STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
DONALD A. HULL, STATE GEOLOGIST

GEOLOGY AND MINERAL RESOURCES MAP OF THE SOUTH MOUNTAIN QUADRANGLE, MALHEUR COUNTY, OREGON

1990

Base map by U.S. Geological Survey
CONTROL BY....................USGS AND NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN....................1966
REVISED FROM AERIAL PHOTOGRAPHS TAKEN....................1985
FIELD CHECKED..........1987. MAP EDITED....................1990
PROJECTION....................LAMBERT CONFORMAL CONIC
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR..........ZONE 11
10,000-FOOT STATE GRID TICKS..........OREGON, SOUTH ZONE
UTM GRID DECLINATION....................0°34' WEST
1990 MAGNETIC NORTH DECLINATION....................17°00' EAST
VERTICAL DATUM..........NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM....................1927 NORTH AMERICAN DATUM
To place on the predicted North American Datum of 1983, move the projection lines as shown by dashed corner ticks (17 meters north and 81 meters east)
There may be private inholdings within the boundaries of any Federal or State reservations shown on this map

NORTH

SCALE 1:24 000

KILOMETERS · METERS · MILES · FEET

CONTOUR INTERVAL 40 FEET
SUPPLEMENTARY CONTOUR INTERVAL 20 FEET
To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by .3048

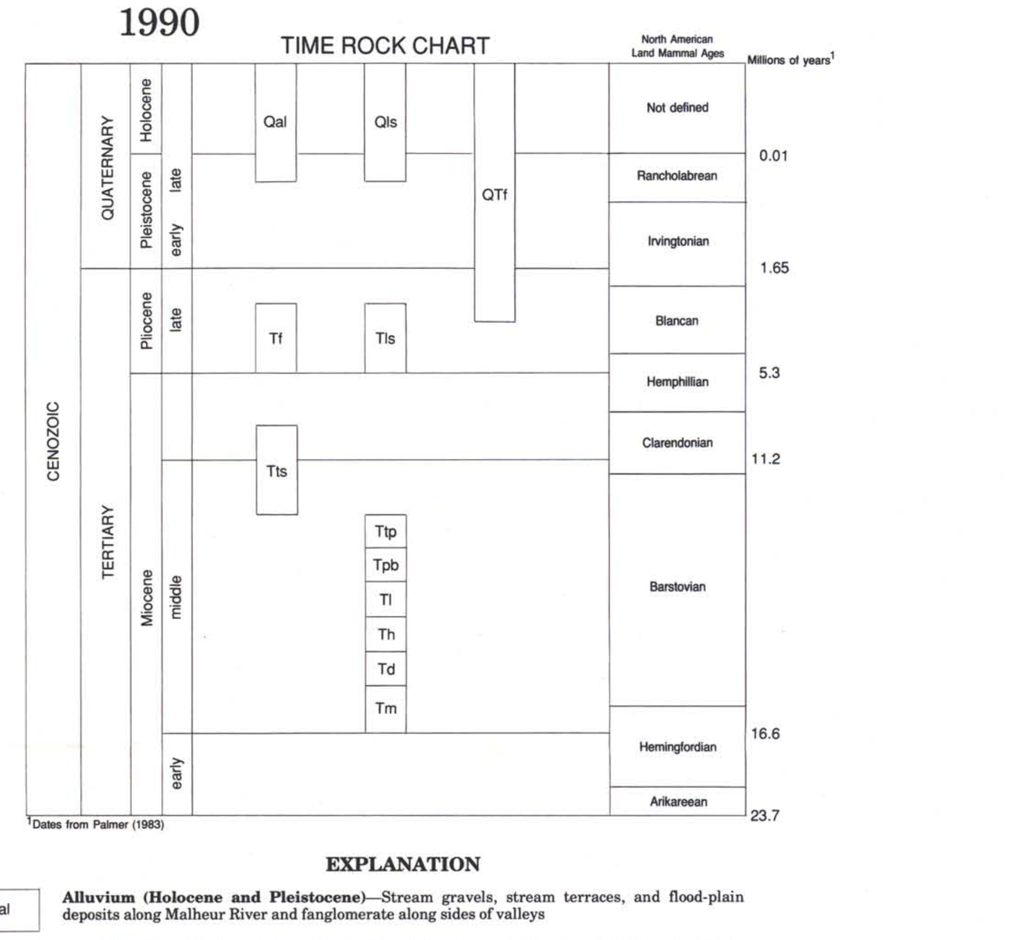
OREGON
QUADRANGLE LOCATION

Geology by James G. Evans, U.S. Geological Survey.

Mapping was conducted in 1988 and 1989 as part of the U.S. Geological Survey's Wilderness Study (Evans and others, 1990a,b) and COGEOMAP programs.

Acknowledgments: The section on analytical methods was prepared by G.L. Baxter, Geochemist, Oregon Department of Geology and Mineral Industries. This map was reviewed by James J. Rytuba and Dean Vander Meulen, U.S. Geological Survey, Menlo Park, California, and Mark L. Ferns and Howard C. Brooks, Oregon Department of Geology and Mineral Industries, Baker City, Oregon.

