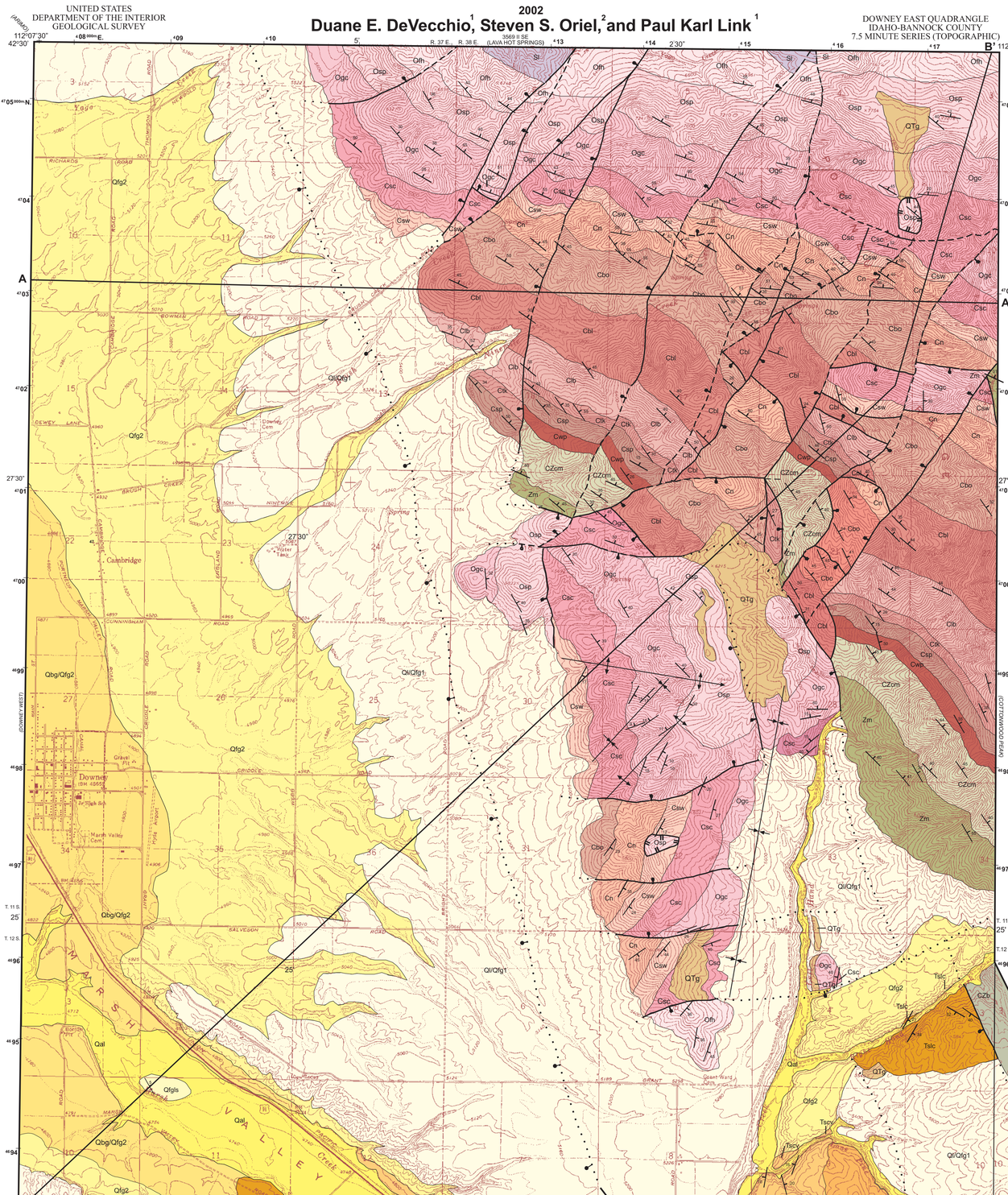
Geologic Map of the Downey East Quadrangle and regions of the Swan Lake, Oxford, and Cottonwood Peak Quadrangles, Bannock County, Idaho

