UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Geologic map of the Challis 1^{o} x 2^{o} quadrangle, Idaho

Compiled by

Frederick S. Fisher[1], David H. McIntyre[1], and Kathleen M. Johnson[1]

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[1] Denver, Colorado

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ILLUSTRATIONS

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS (QUATERNARY)

Qa ALLUVIUM, UNDIVIDED--Includes floodplain, terrace, and alluvial fan deposits. Materials include stream-deposited gravel, sand, and silt; gravel and peat in filled ponds and lakes

Qf ALLUVIAL FAN DEPOSITS--Shown separately only in area near Challis and at southeast corner of quadrangle

Ql LANDSLIDE AND RELATED DEPOSITS

Qm GLACIAL DEPOSITS, UNDIVIDED--Unsorted boulders, cobbles, pebbles, sand, silt, and clay in moraines and in glaciofluvatile outwash. Piedmont belt of coalescent moraines along the eastern front of the Sawtooth Range has been attributed to two major late Pleistocene glaciations, the Bull Lake and the Pinedale (Williams, 1961)

Qd QUATERNARY DEPOSITS, UNDIVIDED--Includes modern stream alluvium, terrace gravel, talus and related slope material, landslide debris, unconsolidated glacial moraines and outwash gravel

MIOCENE VOLCANIC AND SEDIMENTARY ROCKS

Tcb COLUMBIA RIVER BASALT--Dark gray to black, fine-grained, consists chiefly of plagioclase laths embedded in augite, and scattered crystals of magnetite. Exposures include a small cap on the ridge immediately west of Grimes Pass, and small outcrops west of Paddy Flat, near the west border of the map

Tmp PAYETTE FORMATION--Stratified, tan to gray, loosely consolidated arkosic sandstone and siltstone with interstratified conglomerate, and thin-bedded dark-gray to black shale in which are abundant impressions of upper middle to lower upper Miocene leaves (W. C. Rember, written commun., 1983). It also contains seams of low-rank coal as much as 30 cm thick, bedded intervals several m thick of light gray to white diatomaceous earth, and beds of gray volcanic ash as much as 30 cm thick. The formation crops out along the west side of Middle Fork Payette River northwest of Crouch. It was deposited in an intermontane basin and now exists as a west-tilted down-faulted block. Minimum thickness 1,680 m; base is not exposed

CHALLIS VOLCANICS AND RELATED SEDIMENTARY AND INTRUSIVE ROCKS (EOCENE)

[Modal analyses are reported as follows: phenocryst abundance as percent of rock sample ("Phenocrysts 30" means that 30 percent of the rock consists of phenocrysts). Phenocryst mineral abundance is reported as percent of total phenocrysts. Names of phenocryst minerals are abbreviated as follows: q=quartz, af=alkali feldspar, pf=plagioclase feldspar, b=biotite, hb=hornblende, px=pyroxene, cpx=clinopyroxene, opx=orthopyroxene, ol=olivine, op=opaque oxides. All K-Ar ages are calculated using the constants of Steiger and Jaeger (1977).]

SUNNYSIDE MINE-MARBLE CREEK AREA

Tl LATITE OF LOOKOUT MOUNTAIN--Black, nearly aphyric, vesicular lavas interbedded with cinders and bombs. Rock locally contains sparse small (0.5 mm) phenocrysts of plagioclase and small prisms (to 1.0 mm) of hypersthene set in a groundmass of randomly oriented plagioclase microlites and glass. Leonard and Marvin (in press) report K-Ar ages of 41.0 to 43.4 $\pm$ 1.4 m.y. Thickness 0-50 m

Tqp QUARTZ PORPHYRY INTRUSIVE MASSES--For description see Yellowjacket area

Tir RHYOLITE INTRUSIVE MASSES--For description see Yellowjacket area

Tds DEWEY BEDS--Cauldron-filling sedimentary rocks and bedded, reworked air-fall tuff. Includes siltstone in varved lake beds and coarse volcaniclastic conglomerate with intercalated landslide debris and talus; carbonacaeous in part. Thickness 0-50 m

Tmi MAFIC INTRUSIVES--see description for Yellowjacket area

SUNNYSIDE RHYOLITE TUFFS AND RELATED ROCKS

Tsu Upper Sunnyside Tuff--Red and red-brown weathering, densely welded, devitrified rhyolite tuff; multiple-flow compound cooling unit that contains numerous small volcanic fragments and fairly obvious well-flattened pumice lapilli from base to top. Base is marked by a lithic fragment-rich black vitrophyre 3-10 m thick. Extremely sparse biotite flakes are the only visible mafic minerals in the devitrified rock; pyroxene and hornblende are the only visible mafic minerals in the vitrophyre. Phenocrysts 12-31: q 15-60, af 40-75, b 0-1, hb trace (as many as 4 grains per thin section in basal vitrophyre only), cpx trace (as many as 8 grains pigeonite per thin section in basal vitrophyre only). Allanite is a common accessory in basal vitrophyre only. Thickness 0-300 m

Tmx Megabreccia--Varicolored breccia consisting of fragments of Tsl (see below), a few cm to several m in diameter, in a matrix of Tsu. The megabreccia is confined to the western part of the innermost subsided zone, the "Thunder Mountain Caldera" of Leonard and Marvin (in press). The fragments presumably slid into the caldera from the outer rims while eruptions of Tsu were still in progress. Thickness 0-100 m

Tslu Uppermost Cooling Unit of Lower Mineralogy--Reddish-gray, simple cooling unit of densely welded rhyolite tuff. Distinguished from Tsu by more abundant plagioclase and biotite; separated from Tsu by a few meters of bedded tuff. Phenocrysts 26: q

40, af 56, pf 12, b 2-3, altered mafic 1. Thickness 0-40 m

Tsrl Rhyolite Lava--Red flow-layered lava or extremely hot ash-flow tuff; occurrence of several black vitrophyres within the rhyolite suggests the presence of two or more cooling units; east of Marble Creek a thin flow of black vesicular latite is intercalated within the unit. Although the rock in all localities looks very similar in outcrop, the rock east of Marble Creek contains more plagioclase than alkali feldspar, and the rock exposed north of Dynamite Creek contains more alkali feldspar than plagioclase. The rock in both localities contains 5-10 percent phenocrysts consisting of varying proportions of alkali feldspar and plagioclase, both 0.5-5 mm in size. Thickness 0-100 $\pm$ m

Tsl Lower Sunnyside Tuff--At least three cooling units, all of which grade upward from white to pink, non-welded to slightly welded rhyolite at base to gray, densely welded quartz latite at top. The upper and middle cooling units commonly display vertical sheeting and contain very little recognizable pumice, whereas the lower unit contains abundant pumice. Upper unit along Marble Creek contains 28 to 49 percent phenocrysts: q 9-45, af 32-51, pf 16-33, b 2-11; hb 0-3, zircon trace. The middle unit along Little Cottonwood Creek contains 15 to 34 percent phenocrysts: q 26-51, af 23-39, pf 2-26, b 4-13, hb trace. The quartz latite upper part of this cooling unit contains sanidine phenocrysts as long as 8 mm. The lower cooling unit, same locality, contains 18 to 28 percent phenocrysts: q 6-51, af 11-38, pf 12-62, b 9-21 in books, zircon trace. Phenocrysts in lower parts of all three cooling units rarely exceed 2 mm. Cauldron-wide hydrothermal alteration (mostly propylitization) has led to perthitic replacement of sanidine. K-Ar ages range from 47.1 to 50.8 $\pm$ 1.7 m.y. (Leonard and Marvin, in press). Thickness 0-500 m

Tpl PERLITIC RHYOLITE--Three rhyolite cooling units separated by green epiclastic sediments. All units have black vitrophyres at the base, grading upward to densely welded, lavender to salmon flow-layered lavas or high-temperature welded tuffs. The upper cooling unit has a non-welded top. Upper unit vitrophyre in the headwaters of Rush Creek contains 14 percent phenocrysts: pf 82, af 11, hb 7, cpx trace. Lower unit, same locality, contains 3 to 5 percent phenocrysts: pf 31-76, af 24-69, hb 0-2, cpx trace. Phenocrysts rarely exceed 2 mm in size. Thickness 0-300 + m

Tdq DIME AND QUARTER TUFF--A complex sequence of mostly densely welded ash-flow tuffs, commonly separated by tuffaceous sandstones and siltstones and locally by thin black latite lavas. The eruption of these tuffs caused the initial collapse of the Thunder Mountain cauldron complex. They are the Thunder Mountain analogue of the Camas-Black Mountain tuffs in the Van Horn Peak cauldron complex. Most are densely welded with collapsed pumice lapilli that in plan view are mostly about the size of dimes and quarters; locally they are larger. The lapilli are mostly dark green or brownish green and contrast with the lighter colored green-gray or buff matrix. The tuffs are pervasively propylitized and mafic minerals are altered to

chlorite, calcite, and iron oxide. In contrast to the overlying Tsl, the Tdq is chiefly pyroxene-bearing. If a single fresh rock from Indian Creek is representative, the pyroxene is principally clinopyroxene. Phenocrysts generally are less abundant and smaller than those in Tsl and most of the tuffs are quartz poor. Phenocrysts 9-16: q trace-5, af 2-8, pf 70-83, b trace-2, hb 0-4, cpx (mostly altered) trace-16. Some crystal-poor, quartz-free, flow-layered tuffs occur near the head of Prospect Creek east of Marble Creek that contain more alkali feldspar than plagioclase. Similar tuffs occur west of Shellrock Peak just below unit Tpl. Thickness 0-500 + m

Tbr BUFF RHYOLITE--Mapped by B. F. Leonard in the northwest part of the cauldron complex, where it presumably occupies the same stratigraphic interval as unit Tdq. The "buff rhyolite", in contrast to unit Tdq, is nearly aphyric, containing only about 1 percent phenocrysts consisting of plagioclase (0.5-1.5 mm), traces of biotite, and an altered prismatic mafic mineral. The rhyolite is flow laminated and layered; either it is an unusually widespread lava or it originated as an extremely hot ash-flow tuff. Thickness 0-300 + m

Tdql LOWER DENSELY WELDED TUFF--Quartz-rich gray tuff within unit Tdq that closely resembles unit Tsl. In places, this densely welded tuff rests directly on the lower latite (unit Tll). Phenocrysts 23-30: q 27-35, af 20-26, pf 34-38, b 1-3,hb tr-1, altered mafic mineral 2-11. Thickness 0-30 + m

Tll LOWER "LATITE" LAVAS--Mostly dark gray and dark purplish-gray flow-layered lavas consisting of crystal-poor flows that probably are about the same composition as the much younger latite of Lookout Mountain (unit Tl) and conspicuously porphyritic flows that probably are dacite or rhyodacite in composition. The latter contain 30-40 percent phenocrysts of plagioclase as large as 6 mm and abundant mafic minerals, consisting of varying proportions of biotite, hornblende, and pyroxene. K-Ar ages reported by Leonard and Marvin (in press) suggest an age range of 48-50 m.y. for this sequence--virtually the same as reported for the older intermediate lavas (unit Td) exposed farther east and southeast (McIntyre and others, in press). Thickness 0-500 + m

Tdc DACITE AND DIORITE COMPLEX--Porphyritic gray rocks of intermediate composition consisting of both dacite porphyry and relatively minor diorite porphyry. This sequence, like the "gray porphyry" (unit Tgp) exposed in and adjacent to the Van Horn Peak cauldron complex, consists of both extrusive and intrusive rock. In places, the dacitic rocks clearly intrude unit Tdq and possibly younger tuff units as well. In other places, the rocks appear to be stratiform with flow layering that defines gentle dips and with interlayered zones of flow breccia characteristic of contact zones between lava flows. These rocks mostly have a dense or cryptocrystalline groundmass but, locally, have a holocrystalline fine-grained groundmass (diorite porphyry). Phenocrysts of plagioclase generally are conspicuous and, in the Indian Creek area, commonly are 2-3 mm long. Quartz is sparse, but commonly present. Mafic minerals

consist of varying proportions of biotite, hornblende, and pyroxene. The total phenocryst content varies from about 20 to 50 percent. As mapped, therefore, this unit probably includes dacite lavas that are essentially part of the "lower latite" lava pile (unit Tll) and, in other places, the unit includes dikes and irregular intrusive masses that probably are younger than unit Tdq

Tcv CHALLIS VOLCANICS, UNDIVIDED--Thickness 0-50 ± m

Tsi SILICIFIED ROCKS

EOCENE GRANITIC ROCKS OF THE CASTO PLUTON

Tg Pink granite and light-gray quartz monzonite--see description for Yellowjacket area

Thg Hornblende granite of Ross (1934)--see description for Yellowjacket area

YELLOWJACKET CREEK-CAMAS CREEK-PANTHER CREEK-MORGAN CREEK AREA

Toc OLDER COLLUVIUM OF PANTHER CREEK--Poorly consolidated sandstone, mudstone, boulder conglomerate, and tephra; locally carbonaceous; includes large landslide masses of variegated volcanic rocks. Unit was deposited in the Panther Creek graben that subsided rapidly after extrusion of the younger monolith-forming ash-flow tuff (unit Tmt). Some subsidence of the graben may have been due to magma withdrawal but most was probably due to regional rifting concurrent with volcanism. This incompetent sequence of rocks is easily eroded and has landslipped everywhere to a considerable degree

