

equigranular, locally granophyric granite composed of weakly sericitized and argillitized orthoclase, anhedral quartz, subordinate plagioclase (An₅₋₂₀), chloritized biotite, and opaque iron oxides; chloritized hornblende was reported by Anderson (1929, r 23). Weathers very light gray and pale pink; spheroidal weathering common. Intrude volcanic rocks of the Challis Group along southern border of quadrangle; 2 mi south of quadrangle is intruded by a hornblende leucogranite porphyry (Sidle, 1979) Rhyolite lava flows--Lightbrownish-gray, moderategrayish-red-purple to dusky gravish-red-purple, and ligh gray, banded and locally precciated, largely devitrified lava flows. Flows contain 5-10 percent phenocrysts, as much as 1 cm (.39 in) long, of sanidine, plagioclase, chiefly smoky quartz, biotite, and minor amphibole and pyroxene Rhyolite weathers grayish red purple. Flows are vertically jointed, and form ledges and ridges. Unit unconformabl overlies tuffs of Stoddard Gulch (Tts). Unit probably older than dikes of unit Trd (see unit Trp). Estimated thickness ranges from an eroded edge to 400 ft Rhyolite pipes--Gravish-purple to light-gray banded and locally brecciated porphyritic rhyolit containing 10-20 percent phenocrysts as long as 2.5 cm (1 in) of sanidine, plagioclase. quartz and biotite in a finegrained devitrified groundmass. Flowbanding is vertical to subvertical. Monolithologic breccia with fragments as much as 22 ft (7 m) across present locally. Rhyolite is vesicular in places, and black glassy porphyritic chill zones are common. Weathers light olive gray to brownish gray. Locally forms the topographic spires of The Needles where vertically jointed. Pipes probably vent for flows of unit Tr. Ar⁴⁰/Ar³⁹ ages (sanidine and biotite) for rocks of The Needles are 47.38±0.20 Ma and 47.81 + 0.20 Ma. respectively (F.J. Moye and L.W. Snee, written commun. Tuffs of Stoddard Gulch-Gravish-red-purple, pale-red purple, light-olive-gray, very pale orange, brownish-gray to brownish-black, unwelded to densely welded, porphyritic rhyodacitic ash-flow tuff interbedded with thin lava flows and ash-fall and waterlaid tuff. Ash-flow tuff and lava contain 5-30 percent crystal fragments of hornblende, biotite, and minor potassium feldspar and quartz in a fine-grained glassy or devitrified matrix. Pumice lapilli and volcanic, sedimentary, and metamorphic lithic fragments locally are abundant. Vitrophyre, vitrophyre breccia, and hyaloclastite are present locally. Ash-fall and water-laid tuff are well bedded and light gray. Eutaxitic structures are common in welded tuff. Densely welded parts of ash flow tuff and lava flows form ledges. Maximum preserved thickness is 1,500 ft. K-Ar age of flow in lower part of unit in quadrangle to the northeast is 44.3 ± 2.7 Ma (R.F. Marvin, written commun., 1982; Skipp. 1988). This hornblende age probably reflects argon loss and is too young. An arbitrary contact between this unit and the underlying tuff unit (Tta) is shown on the map in the E 1/ sec. 22, and W 1/2 sec. 23, T 3 N., R. 23 E., where rocks of unit Tdl, intervening dacite lava flows, are absent Dacite lava flows--Grayish-redpurple, pale-red-purple, greenish-gray, brownish-gray and medium-gray to grayishblack, porphyritic to glomeroporphyritic dacite and minor quartz latite lava flows Flows contain 10-30 percent phenocrysts of plagioclase, pyroxene, hornblende, biotite, and minor potassium feldspar and quartz. Xenoliths of underlying volcanic rocks, argillite, quartzite, and granitic gneiss are rare. Groundmass of dacite is a very fine- to finegrained mosaic of plagioclase, quartz, opaque minerals, and potassium feldspar. Chilled glassy margins locally are present; flow-banding is common; unit locally brecciated. Flows weather dark yellowish brown, moderate brown, and gravish red where unaltered, and ligh gray to yellowish gray in areas of argillic alteration. Unit has reversed magnetic polarity (Skipp, 1988). Lava flows form cliffs and irregular knobs Thickness ranges from a southern zero edge to about 1,700 ft. Unconformably overlies tuffs of Antelope Creek (unit Tta) Rhyodacite tuff breccia and lav flows--Chiefly grayish-green to greenish-gray, gray, or light vellowish-gray, heterolithologic tuff breccia containing lenses of crystal-vitric tuff, and nterbedded dark-gray lava flows that weather greenish gray, brownish gray, and ligh brownish gray. Tuff breccia averages 65 percent subangular fragments of porphyritic rhyodacite and pumice that average 2 in. (4.5 cm) in diameter, and 23 percent crystals of potassium-feldspa plagioclase, biotite, and hornblende in a fine-grained partly devitrified, chloritic glassy matrix. Tuff lenses contain an average of 40 percent crystal fragments of potassium-feldspar and quarta and lesser amounts of plagioclase, biotite, hornblende, and opaque iron oxides, and 20 percent lithic fragments, including pumice, in a dark-brown glassy matrix. Lava flows consist of porphyritic hornblende-biotite rhyodacite containing 45-60 percent phenocrysts of kaolinized orthoclase, anhedral quartz, partly sericitized and chloritized anhedral sodic plagioclase, and hornblende, biotite, and opaque iron oxides in a finely crystalline matrix of feldspar and quartz. Total thickness of unit about 3,500 ft. Petrographic descriptions and thickness after Sidle (1979). Stratigraphic relationship of unit, which is present only in the southeastern part of the quadrangle, to other Challis Group volcanic units is not clear. The tuff breccia is overlain unconformably by ash flow tuff south of Dry Fork Creek that tentatively is correlated with the tuff of Stoddard Gulch (Tts). Rocks of the rhyodacite tuff breccia unit are faulted against volcanic rocks assigned to the tuffs of Antelope Creek (Tta) in the quadrangle adjacent on the east (Skipp and others, 1990) Andesite dike--Medium-gray porphyritic andesite consisting of phenocrysts up to 5 cm (2 in) long of zoned plagioclase (An₃₅₋₅₅) and pyroxene in a groundmass of plagioclase, biotite, rare hornblende, and apatite, and calcite and chlorite