TIME ROCK CHART



EXPLANATION

Qal — **Alluvium (Holocene and Pleistocene)**—Stream gravels, stream terraces, and flood-plain deposits along Malheur River and fanglomerate along sides of valleys

Qls — **Landslide deposits (Holocene and Pleistocene)** — Common near steep faults and contact of the Littlefield Rhyolite of Kittleman and others (1965) and the Hunter Creek Basalt. Large deposit covering 1 mi^2 occurs in southeast corner of quadrangle. Surface of unit is hummocky. Landslide deposits contain large angular blocks. Layering in rotated blocks commonly tilts toward headwalls; closed depressions, some containing thin playa deposits, occur below some headwalls

QTf — **Younger fanglomerate (Holocene, Pleistocene, and Pliocene)**—Mostly coarse unconsolidated, poorly sorted sediments that contain angular boulders. Boulders, mostly basalt, are as much as 4 ft across. Vitrophyre and rhyolite boulders are locally abundant. In places, fanglomerate overlies caliche-cemented sandstone and white tuffaceous siltstone and claystone (lake beds) that are included in unit. Alluvial fan morphology is well preserved. Fanglomerate may be as much as 250 ft thick on the west side of Hog Creek in southeastern part of quadrangle

Tf — **Older fanglomerate (Pliocene)**—Poorly sorted, unconsolidated sediments containing angular basalt and rhyolite boulders as much as 2 ft across. Fanglomerate may be as much as 100 ft thick along the northern edge of the quadrangle. Age of unit is estimated to be predominantly older than unit **QTf** because alluvial fan morphology is poorly preserved, and unit is faulted

Tls — **Older landslide deposits (Pliocene)**—Unsorted angular boulders of rhyolite as much as 6 ft long. Occurs along contact of the Littlefield Rhyolite of Kittleman and others (1965) and the Hunter Creek Basalt. Age of unit estimated to be older than that of unit **Qls** because unit lacks landslide morphology and is locally faulted

Tts — **Tuff, lapilli tuff, and tuffaceous sedimentary rocks (upper and middle Miocene)**—Light-gray and pale-brown tuff, partly welded pumice lapilli tuff, and white tuffaceous sandstone, siltstone, and claystone. Unit is 200 ft thick in southeast corner of quadrangle and north of Malheur River along west edge of quadrangle. Age of unit is based on tentative correlation with the Juntura and Bully Creek Formations of Kittleman and others (1965)

Ttp — **Tims Peak Basalt (middle Miocene)**—Dark-gray to black basalt flows. Forms cliffs as much as 20 ft high along northern edge of plateau in southwest corner of the quadrangle. Unit has coarse columnar jointing and tends to break into crude slabs as much as 3 ft across that form perpendicular to column axes. Basalt flows are vesicular and diktytaxitic (5 to 15 percent cavities). Chemically, rock unit resembles high-alumina olivine tholeiites (Table 1, Plate 2) (Evans, in press), although olivine is not abundant modally and is absent in some samples. Plagioclase laths are as much as 0.08 in. long, but the mineral grains are not clearly divided into phenocryst and groundmass phases. Most of the rock consists of plagioclase (45 to 60 percent), clinopyroxene (25 to 40 percent), and olivine (as much as 10 percent). Minor ilmenite is present. Clinopyroxene is interstitial or forms oikocrysts as much as 0.16 in. long. Haddock (1967) determined an average modal composition for his samples: laboradorite, 55 percent; subcalcic augite, 20 percent; olivine, 10 percent; opaque minerals, 5 percent; glass, 5 percent; voids, 5 percent; and traces of apatite and alteration products. Olivine is partly altered to bowlingite. Basalt unit is 160 ft thick in quadrangle. Age of the basalt unit (12.4 Ma) is based on its correlation with radiometrically dated Shumuray Ranch Basalt of Kittleman and others (1965, 1967)

Tpb — **Pillow-basalt breccia (middle Miocene)**—Yellow-green basalt flows and palagonite breccia and hyaloclastite deposits containing whole and broken basalt pillows as much as 3 ft long in southwest corner of quadrangle. In the Tims Peak quadrangle to the south, unit is cemented by orange and white silica. Unit contains laminated to thin-bedded tuffaceous sandstone, rare olivine basalt flows, and pale-brown pebble sandstone that contains pebbles of rhyolite, black perlitic glass, and basalt. Basalt flows contain as much as 25 percent phenocrysts, mostly plagioclase laths as much as 0.04 in. long, and 5 percent olivine as much as 0.02 in. across. Phenocrysts tend to be glomeroporphyritic. Groundmass is mostly opaque minerals (ilmenite and/or magnetite) and also contains plagioclase laths and ophitic clinopyroxene. Unit thickens from 120 to 160 ft from west to east. Age of unit is based on its stratigraphic position between two units (unit **Ttp**, 12.4 Ma, and unit **Td**, 15 Ma), which have been assigned middle Miocene ages

Tl — **Littlefield Rhyolite of Kittleman and others (1965) (middle Miocene)**—Mostly massive gray porphyritic rhyolite flows that contain 5 to 15 percent white phenocrysts; weathers brown. Locally forms cliffs and pinnacles as much as 200 ft high. Rock commonly breaks along closely spaced cleavage that is not clearly related to flow layering. Base of unit consists of either as much as 40 ft of black vitrophyre or light-gray tuffaceous sandstone and light-gray and yellow tuff and welded tuff as much as 120 ft thick below the vitrophyre. Sandstone contains subrounded and rounded pebbles as much as 0.5 in. long as well as angular feldspar grains and sand-sized clasts of gray and black glass in a matrix of silt and clay. Flows in rhyolite unit are crudely divided by zones of black vitrophyre and by pyroclastic beds as much as 40 ft thick of pale-gray and white lithic lapilli tuff, siltstone, and sandstone. Individual flows may be as much as 200 ft thick. Phenocrysts, mostly plagioclase, are as much as 0.12 in. long and include minor quartz and magnetite. Kittleman and others (1965) also identified phenocrysts of sanidine, intermediate plagioclase, orthoclase, clinopyroxene, hypersthene, and magnetite that are glomeroporphyritic and commonly eroded by the groundmass. Groundmass consists of plagioclase laths as much as 0.008 in. long, opaque minerals, probably magnetite and hematite, and quartz. A rhyolite dike, 10 ft thick, in the basalt of Malheur Gorge in a roadcut of U.S. Highway 20 in NE¼ sec. 1, T. 21 S., R. 40 E., also contains minor hornblende, biotite, and tourmaline. Gas cavities are locally developed and filled with tridymite and zeolite minerals. In places, spherulites as much as 0.5 in. and poikiloblasts of feldspar as much as 0.01 in. have formed in the groundmass. Rhyolite unit ranges from 520 ft thick in the western part of the quadrangle to 880 ft in the eastern part and is more than 1,200 ft thick to the south in the adjacent Tims Peak quadrangle. Age of the unit is based on its stratigraphic position between two rock units (units **Ttp** and **Td**) that have been assigned middle Miocene ages

