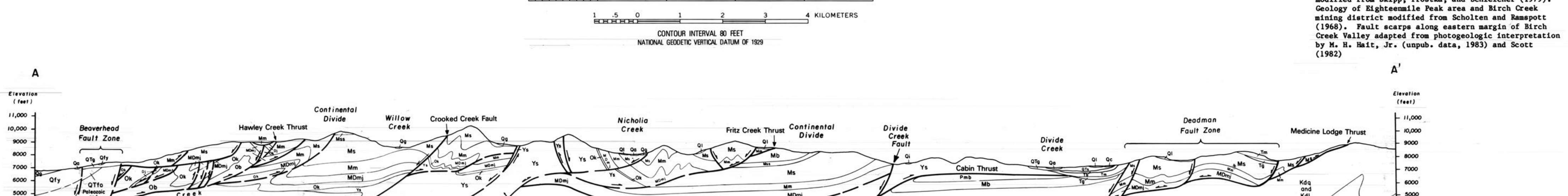
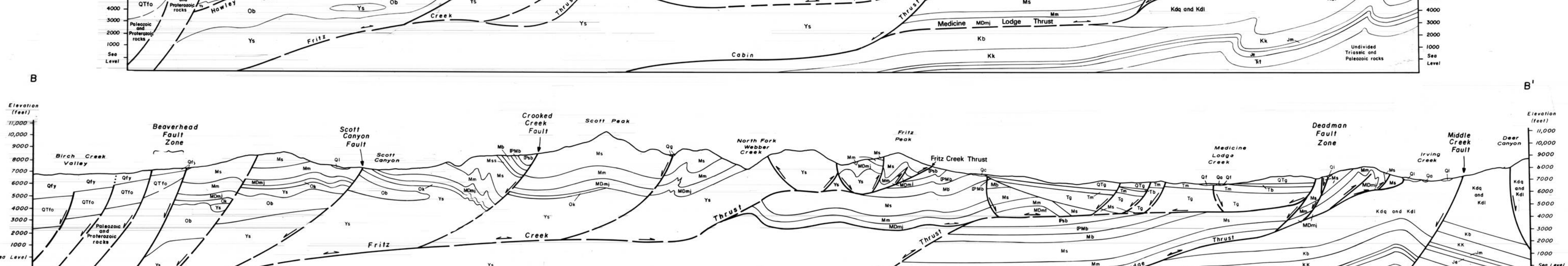
Base from U.S. Geological Survey, Nicholia, 1:62,500, 1956; Scott Peak, 1:62,500, 1957; and Edie Ranch, 1:62,500, 1957

SCALE 1:62 500

CONTOUR INTERVAL 80 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology by Betty Skipp, 1980-82; assisted by Nancy S. Williams, 1980, Jean D. MacKenzie, 1981, and Jean M. LaDue, 1982. Geology of Edie Ranch Quadrangle modified from Skipp, Prostka, and Schleicher (1979). Geology of Eighteenmile Peak area and Birch Creek mining district modified from Scholten and Ramspott (1968). Fault scarps along eastern margin of Birch Creek Valley adapted from photogeologic interpretation by M. H. Hait, Jr. (unpub. data, 1983) and Scott (1982)





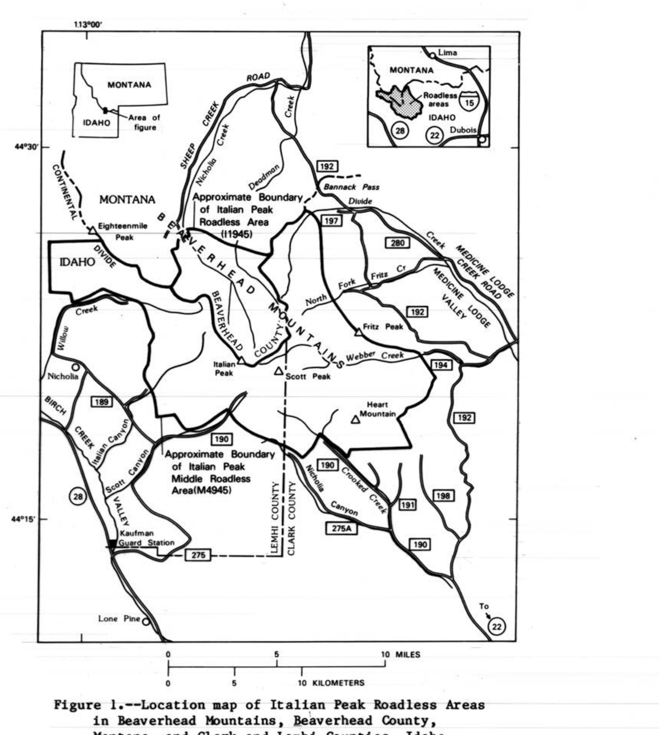
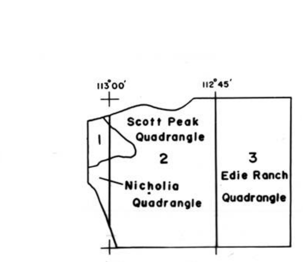


Figure 1.--Location map of Italian Peak Roadless Areas in Beaverhead Mountains, Beaverhead County, Montana, and Clark and Lemhi Counties, Idaho.



SOURCES OF INFORMATION

1. From Scholton and Ramspott (1968) and Skipp and others (1984)
2. Mapping by Betty Skipp (1980-1982)
3. Modified from Skipp, Prostka, and Schleicher (1979). Includes new mapping by Betty Skipp (1980-1982) and H. J. Prostka (1979)

This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards.

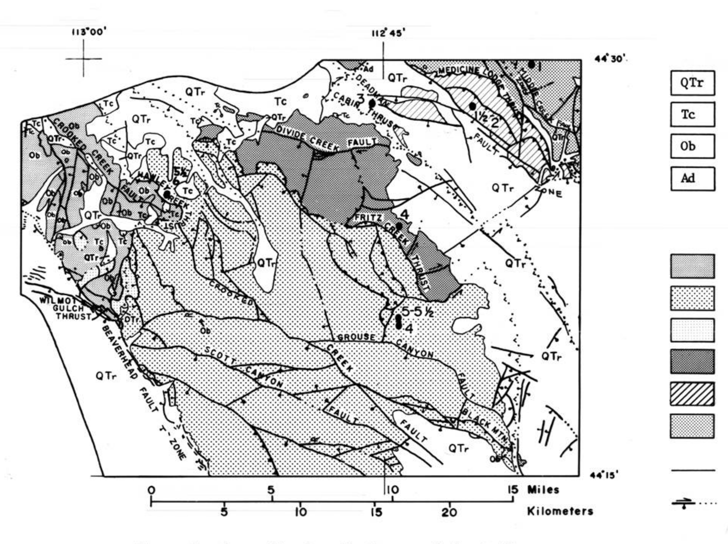


Figure 2.--Generalized geologic map of the Italian Peak Roadless Areas and vicinity.

