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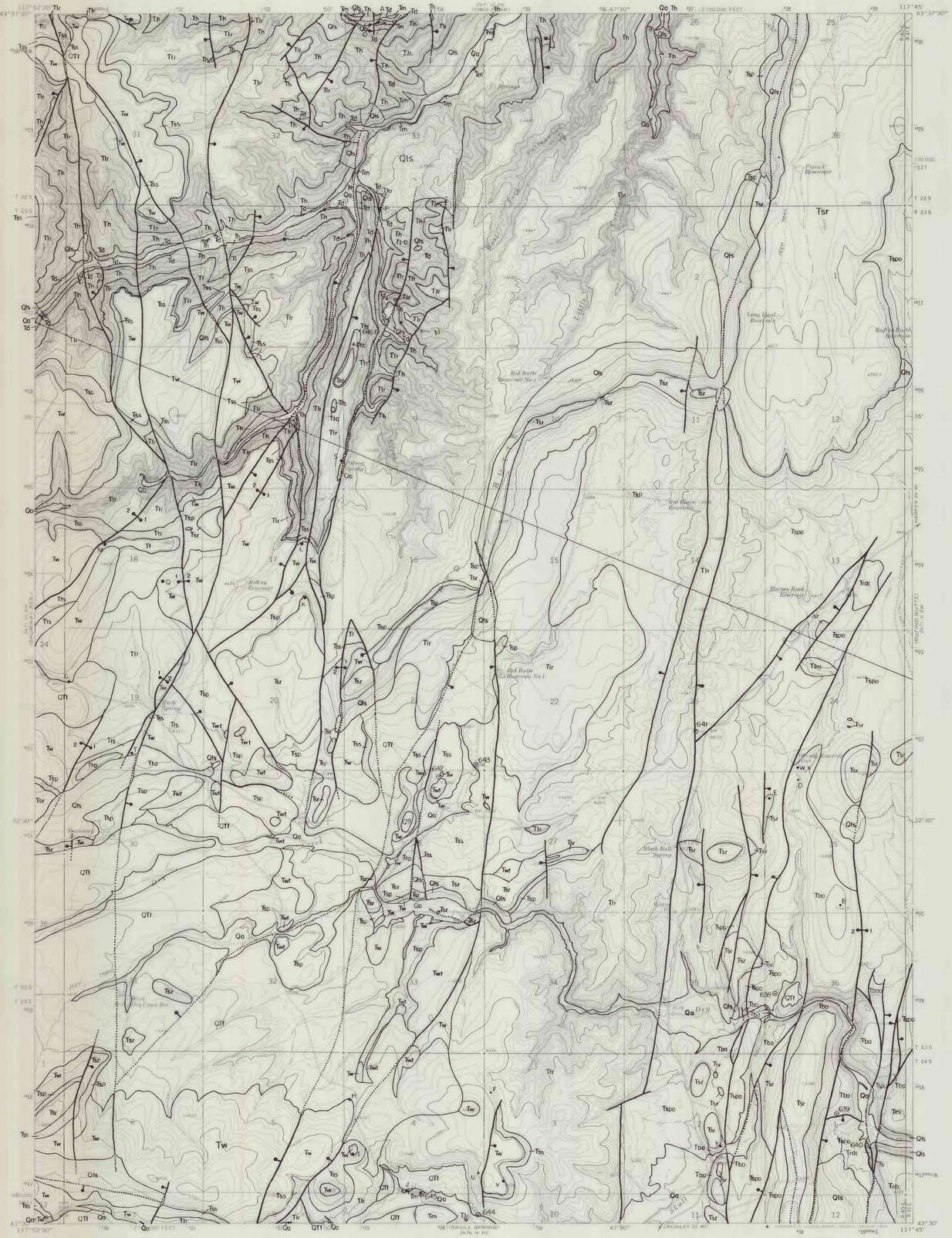
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT 98-494
Pamphlet accompanies map



Base from U.S. Geological Survey, 1990

Lambert conformal conic projection. 1927 North American datum
10,000-foot grid based on Oregon coordinate system, south zone
1000-meter Universal Transverse Mercator grid ticks, zone 11

