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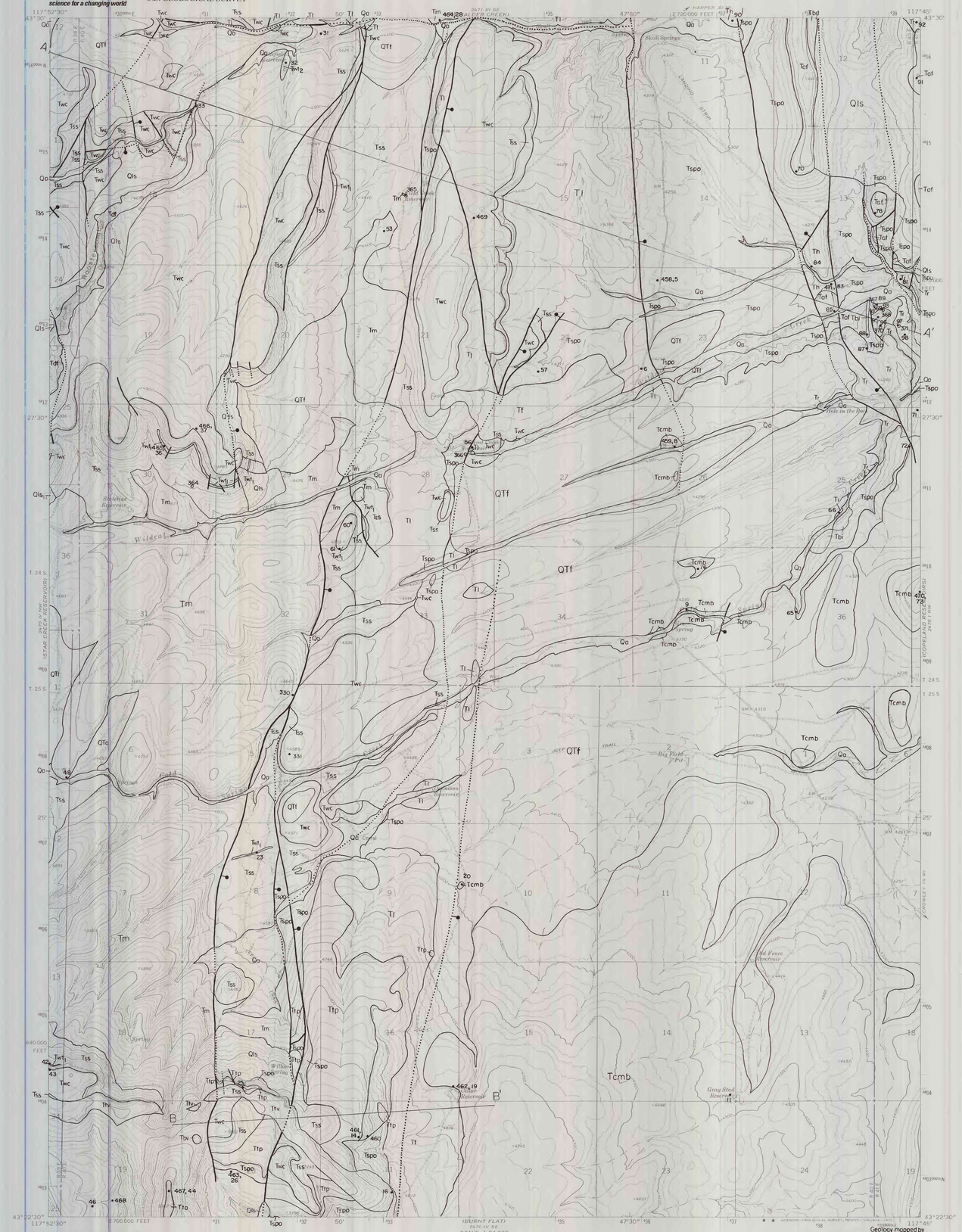

Base from U.S. Geological Survey, 1990

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

Geology mapped in 1992

Geology mapped by James G. Evans, 1992

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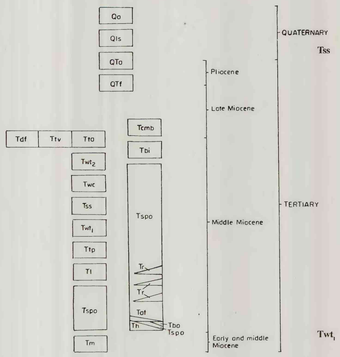
CORRELATION OF MAP UNITS