EXPLANATION FOR FIGURE 2

LIST OF MAP UNITS

QTr Quaternary and Tertiary rocks, undivided

Tc Eocene Challis Volcanics

Ob Ordovician Beaverhead Mountains pluton

Ad Archean(?) Dillon Granite Gneiss of Heinrich (1953)

LIST OF THRUST PLATES

Rocks of Hawley Creek thrust plate

Rocks of Fritz Creek thrust plate

Slide blocks from Fritz Creek(?) thrust plate

Rocks of Cabin thrust plate

Rocks of Medicine Lodge thrust plate

Rocks of Tendoy thrust plate

CONTACT

FAULT--Dotted where concealed. Bar and ball on downthrown side where mostly normal slip. Arrows indicate mostly strike-slip

THRUST FAULT--Dotted where concealed. Sawteeth on upper plate

REVERSE FAULT--Dotted where concealed. R on upthrown side

APPROXIMATE OUTLINE OF ROADLESS AREAS

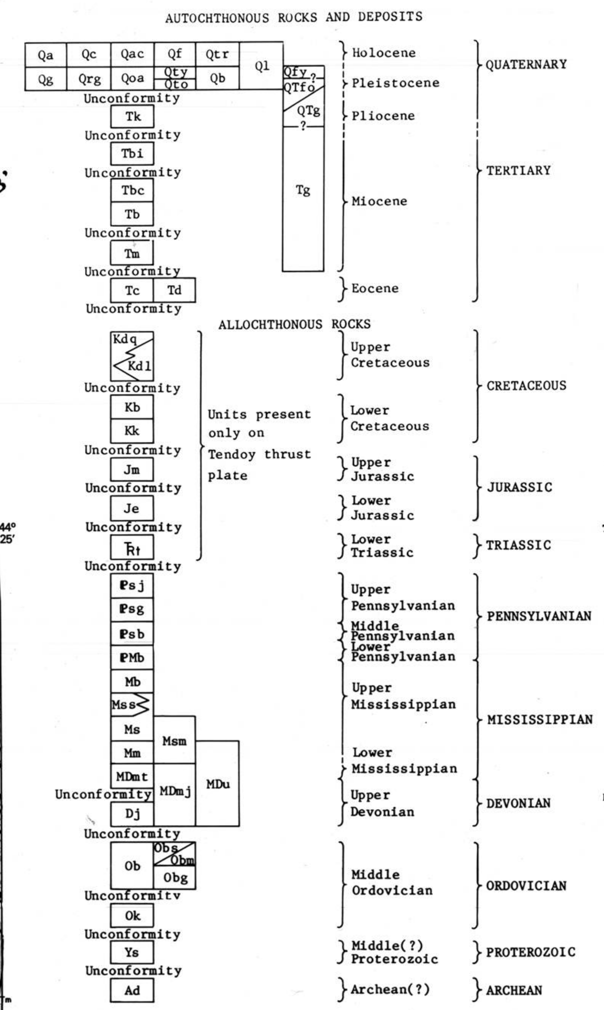
•3 CONODONT COLOR ALTERATION INDEX VALUE--**From Epstein and others (1977)**

GEOLOGIC MAP AND CROSS SECTIONS OF THE ITALIAN PEAK AND ITALIAN PEAK MIDDLE ROADLESS AREAS, BEAVERHEAD COUNTY, MONTANA, AND CLARK AND LEMHI COUNTIES, IDAHO

By
Betty Skipp

1984

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

AUTOCHTHONOUS ROCKS AND DEPOSITS

Qa ALLUVIUM (HOLOCENE)--Unconsolidated, poorly sorted deposits of fluvial mud, silt, sand, and gravel

Qc COLLUVIUM (HOLOCENE)--Unconsolidated locally derived rubble chiefly at base of steep slopes; includes talus

Qac ALLUVIUM AND COLLUVIUM UNDIFFERENTIATED (HOLOCENE)

Qf ALLUVIAL FAN DEPOSITS (HOLOCENE)--Fan-shaped deposits of unconsolidated gravel, sand, and silt

Qtr TRAVERTINE (HOLOCENE)--Mounds and terraces of travertine localized along faults in sec. 13, T. 11 N., R. 23 E.

Ql LANDSLIDE DEPOSITS (QUATERNARY)--Unconsolidated and partly consolidated deposits of coarse, mostly angular, unsorted, locally derived debris

Qg GLACIAL DEPOSITS OF PINEDALE GLACIATION (UPPER PLEISTOCENE)--Loosely consolidated to unconsolidated, coarse to fine, subangular to round, nonsorted to moderately sorted pebble to boulder gravel in matrix of silty sand to clayey sandy silt; includes till and outwash deposits (Scott, 1982); unit disrupted by fault scarps near mouth of Willow Creek in Harkness Lakes area

Qrg ROCK GLACIER DEPOSITS (UPPER PLEISTOCENE)--Unconsolidated, locally derived, largely angular boulders in tonguelike bodies that resemble deposits of small glaciers

Qoa OLD ALLUVIUM (UPPER PLEISTOCENE)--Unconsolidated deposits of fluvial gravel, sand, and silt present in dry or nearly dry canyons in southwestern part of map area

Qty YOUNGER TERRACE GRAVEL (UPPER PLEISTOCENE)--Steep-sided, gently dipping deposits of relatively younger unconsolidated fluvial gravel, sand, and silt locally preserved at elevations from about 30 to 100 ft above present stream levels along Willow and Nicholia Creeks in northwestern part of area

Qto OLDER TERRACE GRAVEL (UPPER PLEISTOCENE)--Steep-sided, gently dipping deposits of relatively older unconsolidated fluvial gravel, sand, and silt, locally preserved at elevations from about 80 to 320 ft above present stream levels along Willow and Nicholia Creek; locally offset by fault scarp at mouth of Willow Creek

Qb BOULDER TRAIN (UPPER PLEISTOCENE)--Lines of boulders derived from rock glacier deposits; boulders as much as 10 ft in diameter of light-colored Kinnikinic Quartzite and Beaverhead Mountains granite on southwest flank of Eighteenmile Peak; locally offset by fault scarp

Qfy YOUNGER ALLUVIAL FAN GRAVEL (PLEISTOCENE)--Fan-shaped deposits, of unconsolidated to poorly consolidated gravel, sand, and silt; slightly dissected, mapped in Birch Creek and Medicine Lodge valleys; includes fan alluviums 2 and 3 of W. E. Scott (1982) of late to early(?) Pleistocene age; locally disrupted by fault scarps in Birch Creek Valley

QTfo OLDER ALLUVIAL FAN GRAVEL (LOWER PLEISTOCENE TO PLIOCENE)--Fan-shaped deposits, deeply dissected, of nonconsolidated to poorly consolidated gravel, sand, and silt; mapped only in Birch Creek Valley area; locally disrupted by fault scarps

QTg GRAVEL (LOWER PLEISTOCENE AND PLIOCENE)--Consolidated to unconsolidated, nonsorted to moderately sorted, subangular to rounded gravel, sand, and silt; probably dissected old alluvial or alluvial fan deposits; includes high-level terrace deposits at mouth of Willow Creek, extensive older gravels beneath glacial deposits in Harkness Lakes area, extensive high-level gravels at Bannack Pass and south Medicine Lodge Creek, and cemented gravels that locally overlie the tuff of Kilgore south of Black Mountain; locally disrupted by fault scarps

AUTOCHTHONOUS ROCKS

Tk TUFF OF KILGORE (PLIOCENE)--Rhyolite ashflow tuff, light-gray, purple, pink, red, and brown; weathers gray, grayish red, light brown, and black, crystal poor, densely welded, devitrified to glassy, thick lithophysal zone, characteristic maroon pumice fragments throughout. Phenocrysts range from 5 to 7 percent at base to about 1 percent at top, and consist of sodic plagioclase, and minor sanidine, quartz, and pyroxene. Locally forms cliffs. Description modified from McBroome (1981), Morgan and others (1984); same as tuff of Spencer (Skipp and others, 1979). Thickness from depositional or erosional edge to 200 ft

Tbi BASALT OF INDIAN CREEK (MIOCENE)--Basalt, dark- to medium-gray; blocky; contains sparse, up to 2 percent, phenocrysts of olivine and(or) plagioclase in a dense to diktytaxitic groundmass; several flows; reversed magnetic polarity; K-Ar age 5.17±0.16 m.y. (G. Brent Dalrymple, written commun., 1979)

Tbc TUFF OF BLUE CREEK (MIOCENE)--Rhyolite ashflow tuff, maroon, light-gray, black, tan, and orange; weathers light gray, yellowish brown, maroon, and black; crystal poor, densely welded, devitrified to glassy, spherulitic to lithophysal. Tuff contains an average 1 percent sodic plagioclase phenocrysts with trace amounts of pyroxene, magnetite, and zircon. Thin black vitrophyre near base. Locally forms cliffs. Description modified from McBroome (1981). Thickness from depositional or erosional edge to 590 ft