Th — **Hunter Creek Basalt (middle Miocene)**—Mostly aphyric black massive basalt flows that typically weather into irregular, angular, equant fragments as much as 8 in. across. In places, unit has as much as 15 percent white phenocrysts of plagioclase as much as 0.12 in. long. Rarely vesicular. Contains little flow layering or flow breccia and few sedimentary interbeds. Locally has red obsidian flow layering and pale-brown siltstone and sandstone beds as much as 10 ft thick. Plagioclase phenocrysts are euhedral and glomeroporphyritic in a groundmass of plagioclase laths 0.01 in. long. Some of the rock contains as much as 50 percent glass that contains trichites or is opaque owing to disseminated ilmenite or magnetite. Olivine, a minor constituent, is locally altered to bowlingite. Locally, basalt groundmass does not contain glass and consists largely of magnetite partly altered to hematite. Haddock (1967) determined modal compositions of three samples that were coarser grained than average: labradorite, 46 to 55 percent; clinopyroxene, 27 to 33 percent; opaque minerals, 5 to 8 percent; and glass, 13 to 15 percent. Unit is as much as 440 ft thick in quadrangle, has erosional unconformities at base and top, and pinches out in southeast corner of the quadrangle. Age of unit is based on its stratigraphic position between two units (units **Ttp** and **Td**) that have been assigned middle Miocene ages

Td — **Dinner Creek Welded Tuff (middle Miocene)**—Rhyolitic welded ash-flow and air-fall tuff. The densely welded part of unit is typically exposed and forms brown and gray cliffs 10 to 20 ft high. The poorly welded parts of the unit above and below the cliffs are usually covered by talus deposits. The strongly welded part has undergone enough crystallization to obliterate most of the primary pyroclastic structures and textures. It commonly contains lithophysae as much as 1 in. across and is cut by numerous white, yellow, and black quartz veins, especially in SE¼ sec. 22, T. 20 S., R. 40 E. In places, parts of the ash-flow unit above and below the cliffs are exposed: the unit is generally 10 to 20 ft thick above the cliffs and 20 to 40 ft thick below the cliffs. In places, only the strongly welded tuff is present. These poorly exposed rocks are light- to dark-gray, black, and yellow lapilli tuff welded to varying degrees and locally thin bedded (0.5 to 6 in.). Lapilli include mostly pumice but also black glass, welded tuff, and vitrophyre. Locally, black glass comprises as much as 50 percent of the rock. Pumice fragments as much as 5 in. across tend to be discoid and flattened along a compaction foliation. Sparse phenocrysts as much as 0.12 in. long consist of angular anhedral plagioclase, quartz, and rare olivine. Haddock (1967) identified anorthoclase as the most common feldspar phenocryst along with minor oligoclase and clinopyroxene in his samples. The Dinner Creek unit contains at least two cooling units and is about 60 ft thick over most of the quadrangle. It is thinner in the southern and southeastern parts of the quadrangle, where it is locally absent due to an unconformity. Age of the unit is middle Miocene, based on radiometric data (average 15 Ma)

Tm — **Basalt of Malheur Gorge (middle Miocene or older)**—These rocks were previously called the "unnamed igneous complex" by Kittleman and others (1965). Mostly dark-gray basalt flows weathering brown and greenish-brown that form discontinuous ledges 10 to 40 ft thick that represent individual flows. Chemically, rocks are tholeiitic basalts (Table 1, Plate 2). Basalt flows locally have columnar jointing. Lithologies include massive basalt, platy basalt, and black glassy vesicular basalt breccia. Basalt unit contains as much as 50 percent phenocrysts that are mostly plagioclase as much as 0.08 in. long and locally as long as 1 in. Minor olivine and ilmenite phenocrysts are also present in some flows. Groundmass is generally holocrystalline, consisting of plagioclase, olivine, and clinopyroxene (ophitic and intersertal). Proportions of major constituents are plagioclase, 40 to 75 percent; clinopyroxene, 0 to 35 percent; olivine, 0 to 20 percent; and ilmenite, as much as 5 percent. Haddock (1967) determined modal composition of 11 samples of the basalt to be labradorite, 41 to 52 percent; subcalcic augite, 22 to 35 percent; olivine, as much as 10 percent; opaque minerals, 3 to 9 percent; glass, 3 to 17 percent; and alteration products, as much as 19 percent. Olivine is locally altered to serpentine, magnetite, hematite, and bowlingite. Beds of pyroclastic and sedimentary rocks 6 to 40 ft thick comprise up to 10 percent of the unit. Lithologies include white to pale-gray and light-brown welded tuff, tuffaceous and arkosic sandstone, siltstone, and claystone, hyaloclastite, and red basaltic welded tuff. Hyaloclastite contains as much as 30 percent pale-brown, poorly indurated silt and angular glassy basalt fragments as much as 1 ft across. A few rounded basalt fragments in the hyaloclastite contain plagioclase laths as much as 0.04 in. long and minor olivine. Basaltic glass contains as much as 10 percent plagioclase laths as long as 0.04 in. and minor olivine. Basaltic welded tuff contains abundant angular lithic fragments of basalt and basaltic welded tuff and minor rhyolitic glass, rhyolitic welded tuff, and diatomite. A few basalt dikes as much as 20 ft thick were recognized cutting the lower part of the unit in the adjacent Jonesboro quadrangle (Evans, in press). The lower part of the unit is plagioclase phyric and contains sedimentary and pyroclastic interbeds. Upper part of unit is commonly aphyric, platy basalt lacking interbeds of other lithologies. Unit is at least 2,000 ft thick north of Malheur River. Unit is at least 1,400 ft thick in the Black Canyon area along the west boundary of the South Mountain quadrangle; at least 2,000 ft of the unit are exposed in the Jonesboro quadrangle (Evans, in press). Age of the unit is middle Miocene or older, as it underlies the middle Miocene Dinner Creek Welded Tuff

