforced by a voluminous mantle of basaltic andesite lavas. During early Miocene time, Grizzly Peak was perhaps much the same type of structure as Mt. McLoughlin, a predominantly basaltic andesite edifice (Maynard, 1974). Grizzly Peak is now bisected by Antelope Creek, whose headwaters near Climax lie in the belly of an ancient volcano. This deep incision into an ancient volcano of the Western Cascades provides a glimpse into its internal structure, including a view of large volumes of vent agglutinate and the small but prominent feeder dikes (unit Tgib) that provided lava for subsequent basaltic andesite lava eruptions. Lava from these eruptions inundated earlier volcanic structures, including parts of the structures at and near Chimney Rock.

Approximately coeval with the development of the basaltic andesite center at Grizzly Peak was the development of the Eagle Butte silicic eruptive complex (EBSEC) that includes an arcuate feature that encompasses the Deer Creek and Soda Creek basins. The arc of this arcuate feature can be roughly delineated by three points: mile 24 on South Fork Little Butte Creek, Eagle Butte, and Hill 4806 above Lost

Lake. This arcuate feature delineates the northwestern portion of the EBSEC. The southwestern portion of the EBSEC abuts Grizzly Peak. The northern, southern, and eastern portions are obscured by the rocks of the Heppsie Formation. From the EBSEC burst voluminous ash-flow sheets. The first, the buff tuff of Wells (1956) (unit Twbt), ejected large volumes of material to the north. This unit is tracked well into the northern parts of the adjoining Lakecreek quadrangle (Hladky, 1995). Its persistent, densely welded vitrophyre (unit Twby), extends nearly 6 km (4 mi) to the northwest from the interior of the EBSEC. The buff tuff of Wells (1956) is coarsest near its source area, containing ash tuff breccias (ash-flow tuffs with less than 25 percent ash and less than 75 percent blocks) (Dietrich and Skinner, 1979) on either flank of today's Eagle Butte and some notable blocks up to 2.5 m at Lost Lake. Finer grained facies were ejected to the north and east. It is conjectured that a volcanic depression resulted from the initial cataclysmic eruptions, allowing the deposition of lacustrine sediments. Small, postcataclysmic eruptions produced ash-falls that entrained and preserved leaves. The fossil leaves indicate sufficient passage of time for the establishment of trees in the EBSEC. The establishment of this volcanic depression, or caldera, was temporary, because resurgence and renewed pyroclastic activity uplifted and overwhelmed early lacustrine deposits.

From unknown sources to the north, perhaps from the Esmond Mountain-Slinger Rock area of the Lakecreek quadrangle, basaltic andesite lavas (unit Twf) were erupted onto the surface of the buff tuff of Wells (1956) in the area north of South Fork Little Butte Creek. This area comprises the south flank of Heppsie Mountain. The Heppsie Mountain member of the Wasson Formation, a series of alternating tuffs and lavas, was deposited here. The white tuff of Wells (1956) (unit Twwt), is thought to be derived from distant sources to the north. Subsequent, alternating lavas and tuffs (units Twba1, Twt1, Twba2, Twt2) were derived locally, the lavas probably originating from Heppsie Mountain and the tuffs from the EBSEC. Dacite lava of the Eagle Butte-Shale City member (unit Twd3), caps the sequence of primarily silicic rocks of the Heppsie Mountain member on the flanks of Heppsie Mountain. Basaltic andesite lavas of the Heppsie Formation, in turn, cap the Wasson Formation sequence.

Within the EBSEC, large volumes of viscous dacite lava (unit Twd1) extruded from the foundered remains of the silicic volcano, locally concentrated along ring fractures near the outer margins. Resurgence within the EBSEC produced silicic lavas and intrusions in the interior of the structure (units Twda, Twir). On the southwestern periphery of the EBSEC between Lost Lake and Grizzly Peak, in secs. 2 and 3, T. 38 S., R. 2 E., substantial accumulations of dacite lava in at least two stages (units Twd1, Twd2) were erupted. At least some of the vent facies rocks are exposed (unit Twdv). Some of these eruptions produced intra-caldera debris flows (unit Twp).