DESCRIPTIONS OF MAP UNITS

Qa **Alluvium (Quaternary)**—Sand and gravel deposits along creeks in the quadrangle, especially Skull Creek, Wildcat Creek, and Cold Spring Creek. Qls Landslide deposits (Quaternary)—Debris from resistant rock units, such as Ttp, Twc, Tdf, and Taf (see below) onto older map units, especially on poorly lithified units such as Tspo and Tss (see below)

Qta **Older alluvium (Pliocene and (or) Quaternary)**—Brown clay-rich soil in topographic depression in W1/2 sec. 6, T. 25 S., R. 40 E. along western margin of quadrangle

QTf **Alluvial fan deposits (Late Miocene and (or)Pliocene and (or) Quaternary)**—Brown, light brown, yellow-brown, and gray unconsolidated to moderately lithified and poorly sorted deposits of silt, sand, and gravel. Gravel contains as much as 25 percent cobbles generally less than 15 cm across (maximum 25 cm) of basalt, Littlefield Rhyolite (map unit Tl; see below), Wildcat Creek Welded Ash-Flow Tuff (map unit Twc; see below), and opalite. In places, unit is cemented with brown chalcedony. Also contains light gray, light brown, and yellow-brown, poorly to moderately lithified, poorly to moderately sorted, and thin- bedded (1 to 10 cm) and massive sandstone that contains as much as 10 percent subrounded pebbles of white pumice, siltstone, and basalt. Maximum thickness is about 30 m. Age is based on stratigraphic position above late Miocene basalt of Cedar Mountain, faulting of unit in places, and partial preservation of alluvial fan morphology

Map units of the Horst

Ttv **Trachyandesite valley-fill (Middle or late Miocene)**—Mostly black platy trachyandesite (sample 16, Table 2). In places, contains finely vesicular aphyric black trachyandesite that weathers to angular boulders. The rock contains less than 5 percent plagioclase phenocrysts less than 1 mm across in aphanitic groundmass. The map pattern of the unit suggests that it originated as one or more lava flows that occupied a formerly east-west-trending valley eroded into middle Miocene strata. Much of the unit is about 30 m thick; on its eastern end, it may be as much as 60 m thick. Age of unit is based on its occurrence in a paleovalley eroded into middle Miocene strata and the possibility that the flow came from the Cedar Mountain volcanic center to the southeast

Tta **Trachyandesite flow (Middle or late Miocene)**—Dark gray platy trachyandesite in southwest corner of quadrangle (analyses 44 and 467, Table 2). Unit contains 5 percent plagioclase phenocrysts as much as 4 mm long in a very fine-grained groundmass. Possibly related to map unit Ttv above. Flow rests unconformably on map unit Tm. Thickness of unit is as much as 6 m. Age of unit is based on its possible relation to late Miocene map unit Ttv (see above)

Tdf **Dacite flow (Middle or late Miocene)**—Dark gray to black dacitic vitrophyre with perlitic alteration (sample 33, Table 2). Occupies what may have been a narrow northeast-trending paleovalley eroded into unit Twc in northwestern corner of quadrangle. Maximum thickness of unit in quadrangle is 36 m. Age of unit is based on its interpretation as a paleovalley deposit that postdates Wildcat Creek Welded Ash-Flow Tuff (map unit Twc; see below)

Twt_2 **Younger welded tuff (Middle Miocene)**—Pale gray, friable welded tuff present south of Littlefield Reservoir in sec. 8, T. 24 S., R. 40 E. Same as map unit Twt in Shumway Reservoir and Alder Creek quadrangles (Evans and Binger, 1998a; Evans, unpub. mapping, 1991). A sample of the welded tuff analyzed for major oxides is a rhyolite (sample 32, Table 2). Age of unit is based on its stratigraphic position between middle Miocene rock units north in Alder Creek quadrangle (Evans and Binger, 1998a)