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

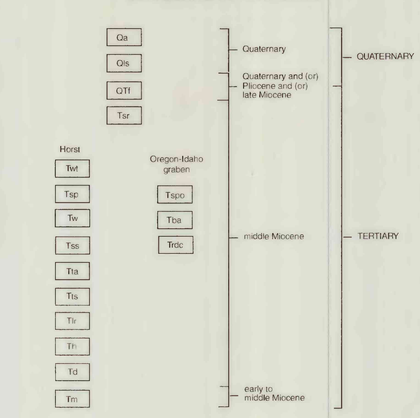
UTM GRID AND 1972 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

Geology mapped in 1991

Manuscript approved for publication on September 9, 1998

CORRELATION OF MAP UNITS



DESCRIPTIONS OF MAP UNITS

Qa **Alluvium (Holocene)**—Unconsolidated sand, gravel and conglomerate deposits along Cottonwood, Little Cottonwood, Cherry, Alder, Dry, and Skull Creeks and some of their tributaries

Qls **Landslide deposits (Holocene)**—Unconsolidated chaotic deposits of various volcanic and sedimentary rocks. The two largest deposits, covering about 2.5 km^2 each, are in the north-central part of the quadrangle along Cottonwood Creek and in the northeastern part of the quadrangle. The deposit along Cottonwood Creek consists largely of debris from Littlefield Rhyolite, which forms cliffs as high as 120 m. The deposit in the northeastern part of the quadrangle consists largely of Shumway Ranch Basalt. Smaller landslide deposits occur in places at the base of Littlefield Rhyolite, the lower contacts of basalt map units, and in places where faults have weakened the rocks

QTf **Alluvial fan deposits (Quaternary, and (or) Pliocene and (or) late Miocene)**—Poorly bedded, sorted, and lithified white, light yellow, and light brown siltstone, sandstone, and arkose. In places, beds are 30 to 200 cm thick. Sandstone rip-ups suggest parts of the unit were deposited during one or more floods. Cemented in places by white caliche. Volcaniclastic sandstone contains as much as 55% angular clasts of laminated welded tuff, clear obsidian containing microlites, light green glass, vitrophyre, pumice, devitrified brown obsidian, fine grained basalt rich in magnetite and hematite, clear glass shards, and rhyolite in a matrix of silt and sand. Clasts include plagioclase some of which have rutile inclusions, pyroxene, hematite, hornblende, tourmaline, quartz, orthoclase, and opaque minerals. Sericite and biotite (?) appear to have grown in place and may constitute most of the cement. The unit is found in the southeastern part of the quadrangle where it is as much as 40 m thick

Tsr **Shumway Ranch Basalt (middle Miocene)**—Unit originally named by Kittleman and others (1965; used name "Shumuray" from a U.S. Army spelling; referred to in this report as Shumway Ranch Basalt to reflect updated spelling of name). In the quadrangle the unit is dark gray to black fine-grained basalt that is vesicular and diktytaxitic in places. The rock is aphyric or contains as much as 40% subhedral plagioclase and euhedral olivine phenocrysts as long as 5 mm that are locally glomeroporphyritic with aggregates of grains as much as 1 cm across. Some of the plagioclase has inclusions of olivine or acicular rutile, and some of the olivine has inclusions of plagioclase. The groundmass, which embays some of the phenocrysts, consists largely of plagioclase laths as long as 1 mm, and also contains ophitic, interstitial, and intersertal clinopyroxene, intersertal olivine and magnetite, yellow glass, and glass that is nearly opaque owing to minute grains of magnetite. Some of the clinopyroxene contains so much fine-grained magnetite that it is almost opaque. In some samples there is no obvious bimodality in grain size, and phenocrysts phases are not easily differentiated from groundmass. Modal composition is plagioclase 45 to 55 percent, olivine 2 to 20 percent; clinopyroxene 25 to 40 percent, magnetite 5 to 10 percent, and rutile as much as 1 percent. Two samples from the quadrangle that were analyzed are basaltic andesite and basaltic trachyandesite (samples E and K, table 2). Plagioclase is slightly altered to sericite. Olivine is altered to bowlingite, iddingsite, hematite, and biotite. Clinopyroxene is altered to actinolite, biotite and hematite. Some of the unit contains carbonate amygdules as much as 6 mm across. Some of the amygdules have shells of light greenish-brown mica oriented with basal cleavages perpendicular to vesicle walls. One sample contained quartz that could be a xenocryst. A brick-red basaltic tuff consisting of welded basaltic pellets and glass and showing alteration of mafic minerals to biotite occurs in places at the base of the unit. In the quadrangle the unit is as much as 30 m thick. Equivalent stratigraphically to unit Tsb of Brooks (1992) in the adjacent Rufino Butte quadrangle (samples 302 and 304, table 4, trachybasalt). Age is based on K-Ar age determination of 12.4±0.5 Ma (Fiebelkorn and others, 1983)