Following the effusion of viscous dacitic lava, another series of explosive eruptions ensued. Perhaps less energetic than prior explosive eruptions, these produced less densely welded, finer grained ash-flow tuffs, the tuff of Shale City (unit Twst). Vent facies rocks (unit Twdv) in the S½ sec. 3, T. 38 S., R. 2 E., may indicate a possible source for these tuffs. The tuff of Shale City contains some small, local, waterlain tuffs and shales large enough to be mapped in sec. 16, T. 38 S., R. 2 E., and leading to the naming of Shale City. Sufficient organic material collected in restricted intermontane basins during volcanically quiescent periods to produce thin seams of oil shale.

Renewed activity in the EBSEC produced the tuff of Eagle Butte, a succession of welded tuffs alternating with associated nonwelded facies. The complex character of this unit is exposed in the Sharon Fen area in the southeastern corner of the quadrangle. The tuff of Eagle Butte surmounted earlier dacitic lavas that rimmed the EBSEC and filled intermontane paleovalleys mainly to the south and east of Eagle Butte.

The eruption of dacite lava (unit Twd3) and the intrusion of small silicic dikes and intrusive bodies (units Twid, Twir) concluded silicic volcanism in the quadrangle. The EBSEC, though of major influence in shaping the geology of the quadrangle, was active only from about 23 Ma to 21 Ma.

Multiple and extensive basaltic andesite lava flows of the Heppsie Formation with sources north and east of the quadrangle inundated the silicic rocks. These lavas, dated at 22.8±0.8 Ma (K-Ar age of Fiebelkorn and others, 1983), note the range in precision), are only slightly younger than the underlying tuff of Eagle Butte (unit Twew) with a $^{40}Ar/^{39}Ar$ age of 21.43±0.76 Ma (this report). Small, westerly remnants of these flows are found on Eagle Butte. Extensive erosion during the last 20 million years has removed much of these capping lavas to reveal the silicic rocks beneath. Younger, late Miocene to Pleistocene? volcanism occurred north (Hladky, 1995) and east (Naslund, 1977) of the quadrangle, but probably did not encroach upon the Grizzly Peak quadrangle.

Chemical weathering, mass wasting, and colluvial and fluvial processes have dominated the geologic events since early Miocene time in the Grizzly Peak quadrangle. Tuff beds have become infiltrated with water and decomposed, which lowered their load-bearing strength. Headward erosion up creeks and draws has removed lateral buttresses. As a result, many slump blocks and landslides have developed in the quadrangle. The area of most extensive mass wasting is in the southern part of the quadrangle, particularly in the Sharon Fen area, sec. 13, T. 38 S., R. 2 E. The area stands out for its normal faults, scarps, chasms, slump blocks, sag ponds, glide blocks, and rotated blocks. Landslide deposits drape many of the hillsides and in many cases are well forested. A landslide deposit in the NW¼NW¼ sec. 35, T. 37 S., R. 2 E., impounds Lost Creek to form Lost Lake. The timber on the landslide is mature.

Landslide deposits in the Grizzly Peak quadrangle are thought to be of Quaternary age. Some features, such as the sag ponds of Sharon Fen, would have deteriorated in a few millennia, filling in with sediment without some downslope movement to rejuvenate the undulating topography from time to time. Many of the landslide features are still intermittently active today. The oldest landslide features we see today are probably no older than about Pleistocene.

As a result of various mass-wasting mechanisms, blankets of colluvium have developed on some slopes. Colluvium is mapped where thick deposits obscure the underlying units and the underlying bedrock relationships.

At the mouths of several draws that empty into South Fork Little Butte Creek are Quaternary alluvial fans. These draws are only intermittently flowing, but during high-precipitation events they can carry a substantial bedload down the steep slopes. At the base of the slope, the streams dump much of their bedload at the slope-valley interface. South Fork Little Butte Creek occupies only a small part of the valley in which it resides. As a result, it moves these fan deposits only when the toes of the fans encroach upon the creek's channel, or perhaps during the highest flood events. The extent of the fan deposits up the draws indicates that South Fork Little Butte Creek is cutting its bed downward, leaving behind the fan deposits. This downward-cutting of the South Fork Little Butte Creek is consistent with the behavior of North Fork Little Butte Creek, which has left stranded terrace gravel in the adjoining Lakecreek quadrangle (Hladky, 1995). Bedloads of sediment during the wetter Pleistocene were probably higher, and Holocene dryness and its resultant decrease in sediment loads probably has contributed to the incisement of alluvial fans in the quadrangle.