sandstone, conglomerate, and breccia. Crystal-rich, welded ash-flow tuff is gray, brown, gravish red and gravish green, and contains crystal fragments of plagioclase and pyroxene in the lower part, and plagioclase, pyroxene, hornblende, and biotite in the upper part. Tuffs in both upper and lower parts also contain crystal fragments of opaque oxide minerals, some sanidine, minor quartz, accessory apatite, and local abundant pumice and volcanic and sandstone lithic fragments; the matrix is glassy or devitrified. Black vitrophyres and eutaxitic structures are common, and small vesicles are rare. The ash-flow tuff weathers mostly moderate brown and dark yellowish brown, but locally medium dark gray and vellowish gray Interbedded light gray air-fall tuff commonly is biotite rich. The lava flows contain phenocrysts and volcanic lithic fragments, that are similar to those in the ashflow tuff, in a finely crystalline, locally felty matrix. Light-colored argillic alteration is present in places, and commonly contains secondary sericite, silica, chlorite, actinolite, and calcite. Densely welded parts of the ash-flow tuff and the lava flows locally form ledges; ash-fall tuff and areas of alteration form slopes. Maximum exposed thickness about 2,000 ft. K-A age (biotite) of ash-flow tuff of unit is 47.6 ± 2.1 Ma (R.F. Marvin, written commun. 1982; Skipp and others, 1990) Andesitic tuff breccia--Gravishpurple, grayish-green, mediumlight-gray to dark-gray, potassium-rich, andesite tuff breccia, andesite flows, vitriccrystal tuff, ash-fall tuff, and water-laid tuffaceous claystone, sandstone, conglomerate, and breccia. Tuff breccia, the most abundant rock type, is both monolithologic locally, and heterolithologic, and contains subangular fragments of porphyritic andesite, dacite, and vitric tuff as much as 2 m across, but most are 1-6 cm. Fragments occur in a crystalrich tuffaceous matrix; rims of volcanic clasts are bleached to light gray locally; fragments of argillite and sandstone present in places. Flows consist of glomeroporphyritic andesite which contains 2-25 percent phenocrysts of plagioclase, hornblende, pyroxene, biotite, opaque iron oxide minerals and minor sanidine in a finely microcrystalline groundmass of feldspar and quartz. Felty texture is common; flowbanding is rare. Locally, flows have only mafic phenocrysts as much as 1 cm (.39 in) long clustered in cross-shaped or stellate patterns. Gravish-green sandstone, claystone conglomerate, and breccia are composed of locally derived volcanic clasts, form graded beds, and contain macerated carbonaceous plant material; rare fresh-water clams indicate the presence of ephemeral lakes. All rocks of unit weather grayish green, grayish purple, light olive gray, moderate brown, and medium dark gray; argillic, sericitic, chloritic, and calcitic alteration is common. Flows and breccia form ledges, whereas tuffs and clastic sedimentary rocks form slopes. Unit unconformably overlies basal conglomerate (Tc), and is about 200 to 500 f thick in northwestern corner and central western edge of quadrangle. K-Ar age (hornblende) of flow near base of unit (J.D. Obradovich, written commun. 