Twc **Wildcat Creek Welded Ash-flow Tuff (Middle Miocene)**—Named by Kittleman and others (1965). Light to dark gray and black, lavender, dark purple, and maroon strongly welded tuff generally with well developed compaction foliation. Parts of it show columnar jointing. Locally red-brown, pumiceous, and scoriaceous. In places, it is a scoria flow. Parts are breccia of black glassy welded tuff and scoria with angular fragments to 15 cm. Gas cavities are lined with clear yellow[3] and white opal. Rock also contains amygdules of quartz and zeolite. The rock is finely laminated with glass shards containing variable amounts of disseminated hematite and zones of devitrification parallel to compaction foliation. Devitrified zones in the rock surround vesicles filled with tridymite, carbonate, and feldspar; locally eutaxitic. Rock contains as much as 5 percent phenocrysts as long as 5 mm of quartz, plagioclase, microcline (?), sanidine, and hornblende in a matrix of partly devitrified shards and disseminated hematite, and as much as 10 percent angular fragments as long as 2 cm of hematite-rich material, which is probably metamorphosed to disaggregated basalt or basaltic andesite, and rhyolite. Mafic minerals in mafic xenoliths are altered to chlorite and hematite; plagioclase of xenoliths is saussuritized. Four samples of the unit were analyzed for major oxides (Table 2); two are trachyandesite, one is trachydacite, and one is rhyolite. Nine samples of the unit from the Shumway Reservoir and Alder Creek quadrangles are mostly rhyolite. Thickness of the unit in the quadrangle is as much as 30 m. Age of the unit is based on its stratigraphic position between middle Miocene strata (Evans and Binger, 1998a)

Tss **Tuffaceous sandstone (Middle Miocene)**—Pale to light brown, brown, yellow, yellow brown, and white tuff, tuffaceous sandstone, silty sandstone, claystone, tuff, and welded tuff. Sandstone is poorly to moderately lithified, massive, or thin-bedded (2 cm) to thick-bedded (30-200 cm). In places bedding surfaces are irregular showing minor paleorelief, and festoon cross-bedding is present. In places, rock is brown from hematite cement. Yellow and yellow-brown clay-rich sediment found at Field Creek Reservoir (near center sec. 16, T. 24 S., R. 40 E.) may be clay-altered tuffaceous sandstone. Tuff is massive; in places lapilli tuff is moderately to strongly welded with development of compaction foliation. The white strongly welded tuff, found in the unit southwest of Willow Spring (sec. 17, T. 25 S., R. 40 E.) and southwest of Field Creek Reservoir (NE1/4 sec. 20, T. 24 S., R. 40 E.) is about 2 m thick and is of rhyolite composition (sample 25, Table 2). Much of unit is equivalent to unit Tss of Alder Creek quadrangle to north. May also be equivalent to parts of sedimentary rocks of the OIG included in map unit Tspo (see below). Thickness of unit is as much as 107 m. Age of unit is based on its stratigraphic position between middle Miocene strata

Twt_1 **Older welded tuff (Middle Miocene)**—White, light gray, pink, red, lavender, light brown, weakly to strongly welded glassy tuff that is commonly thinly foliated, and contains fiamme and as much as 5 percent pumice fragments as much as 2 cm across. Some of the rock is very hard and phonolitic. Other lithic fragments include fine-grained basaltic andesite, cryptocrystalline material, mylonite, welded tuff, rhyolite, and hornblende granite. Glass shards are clear and light brown in thin section, usually devitrified, and contain abundant disseminated hematite. Uncommon phenocrysts include plagioclase, sanidine, pyroxene, magnetite, and hornblende. The feldspar phenocrysts are embayed by the devitrified glass matrix. Plagioclase in some of the lithic fragments is altered to epidote. Unit is about 3 m thick. Age of unit is based on its stratigraphic position in middle Miocene map unit Tss

Ttp **Tims Peak Basalt (Middle Miocene)**—Named by Kittleman and others (1965). Gray diktytaxitic porphyritic basalt containing 25 percent phenocrysts to 2 cm (most less than 0.5 cm) of plagioclase. Weathers to angular blocks as much as 1 m across. A possible dike of Tims Peak Basalt is found in N1/2 sec. 21, T. 25 S., R. 40 E. A sample from the unit was analyzed for major oxides and is a basalt (analyses 461 and 14, Table 2). See Evans (1996) for detailed description of unit. Age of unit is based on its stratigraphic position between middle Miocene strata

Tl **Littlefield Rhyolite (Middle Miocene)**—Named by Kittleman and others (1965). Generally platy gray rhyolite with abundant brown iron oxide staining and yellow-green chalcedony on fractures. Plates are subhorizontal or dip at low angles toward the northeast. Locally the rhyolite is blocky, or consists of black perlitic obsidian. Rock contains as much as 15 percent phenocrysts as much as 8 mm long (generally less than 3 mm) mostly of feldspar and minor hornblende in a very fine-grained groundmass. Four samples of the unit were analyzed for major oxides (Table 4) and are rhyolites. As much as 60 m of the unit is exposed in thequadrangle. Age of unit is based on its resemblance to the middle Miocene Littlefield Rhyolite.