GROUNDWATER RESOURCES

Groundwater resources are tapped by domestic wells within the quadrangle. The capacity of the groundwater resource is unknown. The water table, however, fluctuates seasonally. Transmissivity and water quality are largely determined by rock formation characteristics. Altered tuffs tend to be less transmissive. Tuffaceous, carbonaceous shales at Shale City were found to contain high levels of metals, including arsenic and mercury (map no. 23, Table 4). The absorbent characteristics of the shale make it probable that these rocks initially absorbed metals from hydrothermal systems and may continue to absorb metals from groundwater today. The EBSEC shows indications of past hydrothermal activity that has mobilized metals in the groundwater and induced argillization and propyllitization. Subsequent leaching of propyllitized rocks has produced gossans. Arsenic springs are modern remnants of ancient hydrothermal systems. Wells drilled into silicic rocks in the area are likely to encounter elevated levels of metals. Mrs. Stone, owner of the Stone Ranch in secs. 3 and 10, T. 37 S., R. 2 E., reported that arsenic in three of her wells adversely affected the health of household members for several years until the problem was discovered. She also reported an arsenic spring in Soda Creek that had poisoned cattle. This spring is located at map no. 9 in sec. 18 T. 37 S., R. 3 E. A sample of the limonite deposits at the spring yielded very high arsenic content (Table 4). Water testing of wells in the Grizzly Peak quadrangle indicates that elevated arsenic is a common water quality problem (Charles Lane, SOSC, and Fay Fowler, Neilson Research Corporation, personal communications, 1995).

Table 1 below presents maximum contaminant levels (MCLs) for drinking water of selected elements as mandated by the Environmental Protection Agency . These data can then be compared with the trace-element data in Table 4 to draw correlations between mineralized rocks and possible sources for naturally contaminated groundwater. Areas of highly mineralized rocks are of potential concern to meeting the drinking-water standards shown.

Table 1. *MCLs of selected elements for drinking water. (Data from Fay Fowler, Neilsen Research Corp., 1996)*

As	Cu	Hg	Pb	Sb	Zn
50 ppb	15 ppb	2 ppb	15 ppb	6 ppb	5,000 ppb

MINERAL RESOURCES

Rock resources are the most utilized mineral resource in the Grizzly Peak quadrangle. Quarries are located on both private and BLM land, mostly in dacite lavas but also tuff and basaltic andesite (Table 5). The rock is used for surfacing the unpaved roads in the quadrangle.

Manganese was prospected in the Grizzly Peak quadrangle at no less than five sites (Gray, 1993). The size of the pit at map no. M5 indicates past production of a few tens of cubic yards. Manganese oxides (manganite) fill fissures and vugs in fractured and vesicular dacitic tuff vitrophyre (unit Twby). At the Tyrrell Mine, Libbey and others (1942) reported a surface pit 30 m (100 ft) long and 6–10 m (20–30 ft) deep and 45 m (150 ft) of tunnels. These workings produced 200 tons of manganese concentrate prior to 1920. Ore grades averaged 20 percent manganese, with some samples exceeding 50 percent. The principal ore mineral was manganite with some psilomelane (Libbey and others, 1942). Today, the tunnel entrances are hidden beneath soil and vegetation. Trees in the main surface pit have 25–cm girths. Rich, 1-cm-wide veinlets of manganite can be seen in the basaltic andesite outcrops and dump rocks at the site. Complexly interwoven veinlets indicate locally severe premineralization fracturing. The remaining three manganese prospects (map nos. M1, M2, M8) could not be found.

On the hills west of Shale City, mercury was prospected at three sites, but no production is reported (Gray, 1993). These prospects are hosted in the tuff of Shale City (unit Twst). At the Mammoth Prospect (map no. M13) silicification is intense: the rock has become porcelaneous to cherty. The rock is highly fractured and contains a complex web of thin, submillimeter veinlets of red cinnabar and orange iron oxides in a white, porcelaneous to glassy silica groundmass.. The Lucky 13 Prospect (map no. M14) is less intensely fractured and mineralized, and shows little silicification. The tuffaceous character of the rock remains largely intact. The Hopeless Prospect (map no. M15) was not found.