1976). recalculated to 49.3+0.7 Ma by R.F. Marvin (written commun., 1987; Skipp, 1989) Basal conglomerate, breccia, and sandstone--Light-gray, poorly to moderately consolidated, boulder-to-granule conglomerate and breccia containing rare lenses of coarse-grained sandstone. granule conglomerate, and mudstone. Conglomerate and breccia clasts, as much as 2 m (6.56 ft) long, but commonly less than 10 cm (3.93 in) in diameter, consist of locally derived quartzite, argillite, granule conglomerate, sandstone, chert, and siltstone. set in a matrix of light-gray sandstone or grayish-red mudstone. Matrix is commonly silicified but may be calcareous or absent in places Both matrix-supported and clast-supported fabrics common. Sandstone and mudstone lenses are as much as 3 ft (.91 m thick, and make up less than 10 percent of unit. The unit is thick bedded, locally crossbedded, and weathers moderate brown to yellowish gray. Inferred to have been deposited in an alluvial-fan setting (Paul) 1974: Burton and Blakley 1988). Unconformably overlain by volcanic rocks of the Challis Group. Estimated maximum thickness in quadrangle about 300 ft SEDIMENTARY ROCKS Bloom Member of Snaky Canyon Formation (Upper Pennsylvanian to Upper Mississippian)--Light-gray to gravish-black, mostly mediumto dark-gray, chiefly impure fossiliferous, variably chert limestone. Contains minor interbedded light-gray, very fine grained calcareous sandstone and siltstone. Limestone, commonly sandy, is thick to thin bedded. Faunas include brachiopods, bryozoans, corals, foraminifers, and mollusks that indicate a Late Pennsylvanian to Late Mississippian age (Nelson and Ross, 1969, 1970; Skipp, Hoggan, and others, 1979) for the member. Neither top nor bottom of member is exposed in quadrangle, but a total thickness of 2,200 ft was measured in Mackay 4 (Grouse) NE quadrangle northeast of this quadrangle (Skipp, 1988) (fig. 1) laminated siltstone. Sandstone **Surrett Canyon Formation** is mostly medium gray or (Upper Mississippian)-medium dark gray and Medium-light- to dark-gray, weathers light gray, light medium-gray-weathering brownish gray, and pale chiefly pure, variably cherty yellowish orange. Grain size fossiliferous, medium- to thickranges from fine to very bedded, cliff-forming, locally coarse, but is chiefly medium cavernous limestone. Darker to coarse. Grains are quartz, limestone beds have fetid odor chert, siltstone, argillite, Black and light-gray chert in plagioclase, and quartzite in thin stringers and nodules order of decreasing abundance comprise as much as 25 percent and vary from angular to wel of some beds in upper part, and rounded. Sorting is poor to thin beds and nodules of moderate. Rock fragments are yellowish-brown-weathering more abundant in the coarserincipient chert make up as grained sandstones. Quartz is much as 30 percent of some the dominant cement, but lower beds. Some silty beds interstitial clay and are present in middle part. carbonaceous material are also Thin silty and argillaceous present. Sandstone is limestone partings in upper par interbedded with or grades into weather yellowish gray and gravish-black to medium-dark gravish red. Limestone is gray silty mudstone that typically fossiliferous medium weathers light gray, light olive to coarse-grained wackestone gray, and pale yellowish with lesser mudstone and orange. Mudstone is mostly packstone. Fossils include thin to medium bedded, but is algae, brachiopods, bryozoa, thinly laminated or thick conodonts, corals, crinoids and bedded in places. Mudstone is echinoids, foraminifers, composed chiefly of clay, mollusks, ostracodes, and partially altered to sericite, and trilobites that indicate a Late quartz, epidote, and minor Mississippian (Chesterian) age opaque iron oxides. Minor (Skipp, 1961; Nelson and thinly laminated siltstone is Ross, 1969, 1970; Mamet and light to medium gray and others, 1971). Neither top nor weathers light olive gray and bottom of formation is exposed moderate brown. Siltstone