TUFF OF CASTLE ROCK AND RELATED ROCKS--Except for strata preserved within the Castle Rock half-moon or trapdoor cauldron, the sequence is mostly partially welded and forms slopes. A single densely welded cooling unit outside the cauldron forms cliffs and is mapped separately

Tmt Monolith-forming tuff--Varicolored, non-welded to partially welded ash-flow and ash-fall rhyolite tuff. Sequence overlies and underlies a genetically related densely welded cooling unit (unit Tck) with identical phenocryst mineralogy. Locally mapped to include non-related, soft bedded tuff in lower part that contains abundant biotite; includes several zones rich in small variegated volcanic lithics. Rock above and below the densely welded part weathers to tepee-shaped hoodoos and other variously-shaped monoliths. Typically with vitric, silky pumice lapilli and fresh black glass shards, but zeolitized and otherwise altered in many locales. Phenocrysts 15-25: q 30-50, af 50-60, pf 0-3, b 0-1, hb 0-trace, px (mostly pseudomorphs) 0-3; commonly with smoky quartz and chatoyant alkali feldspar. Thickness 0-300 m

Tck Tuff within Castle Rock cauldron and one densely-welded outflow cooling unit--Within the cauldron includes five cooling units of reddish ash-flow tuff with interbedded thin beds of ash-fall tuff; consists of a densely welded unit at top about 228 m thick; two thin partially welded, lithic-rich cooling units, each about 30 m thick; a lower cliff-forming, moderately welded

cooling unit about 150 m thick; and a lowermost slope-forming, partially welded, lithic-rich cooling unit about 190 m thick. The densely welded upper unit is inferred to correlate with the densely welded outflow unit. If this is the case, the soft tuff preserved above the densely welded unit in the Panther Creek graben has been stripped away at Castle Rock. Phenocrysts, upper cliff-former, 28: q 47, af 50, pf 0.7, b 0.3-0.7, altered cpx 0.7 (base) - 2.9 (top); unit has same mineralogy at top as at base. Phenocrysts in lower cliff-former show considerable variation from base to top: q 15 (base) - 45 (top), af 78 (base) - 49 (top), pf 3.8 (base) - 4.1 (top), b trace (base) - 1.0 (top), hb trace, cpx 3.1 (base) - 1.4 (top). Thin cooling units between cliff formers and thick partially welded unit below show virtually this same mineralogy. Quartz is slightly smoky throughout the sequence and all units contain zones of chatoyant alkali feldspar. Thickness 620 m

Tfl Flow-layered rhyolite or remobilized tuff--Probably at least two cooling units of reddish flow-laminated and layered rhyolite lava or very hot tuff; had a source outside the Castle Rock cauldron but is intercalated with the Castle Rock sequence within the Panther Creek graben. Phenocrysts 8-11: q 0-2.9, af 78-95, pf 0-5, b 0-trace, altered px 2-12

Tqp QUARTZ PORPHYRY INTRUSIVE MASSES--Dikes and plugs of pink porphyry with phenocryst sizes and groundmass textures that vary exceedingly; typically with smoky quartz phenocrysts up to 3 or 4 mm in size, tabular alkali feldspar and sparse plagioclase up to 6 - 8 mm in size, and sparse flakes or books of biotite up to 3 mm in size, in a dense micrographic groundmass of quartz and alkali feldspar; commonly, however, with a microgranular or cryptocrystalline groundmass; locally with extremely coarse phenocrysts consisting of worm-eaten bipyramids of quartz up to 1 cm in size and both alkali feldspar and plagioclase up to 3 cm in size. This rock has a graphic-textured groundmass. A single large sanidine crystal 3 cm long from a dike east of Yellowjacket Creek yielded a K-Ar age of 44.4 $\pm$ 1.0 m.y. (R. F. Marvin, written commun, 1980). The quartz porphyry corresponds to the pink granophyre of Ross (1934). Some dikes are composite masses containing rhyolite without quartz phenocrysts; in places these quartz-poor dikes were included with unit Tqp, in other places with Tir (see below). Phenocrysts 19-35: q 15-58, af 37-83, pf 0-12, b tr-4

Tir RHYOLITE INTRUSIVE MASSES--Dikes and plugs of mostly light gray, dense, phenocryst-poor rhyolite; locally with conspicuous phenocrysts of sanidine as long as 8 mm and with sparse phenocrysts of quartz as at Red Rock Peak, along the Challis quadrangle northern border at 114° 25′ 30" W; the latter rock is compositionally gradational with and forms composite masses with Tqp. Sanidine from Red Rock Peak yielded a K-Ar age of 44.6 $\pm$ 1.5 (R. F. Marvin, written commun., 1981)

Tb BASALTIC LAVAS--Black and brownish-gray, mostly vesicular lavas that probably range in composition from potassium-rich basalt to trachyandesite or latite; mostly dense with scattered small (0.5-2 mm) phenocrysts of pyroxene and plagioclase in a

pilotaxitic groundmass composed of plagioclase laths, pyroxene, and glass; locally with small altered olivine phenocrysts and commonly with xenocrysts of quartz with reaction rims composed of tiny pyroxene prisms and glass; unit is intercalated with tuffs as young as the basal rocks of Castle Rock (unit Tck) and with rocks as old as the tuff of Ellis Creek (unit Te, see below). Thickness 0-50 m

Tmi MAFIC INTRUSIVES--Dikes and plugs of basaltic composition similar to or the same as basaltic lavas described above. Mapped to include rocks of mafic to intermediate composition near Van Horn Peak and elsewhere that are conspicuously porphyritic, containing pyroxene and plagioclase phenocrysts as large as 5 mm; pyroxene may be entirely hypersthene or pigeonite or varying mixtures of the two; locally with sparse biotite and hornblende

Tqb QUARTZ-BIOTITE TUFF--Light green-gray and reddish-gray, locally flow-layered, densely welded ash-flow tuff that consists of at least two cooling units. Locally, the unit in the Panther Creek graben is flow laminated and layered from base to top, indicating that the hot ash flows there coalesced to liquids before coming to rest; elsewhere, especially in slopes south of the West Fork of Camas Creek, the rock is only locally flow layered and displays zones with abundant brown-green pumice lapilli that are darker than the light gray or light greenish-gray enclosing matrix. Phenocrysts show large variations in abundance and relative proportions of quartz, alkali feldspar and plagioclase. Mostly 20-35 percent phenocrysts: q 19-50, af 25-45, pf 15-40, b 2-20, hb trace-5, px trace. Some quartz phenocrysts in this unit show a peculiar tendency to be biaxial even where they obviously are not strained. They tend to be smoky and nearly everywhere are incipiently to strongly resorbed. Allanite is a common accessory mineral. Thickness 0-300 m

Tap ALKALI FELDSPAR-PLAGIOCLASE TUFF--Light green gray and reddish gray, commonly altered to yellow and various pastel shades; flow-layered and laminated densely welded tuff, locally with recognizable well-flattened pumice lapilli. Ash flows in this unit coalesced to liquids before coming to rest. Named for the sparse, but conspicuous, euhedral phenocrysts of water-clear, "plate glass" tabular alkali feldspars as long as 5 - 6 mm and altered and inconspicuous plagioclase, equally euhedral, as long as 5 - 6 mm. Spherulitic in several localities; unit has a metaperlite basal vitrophyre. Phenocrysts 6-10: af 30-40 (locally to 50), pf 45-66, altered mafic mineral (probably pyroxene) 2-8. This unit is intruded by dense rhyolite and locally is somewhat mineralized. Thickness 0-300 m

Tdt DIRTY TUFFS--Three thin vitric cooling units of densely welded, lithic-rich ash-flow tuffs; locally flow laminated and devitrified; typically with vitric gray matrices and well-flattened black glassy pumice fragments as long as 15 cm. "Tiger rock" of local usage. These three units presumably are the distal ends of hot ash flows erupted from the Thunder Mountain cauldron complex to the west but their counterparts there have not been positively identified. They are crystal-

poor plagioclase-bearing tuffs that most closely resemble some of the crystal-poor plagioclase tuffs in the "dime and quarter tuffs" (unit Tdq) exposed near Shellrock Peak. Phenocrysts 1.6-8.6: q 0, af 0-6, pf 73-98 (0.4-2 mm, extensively resorbed), b 0-trace, hb 0-trace, opx trace-18.5; Thickness 0-150 m

TUFFS OF CAMAS CREEK-BLACK MOUNTAIN AND RELATED ROCKS

Tc Tuffs of Camas Creek-Black Mountain, undivided--A cauldron-filling sequence of mostly very densely welded ash-flow tuff consisting of 10 or more separate cooling units that all are characterized by small phenocrysts (about 2 mm) which, in the upper part of the sequence, consist of plagioclase and fairly abundant mafic minerals; plagioclase and sparse to moderate amounts of alkali feldspar in the middle part; and plagioclase with sparse alkali feldspar and quartz in the lower part. The entire sequence contains abundant to fairly abundant mafic minerals consisting mostly of altered pyroxene, but with variable amounts of biotite and sparse hornblende. The lower part of the sequence contains the same kind of phenocrysts as the tuff of Eightmile Creek (unit Tem, see below) but they are less abundant. This lower part, like the Eightmile, contains more biotite and hornblende than pyroxene. Phenocrysts (upper) 11-40: q 0-trace, af 0-trace, pf 65-75, b trace-10, altered hb 0-trace, altered pyroxene 10-20. Phenocrysts (middle) 5-25: q 0-trace, af trace-20, pf 65-77, altered b trace-9, altered hb trace-3, altered px 3-10. Phenocrysts (lower) 3-15: q 2-12, af 2-8, pf 60-75, altered b 2-10, altered hb trace-3, altered px trace-10. This sequence appears to have been almost entirely confined to the cauldron complex formed principally as a result of the eruption of the tuff of Eightmile Creek and the tuff of Ellis Creek (unit Te, see below). Only thin, partially welded ash-flow tuffs and minor ash-fall tuffs appear outside the complex. The outflow units are mapped with the tuff of Pennal Gulch (unit Tp, see below). Thickness 0-3,000 m

Tvp Tuff of Van Horn Peak--Forms a vent nearly 1.6 km in diameter at Van Horn Peak. For description see Corral Creek area. This unit is the youngest tuff of the Camas Creek-Black Mountain sequence

Ttm Tuff of Table Mountain--Outflow equivalent of the tuff of Van Horn Peak--for description see Corral Creek area

Tcs Tuff of Camas Creek-Black Mountain and bedded strata, undivided--Thin ash-flow tuff cooling unit of Camas Creek-Black Mountain lithology interbedded with thin-bedded ash-fall tuff of similar lithology and lacustrine tuffaceous siltstones, sandstones, and conglomerate. This sequence is the intracauldron equivalent of the tuff of Pennal Gulch (unit Tp). Thickness 0-100 m

Tp TUFF OF PENNAL GULCH--For description see Challis area. Thickness 0-300 m

Trb RHYOLITE OF RED BUTTE--Red, reddish-gray, pale brown flow-laminated and layered densely welded tuff whose pyroclastic characteristics are preserved in only a few local areas; this rock not only flowed after coalescing to liquid, it also flow-brecciated its base in several areas. Phenocrysts 6-16: q 0, af 0-trace (with reaction rims of tiny pf), pf 61-75, b 18-37,

hb 0-6.3 (rare). Thickness 0-250 m

Tpq QUARTZ-PHENOCRYST PERLITE--Pink and orange-gray flow-laminated, hydrated rhyolite glass that has retained its perlitic texture despite deep weathering and alteration; mapped in all localities to include sub- and superjacent flat bedded tuffs and tuffaceous sandstones. Quartz is amethyst to smoky and up to 4 mm in size. Phenocrysts 21-33: q 27-35, af 9-31, pf 19-47, b 6-12, hb 4-6.5, altered px 2. Thickness 0-35 m

Tem TUFF OF EIGHTMILE CREEK--Two or more cooling units of green-gray rhyodacitic ash-flow tuff that together are 300 + m thick near Sleeping Deer Mountain within the cauldron complex, but that rarely exceed a few tens of meters each outside the cauldron complex and the Custer graben. Unit overlies the tuff of Ellis Creek and underlies the tuff of Camas Creek-Black Mountain and locally shares some characteristics of both units. Where densely welded and rich in phenocrysts, it is not easily distinguished from the tuff of Ellis Creek; it differs only in containing significant amounts of alkali feldspar. Phenocrysts 14 (weakly welded)-46 (densely welded within the cauldron complex): q 10-22, af 6-16, pf 44-63, b 6-16, hb 1-5, px trace-2. Unit contains abundant apatite, modest amounts of zircon, and sparse allanite as accessories. Quartz phenocrysts are mostly slightly embayed, but a few ubiquitous large grains occur that are virtual sieves. Thickness 0-300 + m

Tl K-RICH ANDESITE AND LATITE LAVAS--For description see Corral Creek area

Til K-RICH ANDESITE AND LATITE DIKES--For description see Corral Creek area

Te TUFF OF ELLIS CREEK--For description see Corral Creek area. Thickness 0-2,000 $\pm$ m

Td INTERMEDIATE LAVAS--For description see Corral Creek area. Thickness 0-1,000 $\pm$ m

Tmz INTERMEDIATE LAVAS AND BRECCIAS OF MIXED ZONE--For description see Corral Creek area

Tdi DIKES OF DACITIC COMPOSITION

Tlt LITHIC TUFF OF MIXED ZONE--For description see Corral Creek area

Tfr FLOW-LAMINATED RHYOLITE OR QUARTZ LATITE LAVA--for description see Corral Creek area

Tgp GRAY PORPHYRY--A mixed sequence of gray and green-gray extrusive and intrusive rocks of intermediate composition. Some display flow layering and flow brecciation and dense to glassy groundmasses that indicate they are lavas; most are massive with crystalline groundmasses. This massive rock, in places, exhibits intrusive contacts with country rock as young as the basal part of the tuffs of Camas Creek-Black Mountain (unit Tc). Therefore, the unit, as mapped, probably includes intermediate lavas as old as 51 m.y. and younger dikes and irregular intrusive masses 48 m.y. old or less. Phenocrysts 30-45: q 0 (in most rocks)-5, af 0, pf 60-75, b 1-12, hb trace-25, px (mostly altered but in places including both fresh opx and cpx) trace-20. The rocks grade, without sharp contacts, from hornblende- and biotite-rich varieties to pyroxene-rich varieties within short distances. Thickness 0-

500 ± m

GRANITIC ROCKS (EOCENE--43.9-46.6 m.y.)