Previous reports of the U.S. Geological Survey and the Oregon Department of Geology and Mineral Industries indicated a small, but high-grade occurrence of oil shale at Shale City (Weissenborn, 1969). The reports indicated 150,000 tons of oil shale grading as high as 36 gallons per ton. This deposit was retorted in the 1920s without commercial success. The shale was mined and mixed with water to make a medicinal tonic for several decades (Weissenborn, 1969). The deposit is now mostly mined out. A homesite is currently being constructed adjacent to the mine pit. An examination of the homesite excavation and nearby outcrops indicates that the occurrence of shale is limited to an area of 5 acres or less. Of the organic seams that remain in the abandoned mining pit, none is more than 4–5 cm thick, and these seams are discontinuous within the pit. An analysis of the darkest carbonaceous seams (map no. 23, Table 4) shows a high level of mercury (43,500 ppb), elevated levels of arsenic (148,000 ppb), and copper and zinc concentrations that also vastly exceed the maximum contaminant levels for drinking water. In September 1994, acrid-smelling water was pooled in the bottom of the pit. The water emanated from seeps in the shale.

This study discovered mineralization and alteration patterns indicative of possible disseminated precious (Au, Ag) and/or base (Cu, Zn, Hg) metal deposits in the Eagle Butte silicic eruptive complex (EBSEC) between Lost Creek and Soda Creek. Mercury has been prospected at the periphery of the EBSEC in the Shale City area. Cinnabar is present at the Mammoth Prospect (map no. M13). Mercury may or may not be an indicator of precious and other base-metal mineralization. It is an indicator of hydrothermal activity but not necessarily of the type associated with other base and precious metals. In hydrothermal systems it is more mobile than most other metallic elements. If mercury is present in a Au-Ag system, for example, it is often found as a distal halo. It is noteworthy, however, that Fischer-Watt Gold Company encountered anomalous values of mercury associated with the Al Sarena Mine (Bud Hillemeyer, Fischer-Watt Gold Company, personal communication, 1993). The mercury values at the Al Sarena Mine ran as high as 21,000 ppb. The Al Sarena Mine is a high-grade Au-Ag vein system with associated low-grade disseminated Au-Ag-Pb-Zn hosted within Miocene silicic rocks of the Western Cascades west of Prospect, Oregon. The carbonaceous shale beds of the tuff of Shale City (unit Twst) also contain anomalous levels of arsenic, copper, and zinc in addition to mercury (map no. 23, Table 4). In the E½SW¼SE¼NE¼ sec. 27, T. 37 S., R. 2 E., malachite was found lining vesicles in dacite lavas rimming the EBSEC. Argillization generally increases toward the center of the EBSEC, becoming acute in areas of dacite of the Eagle Butte-Shale City member (unit Twda). Propyllitization with associated disseminated pyrite is found at deeper levels of the EBSEC and generally increases toward silicic dikes and stocks. These propyllitized dikes are conspicuous in and near Soda Creek in secs. 17 and 18, T. 37 S., R. 3 E., and at map no. 5 along South Fork Little Butte Creek. Arsenic levels are elevated within the EBSEC (map nos. 4, 5, 9, Table 4). Incredibly high levels of arsenic emanate from a spring in Soda Creek (map no. 9, Table 4). High-level arsenic is often a pathfinder for volcanogenic gold-silver deposits in the western U.S. Notably, the Al Sarena Au-Ag deposit hosted in Miocene silicic rocks of the Western Cascades to the north contains high arsenic anomalies (Hladky, 1993). The Al Sarena Mine produced approximately 1,200 oz of gold between 1909 and 1918 (Brooks and Ramp, 1968).

The total disturbed area in the quadrangle from all mineral activities is <20 acres. Much of it is now overgrown.

GEOCHEMISTRY

Sampling methods

Rock samples were collected and analyzed for combined major and minor oxides and trace elements to determine their compositions (Tables 3 and 4). Samples were analyzed by X-Ray Assay Laboratories (XRAL) of Don Mills, Ontario, Canada. The suite of samples analyzed does not constitute a complete sampling of all the rock types found within the quadrangle.

Sample preparation

All samples were prepared at XRAL facilities. Samples were dried, crushed to minus 3 mm, riffle divided to a maximum split of 250 gm, and milled in chrome steel equipment. Silica cleaner was run between samples to minimize the risk of contamination from mineralized samples.