Tb TUFF OF BLACKTAIL BUTTE (MIOCENE)--Rhyolite ashflow tuff, light-gray, lavender, pale orange, and dark-brown; weathers gray, brown, yellowish brown, and black; densely welded, crystal rich, glassy to devitrified; spherulitic to lithophysal. Phenocryst content is 15 percent at base and about 5 percent at top, and includes sodic plagioclase, sanidine, quartz, augite, zircon, and opaque oxides. Relative amount of augite content increases upward in sheet. Locally forms cliffs. Description modified from McBroome (1981) and Morgan and others (1984); same as Edie School Rhyolites of Scholten and Ramspott (1968). Thickness from depositional or erosional edge to 330 ft

Tm MEDICINE LODGE BEDS OF SCHOLTEN AND RAMSPOTT, 1968 (MIOCENE)--Travertine limestone, tuffaceous lacustrine mudstone, airfall tuff, and gravel. Travertine limestone, light-gray, and white; thick bedded, freshwater; vuggy; forms prominent ledge as much as 165 ft high at top of unit; quarried locally for decorative stone. Tuffaceous lacustrine mudstone, light-brown, and light-gray; soft, highly susceptible to landsliding; makes up most of unit. Airfall tuff, biotite-rich; present in upper part of sequence. Locally derived conglomerate wedges present near margins of the depositional basin, such as southeast of Black Mountain. Thickness from depositional or erosional edge to 1,000 ft

Tg GRAVEL (MIOCENE)--Poorly consolidated to consolidated gravel, sand, and silt; locally interbedded with Miocene volcanic and sedimentary rocks; from depositional or erosional edge to 200 ft thick at surface in map area, but estimated to be as much as 2,000 ft thick on cross section B-B'

Tc CHALLIS VOLCANICS (EOCENE)--Rhyodacite tuff and volcanic breccia, tuffaceous sandstone and conglomerate, and latite flows. Rhyodacite tuff, light-gray and yellowish-gray; weathers the same; largely friable; fine to coarse grained; crudely bedded; composed of hydrated glassy pumice and fragments of volcanic and country rocks (quartzite, granite, and syenite). Light-colored, waterlaid tuffaceous sandstone and conglomerate interbedded with the tuffs are composed largely of volcanic clasts and locally are crossbedded. Rhyodacite volcanic breccia, medium-gray and grayish green; weathers medium gray and moderate brown; composed of fragments of aphanitic to porphyritic rhyodacite and a few fragments of country rock including granite of the Beaverhead Mountains pluton (Scholten and Ramspott, 1968, p. 11). Latite flows, black, gray, and dark-greenish-gray; weather with brownish gray rind; dense, aphanitic to porphyritic and contain 1-15 percent phenocrysts of pyroxene, plagioclase, and a few large olivine pseudomorphs altered to serpentine, in a hyalopilitic matrix. Latite locally forms ledges and cliffs. Called Medicine Lodge volcanic rocks of Oligocene to Miocene(?) age by Robert Scholten (Scholten and others, 1955; Scholten and Ramspott, 1968). K-Ar ages determined by R. F. Marvin, H. H. Mehnert, E. L. Brandt, and Kyoto Futa (written communs., 1983) are 47.0 ± 1.3 m.y. on biotite from rhyodacite tuff (locality 1), 47.7 ± 1.3 m.y. on hornblende from a rhyodacite breccia flow (locality 2), 49.0 ± 3.0 m.y. and 51.4 ± 3.1 m.y. on same sample of hornblende from a boulder in a rhyodacite breccia (locality 4). Thickness from erosional or depositional edge to about 2,000 ft

Td DIKE (EOCENE)--Altered intermediate to basic intrusive rocks; dark gray to olive gray; aphanitic to porphyritic. Original minerals include plagioclase, titan-augite, olivine, opaque iron oxides, biotite, and accessory apatite; hydrothermally altered to serpentine, talc, carbonate, actinolite, feldspar, zoisite, and other minerals. Dikes weather gray, yellowish brown, and produce an olive-brown soil. They constitute small bodies, several tens of feet long, in the vicinity of the Continental Divide in the northern part of the area, that may have been feeders to the Challis Volcanics (Scholten and Ramspott, 1968)

ALLOCHTHONOUS ROCKS

BEAVERHEAD FORMATION (UPPER CRETACEOUS)

Kdq Divide quartzite conglomerate unit (Upper Cretaceous)--Conglomerate, sandstone, and minor carbonaceous shale. Conglomerate consists of boulders as much as 3 ft in diameter of quartzite, sandstone, limestone, chert conglomerate, volcanic rocks of intermediate and felsic compositions, and granitic gneiss in decreasing order of abundance. Interbedded sandstone, olive-gray; coarse grained to conglomeratic; calcareous with brown weathering "cannon ball" concretions; weakly indurated; crossbedded in places. Palynomorphs collected by R. T. Ryder from a thin carbonaceous shale bed in the E1/2 sec. 16, T. 13 N., R. 33 E. and identified by R. H. Tschudy (written commun., 1983) indicate a Late (post-Santonian) Cretaceous age. Unit interbedded with Divide limestone conglomerate unit (Kdl), and forms barren steep-sided slopes. Estimated maximum thickness more than 7,000 ft

Kdl Divide limestone conglomerate unit (Upper Cretaceous)--Interbedded conglomerate and sandstone. Conglomerate clasts as much as 15 ft in diameter, consist of limestone, dolomite, sandstone, and quartzite, in decreasing order of abundance. Interbedded sandstone, very pale orange and grayish-orange-pink; fine grained to conglomeratic; calcareous; thin to thick bedded (beds up to 20 ft thick); local large-scale foreset bedding. Unit weathers light brownish gray and grayish orange pink. Unit forms ledges and cliffs, is interbedded with the Divide quartzite conglomerate unit, and has an unconformable contact with underlying Mesozoic rocks. About 4,700 ft was measured by Ryder and Scholten (1973)

Kb BLACKLEAF FORMATION (LOWER CRETACEOUS)--Interbedded sandstone, claystone, and tuff. Sandstone, light-olive-gray and yellowish-brown, salt-and-pepper in part; and very fine to medium grained; tuffaceous, argillaceous, partly calcareous and friable; medium bedded; weathers dark greenish gray and yellowish brown. Claystone, pale-olive and light-olive-gray; silty; bentonitic. Tuff, light-gray; fine to medium grained; massive; weathers medium brownish gray. Unit forms slopes with numerous landslides, and has an unconformable contact with overlying Beaverhead Formation. Contact with underlying Kootenai Formation is conformable. Formation is upper part of Aspen Formation of Scholten and others (1955). Early Cretaceous age determined from pollen (Ryder and Scholten, 1973). Thickness varies from an erosional edge to greater than 1,000 ft

Kk KOOTENAI FORMATION (LOWER CRETACEOUS)--Interbedded sandstone, mudstone, limestone, and conglomerate. Freshwater gastropod-rich limestone at top is medium gray, aphanitic, argillaceous, thin- to medium-bedded, weathers medium light gray, and is approximately 200 ft thick. A largely covered interval about 800 ft thick, consisting of interbedded fine- to coarse-grained sandstone, gray and red mudstone, and minor limestone is present below the upper gastropod limestone. A basal sandstone and conglomerate ledge, about 30 ft thick, contains conglomerate fragments of medium-gray chert as much as 1.5 cm in diameter in a noncalcareous, very fine to fine-grained quartzose sandstone matrix. Overlain conformably by Blackleaf Formation and unconformably by Beaverhead Formation; unconformably overlies Morrison Formation. Formation is about 1,000 ft thick

Jm MORRISON FORMATION (UPPER JURASSIC)--Mudstone and salt-and-pepper sandstone. Mudstone, moderate-reddish-orange; sandy; calcareous; forms slope at top of formation; about 150 ft thick. Salt-and-pepper sandstone, medium-light-gray; coarse grained; calcareous; fine to medium bedded; crossbedded; forms a ridge of low rounded ledges at base of formation; weathers moderate brown. Unconformably overlies Ellis Group. Total thickness of formation about 200 ft