Tg Pink granite and light-gray quartz monzonite--Corresponds to the "Casto Pluton" of Ross (1934) and Cater and others (1973). Mostly pink granite: q 22-34 (0.2-5 mm), af (perthitic cloudy orthoclase and microcline) 31-57 (0.5-10.0 mm), pf 18-33, b 20-67, hb 0-3.5, trace amounts of sphene and allanite. The pink rocks plot in the granite field both of Johannsen (1948) and Streckeisen (1973). The light gray rocks are distinctly richer in plagioclase and fall in the quartz monzonite field of Johannsen (1948). Biotite from fine-grained light-gray rock exposed near Grouse Lake gave a K-Ar age of 46.6 ± 1.6 m.y. (R. F. Marvin, written commun., 1981)

Thg Hornblende granite of Ross (1934)--Buff to pink, medium-grained hornblende granite (Johannsen, 1948) or quartz syenite (Streckeisen, 1973) for two samples; one from Marble Creek, the other from Loon Creek. A sample from just south of Woodtick Summit contained less quartz and alkali feldspar and is quartz monzonite according to both classifications. Rock in all three localities tends to weather rusty. Composition: q 8-3 (Woodtick area) - 9.3 (Loon Creek) - 13.4 (Marble Creek), af (mostly cloudy orthoclase) 39.7 - 54.9 - 57.4, pf 36.7 - 20.1 - 12.1, b 2.2 - 0.6 - 1.3, hb 13.1 - 12.5 - 15.1. The Loon Creek and Marble Creek thin sections each contained several grains of allanite

INTRUSIVE ROCKS OF UNCERTAIN AGE

TKd DIORITE AND QUARTZ DIORITE--In the Yellowjacket area corresponds to "hornblende quartz diorite" of Ross (1934). This unit is a mixed sequence of mostly gray melanocratic rock ranging in composition from reconstituted gabbro to mafic-rich quartz monzonite. The composition of gabbro from near Middle Fork Peak: pf (1 mm-10 mm) 34.4, b 2.8, hb (mostly after px) 18.4, fibrous actinolite-tremolite 5.2, non-fibrous actinolite-tremolite 15.1, chlorite 7.6, black opaque oxides 10.8, apatite 5.7. According to Ross (1934, p. 58), the typical hornblende quartz diorite is nearly white and contains: q trace-5 (locally as much as 20), af trace-10, pf 60, hb and b (mostly intergrown) 20-40 (locally hb 43, b 38). The rock commonly is altered to epidote, chlorite, sericite, and calcite. Cater and others (1973) considered these rocks to be Precambrian in age and Peale (1982, p. 58) considered them to be Cambrian (?) to Ordovician (?)

TKs QUARTZ SYENITE, SYENITE, AND GRANITE OF PEALE (1982)--A composite mass that Ross (1934) considered to be Tertiary in age, ranging in composition from quartz diorite to granite. According to Peale (1982, p. 61-62), the rocks all contain quartz except for the syenite, which is rare. The mode is: q 5-32, af (mostly microcline-microperthite) 37-85, pf 1-28, b 0-5, ferrohastingsite 0-15

CORRAL CREEK-IRON CREEK AREA

Ttm TUFF OF VAN HORN PEAK AND TABLE MOUNTAIN--Pale grayish-red to yellowish-brown, densely welded rhyolite or quartz latite ash-flow tuff; probably a simple cooling unit. Phenocrysts 10-13: pf 80-90, b 7-13, altered px 2-5. Black basal vitrophyre a few meters thick contains abundant small volcanic lithic fragments a few mm to a few cm in diameter. Biotite from the vitrophyre gave a K-Ar age of 47.8 $\pm$ 1.7 m.y. (R. F. Marvin, written commun., 1982). Reversed magnetic polarity. The source for this unit is a vent at Van Horn Peak, about 11 km northwest of Table Mountain (Ekren, 1981). Thickness 0-100 + m

Tp TUFF OF PENNAL GULCH--see description for Challis area

Tem TUFF OF EIGHTMILE CREEK--Light gray and green-gray, massive-weathering, partly welded and densely welded quartz latite or rhyodacite ash-flow tuff; appears to be a simple cooling unit in the Corral Creek area where it is poorly exposed and, in most areas, was not mapped separately at the base of the tuff of Pennal Gulch (unit Tp). Phenocrysts 25-35: q 13-17, af 12-16, pf 45-55, b 9-12, hb trace-2, cpx trace. Thickness 0-50 m

Tl INTERMEDIATE AND MAFIC LAVAS--Predominantly aphyric reddish-brown weathering, gray and greenish-gray, brittle, blocky to platy lavas; locally containing minor interbedded oxidized breccias. Pyroxene phenocrysts visible in a few specimens. Microphenocrysts include olivine, clinopyroxene, orthopyroxene, and, commonly, xenocrystic quartz. Plagioclase-rich groundmass is trachytic or pilotaxitic and may contain apatite and reddish-brown strongly pleochroic mica. Compositions range from potassium-rich basalt to andesite, with probable predominance of andesite. Thickness 0-700 m

Tdm TUFF OF DEGAN MOUNTAIN--Pink and reddish-gray, densely welded rhyodacite ash-flow tuff; uncommonly rich in mafic minerals; appears to have erupted from west flank of Degan Mountain where a composite vent occurs that also contains mafic non-fragmental intrusive rock (unit Til). Contains numerous small quartz phenocrysts about 1 mm in size and a few slightly larger quartz xenocrysts with reaction rims consisting of tiny pyroxene microlites and glass. Phenocrysts 20-32: q (includes xenocrysts) 5-15, af 4-18, pf 29-58, b 2-8, hb 14-36, cpx 6-26, opx trace. Thickness 0-50 m

Te TUFF OF ELLIS CREEK--Light green-gray, massive-weathering, densely welded rhyodacite ash-flow tuff; a multiple-flow compound cooling unit or, possibly, two cooling units; everywhere with conspicuous pumice; contains zones within which pumice lapilli are lighter than the matrix and zones within which the lapilli are darker than the matrix. Phenocrysts 36-50: q 4-15 (commonly "worm-eaten" and up to 4 mm), af 0, pf 60-75 (as long as 6 mm), b 12-20, hb 8-16, cpx trace. Thickness 0-300 m

Td INTERMEDIATE LAVAS--Principally cliff-forming, dark gray, conspicuously porphyritic lavas of dacitic composition; blocky weathering, with inconspicuous flow layering; unit locally includes phenocryst-poor dark purplish-gray latite or andesite.

Phenocrysts (dacitic lavas) 25-40: q 0-trace, pf 60-70 (as long as 6 mm), b 0-4, hb 15-23, cpx trace-15, opx trace. All mafic minerals locally are oxidized to black opaque iron oxides or replaced by chlorite and iron oxide. Latite or andesite lavas contain 5-15 percent small phenocrysts (0.5-2 mm) of plagioclase and clinopyroxene with traces of orthopyroxene and oxidized hornblende. Thickness 0-900 m

Tmz INTERMEDIATE LAVAS AND BRECCIAS OF MIXED ZONE--A heterogeneous mixture of mafic and dacitic lavas and flow breccias interbedded with tuff breccias, mud flows, and debris flows; locally with well-stratified boulder and cobble conglomerates containing petrified tree stumps and logs; entire sequence is principally slope-forming, but in and adjacent to canyons weathers to hoodoos and monoliths. Matrix of breccias and mud flows is rich in montmorillonite and weathers frothy; slimy when wet. Individual tabular lava flows are mostly latites or andesites that appear to be the same composition as lavas in the younger map unit Tl. These lavas are dark purplish gray and brownish gray; vesicular. Phenocrysts 5-30: pf 50-70 (0.5-2 mm), cpx 10-20 (mostly less than 3 mm), opx 10-20 (mostly less than 2 mm), hb trace to 5. Some of these mafic lavas contain only clinopyroxene (as long as 1 cm) as phenocrysts; some contain hornblende as long as 3 cm as the only phenocryst. Groundmasses are principally pilotaxitic. Dacitic lavas and breccias are identical in composition to the cliff-forming, conspicuously porphyritic lavas of Block Creek (unit Tab) but, in this unit, they consist mostly of slope-forming flow breccias. A porphyritic rhyodacite lava near the base of this unit contains the same phenocryst assemblage as the tuff of Ellis Creek (unit Te). This lava also crops out on the east side of Morgan Creek Summit and just east of Opal Creek. Thickness 0-900 m

Tlt LITHIC TUFF OF MIXED ZONE--Reddish-gray, green-gray, and yellowish-gray densely welded, cliff-forming, lithic-rich ash-flow tuff; possibly comprising two separate multiple-flow cooling units. Phenocrysts 13-38: q 0-1, pf 72-85, b 0-4, hb 3-5, opx 7.5-22. The extrusion of this tuff apparently triggered the subsidence of the Corral Creek segment of the Van Horn Peak cauldron complex. In places the tuff grades upward into a debris flow containing abundant latite and dacite clasts. Thickness 0-200 m

Tfr FLOW-LAMINATED RHYOLITE OR QUARTZ LATITE LAVA--Yellowish-brown, slope-forming, massive-weathering, aphyric; in most exposures this rock more closely resembles a massive siltstone than a volcanic rock. In thin section may contain a crystal or two of albite (2 mm) and a single flake of biotite. The groundmass is a dense felt of alkali feldspar microlites

TWIN PEAKS CALDERA - EAST FORK MAYFIELD CREEK AREA

Tir RHYOLITE DIKES, PLUGS, AND FLOWS--Light gray, tan, and pinkish-red, generally crystal-poor or only moderately crystal-rich,

porphyritic intrusive rocks and minor flows. Rock typically contains phenocrysts of quartz and sanidine in variable amounts; plagioclase locally present in minor amounts. Locally contains minor biotite and, rarely, trace amounts of pyroxene. These rocks display fabrics ranging from massive to flow-laminated to autobrecciated. In thin section textures range from glassy to devitrified to fine grained allotriomorphic granular. In the ridges between the East Fork of Mayfield Creek and Yankee Fork at least two generations of rhyolite are present. The older rhyolites are glassy to devitrified and intruded by dikes and pluglike masses of more massive rhyolite. Narrow rhyolite dikes and irregular intrusive masses pervade the west and north margins of the Twin Peaks caldera and crosscut the tuff of Challis Creek (unit Tcr_1) and the caldera wall slump debris (unit Tsd)

Tit FELSIC DIKE ROCKS--Light gray to brown-gray, light brown weathering dikes of porphyritic trachyte and/or rhyolite that contain phenocrysts of sanidine up to 5 mm in size, and locally contain minor amounts of pyroxene and biotite. Plagioclase, if present, generally is small, resorbed, and mantled by alkali feldspar. These dike rocks occur principally within the Twin Peaks caldera, where they intrude the tuff of Challis Creek (unit Tcr_1) and caldera wall slump debris (unit Tsd)

Tqp QUARTZ PORPHYRY INTRUSIVE MASSES--See description for Yellowjacket area

Tgp GRAY PORPHYRY--See description for Yellowjacket area

Til INTRUSIVE ROCKS OF PATS CREEK-UPPER EDDY CREEK--Light gray to pinkish red or lavender, red to lavender weathering, fissile to flaggy, flow-laminated and locally autobrecciated intrusive rock that occurs along the north and east margins of the Twin Peaks caldera. Phenocrysts 9-21 percent: af 0-25, pf (strong oscillatory zoning) 53-69, b 17-34, hb 0-5. Locally, near contacts, this rock is black and vitrophyric or perlitic-devitrified, and gray-green weathering. Rock has steep to vertical flow foliation and locally has isoclinal flow folds with steep to vertial axial planes of variable strike. Locally, this rock contains cavities lined with chalcedonic quartz. In hand specimen this rock resembles the rhyolite of Red Butte (unit Trb, see below), but this unit, unlike unit Trb, generally, but not always, contains scattered sanidine phenocrysts. The unit is in intrusive contact with the tuff of Challis Creek (unit Tcr) in the upper Pats Creek area and in upper Eddy Creek above Eddy Basin. A pluglike mass containing plagioclase, biotite, sanidine, and hornblende phenocrysts occurs on Spider Creek. This rock is light greenish-gray, medium-brown weathering, steeply flow-foliated, and contains abundant gas cavities containing rosettes of gypsum and minor calcite

Tii INTERMEDIATE DIKE-LAVA ROCKS--Dark brown to purple-brown, dark-brown weathering, porphyritic dike or lava rocks containing abundant phenocrysts up to 3 mm in size of plagioclase and pyroxene, less abundant hornblende, and minor biotite. On lower Bear Creek an apparent dike of this unit, which appears to occupy the ring fracture fault of the Twin Peaks caldera, contains

phenocrysts of sanidine in addition to the above minerals. Contacts of this unit near Mosquito Flat Reservoir are not exposed and relationships with the tuff of Challis Creek are uncertain

TUFF OF CHALLIS CREEK--Principal ash-flow tuff sequence erupted with the collapse of the Twin Peaks caldera (Hardyman, 1981). One unit of caldera wall slump debris and three units of ash-flow tuff are mapped within the caldera.