Chemical analysis

Whole-rock analysis

Whole-rock analyses were determined by roasting a 1.3-g sample at 950°C for one hour, fusing it with 5 g of lithium tetraborate and then casting the sample into a 40-mm button. The button was analyzed on a Philips PW1600 simultaneous X-Ray fluorescence spectrometer which is calibrated using more than 40 reference materials. Loss on ignition (LOI) was measured by weighing before and after roasting. Instrument precision on most major elements is better than 0.5 percent of the reported value.

Trace-element analysis

Fifteen trace elements including gold were analyzed for five mineralized samples (Table 4). Gold was determined by lead fire assay and plasma spectrometry on a 30-g sample. Mercury was determined by cold vapor spectrometry on a 0.25-g sample. Arsenic, antimony, and bismuth were determined by hydride-atomic absorption spectrometry for samples with low concentrations of these elements on a 0.25-g sample. Selenium and tellurium were determined by a method using acid extraction followed by graphite furnace atomic absorption. The remaining elements were determined by ICP spectrometry on a nitric aqua regia digestion of a 0.5-g sample. More detailed method descriptions can be obtained from XRAL or the Grants Pass office of the Oregon Department of Geology and Mineral Industries.

RADIOMETRIC AGES

Radiometric $^{40}Ar/^{39}Ar$ dating of three volcanic rock samples from the Grizzly Peak quadrangle was conducted in the laboratory of Robert A. Duncan, Oregon State University. The ages are total fusion ages and were obtained from samples GP2295-1, GP83194-2, GP81794-5, (map nos. 1, 19, 20, respectively). The Heppsie Formation, which erupted soon after the tuff of Eagle Butte, has a K-Ar age of 22.8±0.8 Ma (Fiebelkorn and others, 1983). Taking into account the levels of precision, the ages essentially bracket the age of the Eagle Butte silicic eruptive complex (Table 2).

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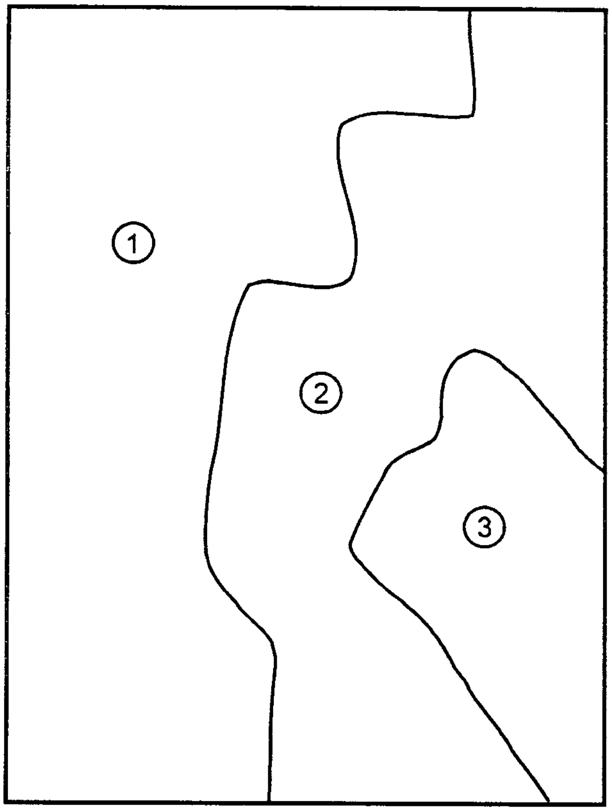

INDEX TO MAP RELIABILITY

1. Ground traverses at 0.1-1 km spacing; positions determined by inspection of topography and altimetry; supplemented by interpretation of 1:12,000 aerial photographs.
2. Ground traverses at 0.1-0.5 km spacing; positions determined by inspection of topography and altimetry.
3. Reconnaissance geologic mapping along roads and trails.