Tm **Basalt of Malheur Gorge (Early to middle Miocene)**—Named by Evans (1990a,b) for exposures in Malheur Gorge. (Formerly named "unnamed igneous complex" by Kittleman and others, 1965.) Rock is dark gray to black and blue-black mafic volcanic flows varying in composition from basalt to basaltic andesite, (Table 2). Much of unit is platy. In places, unit is a flow breccia. Rock contains as much as 10 percent phenocrysts of plagioclase and olivine as long as 4 mm in a very fine-grained groundmass. In southwest corner of quadrangle rock contains green and light gray altered spots and has undergone silicification (samples 468 and 46, Table 2). A boulder of very vesicular porphyritic basalt with 20 percent flat plagioclase phenocrysts as much as 2 cm long was found in a stream bed in the southwestern part of the quadrangle. This lithology is like much of the lower part of the basalt of Malheur Gorge, but no outcrops of the porphyritic basalt were found. The type of basalt exposed in the unit in the Skull Springs quadrangle is like the upper part of the basalt of Malheur Gorge to the north (Evans, 1990a,b). About 150 m of the unit is exposed in the southwestern part of the quadrangle. Age of the unit is based on its resemblance to the upper part of the more than 600-m-thick early to middle Miocene basalt of Malheur Gorge.

Oregon-Idaho graben

Tcmb **Basalt of Cedar Mountain (Late Miocene)**—Named informally here for unit's connection to mafic flows from the volcanic center of Cedar Mountain. Dark gray to black, very hard, fine grained basalt to andesite. Weathers to blocks 30 -100 cm across. Rock is commonly vesicular with as much as 15% vesicles, some as much as 10 cm across, or rock is finely vesicular. Rock is platy in places. Some of it rings when struck with a hammer, like phonolite. Basalt is aphyric or has as much as 15 percent euhedral to anhedral phenocrysts generally as much as 2 mm long of plagioclase (maximum 2 cm), orthopyroxene, and olivine (maximum 5 mm); glomeroporphyritic in places. Anhedral phenocrysts are embayed by groundmass. Some plagioclase phenocrysts contain biotite and pyroxene inclusions. Pilotaxitic groundmass mostly of plagioclase laths as much as 0.5 mm long includes interstitial clinopyroxene and mafic glass, and intersertal olivine and opaque minerals (iron oxides). Disseminatedmicrocrystalline opaque minerals are locally so concentrated as to make plagioclase and pyroxene grains and glass in groundmass opaque. Calcite fills spaces where rock is diktytaxitic. Modal composition is plagioclase 55 to 70 percent; clinopyroxene 10 to 30 percent; olivine 1 to 10 percent; as much as 10 percent orthopyroxene; magnetite 10 percent; and glass 5 percent. Mafic minerals are altered to hematite. Olivine is slightly altered to bowlingite. Nine samples of the unit were analyzed for major oxides (Table 2). Compositions include basalt, basaltic andesite, andesite, and trachyandesite. Unit is part of map unit Tbcu of Ferns and others (1993b). As much as 150 m of the unit is exposed in the southeastern part of the quadrangle. The late Miocene age is based on a K-Ar date (Hart and Mertzman, 1982).

Thi **Basaltic andesite dikes (Middle or late Miocene)**—Dark gray very fine-grained basaltic andesite dike in NE1/4 sec. 24, T. 24 S., R. 40 E. that strikes north (sample 88, Table 2) intrudes unit Tspo. The twenty-four-meter-thick dike is slabby and platy at upper end and weathers to irregular angular boulders at lower end. Very fine grained sparsely phyric basalt with phenocrysts of plagioclase to 0.2 mm. Contains 30 percent oikocrysts of clinopyroxene as much as 0.4 mm across. Rest of rock is interstitial opaque minerals (magnetite?). Modal composition is plagioclase 60 percent; clinopyroxene 30 percent; and magnetite 10 percent. A sample of the dike was analyzed for major oxides (sample 88, Table 4) and is a basaltic andesite. A steeply dipping, northeast-striking basaltic dike that parallels the lower part of Cold Spring Creek is a probable feeder for some of the lava flows of map unit Tcmb