Map units of the horst

Twt **Welded tuff (middle Miocene)**—Light gray, platy, crystal-poor, strongly welded tuff in the southeastern part of the quadrangle. Contains as much as 4 percent phenocrysts as long as 4 mm of quartz, potassium feldspar (sanidine?), olivine, chlorite, and hematite. Most of the rock is devitrified glass shards which embay phenocrysts. Unit contains less than 1 percent lithic fragments as long as 1 mm of spherulitic material, and hematite- and magnetite-rich fine-grained basalt. An outcrop in NE1/4 sec. 33, T. 23 S., R. 40 E. contains as much as 30 percent lithic fragments most of which are partly digested (disaggregated and recrystallized) fine-grained basalt. The welded tuff is about 6 m thick and underlies the Shumway Ranch Basalt in SW1/4 sec. 27, T. 23 S., R. 40 E. Age is based on unit's stratigraphic position between middle Miocene map units

Tsp **Sedimentary and pyroclastic rocks (middle Miocene)**—Conglomerate, sandstone, siltstone, limestone, tuff and tuff breccia that underlies Shumway Ranch Basalt. The generally poorly lithified conglomerate contains as much as 60% rounded to subrounded clasts as much as 15 cm across of white, gray, and purple laminated welded tuff, and black makarenite. The light brown and gray poorly lithified sandstone is tuffaceous, is locally well-sorted with almost no matrix, and is poorly bedded. It contains angular volcanic clasts including fine-grained basalt, basaltic glass, and rhyolite. The pale brownish-gray, poorly indurated, thin bedded (1 to 4 cm) siltstone contains angular clasts as much as 5 mm long of light gray felsite and red and black glass, white mudstone interbeds and zones of brown hematite enrichment along bedding. The white to pale gray limestone was found in NE1/4 sec. 30, T. 23 S., R. 40 E. The pale brown, brown, and light gray, poorly to well lithified tuff contains pumice fragments as much as 1 cm across and is porous in places. In thin section these rocks contain angular fragments of vitrophyre, clear glass shards, accretionary lapilli, tuff, laminated welded tuff, basaltic glass, fine-grained basalt, intergrown quartz and feldspar (granite), and devitrified glass. Phenocrysts comprise as much as 1 percent of the rock and include largely quartz and feldspar with minor amounts of muscovite, hematite, magnetite, and pyroxene. The massive light gray tuff breccia contains as much as 50 percent angular to rounded fragments mostly of gray pumice and less abundant black obsidian. The tuff and sandstone units are cemented by sericite and brown chalcedony. Mafic minerals are altered to biotite that formed in place. The unit is as much as 76 m thick in the center of the quadrangle. It generally correlates with map unit Ts, in the Monument Peak quadrangle (Evans, 1996) to the north. Where the unit rests on Littlefield Rhyolite, it may contain remnants of map units Tss and Tts. Age of the unit is based on its stratigraphic position between middle Miocene units.

Tw **Wildcat Creek Welded Ash-Flow Tuff (middle Miocene)**—Unit named by Kittleman and others (1965). In the quadrangle the unit is rusty brown, brown, purple, lavender, mottled gray and pink, maroon, dark gray, and black strongly welded tuff and welded lapilli tuff. The unit has a well developed compaction foliation and numerous oval to discoid gas cavities elongated in the foliation and filled with clear chalcedony, tridymite, minor carbonate, opaque minerals, zoisite, biotite, and intergrowths of quartz and feldspar. Some of these cavities and related gas phase mineralization and recrystallization are preferentially weathered resulting in a "swiss cheese" appearance of outcrops, very similar to parts of the older Dinner Creek Welded Tuff (map unit Td; see below). As much as 60% of the rock consists of lithic fragments and lapilli as much as 2 cm across; these include brown pumice, fine-grained basalt some of which are partly digested, basaltic tuff, hornblende- and biotite-bearing granite, perlitic laminated welded tuff, rhyolite containing abundant disseminated minute grains of opaque iron oxide, rhyolite porphyry, and black glass. The bulk of the rock usually consists of very tightly folded glass shards which are devitrified internally, contain microlites, and are outlined by minute grains of hematite. In places, devitrification resulted in obliteration of the shard texture. The rock contains as much as 30% phenocrysts, but most contain less than 1% phenocrysts usually no more than 3 mm long (maximum 1 cm). Phenocrysts include plagioclase, orthoclase, quartz, biotite, clinopyroxene, hornblende, and magnetite. In places, plagioclase is altered to sericite and mafic minerals are altered to biotite; some of this alteration occurred after emplacement of the unit. The compositions of seven samples of the unit are shown in table 2 (samples G to I, L, Q, T, and V). Sample H is a dacite and the rest are rhyolites. The unit is as much as 60 m thick in the western part of the quadrangle. Age is based on its stratigraphic position between middle Miocene units