Table 2. *Radiometric ages for the Grizzly Peak quadrangle.*

Ar-isotopic data for DOGAMI samples (this report):

Map no.	Sample no.	Map unit	Material dated	$^{40}Ar/^{36}Ar \pm 1s$	$^{40}Ar/^{39}Ar \pm 1s$	$^{37}Ar/^{40}Ar \pm 1s$	J	Age ±1s (Ma)
1	GP2295-1	Tub	whole rock	1897.66±136.7	27.5580±0.110	0.050355±0.00010	0.0005459	23.35±0.39
19	GP83194-2	Twdl	whole rock	5420.36±203.2	25.0774±0.032	0.011980±0.00002	0.0005356	22.87±0.21
20	GP81794-5	Twew	plagioclase					
	Step 1			295.300±3.690	2292.96±245.13	0.000349±0.00007	0.0004784	0.1±26.5
	Step 2			320.768±1.856	297.782±3.740	0.010660±0.00008	0.0004784	21.3±1.5
	Step 3			330.622±2.182	220.192±1.445	0.020005±0.00005	0.0004784	21.7±1.2
	Step 4			336.070±2.838	174.684±2.850	0.048322±0.00022	0.0004784	21.2±1.3
	Plateau age (weighted mean of steps 2–4)							21.43±0.76

Ages calculated with the following decay constants and isotope interference corrections (R. A. Duncan, personal communication, 1996):
λ_ε=0.581 x 10^{-10}; λ_β=4.963 × $10^{-10}yr^{-1}$; $(^{36}Ar/^{39}Ar)_{Ca}$=0.000673; $(^{40}Ar/^{39}Ar)_K$=0.001

K-Ar isotopic data for USGS sample reported in Fiebelkorn and others (1983):

Map no.	Sample no.	Map unit	Material dated	K_2O weight percent	$^{40}Ar_{rad} \times 10^{11}$ (moles/gm)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)
25	75OSJ233	Th	plagioclase	(0.4245) 0.424 0.425	1.402	60.0	22.8±0.8

Abundance and decay constants of $^{40}K/K_{total}$=1.167 × 10^{-4}mol/mol; β = 4.962 × $10^{-10}yr^{-1}$; $\lambda + \lambda'$ = 0.581 × $10^{-10}yr^{-1}$; (Steiger and Jager, 1977)

Table 3. *Whole-rock analyses, Grizzly Peak quadrangle, Jackson County, Oregon*[1]

Map no.	Field/ Lab. no.	¼	¼	Sec.	T. (S.)	R. (E.)	UTM coordinates	Elev. (ft)	Lithology	Map unit	SiO_2 (wt. %)
1	GP2295-1	NE	NE	10	37	2	4691137N536178E	1,960	Basaltic andesite	Tub	51.9
2	GP122194-4	NW	NE	12	37	2	4691025N538635E	3,150	Dacite aa lava	Twd3	68.3
3	GP122294-2	NE	SE	11	37	2	4690406N537705E	2,500	Tabular dacite	Twba1	62.5
6	GP11295-1	NW	NW	13	37	2	4689503N537944E	2,200	Welded dacite ash-flow tuff	Twbt	64.4
7	GP11195-2	NW	NE	14	37	2	4689320N537250E	3,000	Platy dacite lava	Twd1	65.6
8	GP2795-2	SE	NE	18	37	3	4689065N540685E	2,640	Laminated rhyolite	Twr	71.0
10	GP12994-1	NE	SE	18	37	2	4688523N531230E	3,100	Dacite agglutinate boulder	Tcv	62.5
11	GP12695-5	SW	SW	13	37	2	4688445N538040E	2,590	Dacite vent agglutinate	Twdv	63.0
12	GP10594-1	NE	NE	24	37	2	4687787N539150E	3,050	Hornblende dacite	Twhd	63.3
13	GP82494-1	NW	NW	23	37	2	4687675N536452E	3,950	Tabular porphyritic dacite	Twd1	70.3
14	GP12695-1	SW	NE	23	37	2	4687411N537180E	3,050	Dacite vitrophyre	Twidy	65.7
15	GP10694-2	SW	SW	19	37	3	4686533N539558E	3,500	Columnar rhyolite dike	Twir	67.9
16	GP41895-1	SE	NE	26	37	2	4685685N537584E	4,150	Massive to tabular dacite	Twd3	65.5
17	GP82994-1	SW	SE	26	37	2	4684909N537340E	4,610	Vesicular dacite	Twd3	67.4
18	GP81794-3	SE	SE	26	37	2	4684919N537782E	4,720	Rhyolite	Twd3	68.9
19	GP83194-2	NE	NW	34	37	2	4684640N535295E	4,270	Platy dacite	Twd1	64.7
20	GP81794-5	SE	NW	36	37	2	4684259N538264E	4,550	Welded rhyolite ash-flow tuff	Twew	68.3
22	GP91394-1	SE	NE	4	38	2	4682533N534553E	5,020	Welded dacite ash-flow tuff	Twew	68.4
24	GP71994-4	SE	NW	17	38	2	4679543N531416E	5,830	Basaltic andesite	Tgub	52.4