Tsd Caldera wall slump debris (megabreccia)--Heterogeneous deposit of coarse epiclastic talus deposits and megabreccia interfingering and admixed with ash-flow tuff. Deposits of this material are localized along the ring-fracture system on the southeast margin of the Twin Peaks caldera (Challis Creek and lower Pats Creek) and an extensive accumulation extends into the caldera from its north margin. Bedded, indurated, coarse conglomeratic sandstone and angular talus deposits, resembling concrete on fresh fracture, occur low in exposure of this unit and form thin lenslike layers and pods throughout the deposit. The megabreccia consists of tuffaceous matrix-supported to block-supported deposits of angular, unsorted pebble- to boulder-sized clasts and house-sized blocks of ash-flow tuff, intermediate and siliceous lavas, epiclastic rocks, and abundant fragments of tuff of Challis Creek. The ash-flow tuff matrix of the megabreccia is nonwelded, crystal-poor and resembles the tuff of Challis Creek except for the higher plagioclase content. Phenocrysts 4-20 percent: af 40-47, q 37-57, pf 3-17, b trace. Thickness: 400 + m

Tcr_3 Tuff of Challis Creek, unit 3--upper cooling unit exposed in Twin Peaks caldera. Multiple flow, compound cooling unit of crystal-rich rhyolite ash-flow tuff. Phenocrysts: 22-26 percent of rock in basal nonwelded tuff, 36-44 percent in remainder of unit; af 54-69, q 25-45, pf 0-3, b trace, hb rare, px 0-4.5. Accessory minerals are zircon, allanite, and trace amounts of apatite. The sanidine phenocrysts, up to 5 mm in size, are chatoyant. Quartz phenocrysts commonly are slightly resorbed, bipyramidal, and smoky. Phenocrysts are somewhat smaller and less abundant in the basal part of the unit than in the densely welded tuff. This unit, as with units Tcr_1 and Tcr_2, is distinct in having little or no plagioclase or ferromagnesian minerals. Plagioclase seldom exceeds 0.5 percent of the total phenocrysts, biotite is only rarely observed, and minor pyroxene grains are preserved only in the most densely welded tuff. Except locally near the base this unit is medium-gray to brownish-gray, brown weathering, densely welded, devitrified ash-flow tuff with pumice lapilli up to 12 cm long and 3 cm thick (rarely up to 26 cm long by 2 cm thick) and scattered pebble- to cobble-sized fragments of gray to lavender aphyric intermedite to rhyolitic lava. Pumice lapilli can be medium to rusty brown and darker than the matrix or light gray and ligher than the matrix. At the base, this tuff is light gray to light brown, nonwelded to moderately welded and glassy and is more lithic-rich than the rocks exposed above, with lithic fragments less than 8 cm in diameter constituting 4-6 percent of the rock and including porphyritic

intermediate lava fragments, ash-flow tuff fragments of tuff of Challis Creek mineralogy, and light gray flow-banded rhyolite fragments (occasionally up to 1 m in size at base of unit). The more pumiceous nonwelded to moderately welded basal part of the tuff is up to 60 m thick and is overlain by densely welded tuff with a laterally discontinuous basal vitrophyre up to 6 m thick. Thickness is in excess of 700 m. The original top of the unit is not exposed

Tcr_2 Tuff of Challis Creek, unit 2--Two, or possibly three, cooling units of light-gray to greenish-gray or brownish-gray, partially to densely welded, pumiceous rhyolitic ash-flow tuff that weathers gray, light brown or lavender. Phenocrysts (up to 2 mm in size), 15-26 percent of rock: af 43-59, q 38-57, pf 0-trace, b 0-1.5, px 0-2. Pumice in upper of two ash-flow tuffs is greenish brown, darker than matrix, and up to 6 cm, but generally less than 1 cm in length. In lower of two tuffs the pumice lapilli are pale green-gray and ligher than the matrix. Unit Tcr_2 typically is in sharp contact with the overlying unit Tcr_3. Concentrations of lithics occur near the contact. Tcr_2 locally overlies thin tuffaceous sediments at the contact with the underlying unit Tcr_1. Thickness: 22-48 m

Tcr_1 Tuff of Challis Creek, unit 1--Light to dark brownish-gray, brownish-gray weathering, moderately to densely welded, crystal-rich, pumiceous, rhyolitic ash-flow tuff. Phenocrysts (2-4 mm in size) 15-48 percent of rock: af 50-71, q 26-47, pf 0-3 (generally less than 0.5), b rare, px (preserved only in vitrophyres) 0-2. Variable amounts of pumice and vertical variation in compaction (welding zonation) within this unit, especially in the upper part, suggest compound cooling. Similar alternating variations in crystal and lithic fragment content also are present. Lithic fragments generally are small and scattered but may locally be up to 0.3 m in diameter and up to 10 percent of the rock. Lithic fragments consist principally of flow-banded aphyric felsic lava and moderately crystal-rich quartz and sanidine-bearing ash-flow tuff fragments that resemble the tuff of Challis Creek. Pumice (lighter or darker than matrix depending on welding) commonly ranges in size from 1 to 6 cm but can be up to 15 cm in size. Vitrophyres of this unit locally are up to 22 m in thickness. Tuff forms distinct buff to pale green treeless or sparsely tree covered outcrops where altered to zeolites north and west of Twin Peaks. Thickness: 610 + m (base not exposed)

Tcr Tuff of Challis Creek, undivided--Reddish- to gray-brown, partially to densely welded rhyolite ash-flow tuff containing 13-45 percent phenocrysts (up to 4 mm in size): af 38-70, q 27-60, pf 0-3, b trace, px 0-3. Map unit used to designate outcrops outside the caldera because correlation with units exposed within the caldera is uncertain. Outflow tuff of Challis Creek, where it caps the high mountain peaks north and west of the Twin Peaks caldera consists of a single cooling unit with a minimum thickness of 200 m. Locally, as exposed on uppermost Tenmile Creek, outflow tuff of Challis Creek grades upward from crystal-rich, moderately welded tuff to very fine-grained crystal-poor airfall tuff

Tqb QUARTZ-BIOTITE TUFF--For description see Yellowjacket area

Trb RHYOLITE OF RED BUTTE--For description see Yellowjacket area. In Red Butte area the rock is lavender to pinkish-gray or buff, pinkish-tan to reddish-brown weathering, flow-laminated and porphyritic. Phenocrysts (2-5 mm in size) 5-15 percent: pf 65-76, b 15-30, hb 0-11. Abundant accessory apatite and zircon. Allanite uncommon. On the ridge between the mouth of Pats Creek and Eddy Creek, just north of Challis Creek, this unit contains a basal flow-banded vitrophyre 10 m thick that grades upward into flow-banded, light reddish-brown, medium tan-brown weathering lava(?) that displays crude columnar jointing and contains abundant flattened gas cavities (up to 8 cm long). Locally, this unit is flow brecciated with blocks up to 0.3 m. Flow foliation locally steep. Biotite from a sample collected on the east side of Red Butte has a K-Ar age of 46.9 $\pm$ 1.6 m.y. (R. F. Marvin, written commun., 1981)

Tp TUFF OF PENNAL GULCH--See descriptions for Challis area. In Darling Creek area, the unit consists of gray-brown to buff to pale green or red bedded tuffs, tuffaceous sediments, nonwelded ash-flow tuffs, and pumice flows. Typical pumice-rich ash-flow tuff or pumice flows contain phenocrysts (2 mm) 9-14: af 0-15, q 0-7, pf 62-83, b 12-26, hb trace. The ash-flow tuffs range in thickness from 1 to 52 m and are pumice rich. Noncollapsed pumice fragments in these tuff beds generally are 1-2 cm in maximum size and comprise 30 to 70 percent of the rock, so that many of these units are pumice flows. Lithic fragments in these tuffs typically are pebble-sized clasts of aphyric felsic lava and intermediate porphyritic lava containing feldspar and biotite phenocrysts. Buff to green and lavender, thin-bedded, fine- to medium-grained fluvial tuffaceous sandstone, siltstone, reworked pumice beds, and coarse conglomerate beds that contain debris-flow lenses and siltstone occur interbedded with the pumice-flow tuffs throughout this map unit. These beds range from 1-35 m thick. The map unit is at least 355 m thick and is unconformably overlain by the tuff of Challis Creek (unit Tcr)

Tem TUFF OF EIGHTMILE CREEK--See description for Challis area. On lower Mill Creek this tuff occurs as an erosional remnant overlying thin-bedded tuffaceous sandstone, siltstone, and reworked pumice beds that rest on the underlying aphanitic intermediate lavas (unit Tl). The tuff is light greenish-gray to brownish-gray, nonwelded, only slightly devitrified, and contains pale green to white pumice lapilli. Phenocrysts approximately 26 percent: af 15, q 22, pf 33 (strong oscillatory zoning), b 23, hb (green) 7. On the southwest side of Corkscrew Mountain erosional remnants of the tuff of Eightmile Creek are light gray to greenish-gray, nonwelded and pumiceous, with medium brownish-gray pumice lapilli that are darker than the matrix. Crystals, up to 2 mm in size, commonly are broken. Phenocrysts 42 percent: af 15, q 8, pf (strong oscillatory zoning) 64, b 12, hb 1. At Red Butte this tuff underlies the rhyolite of Red Butte (unit Trb) and is approximately 60 m thick. The tuff is nonwelded to partly welded, whitish-gray, and pumice-rich. Phenocrysts (up to 2.5 mm in size) 27-33 percent: af 11-12, q

17-22, pf (strong oscillatory zoning) 52-55, b 13-15, hb 0-2. From upper Spider Creek to upper Parker Creek the unit is greenish-gray, densely welded, pumiceous, with whitish-green pumice lapilli that generally are lighter than the matrix. The tuff is altered to calcite and chlorite; sericite, clay minerals and epidote locally are present. Phenocrysts 25-35 percent: af 12-17, q 9-27, pf 43-66, b 7-18, hb 2-4

Tip INTERMEDIATE INTRUSIVE ROCKS OF SPIDER CREEK-PARKER CREEK--Medium to dark gray, brownish-gray, gray to brown weathering, porphyritic intrusive rock containing abundant phenocrysts of plagioclase up to 7 mm in size and less abundant hornblende, pyroxene, and minor biotite in a pilotaxitic microcrystalline to devitrified, blotchy matrix. Where fine-grained, this rock is flow foliated and has a steep foliation of variable strike and locally is flow folded with steep axial planes. This rock intrudes the tuffs of Camas Creek-Black Mountain (unit Tc) at the head of Parker Creek. Contact relations with younger units on upper Spider Creek are unclear. The unit is intruded by rhyolite (unit Tir)

Tc TUFFS OF CAMAS CREEK-BLACK MOUNTAIN--For description see Yellowjacket area.