Taf **Andesite flow (Middle Miocene)**—Dark gray to black, fine-grained, finely vesicular andesite flow in northeast corner of quadrangle (samples 77 and 78, Table 2). Unit in places is coarsely vesicular with lenticular vesicles as long as 10 cm, some of which are filled with white chalcedony and clear opal; some of unit is platy. The rock contains a few percent plagioclase phenocrysts to 4 mm long. Some of the rock rings when struck by a hammer, like phonolite. The rock contains 15 percent phenocrysts of plagioclase and olivine as much as 1 mm long; also glomeroporphyritic with clumps of plagioclase and olivine grains to 2 mm. Some phenocrysts are eroded by groundmass. Goundmass consists mostly of plagioclase laths as much as 0.2 mm long and includes interstitial glass, interstitial to subophitic clinopyroxene and intersertal magnetite. Modal composition is plagioclase 52 percent; olivine 2 percent; clinopyroxene 25 percent; glass 20 percent and magnetite 2 percent. Olivine is altered to iddingsite. Calcite fills spaces in diktytaxitic part of rock. Unit is as much as 17 m thick. Age of unit is based on its stratigraphic position between middle Miocene strata in sec. 24, T. 24 S., T. 40 E.

Tspo **Sedimentary and pyroclastic rocks of the Oregon-Idaho graben (Middle Miocene)**—siltstone, sandstone, pebbly sandstone, conglomerate, tuffaceous sandstone, and tuff, interpreted to be part of sedimentary and volcanic rock assemblage of the OIG. Siltstone is light brown, poorly to moderately lithified, massive, and locally cemented by green chalcedony. Well to poorly sorted, thin- to thick-bedded (0.5 to 100 cm), locally tuffaceous sandstone is white, light gray and light brown, poorly to moderately lithified, locally cemented by green chalcedony, hematite, and calcite. Sandstone shows minor crossbedding and contains as much as 10 percent angular to rounded pebbles of perlite, perlitic glass, white pumice, black glass, and rhyolite. Yellow-brown conglomerate found around Wildcat Reservoir contains as much as 20 percent angular to subangular clasts of basalt commonly 20 cm across or less (maximum 1 m) in a matrix of poorly sorted fine- to coarse-grained sandstone moderately cemented by brown chalcedony. White to gray tuff in SW1/4 sec. 22, T. 24 S., R. 40 E. is poorly to moderately indurated; bedding (0.5 to 100 cm thick) is poorly defined. Unit is continuous with unit Tspo in Alder Creek quadrangle to north (Evans and Binger, 1998a). Based on geophysical studies of Griscom and Halvorson (in Smith, 1994), total thickness of unit may be as much as 2 km. Based on unit's stratigraphic relations, including position of part of it under Littlefield Rhyolite at Littlefield Reservoir and in W1/2 sec. 21, T. 25 S., R. 40 E., at least part of the unit is middle Miocene in age

Tba **Basaltic andesite flows (middle Miocene)**—Dark gray to black, fine-grained, generally aphyric basaltic andesite flows in the northeastern part of quadrangle. See Evans and Binger (1998a) for detailed descriptions of unit

Tr **Rhyolite of Dry Creek (Middle Miocene)**—Named informally by Evans and Binger (1998) from exposures along Dry Creek to the north. Varied rhyolite flows interbedded with map unit Tspo in northeastern part of quadrangle. Multicolored rhyolite commonly brecciated and scoriaceous contains components that are blue-black, green, dark red, red brown, black, red, light gray, gray, brown, maroon, and dark purple. Parts of unit are laminated; laminae are disconnected and in places laminae are folded into intrafolial folds. Some of the rhyolitic glass is altered to gray perlite. Contains green chalcedony locally. Parts of unit have as much as 5% feldspar phenocrysts as long as 5 mm and minor phenocrysts of hornblende, clinopyroxene, orthopyroxene, magnetite, and hematite after hornblende. Plagioclase is recrystallized, altered to epidote, and embayed by groundmass. Groundmass consists of feldspar laths as long as 0.2 mm, quartz, and disseminated hematite. Rock contains scattered xenoliths of partly digested and metamorphosed mafic rock, possibly basalt or basaltic andesite. Xenoliths shows various stages of alteration, including recrystallization of plagioclase, alteration of plagioclase to epidote, and disaggregation of mineral grains. Mafic minerals in xenoliths are altered to iddingsite, biotite, and hematite. Thin veins of quartz and zeolite cut the rock. Eleven samples from the unit were analyzed for major oxides (Table 4); 8 are rhyolites, including high-silica rhyolites (78 to 81 percent SiO_2) that may be silicified rhyolite, one is a dacite, and two are trachydacite. The variation in composition, especially the range in FeO content (0.93 to 5.93 weight-percent) is due to the variation in amount of mafic volcanic xenoliths. Equivalent to unit Tdr of Brooks (1992a) in the Copeland Reservoir quadrangle to the east. Based on stratigraphic relations, the unit contains at least 3 flows and is diachronous (see text). Age of unit is based on its occurrence in the middle Miocene OIG section