MAP SYMBOLS

Contact—Approximately located

Fault—Dotted where concealed; ball and bar on downthrown side

Hot springs

Quartz vein

■35 **Location of whole-rock sample analyzed in Table 1, Plate 2**

▲J **Location of altered-rock sample analyzed in Table 2, Plate 2**

●e **Location of stream-sediment sample analyzed in Table 3, Plate 2**

Note: Cross sections are on accompanying sheet (Plate 2)

GEOLOGY

The formations of the study area were described by Bowen and others (1963) and Kittleman and others (1965). A reconnaissance geologic map (scale of 1:63,360) that included the quadrangle was made by Haddock (1967) as part of a study of the Dinner Creek Welded Tuff of the Malheur Gorge area. Haddock's mapping was incorporated into a geologic map of the Owyhee region by Kittleman and others (1967) at the scale of 1:125,000 and a map of eastern Oregon by Walker (1977) at the scale of 1:500,000. The part of the quadrangle south of the Malheur River was mapped as part of the Gold Creek and Sperry Creek Wilderness Study Areas (Evans and others, 1990a,b) at the scale of 1:24,000. During that study, rock, stream-sediment, and panned concentrate samples were collected by the U.S. Geological Survey and the U.S. Bureau of Mines.

The rocks exposed in the quadrangle mostly comprise a flat-lying to gently-dipping section of volcanic, pyroclastic, and sedimentary rocks of late Tertiary age. The oldest unit, the basalt of Malheur Gorge, is a thick sequence of basalt flows containing minor sedimentary, pyroclastic, and hyaloclastite beds that is at least 1,400 ft thick in the quadrangle but at least 2,000 ft thick in the Jonesboro quadrangle to the west. The informal name of "basalt of Malheur Gorge" is proposed to supersede the original unit name of "unnamed igneous complex" of Kittleman and others (1965). The basalt of Malheur Gorge is common in the Malheur Gorge area and may extend as much as 30 mi south of the quadrangle (Kittleman and others, 1967). The unit is assigned a middle Miocene or older age, as it underlies the radiometrically dated Dinner Creek Welded Tuff.

The Dinner Creek Welded Tuff (Green and others, 1972; formerly the Dinner Creek Welded Ash-Flow Tuff of Kittleman and others, 1965) is clearly marked in the field by cliffs 10 to 20 ft high formed by the central strongly welded part of the unit. The less strongly welded parts of the formation above and below the cliffs are usually buried by debris from the overlying Hunter Creek Basalt. Average composition of the Dinner Creek is close to the average composition of alkali rhyolite (Haddock, 1967) (Table 1, Plate 2). It ranges up to 60 ft in thickness in the quadrangle. Source of the welded tuff, according to Haddock (1967), is a vent at Castle Rock, 15 mi northwest of the quadrangle. Isopachs of the ash-flow tuff show thickening toward that vent (Haddock, 1967). The welded tuff contains at least two cooling units that can be identified locally where the formation is well exposed above the cliffs. Some of the welded tuff contains basalt fragments that could have been derived from other basalt at depth. Fiebelkorn and others (1983) summarized radiometric ages of samples of the Dinner Creek at 15.3±0.4 Ma and 14.7±0.4 Ma in Malheur County and 14.9±0.4 Ma in Baker County. The two samples from Malheur County are from the Dinner Creek on the south side of Malheur Gorge just west of the study area. These ages indicate that the age of the Dinner Creek is about 15 Ma (middle Miocene).

In most of the study area, the Hunter Creek Basalt overlies the Dinner Creek Welded Tuff. In the southeast and south parts of the quadrangle, the Hunter Creek Basalt overlies the basalt of Malheur Gorge or is absent. The Hunter Creek Basalt typically breaks into irregular angular fragments that tend to cover the underlying formations. The Hunter Creek Basalt resembles the uppermost part of the basalt of Malheur Gorge in being black and aphyric and in containing rare sedimentary interbeds. This similarity suggests that the Hunter Creek Basalt and basalt of Malheur Gorge are part of the same basalt-flow assemblage. Chemical differences between the upper part of the basalt of Malheur Gorge and the Hunter Creek Basalt may be indicated by the platy character of the upper part of the basalt of Malheur Gorge and the angular fracturing of the Hunter Creek Basalt. Recent whole-rock analyses indicate that the Hunter Creek Basalt has about 5 percent more SiO_2, 1 percent more K_2O, and 2 percent more Fe_2O_3 than the basalt of Malheur Gorge (Table 1, Plate 2) (Evans, in press).