Je ELLIS GROUP (MIDDLE JURASSIC)--In descending order, consists of the Rierdon and Sawtooth Formations. Rierdon consists of pale-yellowish-brown and light-olive-gray oolitic limestone that weathers the same, is thin bedded, and forms a low ledge about 100 ft thick. Sawtooth consists of upper and lower limestones. Upper limestone, pale-yellowish-brown; aphanitic; weathers grayish orange in part; thin bedded; locally contains pelecypods and gastropods that indicate a Middle Jurassic age (R. W. Imlay, written commun., 1976). Lower limestone, very pale orange; argillaceous; thin bedded. Limestones form a slope, and are about 200 ft thick. Ellis Group unconformably overlies Thaynes Formation and is about 300 ft thick

Rt THAYNES FORMATION (LOWER TRIASSIC)--Interbedded limestone and sandstone. Limestone, light-olive-gray to medium-gray, some mottled very pale orange and medium-light-gray; fine grained; sandy; thin bedded; contains scattered medium gray chert nodules; fossiliferous (pelecypods, brachiopods, crinoids, echinoid spines, and conodonts). Thin sandstone beds, grayish-orange; very fine grained; calcareous. Formation forms a succession of ridges, and is about 700 ft thick. Base not exposed in area

SNAKY CANYON FORMATION (LOWER PERMIAN TO LOWER PENNSYLVANIAN)

Psj Juniper Gulch(?) Member, lower part (Upper Pennsylvanian)--Limestone and dolomite, medium-light-gray to medium-gray; sandy; fossiliferous; medium to thin bedded; weather medium gray and light olive gray; form low ledges. Member assignment queried because all of these beds may be part of Bloom Member. Basal 300 ft present in southern part of area

Psg Gallagher Peak(?) Sandstone Member (Upper Pennsylvanian)--Sandstone and limestone. Sandstone, medium-gray and light-brownish-gray; quartzose; very fine grained to fine grained; calcareous; weathers medium light gray and light brown; is mostly thin bedded. Minor interbedded limestone, medium-gray; sandy; medium bedded. Member mostly forms rubble covered slopes in southern part of area. Member assignment queried because this sandstone possibly may be a lower sandstone bed within Bloom Member. Estimated thickness 100 ft

Psb Bloom Member (Upper and Lower Pennsylvanian)--Limestone and interbedded sandstone. Limestone, medium- to light-gray; weathers medium light gray and light brownish gray; mostly fine to medium grained; largely sandy and silty; contains banded stromatolite mounds and yellowish-brown chert in nodules and layers; fossiliferous. Interbedded thin sandstone beds, medium-gray and light-brownish-gray; very fine grained; calcareous; brown weathering in the lower part. Member is medium to thin bedded, forms slopes with scattered ledges and ridges, and grades into the underlying Bluebird Mountain Formation. Estimated thickness about 1,500 ft

PMb BLUEBIRD MOUNTAIN FORMATION (LOWER PENNSYLVANIAN AND UPPER MISSISSIPPIAN)--Sandstone, with minor interbedded limestone and dolomite. Sandstone is light-gray to medium-gray; very fine grained to medium grained, angular to subangular grains are quartz and up to 5 percent feldspar, opaque iron oxides, biotite, mica, zircon, and chert in a calcareous or siliceous cement; thin to medium bedded; locally crossbedded; weathers moderate yellowish brown to light brown; secondarily silicified near Bannack Pass. Minor gray and greenish-gray limestone and dolomite, in beds 5 ft thick, largely fine grained, and locally fossiliferous. Formation forms cliffs or ledges and is gradational from the underlying Big Snowy Formation into overlying Snaky Canyon Formation. Estimated thickness 300-550 ft

Mb BIG SNOWY FORMATION (UPPER MISSISSIPPIAN)--Mudstone, limestone, limestone conglomerate, and sandstone. Mudstone, medium-gray and grayish-black; largely noncalcareous; shaly; weathers dark gray to black; contains lenses of sandy limestone and calcareous concretions; makes up slightly less than half of the formation. Limestone, medium-gray to grayish-black; very fine to very coarse grained; sandy and silty; nodular to thick bedded (up to 4 ft); weathers gray and pale red. Limestone conglomerate common in lower part, medium-dark-gray; contains subrounded to rounded limestone fragments that range in size from coarse sand to cobbles. Sandstone and sandy limestone in middle part, medium-gray; very fine to fine grained; weather olive gray and medium gray; commonly thin bedded; form low ledges. Brachiopods, including phosphatic form, Orbiculoidea sp., common. Formation forms slopes, has a gradational contact with overlying Bluebird Mountain Formation, and a sharp conformable contact with underlying Surrett Canyon or Scott Peak Formations. Thickness ranges from about 500 to 800 ft

Mss SURRETT CANYON AND SOUTH CREEK FORMATIONS UNDIVIDED (UPPER MISSISSIPPIAN)--Limestone, medium-light-gray to medium-dark-gray; fine to medium grained; locally silty; fossiliferous; weathers medium gray, yellowish gray, and pale yellowish brown; locally thick bedded in upper part (Surrett Canyon Formation), very thin to medium bedded in lower part (South Creek Formation). Units mapped only where thin-bedded limestone of the South Creek Formation recognized; elsewhere, as on Scott Peak, medium-bedded limestones with faunas similar to those found in these formations have been included in the Scott Peak Formation. Thickness of Surrett Canyon Formation ranges from 0 to 75 ft, and South Creek Formation from 0 to 250 ft. Thickness of the unit as defined varies from not being recognized as a separate unit to 325 ft

Ms SCOTT PEAK FORMATION (UPPER MISSISSIPPIAN)--Limestone and minor calcareous siltstone. Limestone, medium-dark-gray to dark-gray; very fine to coarse grained; sandy and silty in lower part; fossiliferous; chert common in layers and nodules; weathers medium to light gray; mostly thick bedded, but includes thin and medium beds in lower and upper parts. Siltstone, yellowish-brown and calcareous. Local diagenetic magnesian limestone and ferrodolomite, present locally on both Fritz Creek and Cabin thrust plates (Skipp and others, 1983), medium-dark-gray and brownish-gray; weather olive gray and brownish gray; finely to coarsely crystalline textures. In magnesian limestone, dolomite has replaced cement between limestone clasts. Formation forms cliffs and steep talus covered slopes; contacts with underlying Middle Canyon and overlying South Creek Formations are gradational. Thickness about 1,230-2,000 ft

Mm MIDDLE CANYON FORMATION (UPPER AND LOWER MISSISSIPPIAN)--Cherty limestone with silty and sandy partings. Limestone, medium- to dark-gray; mostly fine grained; contains some coarse-grained encrinite beds near top; silty and sandy. Black chert, in lenses and beds, comprises as much as 50 percent of middle part. Formation is sparsely fossiliferous, weathers moderate brown, is thin bedded (6-8 in.), and forms brown cliffs below gray cliffs of Scott Peak Formation, or rubble covered slopes. Contact with underlying McGowan Creek gradational. Estimated thickness in area 400-1,000 ft

Msm SCOTT PEAK FORMATION (UPPER MISSISSIPPIAN) AND MIDDLE CANYON FORMATION (UPPER AND LOWER MISSISSIPPIAN) UNDIVIDED--Locally mapped in slide block