Th **Hunter Creek Basalt (Middle Miocene)**—Named by Kittleman and others (1965). Very fine-grained aphyric black basaltic andesite and trachybasalt flows (samples 471, 84 and 90, Table 2). Generally weathers to irregular angular fragments 15 to 30 cm in diameter; locally platy. Some of rock is finely vesicular. Rock is altered in places to lenses of pale green rock. As much as 20 m of the unit is exposed in the northeastern part of the quadrangle. Age of unit is based on its resemblance to middle Miocene Hunter Creek Basalt to north.

Contact

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

• 468 **Location of unaltered rock sample listed in Table 1**

○ 371 **Location of altered rock sample listed in Table 5**

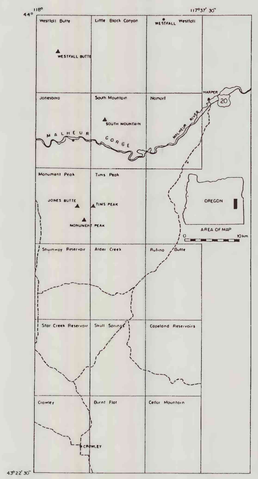


Figure 1. Index map showing locations of the Skull Springs quadrangle, adjacent quadrangles, and other quadrangles mentioned in this report. The thicker uninterrupted line is U.S. Highway 20; dashed lines are dirt roads.

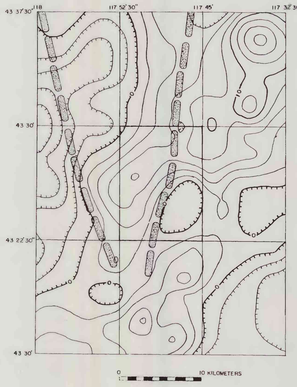


Figure 2. Isostatic residual gravity anomaly map of the Skull Springs quadrangle (bold outline) and adjacent quadrangles. Modified from Griscom and Halvorson (in Smith, 1994). Contour interval 2 milligals. Hachures indicate closed lows. Large dots are locations of gravity stations. Stippled hot-dogs mark the western margin (fault zone) of the Oregon-Idaho graben (NNE) and the western margin of the horst (NNW). See Figure 1 for names of quadrangles adjacent to Skull Springs quadrangle.

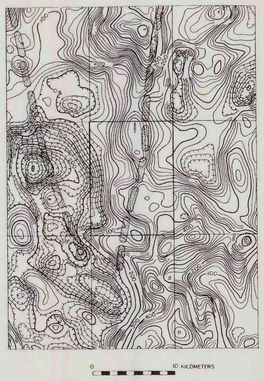
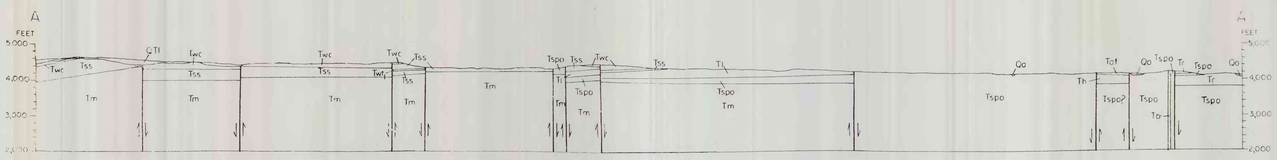
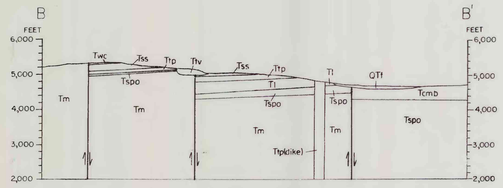


Figure 3. Aeromagnetic map of the Skull Springs quadrangle (bold outline) and adjacent quadrangles. Modified from Griscom and Halvorson (in Smith, 1994). Contour interval 20 and 100 nanoteslas. Hachures indicate closed lows. The stippled hot -dogs are aligned along the western margin (fault zone) of the Oregon-Idaho graben (NNE) and the western margin of the horst (NNW). See Figure 1 for names of quadrangles adjacent to Skull Springs quadrangle.





GEOLOGIC MAP OF THE SKULL SPRINGS QUADRANGLE, MALHEUR COUNTY, OREGON

By
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1999

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