The Littlefield Rhyolite of Kittleman and others (1965) extends along the southern boundary of the quadrangle and is present in the eastern part north of the Malheur River. The rhyolite is not present in the northwest corner of the adjacent Jonesboro quadrangle. The base of the Littlefield Rhyolite cuts down through the section in the southeast corner of the quadrangle so that the rhyolite rests on the basalt of Malheur Gorge. Deposition of the rhyolite was preceded by pyroclastic eruptions that produced tuff, welded tuff, and tuffaceous sedimentary rocks locally preserved under the rhyolite. Pyroclastic rocks were deposited between rhyolite flows. The unit thickens from 520 ft in the southwest corner of the quadrangle to 880 ft in the southeast corner and is even thicker south of the quadrangle. Hagood (1963) suggested that the Littlefield Rhyolite was extruded from vents located about 14 mi south of the quadrangle at the Rooster Comb and Star Mountain (Kittleman and others, 1967). Other silicic vents have been mapped by Walker (1977) in that area. Rhyolite dikes cutting the basalt of Malheur Gorge in roadcuts of U.S. Highway 20 in the southeast part of the quadrangle (N½ sec. 1, T. 21 S., R. 40 E.) suggests the possibility that some large vents may be closer to the rhyolite outcrops in the South Mountain quadrangle. Evans and others (1990a) interpreted the vent for the Littlefield Rhyolite south of the Malheur River to lie in the northeastern part of the Tims Peak quadrangle below a circular aeromagnetic high. Hog Creek Ridge may mark the west edge of a north-south dike that also extruded the Littlefield Rhyolite across much of the east half of the quadrangle north of the Malheur River. The base of the rhyolite in the northeast corner of the quadrangle steepens abruptly so that the underlying Hunter Creek Basalt cannot be found in the bottoms of the deep canyons on the east side of Hog Creek Ridge where projections suggest that the Hunter Creek should be present. Thickness of the rhyolite increases from 400 ft maximum on the west side of the ridge to at least 1,100 ft on the east side. The ridge is marked by a north-south aeromagnetic ridge with a steep gradient on the west flank approximately where the contact of the rhyolite and the basalt appears to steepen.

A K-Ar age of 17.9±0.6 Ma was reported for the Littlefield Rhyolite south of the quadrangle (Fiebelkorn and others, 1983). This age is here considered to be in error because it is inconsistent with the three radiometric ages (average 15 Ma) reported for the underlying Dinner Creek Welded Tuff.

A unit made up predominantly of pillow-basalt breccia overlies the Littlefield Rhyolite and contains interbedded laminated to thin-bedded sandstone. To the south, in the adjacent Tims Peak quadrangle, the stratigraphic relationships suggest that the pillow-basalt breccia unit may have been deposited along the western margin of the basin in which the sedimentary rocks of the underlying Butte Creek Volcanic Sandstone of Kittleman and others (1965; 1967) were deposited (also Evans and Keith, unpublished mapping, 1989). The Butte Creek has been dated radiometrically and by fossils. Gazin (1932) identified Barstovian mammal skulls (middle Miocene in age, according to Berggren and others, 1985). A supportive middle Miocene radiometric age was given by Evernden and others (1964), who dated glass shards from the Butte Creek at 15.5 Ma (K-Ar age recalculated according to Dalrymple, 1979). Therefore, the pillow-basalt breccia unit is younger than 15.5 Ma but may still be middle Miocene in age.

The Tims Peak Basalt overlies the pillow-basalt breccia unit and caps much of the plateau in Tims Peak quadrangle south of the study area. Both Tims Peak Basalt and the underlying pillow-basalt breccia are chemically high-alumina olivine basalts (Table 1, Plate 2) (Evans, in press), suggesting that these two map units are related. Geologic mapping in the Tims Peak quadrangle (Evans and Keith, unpublished mapping, 1989) suggests that the Tims Peak Basalt is laterally continuous with the Shumuray Ranch Basalt of Kittleman and others (1965), which was dated at 12.4±0.5 Ma (middle Miocene; Fiebelkorn and others, 1983).

A K-Ar age of 21.6±2.3 Ma was reported for the Tims Peak Basalt south of the quadrangle (Fiebelkorn and others, 1983). This age is here considered to be in error because it is inconsistent with the middle Miocene ages determined for underlying units.

Tuff, lapilli tuff, and tuffaceous sedimentary rocks (unit Tts) overlie the middle Miocene or older volcanic rocks in small exposures north of the Malheur River along the west boundary of the quadrangle in the southeast corner. The unit north of the river may be related to the Juntura Formation of Bowen and others (1963). The unit in the southeast corner was mapped as part of the Bully Creek Formation by Kittleman and others (1965, 1967). Kittleman and others (1965) suggest that the unfossiliferous Bully Creek Formation may correlate with the Juntura Formation. The uppermost member of the Juntura Formation contains Clarendonian mammalian fossils (Shotwell and Russell, 1963) that are middle to late Miocene in age (Berggren and others, 1985). In the northeastern part of the Tims Peak quadrangle, lithic lapilli composed of brecciated basalt lithologically identical to the brecciated basalt around the rhyolite intrusions north of Monument Peak were found in welded tuff in the pyroclastic and sedimentary unit that Kittleman and others (1967) mapped as the Bully Creek Formation. This evidence suggests that the pyroclastic rocks of the Bully Creek were derived from the rhyolite vents at Monument Peak and that the Bully Creek is younger than 12.4 Ma, as the rhyolite intruded structures that formed after deposition of the Tims Peak Basalt. Some of the tuff may have come from calderas to the southeast such as the caldera inferred at Iron Point along the Owyhee River, 40 mi southeast of the quadrangle (Evans and others, 1990c). In this report, the tuff, lapilli tuff, and tuffaceous sedimentary rock unit is tentatively assigned a middle and late Miocene age. These relations suggest that the tuff, lapilli tuff, and tuffaceous sedimentary rocks in the quadrangle were parts of a network of lake basins formed on the middle Miocene and older volcanic rocks, perhaps not long after deposition of the Tims Peak Basalt.