where present in southeastern

part of quadrangle. Thickness,

determined from map pattern in

quadrangle adjacent on the

and others, 1990)

east, is about 1,300 ft (Skipp

consists of quartz,

of the Helmenthoides

assemblage, and plant stem

impressions are common in both siltstone and mudstone. Well to moderately indurated

conglomerate is light to medium gray, weathers light gray, moderate brown, and grayish orange, and is

carbonaceous mud, chert, and

some plagioclase. Trace fossils

bedded, cliff-forming, locally cavernous limestone. Contains some silty limestone beds, and vellowish-brown-weathering incipient chert nodules and lenses are common in lower part. Black to light-gray chert in lenses and nodules are scattered throughout but make up as much as 50 percent of some beds in the middle part. Limestone is fossiliferous, fine to coarse-grained wackestone packstone, and grainstone with lesser mudstone and boundstone. The abundantly fossiliferous upper two-thirds of unit contains algae. brachiopods, bryozoa. conodonts, corals, echinoids foraminifers, mollusks, ostracodes, pelmatazoa, trilobites, and a few shark teeth that indicate a Late Mississippian Chesterian to Meramecian age (Skipp, 196 Nelson and Ross, 1969, 1970; Mamet and others, 1971). Basal conformable contact is both abrupt and gradational. Top is not exposed in quadrangle. Estimated thickness in quadrangle adjacent to the east is about 1,600 ft (Skipp and others, Middle Canyon Formation (Upper Mississippian)-Medium-gray to grayish-black thin- to medium-bedded. chiefly fine- to mediumgrained, spiculitic, silty limestone that typically has a thin light-gray to light-olivegray rind on weathered surfaces. A few thin noncalcareous siltstone beds ar present in the basal few meters Lower nonfossiliferous beds form steep slopes covered with silty chips; upper laminated beds are poorly exposed and contain a few brachiopods. bryozoa, and some crinoid debris. No age-diagnostic faunas were recovered from this unit in the quadrangle, but foraminifers and conodonts from the formation in the Los River Range to the north (fig. 1) indicate a Late Mississippiar (Meramecian) age (Mamet and others, 1971; Sandberg, 1975 The basal contact is gradationa with the underlying McGowan Creek Formation. Estimated thicknesses in the vicinity of Dry Fork Creek range from 700 ft to about 1,000 ft **McGowan Creek Formation** (Upper(?) and Lower Mississippian)--Chiefly turbidites consisting of mudstone, siltstone, and minor sandstone and limestone. Grayish-black to medium-gray, chiefly fissile, laminated mudstone that weathers light t dark gray, yellowish brown and olive gray. Mudstone is interbedded with varicolored, thin-bedded, calcareous siltstone and fine-grained sandstone, and minor mediun to dark-gray, medium-bedded aphanitic limestone. Granuleto-pebble conglomerates and coarse-grained sandstones present in the lower part of the formation in adjacent quadrangles to the east and northeast (Skipp, 1988; Skipp and others, 1990) are not present in this quadrangle, indicating that only the upper finer grained part of the formation is exposed. Trafossils of the Helmenthoides association, indicate an oxyge poor depositional environment (Ekdale and Mason, 1988), and wood impressions are common In addition, the brachiopods Leiorhynchoidea cf. L. carboniferum (Girty) and Quadratia sp. were identified by J.T. Dutro (written commun., 1974) at fossil locality F-1, and the goniatite Ammonellipsites? sp. was identified at fossil locality Fby Mackenzie Gordon, Jr. (written commun., 1981), who reported that Ammonellipsites is found in middle Osagean