Tss **Sandstone (middle Miocene)**—Light brown and brown, generally poorly lithified sandstone with hematite cement below Wildcat Creek Welded Ash-Flow Tuff. Locally unit is baked red below the welded tuff. The unit is as much as 58 m thick in the northwestern part of the quadrangle. Unit may contain strata equivalent to map unit Tts where trachyandesite (map unit Tta; see below) is not present. Age is based on its stratigraphic position between middle Miocene units

Tta **Trachyandesite flow (middle Miocene)**—Gray crystalline volcanic rock under Wildcat Creek Welded Ash-Flow Tuff in sec. 18, T. 23 S., R. 40 E. and similar rock elsewhere in the west- central part of the quadrangle. Part of the outcrop along the line between secs. 19 and, T. 23 S, R. 40 E. may be a dike. Rock contains 20 to 40 percent phenocrysts generally as long as 3 mm (maximum 1.5 cm) mostly of complexly twinned and zoned plagioclase, and less abundant olivine. Plagioclase phenocrysts contain minute magnetite, pyroxene, and olivine grains aligned along cleavage planes; commonly a shell about 0.2 mm thick has few inclusions. Most of the phenocrysts are eroded by the groundmass. The groundmass consists largely of plagioclase grains as long as 0.5 mm, and magnetite, clinopyroxene, and minor olivine. Vesicles are lined by chalcedony, and carbonate amygdules are present. Modal composition is feldspar (plagioclase and potassium feldspar(?)) 75 percent, clinopyroxene 20 percent, olivine 5 to 10 percent, opaque minerals 5 to 10 percent, and <1 percent carbonate. Muscovite and biotite are found along feldspar cleavages, biotite is altered to chlorite, and the feldspar is partly replaced by carbonate. Olivine is altered to bowlingite and iddingsite. Chemically, the rock is a trachyandesite (samples M and P, table 2). The flow is as much as 12 m thick in the west-central part of the quadrangle. Age of the unit is based on its stratigraphic position between middle Miocene units

Tts **Tuffaceous sandstone (middle Miocene)**—Pale brown tuffaceous sandstone that underlies trachyandesite flow in the west-central part of the quadrangle. The unit is as much as 12 m thick. The age of the unit is based on its stratigraphic position between middle Miocene units