MDmt MCGOWAN CREEK FORMATION (LOWER MISSISSIPPIAN) AND SAPPINGTON MEMBER OF THREE FORKS FORMATION, UNDIVIDED (UPPER DEVONIAN)--Limestone, mudstone, and siltstone. Lower Mississippian McGowan Creek Formation consists of an upper mudstone and siltstone underlain by limestone. Mudstone and siltstone, grayish-black and pale-yellowish-brown; shaly; carbonaceous, largely noncalcareous, but with scattered limestone lenses; largely unfossiliferous except for conodonts (Sandberg and Poole, 1977); weathers dark gray; forms swale; about 150-250 ft thick. Limestone, medium-dark-gray to dark-gray; aphanitic; silty; argillaceous; trace fossils common, body fossils rare;, weathers light olive gray to grayish red; even bedded; beds 0.5-1.5 ft thick; locally forms cliffs, but mostly makes up rubble-covered slopes; thinner sections sheared; estimated thickness of limestone 150-400 ft. McGowan Creek Formation unconformably overlies Three Forks Formation; thickness about 300-600 ft. Upper Devonian Sappington Member of Three Forks Formation consists of siltstone and mudstone, grayish-black, gray, and yellowish-brown; laminated; largely noncalcareous, and silicified; large limestone concretions present in lower part; basal lag sandstone present; formation forms covered swales; overlies unconformably Jefferson Formation where that formation is present. Description modified from Sandberg (1975) and Sandberg and Poole (1977) and Scholten and Ramspott (1968). Thickness of Three Forks 75-100 ft. Local weakly anomalous uranium, vanadium, silver, and base metal concentrations in both formations (Skipp and others, 1983)

Dj JEFFERSON FORMATION (UPPER DEVONIAN)--Dolomite, dolomitic limestone, limestone-dolomite breccia, and conglomeratic sandstone. Dolomite, light-gray to medium-dark-gray; finely crystalline; weathers light gray; thin to medium bedded. Limestone, medium-gray; locally porous with cubic solution cavities "filled with silty limy matrix" (Scholten and Ramspott, 1968, p. 15); weathers yellowish brown and gray. Limestone-dolomite breccia, medium-gray and light-olive-gray, and is composed of subangular fragments that average about an inch on a side in a carbonate matrix, weathers olive gray and gray. Basal conglomeratic sandstone, light-gray; laminated; calcareous; composed of quartz grains and pebbles up to 1/4 in. in diameter of Middle(?) Proterozoic sandstone and Middle Ordovician Kinnikinic Quartzite in a calcareous matrix (Scholten and Ramspott, 1968, p. 15); weathers light olive gray and yellowish brown; about 1 ft thick. Angular solution cavities and limestone-dolomite breccia are mainly evaporite solution features (Poole and others, 1977). Formation medium to thin bedded; unconformably overlies Kinnikinic Quartzite or Middle(?) Proterozoic sandstones. Anomalous silver and base-metal concentrations in dolomite present throughout outcrop area. Formation has been removed locally by Late Devonian (pre-Sappington) erosion. Measured thickness from an eroded edge to 215 ft (Scholten and Ramspott, 1968, p. 15)

MDmj MCGOWAN CREEK FORMATION (LOWER MISSISSIPPIAN), SAPPINGTON MEMBER OF THREE FORKS FORMATION (UPPER DEVONIAN), AND JEFFERSON FORMATION (UPPER DEVONIAN), UNDIVIDED

MDu MIDDLE CANYON FORMATION (UPPER AND LOWER MISSISSIPPIAN), MCGOWAN CREEK FORMATION (LOWER MISSISSIPPIAN), SAPPINGTON MEMBER OF THREE FORKS FORMATION (UPPER DEVONIAN), AND JEFFERSON FORMATION (UPPER DEVONIAN), UNDIVIDED--Locally mapped on Fritz Creek thrust plate in areas of heavy timber

Ob BEAVERHEAD MOUNTAINS PLUTON (FORMERLY BEAVERHEAD PLUTON OF SCHOLTEN AND RAMSPOTT, 1968) (MIDDLE ORDOVICIAN)

Obg Granite, grayish-orange to light-brown; holocrystalline, medium to coarse grained, and includes both one- and two-feldspar rocks. Unaltered rocks contain more than 23 percent quartz, and 65 percent alkali feldspar; in two-feldspar rock, albite commonly makes up less than one-third total feldspar. Biotite, opaque minerals, zircon, and apatite constitute 5 percent of rock. Altered rocks made up of quartz, sericite, and magnetite with no relict structures. Granite intrudes Kinnikinic Quartzite, and is intruded by numerous aplite bodies. ^{207}Pb-^{206}Pb radiometric ages of 481 m.y. and 484 m.y. obtained on zircons from near the mouth of Eighteenmile Creek northeast of study area (Evans and Zartman, 1981). Description modified from Ramspott (1962) and Scholten and Ramspott (1968)

Obs Syenite or leucosyenite, pale-red, to pale-brown; weathers to shades of brown; medium to coarse grained, holocrystalline, phaneritic. Composed of 80-95 percent feldspar, 0-16 percent quartz, less than 5 percent biotite, opaque minerals, zircon, apatite, and as much as 10 percent actinolitic amphibolite altered to chlorite and opaque dust (Skipp and others, 1979), or carbonate and sphene (Scholten and Ramspott, 1968). Secondary minerals include sericite, hematite, chlorite, leucoxene, limonite, magnetite, and quartz. Numerous aplitic dikes cut the syenite. Syenite intrudes Middle(?) Proterozoic sandstone and Kinnikinic Quartzite. Description modified from Ramspott (1962), Scholten and Ramspott (1968), and H. J. Prostka (in Skipp and others, 1979). A K-Ar age of 441 ± 15 m.a. (mega annum) was reported on biotite from a microsyenite dike that cuts the main syenite body near Willow Creek (Ramspott and Scholten, 1964). A Rb-Sr age of 460 ± 10 m.a. determined on syenite from hanging wall of the Black Mountain thrust at locality 7 (C. E. Hedge, written commun., 1980)

Obm Meladiorite, dark-gray to dark-brown, very coarse grained, holocrystalline, granitoid; composed of about equal parts of slightly sericitized plagioclase and hornblende, and a few percent of biotite, magnetite, potassium feldspar, apatite, and zircon; weathers dark gray and brownish black; locally forms knobs. Description modified from H. J. Prostka (in Skipp and others, 1979). Meladiorite present only on hanging wall of Black Mountain thrust where it intrudes Middle Proterozoic(?) sandstone. K-Ar ages of 482 ± 16 m.a. and 467 ± 16 m.a. were determined on biotite and hornblende, respectively, from locality 8 on Black Mountain thrust plate (R. F. Marvin, written commun., 1979)

Ok KINNIKINIC QUARTZITE (MIDDLE ORDOVICIAN)--Orthoquartzite, light-gray to yellowish-gray; medium to thick bedded; locally crossbedded; medium to fine grained; generally well sorted, composed almost entirely of subrounded to well rounded vitreous quartz grains cemented by authigenic quartz overgrowths; includes <5 percent grains of zircon, tourmaline, titanaugite, and alkalic feldspar (Scholten and Ramspott, 1968). Brown or yellowish-brown limonitic stains or blotches common; forms cliffs and ledges. Overlies Middle(?) Proterozoic sandstones with a moderate angular discordance (Scholten and Ramspott, 1968). Estimated thickness from erosional feather edge to a minimum 1,000 ft; removed by pre-Jefferson erosion through much of the area

Ys SANDSTONE (MIDDLE ? PROTEROZOIC)--Sandstone, minor mudstone and conglomerate. Sandstone, mostly pale red, grayish-green, and light- to dark-gray; fine to coarse grained; weathers reddish brown to light gray; medium to thick bedded; locally crossbedded or laminated, exhibits ripple marks, slump structures, and mudcracks (Scholten and Ramspott, 1968); locally conglomeratic; quartzose, feldspathic, or micaceous. Subangular to subrounded grains consist largely of quartz, 10-30 percent altered feldspar, mostly alkali feldspar, some calcic plagioclase, and lithic fragments including chert, quartzite, gneiss and mudstone. Matrix is mostly sericite, clay, and chlorite, and some calcite. Mudstone, dark-reddish-brown and dusky-red-purple; locally silty; commonly micaceous; thin bedded to shaly; locally weathers reddish brown with dusky yellow green spots; sheared locally. Conglomerate, pale-grayish-red and light-olive-gray; matrix supported; granules and pebbles composed of flat, dark reddish brown clay fragments as much as 1 in. in diameter distributed along bedding planes, or subrounded quartz and lithic fragments as much as 0.5 in. in diameter in sandstone matrix. Unit forms ledges, cliffs, and steep slopes, and has unconformable contact with overlying unit. Estimated thickness more than 1,500 ft