(Lower Mississippian) rocks of the Midcontinent. A middle Osagean conodant fauna was identified in limestone about 800 ft above the base of the unit 5 mi east of this quadrangle (Skipp and others 1990). At this locality, the formation unconformably overlies Devonian carbonate rocks. Unit has a minimum exposed thickness of 1,000 ft in the quadrangle. A total thickness of about 2,000 ft was measured in the adjacent quadrangle to the east, and the formation thickens westward as shown on the cross section (Skipp, Sando, and Hall, 1979; Skipp and others, 1990 Copper Basin Formation (Upper and Lower Mississippian Upper member (Upper Mississippian)--Medium-ligh gray to medium-gray and oliv gray, poorly sorted, fine- to very-coarse-grained, mediumto thick-bedded, lithic sandstone that weathers brownish gray to moderate brown, and dark-gray to gravish-black mudstone or argillite that weathers ligh gray to dark gray. Sandsto and argillite have rare molds and casts of brachiopods. mollusks, and crinoid stems Better preserved similar taunas from a dolomitic sandstone lens in argillite about 2 mi northwest of quadrangle abov Iron Bog Creek were identified as Late Mississippian (Chesterian) by J.T. Dutro, Jr. (written communs., 197 1980), and are equivalent in age to faunas of the South Creek and Surrett Canyon Formations. Upper and lower contacts not exposed in quadrangle. Contact with upper clastic member probab gradational to the northwest in Iron Bog Creek. Minimum thickness in Iron Bog Creek i 1,900 ft (Skipp, Sando, and Hall, 1979). Present only in northwesternmost corner of Upper clastic member (Lower Mississippian)--Chiefly turbidites consisting of light-t dark-gray thinly laminated to thickbedded sandstone, gravisl black to dark-gray mudstone granule to cobble conglomerate, and thinly

of chert, quartz, siltstone, approximately located; dotted quartzite, and minor sandstone where concealed; bar and ball on apparent relative and mudstone are set in a downthrown side; number quartz sand or carbonaceous mud matrix. Sole markings, indicates observed dip of fault small-scale crossbedding, cutplane. Arrows indicate and-fill structures, rip-up apparent relative lateral clasts, and slump structures are movement common in the unit. An Photo lineament--Probable fault or ammonoid fauna (USGS collection 27877-PC) fracture with undetermined containing Pericyclus (Goniocyclus)? decipien Thrust fault-Dashed where Gordon of late Kinderhookian age (Gordon, 1986) was collected by R.A. Paull from

mudstone near locality F-4 and supports an Early Mississippian age for the member which has on lateral ramp a gradational contact with the Drummond Mine Limestone below. The upper clastic member is equivalent to the Scorpion Mountain and Muldoon Canyon Formations and lower part of the Brockie Lake Conglomerate of the Copper Basin Group of Bollmann (1971). Measured minimum thickness of these

combined formations in secs.

4, 5, and 10, T.2 N., R. 23 E

is 4,800 ft (Bollmann, 1971).

exposed in the quadrangle

Drummond Mine Limestone

Mississippian)--Limestone

conglomerate and sparse

is chiefly gravish black to

medium gray, but locally is

pale yellowish brown and gray

vellowish gray, pale vellowish

purple. Limestone is chiefly

laminae and thick beds are

common. Limestone locally

(conodonts, foraminifers, and

ostracodes), argillaceous, fine

to medium-grained mudstone.

wackestone, and packstone that

contain minor quartz silt and

fine-grained sand and euhedral

pyrite. Limestone has a fetid

odor on fresh surfaces. Minor

rounded light-gray clasts of

mudstone as much as 10 cm

(3.93 in) in diameter in a dark

onglomerate weathers grayish

gray argillaceous matrix. The

mudstone interbeds are dark

gray or black. These limestone

turbidites appear to represent

characterized by alternating

environments (Bollmann, 197

Nilsen, 1977). The unit is

Mississippian) in age at the

this quadrangle (Paull and

vpe section 9 mi northwest of

others, 1972; Sandberg, 1975)

A late Kinderhookian conodont

fauna containing Bispathodus

Scott), Bispathodus stabilis

communis (Branson and Mehl),

and Siphonodella isosticha-

Sandberg and others (1978)

was identified by J.E. Repetski

(written commun., 1979) from

uppermost part of the member

index (CAI) of elements in the

Unit has a measured minimum

Mine Creek in sec. 3 and 10,

T. 2 N., R. 23 E. where the

base is not exposed (Bollmann

was measured at the type

1971). A thickness of 2,600 ft

section 9 mi northwest of this

quadrangle (Paull and others,

Little Copper Member (Lower

Mississippian)--Chiefly

interbedded dark-gray to

grayish-black mudstone, thinly

minated to medium-bedded

medium-gray to grayish-black

sandstone, and minor granule

interbedded with minor pebble

to cobble mudstone of probable

mudflow origin. Mudstone is

siliceous, commonly laminated

Helmenthoides feeding trails

bedding surfaces, and weathers

light olive gray, light brown.