Tlr **Littlefield Rhyolite (middle Miocene)**—Unit named by Kittleman and others (1965). Dark gray, dark purplish gray, light gray, lavender, and maroon, platy rhyolite flows that weather brown, and black massive vitrophyre. Parts of the rhyolite have flow laminations and parts are scoriaceous. Red, porous, welded tuff as thick as 1 m and gray tuffaceous sandstone as thick as 3 m are found in places at the base. Basal breccias occur above the welded tuff and sandstone and between individual flows. Rhyolites contains 2 to 15 percent phenocrysts as much as 5 mm long of subhedral plagioclase, euhedral olivine, potassium feldspar (sanidine, microcline, perthite), quartz, pyroxene, magnetite, hematite, biotite, muscovite, chlorite, and green hornblende. In most of the rhyolite samples, plagioclase is the principal phenocryst; some of the samples contain a mix of plagioclase and potassium feldspar phenocrysts, and a few samples contain principally potassium feldspar phenocrysts. Some of the phenocrysts are glomeroporphyritic, in aggregates that suggest that they are xenoliths of basalt (plagioclase and pyroxene) or granite (plagioclase and hornblende or biotite). The phenocrysts are embayed by the groundmass which consists of feldspar and quartz as much 0.2 mm long, cryptocrystalline material that is most likely largely feldspar and quartz, and disseminated hematite. In places the groundmass contains porphyroblasts of quartz and feldspar as much as 0.05 mm across. Irregular patches of hematite-rich groundmass, may be partly digested mafic xenoliths. Two samples of the unit were analyzed for major oxides and are rhyolites (samples S and U, table 2). The red welded tuff at the base of the unit is dacitic (sample C, table 2). A sample from NW1/4 sec. 3, T. 24 S., R. 40 E. is a basaltic andesite (sample F, table 2), and indicates that the unit as mapped in the south-central part of the quadrangle includes a large xenolith or an intermediate flow or intrusive unit. In places, the Littlefield Rhyolite contains veins of white chalcedony and yellow jasper. Aeromagnetic anomalies suggest that there is an intrusion of Littlefield Rhyolite in the quadrangle (figure 3; cross section). The most likely intrusion and related dome are in the upper Little Cottonwood Creek-Red Butte-Dry Creek area in the central part of the quadrangle. Elsewhere in the quadrangle, the Littlefield comprises flows as much as 135 m thick. Age is based on unit's stratigraphic position between middle Miocene units and radiometric ages of Lees (1994)

Th **Hunter Creek Basalt (middle Miocene)**—Unit originally named by Kittleman and others (1965) and adopted by Greene and others (1972). Black, fine-grained, aphyric to sparsely phyric, locally platy, basaltic andesite or icelandite flows. Contains rare beds of hyaloclastite, red tuff as much as 2 m thick, and red volcanic sandstone as much as 1 m thick in the upper part of the unit. Some hyaloclastite contains fragments of Dinner Creek Welded Tuff. Ropy vesicular basalt with chalcedonic amygdules occurs at the base of the unit and scoria mixed with red tuffaceous sandstone is found at the top. Rock contains as much as 3 percent phenocrysts to 3 mm long of pyroxene, olivine, plagioclase, and magnetite. Most of the rock consists of plagioclase laths as long as 0.5 mm, intersertal olivine, intersitial clinopyroxene that contains so much disseminated magnetite that it is nearly opaque in thin section, and intersertal magnetite. Some of the clinopyroxene is ophitic. A sample contained a xenolith consisting of tridymite, possibly from the Dinner Creek. Modal composition is plagioclase 55 to 60 percent, clinopyroxene 30 to 35 percent, olivine as much as 15 percent, and magnetite 5 to 15 percent. Olivine is altered to bowlingite and mafic minerals are altered to chlorite, biotite, and hematite. Red andesitic tuff consists largely of angular fragments as much as 5 mm long of pumice, vitrophyre, rhyolite, spherulitic material, tuff, yellow and red-brown glass, fine-grained magnetite-rich basalt, minor clear glass shards, and contains about 3 percent angular grains of quartz, plagioclase, and biotite. The unit is 40 to 100 m thick in the northwestern part of the quadrangle and 0 to 18 m in the southeastern corner. Age is based on its stratigraphic position between middle Miocene units and radiometric ages of the unit to the north (Lees, 1994)

Td **Dinner Creek Welded Tuff (middle Miocene)**—Unit named by Greene and others (1972). Rhyolitic ash-flow tuff, welded tuff, and air-fall tuff that differ from equivalent strata to the north (Evans and Keith, 1996). Pink, red, white, and light brown welded tuff forms cliffs 3 to 5 m high at top of unit. Commonly porous and friable. Lithophysal in places. Locally, uppermost 3 m of the unit is a red cindery lapilli tuff. Bulk of the unit is white, pale yellow and light brown tuff that is poorly bedded and locally cross-bedded. The welded tuff contains as much as 85 percent angular fragments as much as 5 mm across of laminated red, white, and brown welded tuff, devitrified welded tuff, orange and red pumice, vitrophyre, fine grained hematite-rich basalt some of which is partly digested, rhyolite, and biotite granite. Most of the remainder of the rock is red-brown, orange, yellow, and clear, weakly devitrified, folded, and compacted glass shards. As much as 5 percent of the rock consists of phenocrysts as much as 4 mm long of plagioclase, pyroxene, quartz, and magnetite. Gas cavities are filled with tridymite. In places the crystal-poor tuff is cemented by chalcedony and sericite and cut by veins of chalcedony, sericite, and biotite. Red cindery tuff at the top of the unit contains abundant fragments of fine grained basalt and scoria, suggesting transition from peralkaline rhyolitic welded tuff to the overlying basaltic andesite. Two samples of the Dinner Creek were analyzed (samples N and R, table 2) and show a variation in several oxides, some of which may be attributable to the variation in content of lithic fragments. The unit is 35 to 80 m thick in the northwestern part of the quadrangle, and was not recognized above the basalt of Malheur Gorge in the southern part. Age of the unit is based on radiometric ages of about 15 Ma of the unit in the Malheur Gorge area (Fiebelkorn and others, 1983)