Tl INTERMEDIATE AND MAFIC LAVAS--For description see Corral Creek area

Tli INTERMEDIATE AND MAFIC DIKES AND SMALL PLUGS--Includes dark-gray to bluish-black, dark brown weathering, aphanitic, porphyritic intermediate intrusive rocks containing 3-5 percent euhedral plagioclase phenocrysts up to 6 mm in size and 1-2 percent euhedral altered pyroxene phenocrysts. Exposed at mouth of Eddy Creek on Challis Creek

Te TUFF OF ELLIS CREEK--For descriptions see Corral Creek and Yellowjacket areas. Along lower Eddy Creek this unit consists of two cooling units, each approximately 60 m thick, separated by 1-2 m of thin-bedded tuff and reworked, cross-bedded, fluvial tuffaceous sandstone containing abundant biotite. The ash-flow tuff in both cooling units is gray-green, moderately welded, with pale green pumice lapilli up to 3 cm. Phenocrysts 28-34 percent: q 3-6, pf 66-67, b 22-24, hb 5-6

Tsb SEDIMENTARY BRECCIA--A heterogeneous unit consisting primarily of poorly sorted, poorly bedded, coarse sedimentary breccia that contains angular to rounded pebble- to boulder-sized clasts of aphyric and porphyritic intermediate lava and siltstone to claystone fragments in a coarse sandy to clay-rich matrix. Also contains discontinuous beds of tan-gray to light brown, light brown weathering, coarse conglomerate and thin interbeds of coarse-grained tuffaceous sandstone containing abundant grains of feldspar, altered ferromagnesian minerals, and minor quartz. Locally, mudflow breccias containing intermediate lava clasts in a biotite-bearing epiclastic matrix are present. Log-sized and smaller fragments of petrified wood locally present. This unit underlies aphyric intermediate lavas (unit Tl) exposed along lower Challis Creek. This unit may be correlative with unit Tmz exposed in the Corral Creek area. Thickness 0-130 m

Trm RHYOLITE OF MILL CREEK SUMMIT--See description for Challis area

Tt VOLCANICLASTIC AND SEDIMENTARY ROCKS--See description for Challis

area

Td K-RICH ANDESITE, DACITE, AND RHYODACITE LAVAS AND BRECCIAS--See description for Challis area. Rhyodacite lavas and agglomerate exposed southeast of Challis Creek near Corkscrew Mountain and north of Challis Creek between Pats Creek and Eddy Creek. Dark brown weathering, brown to gray, porphyritic, locally vitrophyric, massive rhyodacite lava and coarse agglomeratic breccias containing 0.2 to 3 m blocks of monolithologic rhyodacite porphyry in a matrix of glassy to devitrified rhyodacite. Phenocrysts 28-44 percent: pf (up to 5 mm) 60-75, b 1-14, px (both opx and cpx) 7-35, hb 0-13. Contacts between the massive and agglomeratic phases of this unit are irregular and commonly steep. Cavities filled with chalcedonic silica locally abundant. Biotite from a sample collected from the southwest side of Corkscrew Mountain has a K-Ar age of 50.4 $\pm$ 1.8 m.y. (R. F. Marvin, written commun., 1982)

Tid K-RICH ANDESITE, DACITE AND RHYODACITE INTRUSIVE ROCKS--Intrusive equivalent of unit Td, above

CHALLIS-CUSTER GRABEN-EAST FORK-JERRY PEAK AREA

RHYODACITE DOMES AND PLUGS AT BRADBURY FLAT--Black, columnar, glassy and gray, grayish-brown or red-purple devitrified rhyodacite containing as much as 30 percent phenocrysts up to 4 mm in size of plagioclase, orthopyroxene, clinopyroxene, biotite, apatite, and opaque oxides

Tdbi Cross-cutting plugs of rhyodacite in bluff exposures along the Salmon River west of Bradbury Flat, and in hills north and east of Bradbury Flat. Normal magnetic polarity. A northeast-dipping slab of similar rock at the southwest margin of Bradbury Flat has reversed magnetic polarity

Tdb Irregular domelike masses of rhyodacite in hills northwest of Bradbury Flat. K-Ar age for columnar rhyodacite exposed at northwest margin of Bradbury Flat is 39.7 $\pm$ 1.2 m.y. (Armstrong, 1975; recalculated)

Tr RHYOLITE INTRUSIONS--Gray, white, and pink dikes, plugs, and domes that contain phenocrysts of alkali feldspar and quartz, and minor amounts of biotite and plagioclase. Granophyric matrices common in dikes cutting the Idaho batholith rocks north of Stanley. Some dikes in that area also are composite, with marginal zones more mafic than rhyolite

Tgb GABBRO AND DIABASE DIKES--Gray, brownish-gray and greenish-gray holocrystalline, medium- to fine-grained dike rocks made up chiefly of plagioclase and clinopyroxene; pyroxene commonly partly or wholly altered to chlorite. Reversed magnetic polarity

Trl RHYOLITE LAVA--Gray and grayish-red, chiefly crystal-poor rhyolite with phenocrysts of alkali feldspar and quartz. On ridgecrest east of upper Basin Creek it is unaffected by faults that offset underlying units Tps and Td

Trr TUFF OF RED RIDGE--Red and reddish-brown weathering, grayish-purple

or reddish-purple, blocky to platy, crystal-poor ash-flow tuff with phenocrysts less than 1 mm in size of alkali feldspar (chiefly anorthoclase). Vitrophyre at east end of Red Ridge contains a few crystals of green pyroxene and amphibole. Found only along east flank of White Cloud Peaks and in the Spar Canyon-Sand Hollow area. Thickness 0-140 + m

Tcr TUFF OF CHALLIS CREEK--Red, reddish-purple, yellowish-brown, or gray, densely welded, devitrified ash-flow tuff containing 5-20 percent crystals as large as 3 mm of chatoyant alkali feldspar and smoky quartz in a matrix of fine shards. Locally contains abundant pumice. Also contains sparse zircon, allanite, biotite, and a few crystals of plagioclase. Near Challis, a single cooling unit rests on an irregular erosion surface carved on underlying tuff of Pennal Gulch (unit Tp). Two, or possibly three, densely welded cooling units present in Spar Canyon-Sand Hollow area. One of these units may younger than the tuff of Red Ridge (unit Trr). Normal magnetic polarity. K-Ar age is 45.0 $\pm$ 1.3 m.y. (Armstrong, 1975; McIntyre and others, in press)

Th TUFF OF HERD LAKE--Red-purple or red-brown, devitrified, flow-laminated, locally lithophysal, crystal-poor rhyolitic rock that contains 1 mm phenocrysts of plagioclase, biotite, and clinopyroxene. Two cooling units, separated by a breccia zone, present north of Herd Lake. Exposure on ridge about 3 km south of Jerry Peak reveals a marginal vitrophyre rich in shards. This exposure and the sheetlike aspect of the deposit indicate that the unit was emplaced as a very hot ash flow that coalesced and moved like a lava prior to final chilling. Biotite from the vitrophyre has a K-Ar age of 48.1 $\pm$ 1.7 m.y. (R. F. Marvin, written commun., 1982). Reversed magnetic polarity. Rests directly on unit Tl. Thickness 0-150 m

Tp TUFF OF PENNAL GULCH--Gray, pale pink, or pale green, silicic, crystal-poor pyroclastic flows and tephra, both subaqueous and subaerial. Chiefly massive to crudely bedded pumice-rich coarse tuff and pumice-lapilli tuff, but also includes beds of sorted, thin-bedded volcanic sandstone and mudstone. Commonly contains crystals as much as 2 mm in size of plagioclase, sanidine, and biotite, with subordinate or very minor quartz, amphibole, allanite, zircon, and apatite. Carbonized or silicified plant fragments sparsely represented in some pyroclastic flows. Locally present in exposures east and north of Round Valley and northwest of Ellis is a ledge-forming vitrophyre up to 15 m thick that consists of black, crystal-poor, perlitic, rhyodacitic glass containing crystals of plagioclase, sanidine, clinopyroxene, and zircon. Some samples contain abundant lithic inclusions. Reversed magnetic polarity. Tuff of Eightmile Creek (unit Tem) included within basal part of unit south of Table Mountain. Thickness 0-370 + m

Tpc TUFF OF PENNAL GULCH-CAMAS-BLACK MOUNTAIN, UNDIVIDED--Nonwelded tuff sequence that overlies the tuff of Eightmile Creek in the Custer graben, chiefly east of Jordan Creek. Locally includes the tuff of Ninemile Creek (McIntyre and others, in press), not mapped separately, and possible debris derived from rhyolite

domes in the upper Jordan Creek area (Foster, 1982). Thickness 600 + m

Tps EIGHTMILE-LIKE VOLCANICLASTIC ROCKS--Ash-flow and ash-fall tuff that overlies the tuff of Eightmile Creek west of Bonanza, and ash-flow tuff, thin-bedded volcanic sandstone, siltstone, and mudstone, with local zones of impure lignite exposed from Little Antelope Flat southwestward to Spar Canyon area. The coarser-grained rocks in this unit are characterized by crystals of plagioclase, sanidine, and quartz (quartz usually more abundant than sanidine), and biotite as the only mafic mineral present. On ridge west of Lightning Creek a thin flow of intermediate lava occurs within unit. West of the mouth of Spar Canyon local occurrences of non-welded ash-flow tuff related to the tuff of Challis Creek and densely welded tuff of Challis Creek are present, but have not been mapped separately. A subaqueous pyroclastic flow that is probable equivalent of the Tuff of Eightmile Creek crops out in Spar Canyon and in Sand Hollow

Tem TUFF OF EIGHTMILE CREEK--Gray, greenish-gray, pale brown, and grayish-pink, bluff-forming, pumice-rich, crystal-rich, densely welded, quartz latitic ash-flow tuff characterized by phenocrysts up to 4 mm in size of plagioclase, quartz, sanidine, biotite, amphibole, clinopyroxene, orthopyroxene, zircon, apatite, and allanite. Biotite from vitrophyre exposed west of the mouth of Tenmile Creek has a K-Ar age of 46.9 $\pm$ 1.6 m.y. Biotite from exposures of this unit near the West Fork of Morgan Creek has a K-Ar age of 48.4 $\pm$ 1.7 m.y. (R. F. Marvin, written commun., 1982), which is in agreement with the stratigraphic position of this tuff, below the tuff of Table Mountain. Reversed magnetic polarity. On the west side of Eightmile Creek about 4 km above its mouth are exposed four cooling units with a total thickness of more than 215 m

Tgi INTRUSIVE ROCKS EAST OF BONANZA--Porphyritic to equigranular rocks that range in composition from granodiorite to quartz monzonite. An analysis of the quartz monzonite resembles an analysis of the tuff of Eightmile Creek. Rocks exposed are in roof zone of a pluton intruding andesitic lavas (unit Td, see below); blocks of lava are common as inclusions and, in some exposures, the intrusion more closely resembles a swarm of closely-spaced dikes cutting the lava, as first described by Anderson (1949). Aeromagnetic data and the distribution of thin dikes indicates a buried extension of the intrusion for at least 3 km west of the principal outcrop area. Intrusion and country rock both are propylitized; minor hydrothermal biotite locally developed in the intrusion

Trm RHYOLITE OF MILL CREEK SUMMIT--Black, gray, and greenish-gray vitrophyric and gray to pink banded, devitrified rhyolite lavas containing 1-5 percent phenocrysts, as large as 2 mm, of plagioclase and biotite. Also contains hornblende, allanite, zircon, apatite, opaque oxides. Some flows also contain alkali feldspar and quartz. Four flow units with aggregate thickness of about 235 m are present in butte east of Mill Creek Summit. K-Ar age on biotite is 48.5 $\pm$ 1.2 m.y. (Marvin and Dobson, 1979). All flows have reversed magnetic polarity

Til K-RICH ANDESITE, LATITE, AND BASALT INTRUSIONS--Dikes, sills, and plugs that commonly contain brown or reddish-brown weathering, dark gray, greenish-gray, or black, crystal-poor rocks with variable proportions of the phenocryst minerals clinopyroxene, orthopyroxene, olivine, or plagioclase. Exposed as dikes sills, and plugs along the Salmon River near Centennial Flat, in the region between Summit Rock and Bald Mountain, and as altered, irregular intrusive masses north of Little Antelope Flat. Near Centennial Flat the intrusive rocks, penecontemporaneous with the enclosing sediments, were altered by reaction with the wet, semiconsolidated sediments they intruded to produce chlorite-, clay-, and carbonate-rich, light greenish-gray rocks. A whole-rock K-Ar age for the unaltered portion of one of the intrusive masses is 48.2 $\pm$ 1.4 m.y. (Armstrong, 1975, recalculated). Normal and reversed magnetic polarities

Tsy SYENITE INTRUSION--Irregular, sill-like mass of medium- to coarse-grained, quartz-normative syenite that crops out east of Tub Spring, in upper Spar Canyon. Rock contains potash feldspar, clinopyroxene, biotite, apatite, and magnetite. Clinopyroxene commonly altered to carbonate; both clinopyroxene and biotite commonly altered to chlorite. Carbonate also occurs as veins. Some, if not most, of the carbonate may be primary. Marginal facies of intrusion are dark, basalt-like rocks with altered olivine phenocrysts; thin sections show that these rocks have holocrystalline matrices made up chiefly of alkali feldspar and biotite. Emplacement of intrusion probably penecontemporaneous with eruption of latite lava (unit Tl) that occurs nearby. First described by Ross (1937)

Tl K-RICH ANDESITE, LATITE, AND BASALT LAVAS--Predominantly aphyric reddish-brown weathering, gray and greenish-gray, blocky to platy lavas, locally containing interbedded oxidized breccia. Olivine and pyroxene occur as phenocrysts in some samples. Plagioclase not commonly found as phenocrysts. Microphenocrysts include olivine, clinopyroxene, orthopyroxene, and sieved plagioclase. Quartz xenocrysts commonly present. Matrices commonly are trachytic, plagioclase-rich, and may contain reddish-brown, strongly pleochroic mica and apatite. Rock compositions range from K-rich andesite to K-rich basalt, with probable predominance of andesite in the region surrounding Challis. Farther south, in the area between East Fork Salmon River and Jerry Peak, compositions range from K-rich andesite to latite. Latite is more common toward the top of the section. Magnetic polarity indeterminate in area near Challis; the lavas toward south have reversed magnetic polarity. Near Challis, the lavas overlie the tuff of Ellis Creek (unit Te, 48.4 $\pm$ 1.6 m.y.) and are overlain by the tuff of Eightmile Creek (unit Tem, 48.4 $\pm$ 1.7 m.y. or 46.9 $\pm$ 1.6 m.y.) and the tuff of Table Mountain (unit Ttm, 47.8 $\pm$ 1.7 m.y.). Toward the south, the lavas overlie tuffs dated at 49.0 $\pm$ 2.9 m.y. (unit Tt) and are overlain by the tuff of Herd Lake (unit Th, 48.1 $\pm$ 1.7 m.y.; R. F. Marvin, written commun., 1980-82)