The Miocene rocks are covered by fanglomerate of at least two periods. An older fanglomerate of presumed Pliocene age occurs on the west side of Hog Creek along the northern boundary of the quadrangle and in the west-central part. The relatively older age of the unit is suggested by its poorly preserved alluvial fan morphology and by the fault that cuts the fanglomerate. Younger fanglomerate of late Pliocene and Pleistocene age is common within 2 mi of the Malheur River and along Hog Creek. Along Hog and Spring Creeks, the fanglomerate covers sandstone, tuffaceous siltstone, and claystone. Rocks under the fanglomerate may be related to the middle and upper Miocene pyroclastic and sedimentary rocks of unit Tts. However, this correlation is not certain, and the outcrops of the sedimentary rocks were included in the fanglomerate. The well-preserved alluvial fan morphology and lack of faulting in the unit suggests that this fanglomerate unit is post-tectonic. Locally, the fanglomerate grades into alluvium.

Landslide deposits formed during at least two distinct periods. The older landslide deposits (unit Tls) in the northeast and central parts of the quadrangle consist of unsorted angular boulders of the Littlefield Rhyolite. The relatively older age of these deposits is suggested by the lack of slide morphology and by faulting of some of the deposits. The more recent landslide deposits (unit Qls) in the quadrangle occur where rocks have been weakened adjacent to steep faults and where the Littlefield Rhyolite overlies older rocks. The biggest slide in the quadrangle covers about 1 mi^2 in the southeast corner of the quadrangle. The relatively young age of these deposits is suggested by the well-preserved slide morphology and lack of faulting of the deposits.

The principal deposits of Holocene and Pleistocene alluvium are along the Malheur River where the flood plain is as much as 0.3 mi wide. Alluvium is poorly developed in most tributaries of the river. Hog Creek, an exception, contains a flood plain that locally exceeds 0.1 mi in width.

ISSN 0270-952X

GMS-67

Geology and Mineral Resources Map of the South Mountain Quadrangle, Malheur County, Oregon

By James G. Evans

Funded jointly by the Oregon Department of Geology and Mineral Industries, the Oregon State Lottery, and the U.S. Geological Survey COGEOMAP Program as part of a cooperatiave effort to map the west half of the 1° by 2° Boise sheet, eastern Oregon

Plate 1

STRUCTURE

The Miocene volcanic and sedimentary rocks are mostly flat lying to gently dipping in several directions but generally eastward. Locally, in a small area north of the Malheur River along the west boundary of the quadrangle, the rocks dip moderately to steeply to the south.

The eastward wedging out of the Dinner Creek Welded Tuff and the Hunter Creek Basalt are shown in cross sections C-C' and D-D'.

The rocks are cut by numerous vertical and steeply dipping faults that strike largely north, north-northwest, and west-northwest and intersect in an anastomosing pattern. A few faults strike northeast. In general, the faults striking west-northwest appear to be older than those striking north- and north-northwest because the west-northwest-striking faults are offset along the faults of the other two groups.

The general structure of the rock units of the quadrangle consists of a gently eastward-dipping homocline (cross sections B-B', C-C', and D-D'). The rock units disappear under the tuffaceous and sedimentary rocks of the Harper area to the east. Superimposed on the homocline is a west-northwest-trending graben along the western part of the Malheur Gorge (cross section A-A') into which the volcanic section is dropped about 2,000 ft. One of the faults in the graben appears to control the course of the Malheur River in the west half of the quadrangle.

The structure of the quadrangle may, in part, be a response to emplacement of small plutons nearby. Aeromagnetic data (Boler, 1978) shows a high over a rhyolite intrusion at Westfall Butte (Haddock, 1967) 5 mi northwest of the study area and a low in the Monument Peak area (Hagood, 1967) 5 mi southwest of the study area. The rhyolite intrusions are clearly younger than the Tims Peak Basalt (middle Miocene) because the intrusions cut structures that are younger than the basalt. A possible concealed intrusion (Griscom, unpublished data) 1 mi south of the study area is suggested by a circular aeromagnetic high that is interpreted by Evans and others (1990a) to reflect the vent through which the Littlefield Rhyolite south of the Malheur River was extruded. The aeromagnetic ridge along the east side of the quadrangle may reflect a dike through which the Littlefield Rhyolite was extruded north of the Malheur River.

Other structure in and near the study area may be reflected in the gravity potential data (Lillie, 1977; Boler, 1978). The gravity low, about 3 mi across along the west boundary of the quadrangle, centers over the widest part of the graben along the Malheur Gorge.

Uplift and erosion of the study area has occurred since Miocene rocks were deposited. Stages in the process are preserved in units Tts, Tf, and QTf. In addition, large scattered blocks (3 ft across maximum) of the Dinner Creek Welded Tuff on top of South Mountain may be the relics of fanglomerates that are older than unit Tf. Blocks of the Dinner Creek Welded Tuff that cannot be accounted for by human activity suggest that the Hunter Creek Basalt on the mountaintop was once covered by a fanglomerate. A possible source of the clasts of the Dinner Creek Welded Tuff is the ridge in the adjacent Jonesboro quadrangle on the west side of Black Canyon. That ridge is about 600 ft in elevation above the top of South Mountain and could have supplied clasts of Dinner Creek Welded Tuff to an alluvial fan that has been removed by erosion. It is not clear how much movements along vertical faults influenced the development and removal of the fanglomerate, or whether, lacking major recent uplift, the 2,500-ft relief on the south flank of South Mountain represents downcutting by the Malheur River and erosion of older fanglomerate since approximately early Pliocene time.