Tm **Basalt of Malheur Gorge (early to middle Miocene)**—Unit named by Evans, 1990a,b; formerly "unknown igneous complex of Kittleman and others, 1965). Black to dark gray basalt and basaltic andesite flows. Along Camp and Cottonwood Creeks, in the northwestern part of the quadrangle the unit contains 20 to 30 percent phenocrysts of plagioclase as much as 2 cm long that are embayed by the groundmass. The groundmass consists of plagioclase laths as long as 1 mm and intersertal clinopyroxene, olivine, and magnetite. Modal composition is: plagioclase 45 to 60 percent; clinopyroxene 25 to 35 percent; and magnetite 5 to 10 percent. Clinopyroxene is altered to biotite, magnetite, and actinolite. Exposures of the unit in the southern part of the quadrangle along Skull Creek are black, fine-grained, generally aphyric, vesicular basalt and weakly lithified basaltic flow breccia. The rock contains as much as 1 percent phenocrysts mostly of euhedral to subhedral plagioclase as much as 1 mm long and minor clinopyroxene and magnetite; locally glomeroporphyritic. The groundmass consists of plagioclase as much as 0.2 mm long, intersertal magnetite and interstitial clinopyroxene. Modal composition is: plagioclase 45 to 50 percent, clinopyroxene 35 to 40 percent, magnetite 15 percent. Clinopyroxene is altered to biotite. The rock contains amygdules of brown chalcedony. Two samples of the unit were analyzed; both are basalt (samples A and J, table 2). Another sample, which may be from the basalt of Malheur Gorge, was analyzed for major oxides (samples O, table 2), and is basaltic andesite. The location of this sample at the base of an anomalously thick section of "Hunter Creek Basalt" in SW1/4 sec. 28, T. 22 S., R. 40 E. suggests that some of the upper part of the basalt of Malheur Gorge may be' present there. Twenty-five m of the coarsely phyric part of the unit are exposed along Cottonwood and Camp Creeks, and 9 m of the fine-grained part of the unit along Skull Creek. Age of the unit is based on early Miocene radiometric ages of the unit to the north (Lees, 1994).

Rock units of the Oregon-Idaho graben

Tspo **Sedimentary and pyroclastic rocks of the Oregon-Idaho graben (upper Miocene)**—Includes conglomerate, sandstone, siltstone, tuff and tuff breccia. The conglomerate contains 30 to 60 percent of generally rounded to subrounded clasts as much as 15 cm across of pale gray to white, very hard, laminated welded tuff. Surfaces of the clasts are commonly stained brown from iron oxide. Clasts of makarenite and vitrophyre are also present. The conglomerate is unconsolidated and has a faint flat-pebble imbrication in places that suggests sediment transport to the north. The coarsest conglomerate is in the vicinity of Littlefield Cemetery in sec. 35, T. 23 S., R. 40 E. where clasts as much as 2 m across of the laminated welded tuff are found. The light gray to pale brown sandstone is tuffaceous, has beds that are 1 to 8 cm thick, is poorly lithified, and locally contains few subrounded pebbles of white well-lithified tuff. In places the sandstone is arkosic. The white to pale gray poorly lithified siltstone is tuffaceous and is thick bedded (1 m). The light gray tuff is porous. The tuff breccia is varied and widespread in the eastern part of the quadrangle. It contains 30 to 70 percent angular fragments of vesicular basalt, laminated welded tuff, obsidian, bedded siltstone and fine- grained sandstone, and vitrophyre; one small fragment of granodiorite was also found. The lithic fragments are generally less than 10 cm across, but blocks are as much as 5 m across. The matrix is white to pale gray tuff and welded tuff that locally intrudes the rock fragments. As much as 100 m of the unit are present in the eastern part of the quadrangle. Based on its stratigraphic position above unit Tba, the age of unit Tspo is estimated to be late middle Miocene, and could be equivalent to unit Tsp on the horst