and grayish orange; forms

slopes. Sandstone is chiefly

very fine- to medium-grained,

some conglomeratic; grains are

angular to well rounded and

quartzite, and rare mica and

epidote in a carbonaceous clay

matrix containing abundant

common siliceous cement;

structures, flute casts, ripple

marks, and graded beds are

common; weathers light gray,

Conglomerate is chiefly clast

rounded larger clasts, mostly

diameter (cobble size) of dark

sandstone as described above

weathered argillite in a dark-

weathers light brown and ligh

gray sandstone matrix that

olive gray; thin bedded in

lower part to thick bedded in

upper part; forms ledges.

Pebble- and cobble-bearing

mudstone contains subangula

quartzite, and minor limestone

in a dark gray siltstone or fine-

to rounded clasts of chert,

grained sandstone matrix

structures; forms slopes.

percent, sandstone 25 percent

a partial measured section,

2,325 ft (702 m) thick, on the

east side of the ridge between

Creek (Bollmann, 1971). The

coarser-grained in the upper

part. Strata in the measured

section were assigned to the

Muldoon Canyon Formations

by Bollmann (1971), but are

Member on this map because

they are structurally overlain

Limestone Member along a

normal fault. The member in

by the Drummond Mine

the type section at Little

Copper Creek about 13 mi

west-northwest of Dry Fork

Creek is more than 3,700 ft

conglomerates (Paull and

Gruber, 1977). In both the

type area and at Fish Creek

Reservoir the Little Copper

unconformably by Devonian

rocks (Winkler, 1989; Link and

Formation is underlain

others, 1988).

as coarse as cobble

thick and does not include beds

reassigned to the Little Copper

Scorpion Mountain and

member is thicker-bedded and

Fish Creek and Dry Fork

and conglomerate 10 percent of

characterized by

granule size but locally as

much as 23 cm (9 in) in

gray radiolarian chert,

carbonaceous mudstone

and white and vellow

quartzitic siltstone,

supported and consists of

angular smaller, to well-

light brown, and pale yellowish

opaque iron oxides and

synsedimentary slump

brown; forms ledges.

consist of quartz, chert,

and plant impressions on

to cobble conglomerate,

and silty, contains

turbidites consisting of

thickness of 900 ft near Iron

fauna at locality F-3 is 4.5.

The conodont color alteration

obsoleta transition form of

fossil locality F-3 at the

Branson and Mehl),

Polygnathus communis

orange. Rare argillaceous

basin-plain deposits

stagnant and turbid

Kinderhookian (Early

limestone conglomerate

consists of subangular to

present. Graded beds are

consists of fossiliferous

medium bedded, though thin

reddish purple. Weathered

rocks are white, light gray,

brown, and pale reddish

turbidites and minor limestone

mudstone interbeds. Limestone

Member (Lower

The top of the member is not

Overturned syncline-Showing direction of dip of limbs Overturned anticline-Showing direction of dip of limbs Strike and dip of beds Inclined Vertical

Calcite vein

Argillic alteration

(CAI) value

Small cinder con

STRUCTURE

Basin thrust juxtaposes these two Mississippia

facies and probably broke through near the

Mississippian Antler flysch trough (Nilsen,

to the west in order to accommodate rapid

Mississippian strata. Blocks uplifted along

such inferred faults also may have been the

source for local coarse detritus in rocks of the

(Skipp and others, 1990) indicate that western

clastic strata of the hanging wall block of the

Little Copper Member. CAI values of 4 1/2

west of the thrust and 2-4 east of the thrust

Copper Basin thrust probably were buried

under thicker overburden than those of the

indicate a dip separation of the

footwall block. Cross-section A-A' and the

cross section shown by Skipp and Worl (1990)

Devonian/Mississippian boundary of about a

different, actual transport due to thrusting may

Independent evidence suggests that pre-

have been more; smaller net separation along

the fault could be explained by later normal

down-to-the-west movement on the fault.

contraction in the area. The relatively low

angle (locally 35°) west-dipping Iron Mine

Formation in the hanging wall block of the

Copper Basin thrust, but does not offset rocks

of the Challis Volcanic Group, and is intruded

by late-stage Eocene rhyolite dikes. Normal

novement on the earlier formed Copper Basi

thrust may have taken place at the same time.