Table 3. *Whole-rock analyses, Grizzly Peak quadrangle, Jackson County, Oregon (continued)*

Map	Oxides (wt. percent)										Trace elements (ppm)							
no.	Al_2O_3	TiO_2	Fe_2O_3T	MnO	CaO	MgO	K_2O	Na_2O	P_2O5	Cr_2O_3	Rb	Sr	Y	Zr	Nb	Ba	LOI	SUM[2]
1	17.3	0.718	8.57	0.14	9.45	5.78	0.53	2.61	0.10	0.01	15	315	15	60	<10	231	1.25	98.4
2	15.2	0.873	2.96	0.02	2.99	0.14	1.89	4.83	0.25	<0.01	46	323	40	190	<10	637	1.45	99.0
3	15.9	0.728	5.34	0.08	4.77	1.60	2.11	3.79	0.17	<0.01	54	302	31	167	<10	590	1.50	98.6
6	13.2	0.582	4.58	0.06	3.57	1.56	2.22	2.39	0.13	<0.01	63	1,120	33	160	<10	777	7.00	99.9
7	15.2	0.807	5.30	0.17	3.82	0.96	1.89	4.25	0.23	<0.01	53	295	39	159	<10	565	1.75	100.1
8	15.0	0.338	1.80	0.04	2.37	0.21	1.72	4.64	0.10	<0.01	69	332	30	149	<10	716	2.25	99.6
10	12.0	1.260	9.76	0.27	4.64	1.48	1.31	2.70	0.63	<0.01	39	304	44	118	<10	595	3.30	100.0
11	14.8	0.662	5.27	0.09	4.00	1.84	2.20	3.80	0.14	<0.01	53	292	35	177	<10	593	3.10	99.0
12	16.3	0.624	4.86	0.14	2.79	0.81	1.69	4.17	0.19	<0.01	36	340	18	204	<10	633	3.90	98.9
13	13.9	0.797	3.30	0.02	2.30	0.35	2.37	4.21	0.18	<0.01	60	241	46	213	<10	829	2.05	99.9
14	15.3	0.692	3.89	0.08	3.72	1.21	2.01	3.57	0.17	<0.01	106	293	43	157	<10	726	3.55	100.0
15	14.1	0.530	2.83	0.07	2.49	0.60	2.98	3.45	0.11	<0.01	69	258	38	199	<10	650	4.90	100.1
16	15.2	0.659	4.22	0.09	3.65	1.28	2.04	4.26	0.17	<0.01	69	294	44	203	<10	614	2.20	99.4
17	15.5	0.504	3.67	0.04	2.87	0.40	2.45	3.81	0.11	<0.01	72	261	34	188	<10	683	2.95	99.8
18	14.7	0.478	3.24	0.02	2.90	0.31	2.60	4.09	0.10	<0.01	78	260	38	200	<10	712	1.55	99.0
19	14.6	0.860	5.85	0.10	4.09	1.60	1.87	4.10	0.24	<0.01	64	288	41	163	<10	522	1.75	99.9
20	14.8	0.498	3.25	0.03	2.75	0.32	2.65	3.98	0.09	<0.01	73	253	35	195	<10	729	2.05	98.9
22	15.3	0.583	3.13	0.06	3.03	0.42	2.45	4.04	0.12	<0.01	70	245	58	192	<10	757	1.80	99.5
24	18.4	0.796	8.93	0.17	8.46	4.10	0.89	2.80	0.19	0.01	17	599	17	84	<10	308	1.50	98.8

[1] XRF analyses by XRAL.

[2] Includes trace elements, 1,000 ppm = 0.1 percent.