GEOLOGIC HISTORY

The rocks exposed in the quadrangle reflect a history covering a period of at least middle Miocene to Holocene time. The Miocene or older rocks comprise a sequence of mostly tholeiitic basalt, lesser amounts of rhyolite, and minor sedimentary and pyroclastic rocks that were deposited on an unknown substrate. The source vents of the basalt are not known, but the rhyolite was extruded from vents 1 mi south of the quadrangle and along the east side of the quadrangle. The Dinner Creek Welded Tuff, a major pyroclastic unit in the quadrangle, may have come from Castle Rock, about 6 mi northwest of the quadrangle. Deposition of the volcanic rock units was accompanied by elevation changes so that erosional unconformities occur in the section. Continued tectonism and erosion resulted in formation of a network of irregular basins that may have been occupied at times by lakes. Some of the faulting may have been in response to emplacement of rhyolite intrusions southwest and northwest of the quadrangle. During this period, rhyolitic pyroclastic volcanism occurred in the region, as indicated by the tuff, lapilli tuff, and tuffaceous sedimentary rocks deposited in the basins. The source of much of the tuff was probably the rhyolite vent at Monument Peak, but some of it may have come from calderas as far away as 40 mi southeast of the quadrangle. The Pliocene into the Holocene has been a period of erosion of the Miocene rocks, with stages during which alluvial fans were formed and destroyed. Faults were active in the area up to some time in the Pliocene and were quiescent in the Quaternary.

MINERAL RESOURCES

Mineral-resource and geochemical studies were conducted in the Gold Creek and Sperry Creek Wilderness Study Areas (Miller, 1989; Malcolm and others, 1990; Evans and others, 1990a,b), which include most of the South Mountain quadrangle that lies south of the Malheur River. The results of these studies are summarized here. Identified resources in the South Mountain quadrangle south of the Malheur River include large amounts of basalt suitable for crushed aggregate or production of basalt fiber, subeconomic resources of sand and gravel, and geothermal energy possibly suitable for domestic heating (NW¼NE¼ sec. 4, T. 21 S., R. 40 E.). A part of the north-central Gold Creek Wilderness Study Area is assigned a high gold resource potential (Evans and others, 1990a,b) because of a gold-bearing quartz vein containing up to 1.96 parts per million (ppm) gold in the N½ sec. 4, T. 21 S., R. 40 E., where 34 claims covering the vein and wall rock are held by Manville Corporation. An area of moderate potential for gold, silver, and mercury resources covers the northern part of the Gold Creek and eastern part of the Sperry Creek Wilderness Study Areas that include most of the South Mountain quadrangle lying south of the Malheur River.

Silica carbonate sinter is being deposited at the hot springs in sec. 4. Samples of the sinter and mud at the hot springs contain high concentrations of mercury, arsenic, antimony, tungsten, strontium, and beryllium, and detectable amounts of gold (2 ppb). One sample contains 4 percent fluorine. The mineralization at the hot springs is similar to that which produced the silicification and geochemical anomalies in the northern part of the Gold Creek and eastern part of the Sperry Creek Wilderness Study Areas, but the geothermal and element sources of the hot springs have not been identified. The heat source may be an unidentified intrusion at depth or deep circulation of meteoric waters in a fault zone. The element source may be residues of a crystallized magma or leachate from the country rock. The elements may also have undergone redistribution from earlier deposits from older hydrothermal systems. The geologic structure suggests that deep circulation of meteoric waters along the fault zone that strikes west-northwest along the Malheur River is the most likely model for the hot springs. The fault zone developed during the late Miocene or Pliocene, and the hot springs may have been active since then.

Resources of basalt and sand and gravel occur north of the Malheur River in the South Mountain quadrangle. Thirty-five rock and five stream sediment samples were collected from that area by the author and H.C. Brooks. The results of the chemical analyses are shown in Tables 2 and 3 (Plate 2).

Most of the rocks sampled are brecciated rhyolite from Littlefield Rhyolite and oxidized or silicified basalt from Basalt of Malheur Gorge and Hunter Creek Basalt. Gold was not detected at the 1 part per billion (ppb) level in 23 of the rock samples. The maximum concentration of gold in the other 12 samples is 7 ppb. Silver was not detected at the 15-ppb detection level in 24 samples (not all the same samples that lack gold). The maximum concentration of silver is 38 ppb. Arsenic as high as 437 ppm and antimony as high as 89.9 ppm were also found.

Each of the five stream-sediment samples contains detectable amounts of gold in each of the three fractions. The maximum concentration of gold is 42.6 ppb in the heavy-mineral fraction (sample a) from an unnamed creek about 1 mi east of the Jonesboro quadrangle. The other samples contained 6 ppb or less.

The highest concentration of silver occurred in the heavy-mineral fractions of the stream sediments and ranged from 33.6 to 158 ppm. The maximum amount of silver is from a sample collected from an unnamed creek 1¼ mi east of the Jonesboro quadrangle. The minus 80 mesh fractions contained 12.6 to 19.8 ppm silver. These values may be more representative of average silver concentrations in the drainages.

These results indicate that gold and silver occur in the five drainages sampled (Hog Creek, Miller Creek, China Creek, and two unnamed drainages), but the nature of the sources is not clear. The sediment fractions analyzed, especially the heavy-metal fractions, are highly concentrated residues of the sediment in transport, and it is not possible to relate the gold and silver concentrations of the stream-sediment samples to the character of the bedrock sources. The sources may be small, low-grade, or poorly exposed. Alternatively, the sediment from relatively high-grade or large gold sources may have been greatly diluted by sediment from unmineralized rock. Observations made during field mapping suggest that (1) the gold and silver sources are small and low-grade, inasmuch as few silicified, oxidized, or brecciated zones were found; (2) the ones found were small; and (3) many of the zones were sampled (Table 2, Plate 2) and contain little gold.