The northwest-striking normal fault segment in

the southwest corner of the quadrangle also is

part of a down-to-the-southwest fault that omits

reactivated in post-Challis time, as it appears to

normally offset rocks of the Challis Volcanic

Group. East-west-oriented normal faults that

are common in the Cold Peak area also formed

chiefly in pre-Challis time though they are

represented by the generally north- and east-

trending late-stage Challis dikes and plutons in

nearly orthogonal to the Iron Mine fault.

Syn-Challis (Eocene) extension is

the area. North of the quadrangle, the

extension in a north-northwest to south-

and Paylis, 1988).

dominant dike trend is N 70° E indicating

southeast direction, similar to that associated

with the formation of the Pioneer gneiss dome

18 mi to the northwest (Wust, 1986; O'Neill

Northeast-trending post-Challis extensional

fault zones offset Challis Volcanic Group rocks

in northern and southeastern parts of the

normal fault zone that cuts across the

quadrangle. The sinuous northeast-trending

northwestern part of the quadrangle drops

volcanic rocks of the Challis Volcanic Group

northwest and tilts them to the southeast. This

(Skipp, 1988; 1989) and possibly originated as

a segment of a breakaway fault in the upper

plate of the Pioneer gneiss dome complex of

however, also offset Idavada Volcanics that

north indicating reactivation after 9.4 Ma on

southeast than the underlying Eocene volcanic

fault in the vicinity of Dry Fork Creek and

Price Canyon drops Paleozoic rocks and rocks

of the overlying Challis Volcanic Group down

downwarping of the Snake River Plain. These

two post-Challis fault zones bound a northeast

trending horst block of Paleozoic rocks that

forms the core of the quadrangle.

Volcanics and may be related to Neogene

to the southeast. This fault also offsets Idavada

rocks. Another north-northeast-striking normal

these segments. The downdropped Idavada

Volcanics dip less steeply to the east and

unconformably overlie Challis rocks to the

Eocene age. Large fault segments of this zone,

and underlying Paleozoic strata down to the

fault zone curves into a north to northwest

trend in adjacent quadrangles to the north

Copper Basin Formation strata south of this

quadrangle; this fault may have been

Challis extension followed Mesozoic

normal fault omits beds of the Lower

Mississippian part of the Copper Basin

mile along the Copper Basin thrust. Because

rocks on either side of the thrust are so

1977). Cross section A-A' diagrammatically

shows Devonian and older rocks faulted down

eastern margin of deeper parts of the

westward thickening of the Lower

argillites of the Little Copper Member in secs. 23, 24, and 26, T. 3 N., R. 23 E. Galena was mined from these prospects early in the century Overturned (Anderson, 1929). A small mine located near Folded, showing average orientation of beds Estimated from air photos or from distance on ground Strike and dip of flow bands and eutaxitic structures

Horizontal Strike and dip of prominent cleavage or fracture Inclined Vertical geothermal energy as well as for renewed Tectonic breccia

Fossil locality and number Conodont color alteration inde Last Chance and Hornsilver mines, Lava Creek district, Butte County, Idaho: 56, p. 451-482.

Outline of basalt vent crater Paleozoic rocks of the quadrangle form parts of two Mesozoic Cordilleran thrust plates, the structurally higher Copper Basin plate on the west and the Grouse plate on the east (fig. 1). The Copper Basin thrust, the basal thrust of the Copper Basin plate, is steep, dipping about 60° to the west in the quadrangle, and is offset sinistrally by two oncealed northeast-striking faults. The northern northeast-striking buried fault zone Characteristic trace-fossil associations in that offsets the thrust about 4 miles to the east oxygen-poor sedimentary environments: is interpreted to be a lateral ramp or tear fault Geology, v. 16, p. 720-723.