Ad DILLON GRANITE GNEISS OF HEINRICH (1953) (ARCHEAN?)--Granite gneiss, pinkish-gray to brownish-black; dominant quartz and alkali feldspar, sodic plagioclase, biotite, hornblende, apatite, zircon, and, locally garnet; weathers largely light brown and moderate brown; cut by pegmatite, aplite, and diabase dikes. Overlying sedimentary rocks rest on gneiss with angular unconformity. Description modified from Scholten and Ramspott (1968). Unit exposed only along north-central edge of map area; possible Archean age extrapolated from radiometric ages published for basement crystalline rocks in southwestern Montana by James and Hedge (1980), Perry (1982), and Perry and others (1983)

CONTACT--Dashed where approximately located

FAULTS--Dashed where approximately located; dotted where concealed

Fault--Bar and ball on downthrown side where mostly normal slip. Single arrows indicate mostly strike slip on map, thrust or normal slip on cross section. Double arrows indicate both thrust and normal slip on cross sections

Thrust fault--Sawteeth on upper plate

Reverse fault--R on upthrown side

FOLDS--Showing trace of axial plane; dashed where approximately located

Anticline

Overturned anticline--Showing direction of dip of limbs

Syncline

Overturned syncline--Showing direction of dip of limbs

Monocline--Showing direction of dip of steep limb

STRIKE AND DIP OF BEDS

Inclined

Overturned

Vertical

Horizontal

Crumpled

Estimated

Top of bed verified by sedimentary structures such as crossbeds, ripple marks, or graded beds

STRIKE AND DIP OF CLEAVAGE

Inclined

Vertical

RIDGE-TOP TRENCH PRODUCED BY SACKUNGEN

QUARRY

MINE OR PROSPECT

SAMPLE LOCALITY AND NUMBER

K-Ar (1) Potassium-argon radiometric age determination

Sr-Rb (1) Strontium-rubidium radiometric age determination

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geologic survey of the Italian Peak Roadless Area (I1945) in the Beaverhead National Forest, Beaverhead County, Montana, and the Italian Peak Middle Roadless Area (M4945) in the Targhee National Forest, Clark and Lemhi Counties, Idaho. The Italian Peak and Italian Peak Middle Roadless Areas were classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

INTRODUCTION

Location and topography

The Italian Peak (I1945) and Italian Peak Middle (M4945) Roadless Areas comprise, respectively, about 12,996 acres in the Beaverhead National Forest, Beaverhead County, Mont., and 42,500 acres in the Targhee National Forest, Clark and Lemhi Counties, Idaho. The areas join along the Continental Divide, which is also the Idaho-Montana State boundary. They have similar geology and are referred to collectively as the study area or the roadless areas (fig. 1).

The Italian Peak Roadless Areas are located in the southern Beaverhead Mountains about 17 mi southwest of Lima, Mont., and about 25 mi northwest of Dubois, Idaho (fig. 1). The study area is covered entirely by U.S. Geological Survey 15-minute topographic quadrangle maps. The borders of the area are irregular and are defined by the Targhee Forest boundary on the northwest, parts of the Continental Divide on the north, and segments of township and range and section lines on the east and south. Several segments of the boundary follow drainages.

The Continental Divide trends irregularly eastward through the study area. Several major peaks, including Italian Peak (10,998 ft) make up the divide and stand well above timberline, which occurs at about 9,600 ft. Other major peaks, including Scott Peak (11,393 ft), the highest point in the area, lie southeast of the Continental Divide. Maximum relief in the area is about 4,600 ft, and annual rainfall ranges from 16 to 32 in. (U.S. Geological Survey, 1970).

Pleistocene alpine glaciers, their meltwaters, and steep-gradient, fast-moving streams sculptured the deep valleys and canyons of the area. These valleys and canyons now either are dry or are occupied by small perennial or intermittent streams that reflect the much drier Holocene climate.

For this geologic study of the Italian Peak Roadless Areas, the geology of a part of the Edie Ranch quadrangle (modified from Skipp and others, 1979) has been added to the northeastern corner of the map. This geology is not shown on the mineral resource potential map of the same study area (Skipp and others, 1983). The addition has facilitated construction of diagrammatic cross sections illustrating an interpretation of structures at shallow depths beneath the area.

Previous work

Previously published geologic maps at several scales that have covered parts of the map area of this report include: Umpleby (1913); Kirkham (1927); Scholten and others (1955); Scholten and Ramspott (1968); Skipp and Hait (1977); and Skipp, Prostka, and Schleicher (1979). Maps at the same scale as this report (1:62,500) are included in Scholten and Ramspott (1968) and Skipp, Prostka, and Schleicher (1979).

Various stratigraphic and structural aspects of the region have been discussed in: Sloss and Moritz (1951); Sloss (1954); Scholten (1957, 1960, 1961, 1967, 1968, 1973, 1982); Scholten and Hait (1962); Huh (1967); Sandberg (1975); Rose (1976); Poole and others (1977); Ruppel (1975, 1978, 1982); Skipp, Hoggan, Schleicher, and Douglass (1979); Skipp (1979, 1981, 1982); Gutschick and others (1980); Skipp, Sando, and Hall (1979); Skipp and Hall (1980); Garmezy (1981); Perry and others (1981); Perry and Sando (1982); and Perry and others (1983).

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REGIONAL STRUCTURE AND STRATIGRAPHY

The southern Beaverhead Mountains are both a part of the Cordilleran thrust belt and a part of the younger Basin-and-Range province (Reynolds, 1979). Late Cretaceous, possibly Paleocene, thrusting moved all Archean(?), Proterozoic, Paleozoic, and Mesozoic rocks at least several miles from the southwest or west to their present positions. All Cenozoic rocks and deposits that unconformably overlie these allochthonous rocks have formed in place. Both allochthonous and autochthonous rocks subsequently have been offset and tilted by Cenozoic extension faults, some of which are still active.

Proterozoic and Paleozoic rocks in the southern Beaverhead Mountains were deposited near the Cordilleran hingeline on the cratonic platform (to the east) and outer cratonic platform or shelf margin (to the west). During Late Cretaceous to early Paleocene(?) thrust faulting, rocks deposited on the shelf margin were thrust eastward over those deposited on the cratonic platform primarily along the Medicine Lodge and Cabin thrust faults (fig. 2). Proterozoic and Paleozoic rocks, chiefly sandstones and carbonates, of the Medicine Lodge, Cabin, Fritz Creek, and Hawley Creek thrust plates were deposited in shallow seas west of the shelf margin. Paleozoic rocks of the Tendoy plate underlying the Medicine Lodge thrust were deposited on the cratonic platform. The Tendoy thrust lies northeast of the map area (fig. 2).

The Proterozoic and Paleozoic sedimentary sequences deposited west of the shelf margin record several periods of uplift and erosion and one of intrusion. Uplift and erosion removed parts of or all existing deposits in Late Proterozoic and(or) Cambrian time, in scattered periods of Late Ordovician through Middle Devonian time, in middle Late Devonian time, in latest Devonian and earliest Mississippian time, and in Late Permian time. In Middle Ordovician time, the area was intruded by granite and syenite of the Beaverhead Mountains pluton.

Lower Triassic marine rocks were deposited across both the former Paleozoic cratonic platform and shelf margin areas, but were removed by erosion from large areas of the former shelf margin before and during thrusting.

Jurassic and Lower Cretaceous rocks, largely nonmarine, are preserved only in the area of the Paleozoic cratonic platform.