The rock and stream-sediment samples collected north of the Malheur River suggest widespread weak epithermal alteration and gold and silver mineralization there. The data suggest that the most promising area for prospecting may be in the two unnamed drainages 1 mi east of the Jonesboro quadrangle (samples a, b). No other prospective areas are clearly delineated.

Although the presence of springs indicates some of the mapped units transmit ground water, there is no specific information available on ground water in this quadrangle. There are no records of wells drilled in the quadrangle (Marshall Gannett, written communication, 1990). In places, springs roughly coincide with the contact between the Hunter Creek Basalt and the Dinner Creek Welded Tuff; some springs occur just above or below the cliff-forming strongly welded Dinner Creek Welded Tuff.

REFERENCES

Berggren, W.A., Kent, D.V., and van Couvering, J.A., 1985, The Neogene: Part 2, Neogene geochronology and chronostratigraphy; *in* Snelling, N.J., ed., The chronology of the geologic record: The Geological Society Memoir 10, p. 211-242.

Boler, F.M., 1978, Aeromagnetic measurements, magnetic source depths, and the Curie point isotherm in the Vale-Owyhee, Oregon, geothermal area: Corvallis, Oreg., Oregon State University master's thesis, 104 p.

Bowen, R.G., Gray, W.L., and Gregory, C.D., 1963, General geology of the northern Juntura basin, *in* Shotwell, J.A., ed., The Juntura basin: Studies in earth history and paleoecology: American Philosophical Society Transactions, v. 53, p. 22-34.

Dalrymple, G.B., 1979, Critical tables for conversion of K-Ar ages from old to new constants: Geology, v. 7, no. 11, p. 558-560.

Evans, J.G., in press, Geologic map of the Jonesboro quadrangle, Malheur County, Oregon: Oregon Department of Geology and Mineral Industries Geological Map Series GMS-66, scale 1:24,000.

Evans, J.G., Frisken, J.G., Griscom, A., Sawatkzy, D.L., and Miller, M.S., 1990a, Mineral resources of the Gold Creek and Sperry Creek Wilderness Study Areas, Malheur County, Oregon: U.S. Geological Survey Bulletin 1741-E, 20 p.

------1990b, Mineral resources of the Gold Creek and Sperry Creek Wilderness Study Areas, Malheur County, Oregon: U.S. Geological Survey Open-File Report 90-0517, 21 p.

Evans, J.G., Turner, R.L., Griscom, A., Sawatzky, D.L., and Causey, J.D., 1990c, Mineral resources of the Lower Owyhee Canyon Wilderness Study Area, Malheur County, Oregon: U.S. Geological Survey Bulletin 1741-F, 18 p.

Evernden, J.F., Savage, D.E., Curtis, G.H., and James, G.T., 1964, Potassium-argon dates and the Cenozoic mammalian chronology of North America: American Journal of Science, v. 262, no. 2, p. 145-198.

Fiebelkorn, R.B., Walker, G.W., MacLeod, N.S., McKee, E.H., Smith, J.G., 1983, Index to K-Ar determinations for the State of Oregon: Isochron/West, no. 37, p. 3-60.

Gazin, C.L., 1932, A Miocene mammalian fauna from southeastern Oregon: Contributions to Paleontology: Carnegie Institute of Washington Publication 418, p. 37-86.

Greene, R.C., Walker, G.W., and Corcoran, R.E., 1972, Geologic map of the Burns quadrangle, Oregon: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-680, scale 1:250,000.

Haddock, G.H., 1967, The Dinner Creek Ash-Flow Tuff of the Malheur Gorge area, Malheur County, Oregon: Eugene, Oreg., University of Oregon doctoral dissertation, 110 p.

Hagood, A.R., 1963, Geology of the Monument Peak area, Malheur County, Oregon: Eugene, Oreg., University of Oregon master's thesis, 165 p.

Kittleman, L.R., Green, A.R., Haddock, G.H., Hagood, A.R., Johnson, A.M., McMurray, J. M., Russell, R.G., and Weeden, D.A., 1967, Geologic map of the Owyhee region, Malheur County, Oregon: University of Oregon Museum of Natural History Bulletin 8, scale 1:125,000.

Kittleman, L.R., Green, A.R., Hagood, A.R., Johnson, A.M., McMurray, J.M., Russell, R.G., and Weeden, D.A., 1965, Cenozoic stratigraphy of the Owyhee region, southeastern Oregon: University of Oregon Museum of Natural History Bulletin 1, 45 p.

Lillie, R.J., 1977, Subsurface geologic structure of the Vale, Oregon, Known Geothermal Resource Area from the interpretation of seismic reflection and potential field data: Corvallis, Oreg., Oregon State University master's thesis, 52 p.

Malcolm, M.J., Frisken, J.G., and Motooka, J.M., 1990, Analytical results and sample locality map of stream-sediment, heavy-mineral-concentrate, and rock samples from the Gold Creek (OR-003-033) and the Sperry Creek (OR-003-035) Wilderness Study Areas, Malheur County, Oregon: U.S. Geological Survey Open-File Report 90-29, 29 p.

Miller, M.S., 1989, Mineral resources of the Sperry Creek Wilderness Study Area and Gold Creek Study Area and addition, Malheur County, Oregon: U.S. Bureau of Mines Mineral Land Assessment Open-File Report MLA 22-89, 70 p.

Palmer, A.R., 1983, The decade of North American geology-1983 geologic time scale: Geology, v. 11, no. 9, p. 503-504.

Shotwell, J.A., and Russell, D.E., 1963, Mammalian fauna of the upper Juntura Formation, the Black Butte local fauna, *in* Shotwell, J.A., ed., The Juntura basin: Studies in earth history and paleoecology: American Philosophical Society Transactions, v. 53, p. 43-69.

Walker, G.W., 1977, Geologic map of Oregon east of the 121st meridian: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-902, scale 1:500,000.