Te TUFF OF ELLIS CREEK--In area north of Challis is bluff-forming

sequence of greenish-gray to grayish-brown weathering, massive, pumich-rich, rhyodacitic pyroclastic flows with interlayered, crudely bedded, partly sorted, pumice-rich tuff that locally contains carbonized plant debris. Contains plagioclase, quartz (strongly resorbed), amphibole, biotite, zircon, apatite, sphene, and locally, allanite. Pumice fragments commonly replaced by zeolites. Reversed magnetic polarity. Along the Salmon River south of Centennial Flat this unit is represented by a single subaqueous pyroclastic flow, not mapped separately from unit Tt. All these rocks are the outflow equivalent of the very thick section of the tuff of Ellis Creek exposed within the Van Horn Peak cauldron complex. Thickness 0-300 + m

Tib MAFIC INTRUSIVE ROCKS--Olivine-bearing intrusive rocks that have been mapped separately only along Road Creek

Tb MAFIC LAVAS—Dark, sparsely porphyritic rocks that contain variable proportions of olivine, pyroxene, or plagioclase phenocrysts. Those exposed along the Salmon River near Centennial Flat are extrusive counterparts of the mafic intrusive rocks (unit Til) that crop out nearby. Also included in this unit are flows of K-rich andesite that crop out below and are interbedded with flows of intermediate lava (unit Td) in the hills southwest of Challis, and younger, olivine-bearing lavas that crop out south of Road Creek

Tt VOLCANICLASTIC AND SEDIMENTARY ROCKS--Includes subaqueously deposited pyroclastic flows, mudflow breccia and conglomerate, volcanic sandstone, and mudstone exposed along the Salmon River west and south of Challis, near Centennial Flat and along East Fork Salmon River, Road Creek, and Herd Creek. Also includes subaerial ash-fall and ash-flow deposits intercalated with and overlying intermediate lavas in and north of the Squaw Creek drainage. The volcanic components of all these rocks contain plagioclase, biotite, and amphibole. Quartz is minor and variable in amount. Some samples contain a few grains of pyroxene. Coeval with parts of intermediate lava sequence (unit Td); ranges in age from about 50 m.y. to about 48 m.y. A subaqueous pyroclastic flow that is probable equivalent of the tuff of Ellis Creek (unit Te, 48.4 m.y.) occurs within this unit in the area south of Centennial Flat. Arbitrarily included in this unit are outcrops of a pyroclastic flow exposed south of the mouth of Squaw Creek that contains significant alkali feldspar in addition to plagioclase and quartz, and biotite as the sole mafic mineral

Tdi K-RICH ANDESITE, DACITE, AND RHYODACITE DIKES, PLUGS, AND DOMES--Intrusive equivalent of unit Td (below). The most prominent occurrence is near Sheep Mountain, where a swarm of dikes probably marks the site of a concealed felsic pluton and a source vent for the surrounding pyroclastic rocks and lavas assigned to unit Td. Biotite from an unaltered vitrophyric dike about 3 km south of the mouth of Pine Creek, north of the principal dike swarm, has a K-Ar age of 50.0 $\pm$ 1.8 m.y. (R. F. Marvin, written commun., 1982). The large body northwest of Thompson Creek has well-exposed intrusive contacts near its western end, but toward the east resembles a dome or thick flow mass

Td K-RICH ANDESITE, DACITE, AND RHYODACITE LAVAS AND BRECCIAS--Contains a heterogeneous group of rocks erupted from numerous vents scattered over the area. Individual, local units generally can be consistently distinguished during mapping at large scales (see, for example, Hobbs and others, 1975). K-rich andesites, subordinate members of this unit, are characterized by phenocrysts of pyroxene and/or olivine. The dacites and rhyodacites contain as phenocrysts all combinations of the minerals plagioclase, biotite, amphibole, clinopyroxene and, uncommonly, olivine or quartz. Normal and reversed magnetic polarity. Ranges in age from about 49 m.y. to about 51 m.y.

Tgc TUFF OF GERMANIA CREEK--Densely welded, vitrophyric ash-flow tuff and associated volcanic sediments exposed in ridges northwest and southeast of Germania Creek. Includes "ignimbrite of Germania Creek" of Motzer (1978). Ash-flow tuff contains up to 40 percent phenocrysts as much as 1 mm in size of plagioclase, amphibole, clinopyroxene, orthopyroxene, and biotite. Mafic phenocrysts make up more than 40 percent of total phenocrysts. The ash-flow tuff resembles those in unit Tbc (below) except for the preponderance of amphibole. More thorough sampling may show that this characteristic is not consistent. Reversed magnetic polarity

Tbc LAVAS AND ASH-FLOW TUFFS OF BURNT CREEK--Dacitic lava and ash-flow tuff, locally vitrophyric, but commonly rusty brown devitrified, that contain phenocrysts of plagioclase, orthopyroxene, clinopyroxene, amphibole, and biotite. More than 40 percent of the total phenocrysts in the ash-flow tuffs commonly are mafic minerals. One thin ash-flow tuff cooling unit having Burnt Creek mineralogy present within the tuff of Sage Creek (unit Tsc) in the Sage Creek drainage, showing that the two units are contemporaneous, despite the large contrast in composition. Probable normal magnetic polarity

Tsc TUFF OF SAGE CREEK--Ash-flow and ash-fall tuffs and associated sedimentary rocks characterized by phenocrysts of plagioclase and sanidine, together with minor biotite, amphibole, and rare pyroxene. Quartz never is present. Exposed chiefly near the southeast corner of the map area in the drainage of Sage Creek and on the ridge south of Sheep Mountain. Isolated outcrops of this rock type, too small to show on the map, occur opposite the mouth of Spar Canyon, east of lower Herd Creek, and along East Fork Salmon River northwest of the mouth of McDonald Creek. At all these localities these rocks crop out beneath volcaniclastic rocks of unit Tt. In the Sheep Mountain area, the tuff of Sage Creek passes northward into breccia and lava assigned to unit Td; the contact between the two units is arbitrary. In some samples of breccia containing blocks with phenocrysts of plagioclase, quartz, biotite, and amphibole, the matrix is dominated by crystals of plagioclase and sanidine, demonstrating intermingling of material from two sources and the contemporaneity in this area of rocks assigned to unit Td with the tuff of Sage Creek. Normal magnetic polarity

Tar ARKOSIC SANDSTONE AND CONGLOMERATE--Gray arkosic sandstone and local beds of conglomerate that contain pebbles and cobbles of gray quartzite. Occurs as discontinuous lenses at base of volcanic

rock sequence east of Basin Creek. Many occurrences too small to be shown at this map scale

Tcg CONGLOMERATE--Chiefly cobble and boulder (as large as 2 m) conglomerate with black, pink, gray, or white quartzite clasts predominant near base and volcanic clasts predominant near top. Matrix of conglomerate contains volcanic component, even near base of the unit. Occurs only near southeast corner of map. Also included in this unit is fanglomerate exposed southeast of Lone Pine Peak. Clasts in the fanglomerate were derived from nearby exposures of Paleozoic rocks, which formed topographically high ridges prior to volcanism

Tj JASPEROID--Black silica that locally occurs as replacements of White Knob Limestone (unit Tw) near southeast corner of quadrangle. Evidence obtained elsewhere in the region indicates that this material was formed during or after Eocene volcanism (B. A. Skipp, oral commun., 1983). Fragments of what appears to be this material have been found within the conglomerate (unit Tcg), which suggests that some of the jasperoid in this area may be both older than and penecontemporaneous with the volcanic rocks

AREA WEST AND NORTH OF STANLEY AND WHITE CLOUD PEAKS AREA

Tdl DIABASE AND LAMPHROPHYRE DIKES--Diabase dikes are the more common. Rock is dark, fine- to medium-grained, and consists chiefly of lathlike crystals of plagioclase enclosed in a matrix of pyroxene crystals. Diabase dikes are the youngest dikes and crosscut all others. They are the most continuous and commonly trend northwest. Also included are andesite and diabase dikes that occur in the White Cloud Stock

Tr RHYOLITE AND QUARTZ LATITE-RHYODACITE DIKES--Rocks are light colored, usually porphyritic, and contain rounded and embayed quartz phenocrysts. Potassium-feldspar phenocrysts are more plentiful than plagioclase. Matrices are pinkish-gray, aphanitic. The rocks are altered, with strong development of sericite from feldspars and iron oxides from pyrite. The dikes range from a few meters to more than 30 m wide and up to several hundred meters long. Rhyolite dikes are more numerous near bodies of Tertiary granite (unit Tg), with which they probably are related and, like that rock, are more radioactive than other plutonic rocks or dikes

Tdd ANDESITE, DACITE, AND LATITE DIKES--Rocks are dark green to gray, commonly porphyritic, and contain phenocrysts of zoned plagioclase as much as 2 cm in length. Phenocrysts of hornblende, somewhat altered to chlorite, and euhedral biotite also commonly present. Quartz phenocrysts are sparse. Phenocrysts are set in groundmass of andesine-oligoclase, minor potassium feldspar, hornblende, and magnetite. Sphene and allanite are common accessories. Dikes range from a few meters to more than 30 m in width and as much as several hundred meters in length. They are more numerous near exposures of Tertiary rock of dioritic composition (unit Tdc), with which

they probably are related

Tud TERTIARY DIKES, UNDIVIDED

Twt WELDED TUFF OF OBSIDIAN--Light-gray welded lithic tuff. Weathers reddish purple, brownish gray and brown. Rock is light gray ash-flow tuff with phenocrysts of sanidine and quartz in a fine, light-gray matrix

Tva ANDESITE--Dark gray to black, thinly layered, flow-banded aphanitic lava with pilotaxitic texture. Contains olivine phenocrysts, rimmed by iddingsite, set in groundmass of andesine microlites with interstitial pyroxene and magnetite. Overlies rhyolitic flows where exposed on ridge top between Knapp and Beaver Creeks

Tvr RHYOLITE FLOWS--Yellowish-gray to pale-red to purple, aphanitic lava that commonly shows flow-banding, with flattened quartz-lined vugs along flow laminae. Contains phenocrysts of platy sanidine and rounded, embayed quartz. Rock erodes to conspicous massive knobs on ridge line and to reddish, slabby scree. Preserved in a graben between Knapp and Beaver Creeks

Tcv CHALLIS VOLCANICS, UNDIVIDED--Includes three small ridge caps of rhyolite and discordant rhyolitic tuff near the headwaters of North Fork Boise River

Tir RHYOLITE STOCK--Red weathering, yellowish-gray aphanitic rhyolite that contains sparse phenocrysts of quartz as much as 1 mm in size and pyrite or pyrite casts. Forms massive outcrops. The rhyolite is well exposed on the ridge southeast of Cape Horn Creek, where the stock contains roof pendants of granodiorite (unit Kgd) and metasedimentary rocks (unit rp)

Tg GRANITE--Pink to gray, medium- to coarse-grained granite characterized by pink perthitic feldspar that commonly forms conspicuous phenocrysts. The relative proportion of salic minerals (calculated from the CIPW Norm) is: q 39, af 34, pf 27. The rock contains miarolitic cavities locally lined with smoky quartz crystals, and is more radioactive than granodiorite of the Idaho batholith. Biotite from five samples of the rock, dated by the K-Ar method, gives an average age of 43.9 m.y.; hornblende from one sample was dated at 45.2 m.y. (R. J. Fleck, written commun., 1983)

Tdc DIORITE COMPLEX--Complex suite of rocks ranging from non-porphyritic diorite to porphyritic granodiorite, which is the more prevalent. The rock is characterized by abundance of hornblende, euhedral biotite, and magnetite, which together make up as much as 35 percent of the rock. Phenocrysts in the porphyritic rocks are chiefly zoned plagioclase and pale red perthitic microcline, which may be as much as 1 cm in length and which are set in a fine-grained pale red matrix. Quartz phenocrysts are rare. The relative proportion of salic minerals (calculated from CIPW Norm) is: q 19, af (microcline) 21, pf 60. The rocks weather to a chocolate brown soil, darker than the soils formed from other granitic rocks of the area. The diorite and dark greenish-gray aphanitic andesitic phases are always peripheral to the porphyritic rock. Biotite, hornblende, and whole-rock K-Ar ages for three samples collected in the Jackson Peak and Monumental Peak area, when averaged, indicate an age of 47 $\pm$ 1 m.y. (R. J. Fleck, written

commun., 1983)

GRANITIC ROCKS OF IDAHO BATHOLITH (LATE CRETACEOUS)

Klg LEUCOCRATIC GRANITE--Light gray to white, fine- to medium-grained, with distinctive anhedral texture. Principal minerals are quartz (33 percent), potassium feldspar (29 percent) and plagioclase (An_{26-30} 33 percent). Biotite may constitute as much as 2 percent of the rock, garnets are common, and the feldspars are altered to sericite and small irregular flakes of muscovite. This rock, described as leucocratic quartz monzonite by Reid (1963) and Kiilsgaard and others (1970), as aplite by Cater and others (1973), and as aplitic quartz monzonite by Anderson (1947), occurs as dikes and irregular stocks that are resistant to erosion and tend to form high points on ridges. Rubbly, weathered scree from these high points may be extensive on lower hillsides and may give the impression of being eroded from larger masses than actually exist. The unit intrudes biotite granodiorite (unit Kgd) and is itself intruded by Tertiary granite (unit Tg) and stocks of the Tertiary diorite complex (unit Tdc). The Tertiary stocks and dikes (unit Tdc) collectively underlie a much larger part of the Idaho batholith area than has been previously recognized. Rocks of this unit that contain subequal amounts of alkali feldspar, plagioclase, and quartz, and less than 5 percent biotite, occur as small dikes and plugs intrusive into biotite granodiorite and granite in exposures along the east side of the Stanley Basin