Tba **Basaltic andesite flows (middle Miocene)**—Dark gray to black, fine-grained, generally aphyric basaltic andesite flows in the southeastern part of the quadrangle under map unit Tspo and over map unit Trdc in the adjacent Rufino Butte quadrangle (Brooks, 1992); weathers brown and red-brown. Locally, unit is scoriaceous, platy, has crude columnar jointing, and contains hyaloclastite. Most of the unit contains less than 5 percent phenocrysts (maximum 15 percent) as long as 2 mm of plagioclase that are embayed by the groundmass. The groundmass consists of plagioclase laths as long as 0.5 mm that have trachytic texture in places, glass, intersertal and interstitial clinopyroxene, and intersertal olivine and magnetite. Modal composition is plagioclase 40 to 45 percent; clinopyroxene 20 to 45 percent, olivine 1 to 5 percent; magnetite 10 percent, and glass as much as 10 percent. Plagioclase is altered to epidote and sericite. Olivine is altered to bowlingite. Mafic minerals are altered to biotite, hematite, and actinolite. One sample has an angular anhedral quartz xenocryst. Three samples of the unit were analyzed and are basaltic andesite (samples B, W, X and Y, table 2). Equivalent to unit Tdb of Brooks (1992; samples 323, 330, 331, and 335, table 4). As much as 100 m of the unit is exposed along Dry Creek and some of its tributaries. Based on its stratigraphic position above unit Trdc, age of the unit Tba is estimated to be late middle Miocene

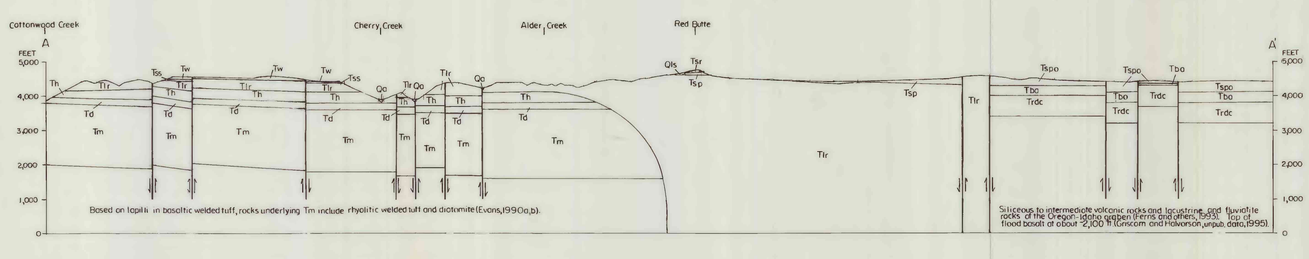
Trdc **Rhyolite of Dry Creek (middle Miocene)**—Informally named here from exposures along Dry Creek. The rhyolite is gray and lavender, laminated, platy, and contains zones of dark gray to black obsidian. Most of the rock consists of microcrystalline feldspar and quartz that has a well developed trachytic texture parallel to flow laminations, disseminated very fine- grained hematite, and irregular clots of hematite. The rock contains less than 1 percent phenocrysts as long as 1 mm of quartz, feldspar, muscovite, and hornblende as well as aggregates as much as 2 mm across of plagioclase and hornblende, which may be xenoliths of granite. Brooks' (1992) description of the unit (his unit Tdr2) suggests more lithologic variability than observed in the Alder Creek quadrangle. See table 4 for composition of the rhyolite (Brooks' samples 328, 329, and 340). Unit is at least 150 m thick, no base exposed, in adjacent Rufino Butte quadrangle. Based on its apparent stratigraphic position high in the 2-km-thick stratigraphic sequence in the Oregon-Idaho graben, the age of Trdc is estimated to be late middle Miocene

—— **Contact**

—— **Fault**—Dotted where concealed; bar and ball on down-thrown side. Where more than one direction of movement is indicated, the oldest direction is labeled "1"

• A **Location of unaltered rock sample listed in table 1**

302 **Location of altered rock sample listed in table 5**



GEOLOGIC MAP OF THE ALDER CREEK QUADRANGLE, MALHEUR COUNTY, OREGON

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1999

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