Table 4. *Analyses of selected trace elements, Grizzly Peak quadrangle, Jackson County, Oregon*[1]

Map no.	Field/ Lab. no.	¼	¼	Sec.	T. (S.)	R. (E.)	UTM coordinates	Elev. (ft)	Lithology	Map unit
4	GP122294-3	NW	SW	12	37	2	4690401N538020E	2,450	Gossaniferous dacite tuff	Twbt
5	GP42695-2	NE	NE	18	37	3	4689574N540980E	2,250	Propyllitic rhyolite dike	Twr
9	GP42795-2	NE	SE	18	37	3	4688635N540635E	2,270	Spring-fed limonitic clay	Twr
21	GP81794-4	SW	NE	36	37	2	4680330N538878E	4,400	Limonitic welded tuff	Twew
23	GP91294-1	NW	NE	16	38	2	4679853N534168E	4,520	Carbonaceous tuffaceous shale	Twsl

[1] Analyses by XRAL

Table 4. *Analyses of selected trace elements, Grizzly Peak quadrangle, Jackson County, Oregon (continued)*

Map no.	Au ppb	Ag ppm	As ppm	Cu ppm	Hg ppb	Mo ppm	Pb ppm	Sb ppm	Bi ppm	Cd ppm	Se ppm	Te ppm	Co ppm	Ni ppm	Zn ppm
4	20	<0.2	350	17.9	3240	2	4	3.3	2.1	<1	1.3	3.7	3	6	8.3
5	3	<0.2	133	18	304	<1	6	4.4	0.1	<1	0.5	<0.02	4	3	10.7
9	2	0.2	35800	1.7	28	<1	<2	49.7	17.8	<1	0.6	<0.02	1	<1	40.9
21	2	<0.2	17.8	8.5	19	<1	<2	0.1	<0.1	<1	0.7	<0.02	8	<1	103
23	3	<0.2	148	68.2	43500	<1	6	2.1	0.2	<1	0.7	<0.02	17	8	47.9

Table 5. *Mines, quarries, and prospects, Grizzly Peak quadrangle, Jackson County, Oregon*

Map no.	Name	¼	¼	Sec.	T. (S.)	R. (E.)	UTM coordinates	Elev. (ft)	Commodity	Map unit	Comments
M1	Fox Prospect	NE	SE	8	37	2	4690300N532736E	2,590	Manganese	Tl6	Not found
M2	Bush Ranch	NE	SW	9	37	2	4690200N533746E	2,350	Manganese	Tl5	Not found
M3	Tyrrell Mine	NW	SW	10	37	2	4690411N534800E	2,360	Manganese	Tl5	Reclaimed
M4	—	SW	SW	12	37	2	4690030N538040E	2,320	Stone (dacite tuff)	Twbt	On private land
M5	—	NW	NE	15	37	2	4689635N535736E	2,670	Manganese	Twby	On BLM land
M6	—	NE	SW	14	37	2	4688858N536620E	3,090	Stone (dacite)	Twd1	On private land
M7	Gravel Pit	SW	NE	23	37	2	4687528N537208E	3,150	Stone (dacite)	Twidy	On BLM land
M8	Coon Creek Claims	NE	SE	20	37	2	4687060N532725E	3,120	Manganese	Tl6	Not found
M9	—	NW	SW	23	37	2	4686900N536550E	3,650	Stone (dacite)	Twd1	On BLM land
M10	Gravel Pit	SW	SE	19	37	3	4686775N540513E	3,180	Stone (dacite)	Twdv	On BLM land
M11	Thorndike Pit	SE	SE	36	37	2	4683477N539200E	4,650	Stone (basaltic andesite)	Th	Stockpile area
M12	Gravel Pit	NW	NE	3	38	2	4682883N535685E	4,850	Stone (dacite)	Twd2	On BLM land
M13	Mammoth Prospect	NW	NE	9	38	2	4681475N533888E	5,020	Mercury	Twst	Reclaimed
M14	Lucky 13 Prospect	SE	NW	9	38	2	4681000N533543E	5,000	Mercury	Twst	Reclaimed
M15	Hopeless Prospect	NW	SW	9	38	2	4680520N533345E	5,210	Mercury	Twst	Not found
M16	Shale City Area	NW	NE	16	38	2	4679807N534183E	4,480	Oil shale (lacustrine tuff)	Twsl	Private homesite
M17	Sharon Lake Quarry	SE	SW	18	38	3	4678482N540183E	5,400	Stone (basaltic andesite)	Th	On BLM land