Kg MUSCOVITE-BIOTITE GRANODIORITE--Gray to light gray, medium- to coarse-grained, equigranular to porphyritic; contains books of muscovite that are visible in the hand specimen and comprise up to 5 percent of the rock. Except for the visible muscovite, the rock is similar to the biotite granodiorite (unit Kgd), with which it is transitional through a zone as much as 2 km or more in width. It is exposed in the western part of the area and comprises what is considered to be the core of the Atlanta lobe of the Idaho batholith. The unit includes the quartz monzonite of Warm Lake of Schmidt (1964)

Kgdp PORPHYRITIC BIOTITE GRANITE AND GRANODIORITE--A coarsely porphyritic granitoid rock with metacrysts of pink potassium feldspar (microcline) from 3 to 10 cm in length in a medium- to coarse-grained matrix that contains roughly equal amounts of microcline, plagioclase, and quartz. The rock generally contains 5 to 15 percent biotite. Forms core unit of White Cloud stock and large pluton east of the Stanley Basin

Kgdph Hornblende-bearing phase of the porphyritic, metasomatic granodiorite. Mapped separately at some localities

Kgd BIOTITE GRANODIORITE AND GRANITE--Gray to light gray, medium- to coarse-grained and equigranular to porphyritic. Plagioclase (An_{22-36}) is chief component of the rock, with lesser quantities of quartz and potassium feldspar; biotite, up to 5 percent (up to 25 percent east of the Stanley Basin), is the

principal mafic mineral; hornblende is absent. Biotite granodiorite is the most common granitic rock of the Idaho batholith and is exposed over vast areas. In the western part of the quadrangle the rock was identified by Schmidt (1964) as the granodiorite of Gold Fork. The biotite granodiorite is intruded into the older tonalite (unit Kt) and in the 60-90 m-wide contact zone it exhibits intensive primary foliation as well as xenoliths of the tonalite.

Kgds Sphene-enriched variety of biotite granodiorite--Mapped by Schmidt (1964) as the leucocratic quartz diorite of Little Valley

Kgdk Equigranular biotite granite and granodiorite cut by abundant veinlets of alkali feldspar or secondary muscovite. Occurs chiefly along the east margin of the Stanley Basin, and in small areas in the White Cloud Stock

Kgdh HORNBLENDE-BIOTITE GRANODIORITE--gray, medium- to coarse-grained, equigranular to porphyritic, and commonly foliated; biotite and hornblende are aligned in the plane of foliation. The rock commonly is associated with xenoliths and pendants on high ridges in western part of the area. It is intermixed with the tonalite (unit Kt); the two rock types form the border zone of the Atlanta lobe of the Idaho batholith

Kt TONALITE--Gray to dark gray, medium- to coarse-grained, equigranular to porphyritic. Plagioclase is the dominant mineral of the rock, which may contain biotite or hornblende and which ranges from massive to highly foliated. It is exposed in the western part of the area and includes the quartz dioritic gneiss of Donnelly (Schmidt, 1964). Southwest of the mouth of Warm Springs Creek this unit is an equigranular, medium-grained, granitoid rock containing 30 to 35 percent amphibole laths, 40 to 50 percent plagioclase, and about 20 percent quartz. The amphibole is partly altered to brown, highly pleochroic biotite and to epidote

Kqm GRANITIC ROCKS OF THE IDAHO BATHOLITH, UNDIVIDED

rp ROOF PENDANTS AND XENOLITHS OF METAMORPHIC ROCK, UNDIVIDED--Includes schist, quartzite, and calc-silicate rocks. At some localities graphite is a common constituent of the rocks, which are of uncertain Precambrian-Paleozoic age. Includes the Thompson Peak Formation of Reid (1963)

rps Schist roof pendant

rpq Quartzite roof pendant

rpc Calc-silicate roof pendant

Kim Mixed rock units--mainly alaskite and Precambrian metamorphic xenoliths

Jg GABBRO (JURASSIC)--Dark grayish-green medium- to coarse-grained rock containing primary mineral assemblage of calcic plagioclase, clinopyroxene, and magnetite, whose texture is overprinted by alteration assemblage of chlorite, pale-green acicular amphibole, albite, and sphene, plus small amounts of apatite, prehnite(?), pumpellyite(?), carbonate and (or) secondary quartz. Occurs as numerous small irregular dikes, small plugs, and sill-like tabular masses scattered over the area east and northeast of Clayton. Most frequently found intruded along or near the thrust fault at base of Clayton Mine Quartzite (unit OCq). A fission-track age of 140.1 $\pm$ 17.4 m.y. was obtained from zircon in quartzite immediately adjacent to the contact with gabbro at the mouth of Bayhorse Creek (R. A. Zimmermann, written commun., 1983). This age for the zircon indicates the time of track annealing caused by heat from the gabbro intrusion. It also serves as a limiting age for the thrust fault beneath the Clayton Mine Quartzite, already in existence prior to intrusion of the gabbro

PALEOZOIC SEDIMENTARY ROCKS

PPpc POLE CREEK FORMATION (LOWER PERMIAN TO UPPER PENNSYLVANIAN)--Well-exposed sequence of fine-grained, dark-gray carbonaceous argillite, siltite, limy siltite, and silty limestone. Weathers dark brown, reddish brown, or dark gray. Much of the sequence is graded, has abundant crossbedding and convolute structures, and has a prominent banded appearance. A measured section on Pole Creek is about 2,000 m thick, but neither the top nor the bottom is exposed. Conodonts collected by C. M. Tschanz from low in the section at Pole Creek are reported to be Leonardian-Roadian (upper Lower Permian) by Bruce Wardlaw (written commun., 1979). On Pungo Mountain a sequence about 100 m thick of thin-bedded limestone and calcareous argillite that have been extensively metamorphosed to tremolite-actinolite is questionably assigned to this unit. Sequence forms black soil. Mapped to include clean, well-sorted quartzite on the east side of Pungo Mountain

PPw WOOD RIVER FORMATION, UPPER PART (LOWER PERMIAN TO UPPER PENNSYLVANIAN)--Includes units 5 and 6 of Hall and others (1974). Thick sequence of gray and light-brown, fine-grained, calcareous sandstone that weathers dark brown and dark reddish brown. Interbedded in the calcareous sandstone are fine-grained sandy limestone, fine- to medium-grained bioclastic limestone, and brown thick-bedded, fine-grained quartzite. Crossbedding and convolute structures are common. Unit is dated on the basis of abundant fusulinids

Pwl WOOD RIVER FORMATION, LOWER PART (UPPER TO MIDDLE PENNSYLVANIAN)--Includes units 1, 2, 3, and 4 of Hall and others (1974). The lower part of the Wood River Formation is present only from Railroad Ridge at the Little Livingston and Hermit mines south to the Livingston mine. Unit 1 is a siliceous chert and quartzite conglomerate present as thin fault slivers at the Little Livingston and Hermit mines. It is overlain by a succession about 150 m thick of fine-grained limy sandstone, silty limestone, and limy siltstone that comprises units 2, 3, and 4

Msr SALMON RIVER SEQUENCE (UPPER MISSISSIPPIAN)--Medium- to dark-gray, thin- to thick-bedded, well-laminated argillite, siltstone, calcareous siltstone, and fine-grained calcareous sandstone; some local grit and nearly pure medium gray limestone. Weathers tan, medium brown to dark brown and, locally, light gray, blue gray and pink. Sandstone is predominantly very fine to fine grained; some medium sand and grit layers; localized thin beds of chertlike very siliceous argillite. Rock composed of different proportions of quartz (predominant), clay minerals, carbonaceous material, sericite, mica, feldspar (usually only a few percent), lithic fragments (argillite, shale, chert, fine-grained quartzite), various accessory minerals, and carbonate. Faint to prominent lamination in most places, with cross lamination, current bedding, and sole structures in many fine-grained thin sandstone beds and laminae. Dark colors related to amount of carbonaceous

material, which ranges from nil to a few impure coaly seams. Base of sequence as exposed in quadrangle is a thrust fault; overthrust by Pole Creek Formation (unit PPpc) in areas to west. Thickness and sequence of units indeterminate in most places because of isoclinal folding and thrust faulting. About 1,400 m is present along Last Chance Creek, but neither the base nor the top is exposed. Named by Nilsen (1977)

Msuc SURRETT CANYON AND SOUTH CREEK FORMATIONS (UPPER MISSISSIPPIAN, UNDIVIDED)--Gray, fossiliferous, pure, cliff-forming limestone and grayish red purple, impure, slope-forming limestone. Top not exposed in quadrangle. Thickness about 400 m in area to east (Mapel and others, 1965)

Msp SCOTT PEAK FORMATION (UPPER MISSISSIPPIAN)--Medium dark-gray, chert-bearing bioclastic limestone; weathers medium dark to medium light gray; chert medium dark to medium gray, weathers brownish tan, forms discontinuous thin layers or nodules scattered along bedding. Medium to thick bedded. Forms ledgy outcrops; contains much crinoidal debris, many corals, and brachiopods. Thickness about 750 m. Occurs only in southeast corner of quadrangle

Mmc MIDDLE CANYON FORMATION (UPPER MISSISSIPPIAN)--Succession of cherty limestone and impure limestone exposed as smooth, float-covered slopes in southeast corner of quadrangle. Upper half is impure, medium dark to medium gray, cherty, microgranular limestone. Black chert abundant in layers and nodules. Weathers to medium or light gray small irregular blocks with a slight yellow or pink mottling. Lower half is very fine-grained sandy limestone, silicified in part. Float in lower half is more strongly colored and more angular than that of the upper part. Thickness about 200 m

Mw WHITE KNOB LIMESTONE (UPPER MISSISSIPPIAN)--Chiefly gray, ledge-forming, thick- to thin-bedded fossiliferous limestone, locally sandy, variably cherty, but in middle part also includes gray to yellowish-brown chert and quartzite granule to cobble conglomerate, sandstone, siltstone, and mudstone. Thickness about 1,150 m

Mmg McGOWAN CREEK FORMATION (LOWER MISSISSIPPIAN)--Poorly exposed unit of mudstone (or argillite), subordinate siltstone, partly calcareous claystone, and sandstone, and minor pebble conglomerate. Extensively sheared; formation sustains steep slopes covered by slabby or platy, locally finely blocky or pencil-like fragments; weathers medium light gray, yellowish gray, or light olive gray. Measured thickness 1,100 m in Lost River Range, east of quadrangle (Mapel and others, 1965; Sandberg, 1975)

Mcb COPPER BASIN FORMATION, LOWER PART (LOWER MISSISSIPPIAN)--Light gray to black, medium- to thick-bedded conglomerate, sandstone, siltstone, and mudstone. Conglomerate contains clasts up to 20 cm in diameter of chert, quartzite, quartz, and argillite in a sandstone matrix. Unit is a series of proximal to distal turbidites (Nilsen, 1977). Crops out chiefly near southeast corner of quadrangle. An isolated outcrop at the confluence of Herd Creek and Lake Creek is questionably assigned to this formation. Thickness in excess of 300 m

Dg GRAND VIEW DOLOMITE (UPPER DEVONIAN)--Includes microgranular, medium dark- to medium light-gray dolomite that weathers medium light gray and lighter, and much recrystallized medium light to very light gray, fine- to coarse-grained dolomite that weathers grayish orange or pale yellowish-brown. Scattered sandy intervals; a few shaly beds. Beds thick, commonly laminated. Formation moderately to highly resistant; forms blocky ledges and, locally, cliffs. Southwest of Grand View Canyon includes a small patch of calcareous shale and dolomite assigned to the Three Forks Formation (Hays and others, 1978). Thickness about 365 m

Dj JEFFERSON DOLOMITE (DEVONIAN)--Resistant, well-exposed unit of medium dark- to medium gray and subordinate dark-gray dolomite. Weathers to similar dark colors, partly mottled, commonly with a brown cast; a few beds weather medium light gray. Grain size ranges from microgranular to fine; little silt or sand; commonly fetid. Beds thick to very thick (0.3-1.5 m); some thin, regular lamination. Highly resistant ledge and cliff former. Thickness about 300 m

Dgj GRAND VIEW AND JEFFERSON DOLOMITES, UNDIVIDED

Dab BEARTOOTH BUTTE FORMATION, UNIT A, AND UNIT B OF HAYS AND OTHERS, (1978), UNDIVIDED (DEVONIAN)--Gray and brownish-gray medium- to thick-bedded, very fine-grained quartzite, sandstone, and siltstone; dark to light gray medium- to thick-bedded, moderately silty dolomite; dark gray to olive gray, medium- to very-thick bedded dolomite and minor dolomitic sandstone

Sl LAKETOWN DOLOMITE (SILURIAN)--Strikingly light colored dolomite that commonly forms ridges and peaks. Dolomite is predominantly medium light to light gray, mostly very fine to fine grained, and almost pure. Few scattered sandy intervals. Beds medium to very thick, mainly 0.3 to 1 m; massive and obscurely defined. Joints common. Resistance to erosion high; forms rounded light- to very light-gray ledges and cliffs. Thickness 215-395 m