By Late Cretaceous time, thrust plates of the Beaverhead Mountains were contributing detritus to the synorogenic Divide quartzite conglomerate unit of the Beaverhead Formation. Late Cretaceous pollen and spores of post-Santonian age have been identified by R. L. Tschudy (written commun., 1983) from the Divide quartzite conglomerate unit beneath the Medicine Lodge thrust 1/2 mi east of the map area. Elsewhere, the Beaverhead Formation has been dated as Late Cretaceous to Paleocene(?) (Ryder and Ames, 1970; Ryder and Scholten, 1973; and Perry and others, 1983).

Autochthonous Cenozoic rocks ranging in age from middle Eocene to Holocene rest with profound angular unconformity on the allochthonous Archean(?), Proterozoic, Paleozoic, and Mesozoic rocks. The Eocene mafic to intermediate Challis Volcanics, Miocene(?) lacustrine, hot springs, and fluvial deposits, Miocene and Pliocene rhyolite ash flow tuffs, and Pliocene to Holocene alluvial and glacial deposits crop out on the flanks of the southern Beaverhead Mountains. Challis Volcanics and Tertiary gravels locally cap the Continental Divide.

At least four sets of extension faults offset the rocks of the southern Beaverhead Mountains. The four sets range in age from pre-middle Eocene (set 1) to Holocene (set 4). Most of the faults probably are listric at depth, and movement on several appears to have occurred either along older Mesozoic thrust faults, or along stratigraphic zones of weakness.

Set 1 consists primarily of the Divide Creek fault zone, parts of which are buried beneath Challis Volcanics (fig. 2). Sets 2 and 3 offset Pliocene rhyolites and fan gravels of early Pleistocene age and effectively drop large blocks of the Beaverhead Mountains down to the south and west. Set 4, the youngest, includes the north-northwest-trending Beaverhead fault zone along the west side of the Beaverhead Mountains, and the Deadman fault zone (fig. 2). Fault scarps along the Beaverhead fault offset younger fan gravels and Pinedale outwash in Birch Creek Valley. Regionally, set 4 includes the reactivated fault scarps that resulted from the October 28, 1983, Borah Peak earthquake in central Idaho.

SUMMARY OF STRUCTURE AND STRATIGRAPHY

Thrust plates and allochthonous rocks

Figure 2 shows the distribution of major thrust plates in the map area. From west to east, and from structurally highest to lowest, these are: the Hawley Creek, the Fritz Creek, the Cabin, the Medicine Lodge, and the Tendoy. Rocks of the upper three thrust plates, the Hawley Creek, the Fritz Creek, and the Cabin, are present at the surface in the Italian Peak Roadless Areas. Rocks of the other plates underlie part of the study area, and are shown diagrammatically in cross sections A-A' and B-B', constructed largely from interpretation of surface geology and gravity data (Kulik, in press).

Paleozoic rocks of all plates are folded and faulted. Open concentric and overturned folds are present, and disharmonic folding is common.

The Hawley Creek thrust plate, the structurally highest plate, and the defining thrust, the Hawley Creek thrust, crop out in the northwestern corner of the study area. The Hawley Creek thrust was first mapped and named by B. K. Lucchitta (1966) for exposures in the central Beaverhead Mountains and is extended into the study area for the first time in this study.

The thrust plate is folded and offset locally by a tear fault along Willow Creek. The Wilmot Gulch thrust just west of the study area is a hanging wall imbricate of the Hawley Creek plate. Two footwall imbricates are illustrated on cross section A-A'.

The thrust plate extends as far north as the central Beaverhead Mountains (Lucchitta, 1966). Southern and western extensions have been faulted down to the west along the Beaverhead fault zone and buried beneath Cenozoic fill of Birch Creek Valley.

Proterozoic and Paleozoic rocks of the Hawley Creek thrust plate include at least several hundred feet of Middle(?) Proterozoic sandstone, a minimum of 1,000 ft of Ordovician Kinnikinic Quartzite, an undetermined thickness of syenite and granite of the Ordovician Beaverhead Mountains pluton (Beaverhead Granite or pluton of Scholten and others, 1955, and Scholten and Ramspott, 1968), 75-215 ft of dolomite, limestone, and sandstone of the Devonian Jefferson Formation, 75-110 ft of siltstone and mudstone of the Devonian Sappington Member of the Three Forks Formation, and about 300 ft of limestone, siltstone, and mudstone of the Mississippian McGowan Creek Formation. Almost all mining activity of the late 19th century adjacent to the study area on the west was concentrated in Devonian rocks of the Hawley Creek thrust sheet (Shenon, 1928; Anderson and Wagner, 1944; Lambeth and Mayerle, 1983; Skipp and others, 1983).

The Fritz Creek thrust plate comprises about 80 percent of the surface of the study area, which is the type area for the Fritz Creek thrust (Scholten and Ramspott, 1968). The Fritz Creek thrust plate is folded and is offset by east-stepping complex tear faults along Fritz and Webber Creeks (figs. 1, 2). The plate has several hanging-wall imbricates, three east of the Hawley Creek thrust, one in the northeastern corner of the study area, and the Black Mountain thrust southeast of the study area. An antithetic thrust is present in the hanging wall in the vicinity of Webber Creek.

The trace of the Fritz Creek thrust is buried beneath Cenozoic deposits both northwest and southeast of the study area. Paleozoic rocks of the Fritz Creek plate make up most of the southern end of the Beaverhead Mountains south of the study area (Skipp and Hait, 1977). The Beaverhead fault zone truncates the plate along the western margin of the Beaverhead Mountains, and Cenozoic lavas and sedimentary deposits cover the southern extension of the plate along the northern margin of the Snake River Plain. The northern extension of the Fritz Creek plate in the central Beaverhead Mountains recently has been mapped (Skipp and others, 1984).

The Fritz Creek plate is offset by four sets of Cenozoic extension faults resulting in the northeastward or northward tilting of several blocks downdropped to the southwest. Slide blocks of Upper Mississippian rocks that override the Hawley Creek thrust plate west of the study area (fig. 2) may have slid westward off Pliocene or early Pleistocene topographic highs generated by tilting of parts of the Fritz Creek plate in the study area.

Exposed rocks of the Fritz Creek thrust plate differ from those of the Hawley Creek thrust plate in that: (1) the outcrop area of Middle(?) Proterozoic sandstone is much larger; (2) the Ordovician Kinnikinic Quartzite is thin or missing due to post-depositional erosion; (3) only small apophyses of the Beaverhead Mountains pluton crop out, though gravity studies suggest the pluton is a major component of the rocks beneath the surface near Scott Canyon (cross section B-B', Skipp and others, 1983); (4) the McGowan Creek Formation is thicker, up to 600 ft, and the basal limestone is as thick as 400 ft in the eastern part of the study area; and (5) Upper Mississippian and Pennsylvanian formations, dominantly carbonate bank deposits, make up most of the outcrop area. Formations comprising the carbonate bank sequences total 5500 ft and are, in ascending order: Middle Canyon, Scott Peak, South Creek, Surrett Canyon, Big Snowy, and Bluebird Mountain Formations; and the lower part of the Snaky Canyon Formation. Although Permian and Mesozoic rocks are not represented in the Fritz Creek plate in the study area, Permian and Triassic rocks are present to the south (Skipp, Hoggan, Schleicher, and Douglass, 1979).

The Cabin thrust plate comprises the northeastern and eastern margins of the study area (fig. 2). The Cabin thrust was mapped and named for hanging wall exposures of granite gneiss northeast of the study area (fig. 2) that extend several miles to the north (Scholten and others, 1955). The Cabin thrust plate is extended southward beneath cover into the vicinity of Bannack Pass (fig. 1). The plate is offset by two tear faults between Fritz and Webber Creeks. The major structure within the Cabin plate is the Divide Creek extension fault zone, along which the southern part of the plate has been dropped down to the south and west (fig. 2, section A-A').