South of this fault, rocks in both the hanging-Epstein, A.G., Epstein, J.B., and Harris, wall and footwall blocks of the Copper Basin L.D., 1977, Conodont color alteration--An thrust are older than rocks north of the fault. index to organic metamorphism: U.S. Clastic rocks above and below the thrust are of Geological Survey Professional Paper 995, Early Mississippian age in the Dry Fork Creek area, whereas rocks in similar structural Gordon, Mackenzie, Jr., 1986, Late Kinderhookian (Early Mississippian) Ammonoids of the Western United State The Paleontological Society Memoir 19 (Journal of Paleontology, v. 60, no. 3, Supplement), 36 p. Kuntz, M.A., Champion, D.E., Lefebvre, R.H., and Covington, H.R., 1988, Geologic map of the Craters of the Moon. Kings Bowl and Wapi lava fields, and the Great Rift volcanic rift zone, south-central Idaho: U.S. Geological Survey Miscellaneous Investigations Series Map I-632, scale 1:100,000. Kuntz, M.A., Spiker, E.C., Rubin, Meyer Champion, D.E., Lefebyre, R.H., 1986 Radiocarbon studies of Latest Pleistocene

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may be related to the downwarping of the Snake River Plain and be Neogene or younger Latest Pleistocene basalt cinder cones and flows in the Dry Fork area are part of a northwest continuation of the Great Rift volcanic rift zone that intersects the Snake River Plain south of the quadrangle (Kuntz and others, 1988). The Great Rift accommodated

extension in the same southwest-northeast direction as Neogene to Holocene basin-range faulting in the mountains north of the Snake A northwest-trending 300 nanotesla positive magnetic anomaly near the uthwestern corner of the quadrangle (U.S. Geological Survey, 1972) suggests the presence

approximately located; dotted where concealed. Sawteeth on upper plate. Arrow indicates of the shallow basaltic dike swarm shown in apparent sense of lateral offset the western part of the cross section. MINERAL AND ENERGY RESOURCES Anticline-Showing trace of axial

plane and plunge direction; The western part of the Lava Creek mining dashed where approximately district is located within the quadrangle (fig. 1). Known mineral deposits of silver-lead ore consist of veins and replacement bodies in Syncline--Showing trace of axial Paleozoic limestones intruded by rhyolite dikes plane and plunge direction; (Anderson, 1929). Small amounts of silverdashed where approximately lead sulfide ore are still being extracted from the Leadbelt mine, first established about 1890. Veins and replacement bodies are in the Upper Mississippian Middle Canvon Formation near the head of Leadbelt Creek. Oxidized silverlead ores in veins in the Drummond Mine

Limestone Member of the Copper Basin Formation were mined in the early part of the century on the north slope of hill 9143 about 1 mi north of Blizzard Mountain, called Boyle Mountain by Anderson (1929), but there has been no recent activity in the area. Some new activity is present in some of the old prospects west of Dry Fork Creek in the quartzites and

the northwest corner of the quadrangle presumably extracted silver ore from altered ndesitic volcanic rocks of the lower part of the Challis Group, similar to the mines of the Champagne Creek subdistrict in the adjacent quadrangle to the east (Skipp and others, Rocks of the quadrangle have a low potential for liquid hydrocarbons and a moderate potential for gas. Known oil

production generally is from rocks with CAI values of less than 2. Dry gas (methane), however, can be produced from rocks with indices as high as 4-4.5 (Epstein and others, 1977). CAI values from the Copper Basin thrust plate are 4.5 and from the Grouse plate are 2-4 (Skipp, 1988, 1989; Skipp and others, The presence of latest Pleistocene basalts associated with the northwest continuation of the Great Rift into the southeastern part of the quadrangle suggests a high potential for

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positions to the north are Upper Mississippian and Pennsylvanian carbonate rocks of the footwall block along Leadbelt Creek, and Upper Mississippian clastic rocks of the hanging wall block in the northwesternmost corner of the quadrangle. Conversely, no significant stratigraphic change is apparent in footwall and hanging wall rocks across the buried southern fault which offsets the Coppe Basin thrust about 3 miles sinistrally to where it is exposed in the adjoining quadrangle to the east (Skipp and others, 1990). The southern fault, however, also appears to be a Mesozoic tear fault, as it does not offset volcanic or intrusive rocks of the Eocene Challis Group. Thicknesses of Lower Mississippian rocks increase more than fivefold from a 2.000-ftthick section of McGowan Creek Formation 1/2 miles east of the quadrangle (Skipp and others, 1990), to the more than 10,000-ft-thick lower part of the Copper Basin Formation in the western part of this quadrangle. Also, western, chiefly proximal, turbidites of the Copper Basin Formation are much coarser grained than the distal turbidites of the coeval cGowan Creek Formation. The Copper

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