Srm ROBERTS MOUNTAINS FORMATION (SILURIAN)--Medium dark to medium gray, carbonate-bearing fine-grained detrital rocks and impure carbonate rocks. Most are mudstone, siltstone, and very fine silty sandstone, mainly dolomitic, partly calcareous; less abundant and irregularly distributed are muddy, silty, or finely sandy microgranular to very fine grained limestone and dolomite; some small amount of siltite and quartzite. Beds medium to very thick. Regular lamination, 3 mm or less thick, and cleavage that may be parallel or oblique to bedding common. Resistance to erosion moderate to weak. Thickness approximately 800 m in Lone Pine Peak quadrangle (Hays and others, 1978). Upper part contains fossils of late Wenlock and probably Ludlow age

Op BLACK CARBONACEOUS GRAPTOLITE-BEARING SHALE AND ARGILLITE (ORDOVICIAN)--Black, fissile, carbonaceous shale; bedding obscured by cleavage. Exposures totalling less than one square kilometer along the lower reaches of Big Lake Creek and Pine Creek, tributaries to East Fork Salmon River. Generally deformed--especially in higher exposures beneath thrust contact with Mississippian Salmon River sequence. Maximum of 35 m of

unit exposed, total thickness unknown. Tentatively correlated with Ordovician Phi Kappa formation to south, as suggested by Dover, Berry, and Ross (1980)

Omu SATURDAY MOUNTAIN FORMATION, KINNIKINIC QUARTZITE, AND ELLA DOLOMITE, UNDIVIDED (ORDOVICIAN)--Saturday Mountain Formation is predominantly medium dark- to medium-gray, microgranular to very fine grained, and fairly pure dolomite that contains abundant (as much as 50 percent) irregular layers of medium dark gray chert in uppermost part of the exposed section; some chert color-laminated. Weathered surfaces medium light gray with yellowish cast. Forms blocky outcrops strongly ribbed by brownish-weathering chert. Contains considerable limestone, siltstone, and black shale in Squaw Creek area. Uppermost part of Saturday Mountain Formation may be Silurian. Kinnikinic Quartzite is fine-grained quartzite that is mainly light to very light gray with yellowish or brownish cast; locally as dark as medium gray or mottled medium dark and lighter gray; very fine to fine grained with some medium rounded grains; clean. Medium to thick bedded (maximum 1 m), bedding commonly obscured by shearing and partial recrystallization; local faint lamination. Ella Dolomite is medium- to dark-gray or brownish-gray medium- to thick-bedded dolomite that contains thin laminae of silt and sand. Total thickness about 1,450 m

Oc UPPER CARBONATE UNIT (ORDOVICIAN)--Heterogeneous sequence of dolomite, silty dolomite, and dolomitic sandstone that crops out in Squaw Creek drainage. Estimated thickness about 150 m

OGrr SILTSTONE, SANDY SILTSTONE, AND QUARTZITE OF ROB ROY MINE AREA (ORDOVICIAN? OR CAMBRIAN?)--Thickness of at least 600 m exposed only near Kinnikinic Creek north of Clayton. Top eroded; thrust fault at base

OGq QUARTZITE (LOWER ORDOVICIAN OR OLDER)--Divided into five map units by Hobbs and others (1975). Over most of the area consists of Clayton Mine Quartzite, which is poorly sorted, coarse- to medium-grained feldspathic quartzite that includes conglomerate layers, pebbly quartzite and scattered pebbles in the upper two-thirds of the section. Very thin shale partings occur throughout. More than 1,000 m thick

OGr RAMSHORN SLATE (ORDOVICIAN? OR CAMBRIAN?)--Gray, greenish-gray, purple, thin-bedded, well-laminated slate, locally phyllitic. Commonly shows well-developed cleavage at an angle to the bedding. Includes thin beds of sandstone toward top. A thick lens of conglomerate occurs at the base in outcrops west of Challis

OGb BAYHORSE DOLOMITE (ORDOVICIAN? OR CAMBRIAN)--Light-gray to yellowish-gray medium to very thick bedded dolomite in upper part and medium- to dark-gray, thin-bedded, fine-grained limestone in lower part. Dolomite contains dark-gray, silicified oval structures resembling pisolites in several layers up to 9 m thick. Both upper and lower parts locally contain thin interbeds of siltstone, argillite, or fine-grained sandstone. Top of the unit is an erosional disconformity characterized by a zone of probable paleokarst topography. Minimum thickness about 400 m

OGg GARDEN CREEK PHYLLITE (ORDOVICIAN? OR CAMBRIAN?)--Dark-gray to black,

slightly calcareous phyllite. As shown, includes small area of underlying dolomite exposed in bed of Bayhorse Creek west of Bayhorse. Estimated thickness is 150 to 300 m

Ecqs QUARTZITE, SHALE, AND CARBONATE ROCKS OF SQUAW CREEK AREA (CAMBRIAN)--Mapped as four separate units by Hobbs and others (1975)

PALEOZOIC ? AND PRECAMBRIAN ROCKS

OEZl INTERBEDDED QUARTZITE, DOLOMITE AND ARGILLITE OF LEATON GULCH AND PENNAL GULCH AREAS (ORDOVICIAN ?, CAMBRIAN ? AND PRECAMBRIAN Z ?)--Sequence of predominantly quartzitic strata containing subordinate dolomite interbeds and some thin argillitic interbeds and local thicker argillite intervals. Quartzite generally deep red to dark purplish-gray to medium gray; some thick zones of light pinkish- or tannish-gray and very light gray to white; medium grays and purplish grays predominate. Thin to medium bedded, platy, laminated; some massive units are thick bedded and structureless; mostly medium to fine grained, locally coarse grained and pebbly; lamination prominent in some thick layers; includes several zones of very coarse conglomerate or intraformational breccia. Much of thin-bedded platy quartzite shows ripple marks, flute casts, worm trails; abundant magnetite in parts of section. Dolomite very fine grained to dense, light to medium tan on fresh surface, weathers rich reddish tan to brown; beds dispersed in quartzites and range from 0.2-0.3 m to several meters in thickness; restricted to area within one kilometer east from Beardsley Hot Springs. Argillite occurs as laminae or thin interbeds in much of the quartzite sequence and locally forms a continuous sequence as much as 100 m thick; generally thin-bedded, fissile; dark gray or purplish gray, in places altered to deep gray green. Many argillaceous layers metamorphosed to phyllite close to thrust faults. Sequence of rock types is indeterminate because of complex structure and discontinuity of exposures. General characteristics of strata and structural relations to Swauger Formation suggest possible correlation with the Wilbert and Summerhouse Formations that are, at least in part, of Cambrian and Ordovician age, or the Early Cambrian Tyler Peak formation of McCandless (Ruppel, 1975; McCandless, 1982)

PRECAMBRIAN ROCKS

Yl LAWSON CREEK FORMATION--Thin- to medium-bedded and interbedded fine-grained, platy, pink to greenish-gray quartzite and dark purplish-gray quartzitic phyllite containing some zones of laminated purple, sandy argillite. Quartzite is feldspathic, locally with much coarse mica on bedding planes, and has good ripple marks and other sedimentary structures. Some thicker quartzite beds similar to Swauger Formation in general characteristics. Base of sequence is gradational through distance of a few meters with the Swauger Formation on which it lies; top not known; minimum thickness approximately 1,300 m (Hobbs, 1980)

Ys SWAUGER FORMATION--Light-pink, pinkish-tan, purplish-gray to locally red, medium- to coarse-grained fairly pure, well-sorted quartzite; commonly contains several percent feldspar; medium to thick bedded, locally prominant cross-lamination; few very thin shaly partings. Base not exposed; top seems to grade over several meters into unit Ylc. Minimum thickness approximately 3,000 m

Yg GUNSIGHT FORMATION--Light brownish-gray, fine- to medium-grained (0.3-0.6 mm), thin- to thick-bedded sericitic quartzite; typically contains about 60-65 percent quartz, 30 percent sericite, 2-4 percent orthoclase and perthite, 3-6 percent microcline, 0.4-0.6 percent plagioclase. The rock is not well sorted; quartz "berries" as large as 0.7 mm commonly occur in a matrix averaging about 0.3 mm. Quartz grains are mostly well rounded. Some exposures contain only trace amounts of alkali feldspar and plagioclase and considerably less than 15 percent sericite, and appear to be gradational with the overlying Swauger Formation. Thickness 400 m (incomplete). The Gunsight Formation is the uppermost formation within the Lemhi Group (Ruppel, 1975), which consists (downward) of the Gunsight, Apple Creek, Big Creek, West Fork (not present in this map area) and Inyo Creek Formations

Ya APPLE CREEK FORMATION--Mainly siltstone and fine-grained sandstone; medium greenish gray to grayish red purple, to dark-gray, thin-bedded and laminated siltstone containing irregular streaks and lenses of a light-gray, pinkish- to pale-brown sandstone cemented by ferrodolomite. The sandstone lenticles are typically a few millimeters to several centimeters thick and a meter, more or less, long, although much longer lenses are known. Medium-gray to brownish-gray to light-gray or pale-red feldspathic, fine-grained quartzite beds several centimeters in thickness occur in what appears to be the stratigraphically higher parts of the unit. Ripple marks and other sedimentary structures are abundant, and many bedding surfaces are coated with detrital mica; lamination and cross-lamination in fine-grained sandstone common. Disconnected exposures and complex structure prevent accurate correlation of beds and determination of thickness. No base or top exposed in quadrangle

Yb BIG CREEK FORMATION--Light greenish-gray, thin- and thick-bedded,

fine- to medium-grained micaceous and feldspathic quartzite; thicker beds are conspicuously cross bedded, with magnetite grains abundant in some laminae and scattered through the rock. In some exposures greenish-gray quartzite grades upward to reddish-gray feldspathic quartzite that weathers brown and brownish gray. Some thinner-bedded exposures contain more siltite and show rather pronounced slaty cleavage, obscure current ripple marks, and some load casts. Typical rocks contain 45-57 percent quartz (0.1-0.3 mm), 10-20 percent orthoclase and microcline, 10-20 percent plagioclase, and 7-20 percent sericite, biotite, and iron oxide. The abundance of plagioclase is distinctive. Thickness 600 m (incomplete)

Yi INYO CREEK FORMATION (?)--Gray and green-gray siltite and fine-grained quartzite; mostly thin bedded but bedding not as obvious as in typical Apple Creek Formation. Quartzite layers contain smeared-out pellets and pebbles of siltite or mudstone. Some fine-grained quartzite layers contain coarser-grained quartzite pebbles. Some small-scale ripple marks and obscure laminations also are present. Thickness more than 200 m (incomplete)

Yy YELLOWJACKET FORMATION--Mostly medium gray and light bluish-gray, thin- and thick-bedded, argillaceous quartzite and siltite with minor beds of argillite grading downward to thin- and thick-bedded, light-gray quartzite that is indistinguishable from the underlying Hoodoo Quartzite (unit Yh, see below). This upper Yellowjacket (sequence above the Hoodoo) is of uncertain thickness but probably has a thickness of several hundred meters. Overall, it is cleaner and lighter colored than the Yellowjacket that underlies the Hoodoo. The sequence below consists of 2340 m of dark-gray, argillaceous, thin- and thick-bedded quartzite and siltite that weathers to hackly chips. Ross (1934) and our work shows that the quartzite beds are composed of 55 to 70 percent quartz grains with an average diameter of 0.1 mm, and about 30 percent biotite, chlorite, and sericite (formed from original argillaceous material) and magnetite. Some beds are sufficiently rich in magnetite that they strongly attract a pencil magnet. The argillaceous quartzite grades downward to varicolored calcareous rocks. According to Carter (1981), the calcareous rocks occur as discrete lenses in the argillaceous quartzite. The thin quartzite beds throughout the Yellowjacket display fine-scale cross-laminated layers, oscillatory ripple marks, and mud cracks. Excellent mud cracks were found just east of Yellowjacket Creek, along Hoodoo Creek, and at the mouth of Musgrove Creek. These occurrences confirm the conclusion of Ross (1934) that the Yellowjacket was deposited under shallow marine conditions. The base of the formation has not been identified in this quadrangle. Thickness 4,000 + m (including the Hoodoo Quartzite)

Yh HOODOO QUARTZITE--White, off-white, and light brownish-gray, massive-weathering, thin- and thick-bedded clean quartzite. Except for outcrops at top and base, bedding is obscure; cross-bedded in beds 0.5 m to 1.0 m thick; contact at base and top transitional with sub- and superjacent Yellowjacket. Intensely fractured

and sheared in most localities. Quartz averages about 85 percent; feldspar averages 5 to 15 percent and consists of microcline, non-perthitic orthoclase, and sparse albite. Rocks near the base and top contain as much as 10 percent biotite, sericite, and iron oxide formed from the original clay-rich cement. Thickness 0-1,100 m

m METAMORPHIC ROCKS OF UNCERTAIN AGE--Principally staurolite-muscovite-biotite-quartz schist. Locally, according to B. F. Leonard (written commun., 1983) contains garnet and andalusite; commonly contains porphyroblastic biotite that cuts across schistosity. Thickness 0-200 $\pm$ m

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