Rocks of the Cabin plate in the study area include: Archean(?) gneiss, Middle(?) Proterozoic sandstone, the Devonian Three Forks Formation, the Mississippian McGowan Creek, Middle Canyon, Scott Peak, South Creek, and Big Snowy Formations, the Bluebird Mountain Formation of Mississippian and Pennsylvania age, and the lower Pennsylvanian part of the Snaky Canyon Formation. Archean(?) granite gneiss constitutes the leading edge of the Cabin thrust plate northeast of the study area (Scholten and others, 1955; fig. 2). Middle Proterozoic sandstones are locally conglomeratic on the Cabin plate. Rocks of the Devonian Jefferson Formation were not identified in the study area, but are known to be part of the Cabin plate to the north. The Big Snowy Formation is about 300 ft thicker (about 800 ft) on the Cabin plate than on the Fritz Creek plate. The Bluebird Mountain Formation is about 250 ft thicker (550 ft) and is coarser grained on the Cabin plate than on the Fritz Creek.

The ages of thrust movement are not closely constrained by stratigraphic and structural relationships within the study area. A post-Pennsylvanian pre-middle Eocene age is indicated. Regionally, the thrust sheets override Upper Cretaceous beds of the Divide quartzite unit of the Beaverhead Formation, and a Late Cretaceous, possibly early Paleocene, time of emplacement is indicated (Ryder and Scholten, 1973; Perry and Sando, 1982).

A west to east progression of movement of the major thrust plates has been assumed in the construction of cross sections A-A' and B-B'. Such a progression has been documented northeast of the study area (Perry and Sando, 1982). Several hanging-wall imbricates, however, such as the Wilmot Gulch thrust, the unnamed imbricate northwest of Italian Peak, and the Black Mountain thrust, seem to have overridden locked eastern parts of the Hawley Creek or Fritz Creek thrust plates.

Transport distances for the thrusts in the study area are not known. Preliminary reconstructions made from the cross sections A-A' and B-B' for the Fritz Creek thrust indicate minimum shortening from west to east of about 1.5 to 2.7 miles respectively. The stratigraphic differences between the Fritz Creek and Cabin plates are compatible with a relatively small displacement on this part of the Fritz Creek thrust.

Autochthonous basement is deep beneath the study area; Skipp and Hait (1977, cross section C-C') estimated depths as great as 24,000 ft below sea level beneath the Medicine Lodge Valley on the east side of the study area.

Extension faults

Four sets of regional extension faults affect the study area, but only the older three are exposed in it. Set 4 extension faults of Holocene to Pleistocene age, primarily the Beaverhead and Deadman fault zones, crop out in bordering valleys (fig. 2).

Set 1 faults include the Divide Creek fault zone, the northwest-trending fault east of Nicholia Creek, and the generally north-trending faults near the headwaters of Willow Creek (fig. 2). The Divide Creek fault zone, formerly identified as a zone of thrust faults (Scholten and Ramspott, 1968; Scholten, 1982), cuts out stratigraphic section along its length and drops Paleozoic rocks down to the southwest against Proterozoic rocks (cross section A-A'). Parts of the zone are buried beneath middle Eocene Challis Volcanics that yield K-Ar ages as old as 51.4±3.1 m.a. (mega annum), and, thus, the fault must be older than about 50 m.a. and younger than the Cabin thrust. An early Eocene to Paleocene age is indicated. The northwest-trending fault east of Nicholia Creek drops the Fritz Creek plate down to the southwest and is intruded by a basic dike, possibly a feeder to the Challis Volcanics. This fault is interpreted to be a listric normal fault soled on the Fritz Creek thrust (cross section A-A'). The north-trending faults near the head of Willow Creek include the one along which the Park prospect is located (Skipp and others, 1983).

Set 2 faults are younger than faults of set 1 and are truncated by faults of set 3. They include the Grouse Canyon fault, and other generally east-trending faults in the southern part of the area, one fault with reverse movement that crosses Italian Canyon (fig. 2), and possibly, the north-trending faults north of Willow Creek. Stratigraphic offset on the Grouse Canyon fault where it crosses Grouse Canyon is about 2,000 ft. Set 2 faults offset Pliocene rhyolites, and early Pleistocene gravels (Scott, 1982).

Set 3 basin-range extension faults truncate faults of set 2 and include the Crooked Creek and Scott Canyon faults in the study area and the Middle Creek fault east of the area (fig. 2). The Crooked Creek fault was first mapped for exposures along Crooked Creek (Scholten and Ramspott, 1968). In this report, the fault is extended across the western part of the study area, across Willow Creek, and into the vicinity of Eighteenmile Peak. The entire southwestern part of the study area has been dropped down to the southwest as much as 2000 ft (cross sections A-A' and B-B'). The hanging wall of the Crooked Creek fault with its cover of Challis Volcanics has been tilted to the northeast. The Crooked Creek fault cuts gravels as young as early Pleistocene (Scott, 1982). Dip slip on the Scott Canyon fault where it crosses Scott Canyon is about 1,700 ft (cross section B-B'), and it, too, cuts early Pleistocene gravels. Movements on the Crooked Creek fault may have generated topographic highs from which slide blocks originated that now rest on the Hawley Creek thrust plate west of the study area.

Autochthonous rocks ranging in age from middle Eocene to Holocene unconformably overlie Proterozoic and Paleozoic rocks of the thrust sheets, and are offset and rotated by extension faults. Challis Volcanics, primarily latite flows, crop out in the northwestern part of the study area where they have been tilted to the northeast. Small patches of Tertiary alluvial gravels are present along the Continental Divide in the northwest part of the study area. Pinedale glacial till and outwash are common in the central and northwest parts of the area. In Nicholia Creek, till has been modified by secondary mass wasting. Rock glaciers scar the walls of the major glacial valleys such as Willow and Nicholia Creeks.

Oil and Gas Potential

Conodonts recovered from Mississippian limestones on the Fritz Creek and Cabin thrust plates (fig. 2) have color alteration index (CAI) values of 4-6 and 4, respectively, indicating that host rocks have been heated to temperatures of more than 190°C (Epstein and others, 1977), and are supermature with respect to oil. Dry gas would be the only possible contained hydrocarbon (Perry and others, 1981; Perry and others, 1983). Limestones from the front of the Medicine Lodge plate (fig. 2) have CAI values of 1 1/2 to 3; Skipp, Prostka, and Schleicher, 1979; Perry and others, 1981). The lower value is from the leading edge of a hanging wall imbricate of the plate, and the higher value is from the western exposed part of the plate. These western rocks have been subjected to temperatures in excess of 110°C and also are supermature with respect to oil. CAI values from the Medicine Lodge plate outside the map area are even higher and indicate a thermal history similar to that of the overlying plates (W. J. Perry, Jr., written commun., 1983). Surface rocks of the Tendoy plate (fig. 2) have CAI values of 1 east of the study area (Perry and others, 1983), indicating that these rocks have not been heated enough or buried deeply enough to generate petroleum from any included organic material. The thermal history and petroleum potential of these rocks at depth beneath the study area is discussed by Perry and others (1983) and Skipp and others (1983).

MINERAL OCCURRENCES

The northwestern part of the study area includes the northern part of the Birch Creek mining district, which produced lead, silver and zinc in the late 19th century, primarily from the Viola mine and associated properties about 2 mi west of the study area boundary (Lambeth and Mayerle, 1983; Skipp and others, 1983). A reevaluation of the mineral occurrences in this district indicates that the ores probably were stratabound deposits in dolomite of the Devonian Jefferson Formation (Lambeth and Mayerle, 1983; Skipp and others, 1983), rather than hydrothermal deposits as originally described (Shenon, 1928; Anderson and Wagner, 1944). All production was from the hanging wall of the Hawley Creek thrust. Weak geochemical anomalies also have been noted in the adjacent footwall in the study area (Skipp and others, 1983).

The southeastern part of the study area includes a part of the Heart Mountain mineralized area (Skipp and others, 1983) that has been prospected extensively for uranium and vanadium, though no production has taken place to date (1983). The uranium and vanadium minerals are concentrated in shales and siltstones of the Upper Devonian Sappington Member of the Three Forks Formation and the Lower Mississippian McGowan Creek Formation (Wodzicki, and Krason, 1981; Skipp and others, 1983).

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