2002

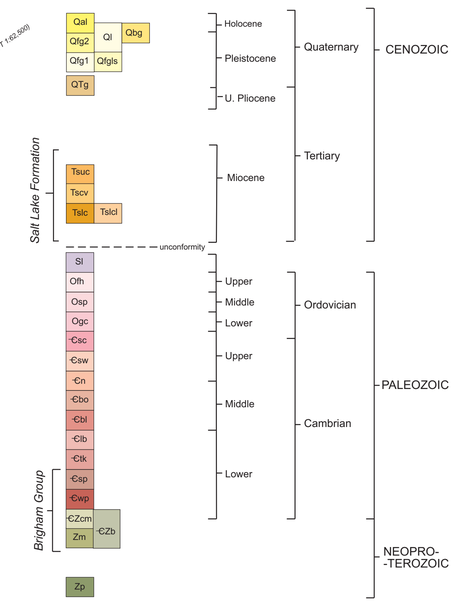
Duane E. DeVecchio,[1] Steven S. Oriel,[2] and Paul Karl Link[1]

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DOWNEY EAST QUADRANGLE
IDAHO-BANNOCK COUNTY
7.5 MINUTE SERIES (TOPOGRAPHIC)



CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qal **ALLUVIUM (Holocene)** - Unconsolidated gravel, sand, and mud deposited in moderately entrenched channels and floodplains of perennial and larger intermittent streams. Thickness 0-30(?) ft (0-9m).

Qbg **BONNEVILLE GRAVEL (Latest Pleistocene)** - Poorly sorted boulder to conglomerate, mantling older alluvial surfaces. Deposited by catastrophic dam failure and subsequent flood of pluvial Lake Bonneville approximately 14.5 ka. Clasts are typically well-rounded and composed of recycled gravels of Late Proterozoic to Early Paleozoic quartzite and limestone, and conglomerate of Tertiary Salt Lake Formation. Extent of deposition was constrained by a maximum flood elevation of 5092 feet (1552m)(O'Connor, 1990). Thickness 0-45ft(?) (0-14m).

Qfgls **Carbonate Cemented Fan Gravel (Pleistocene)** – Tan to white, travertine-cemented conglomerate formed in older Quaternary alluvium. Exposed in only two localities as erosional remnants within the modern floodplain of Marsh Creek, both within 3km of Downata Hot Springs. Thickness 0-30ft (0-9m).

Ql **LOESS (Latest Pleistocene)** - Unconsolidated windblown silt, mantling Quaternary alluvial fan gravels, and Tertiary deposits. Thickness unknown, probably <30 ft. (9m).

Qfg2 **YOUNG ALLUVIAL FAN GRAVEL (Late Pleistocene)** - Unconsolidated alluvial fan, debris flow, and fluvial deposits associated with incision of older Quaternary fanglomerates. The unit is typically unstratified and composed of cobble-sized gravel in a sandy matrix. Exposed along the southeast side of the Downey East quadrangle (Sec 3, T.12S., R.38E.), cobble-supported channels in a 25m section of fluvial sand, fills an incised valley cut in Quaternary older fan gravel, surficially expressed by a loess-mantled fluvial terrace. Thickness <75 ft. (25m).

Qfg1 **OLD ALLUVIAL FAN GRAVEL (Quaternary)** – Crudely stratified, unconsolidated, pebble- to large cobble-sized gravel in a sandy matrix. The presence of >60% Brigham Group Quartzites distinguishes Quaternary fanglomerates from older Tertiary conglomerates. Fan gravels are mantled by loess except where incised by modern drainage and road cuts. Locally a 4m bed of carbonate-cemented conglomerate is exposed along stream incisions both NE (Sec. 2, T.12S, R.37E) and SW(Sec. 14, T.12S, R.37E) of Marsh Creek at an elevation of 4920 feet. Thickness <150 ft. (50m)

QTg **OLDEST GRAVEL- (Late Pliocene to Pleistocene)**- Boulder conglomerate (0.5- 2.8m) mantling strath terraces and filling incised valleys cut in and on Paleozoic bedrock and filling paleo-channels within older Salt Lake Formation. Only two clast lithologies are observed, Ordovician Swan Peak Quartzite and Miocene basalt of the Yago Creek volcanic center located in the Lava Hot Springs quadrangle to the north. Thickness <480ft. (160m).

Tsuc **SALT LAKE FORMATION (UPPER CONGLOMERATE UNIT)(Middle Miocene to Late Miocene)**- Interbedded gray to white, sub-rounded, pebble to cobble conglomerate (0.5-25cm) in a sandy tuffaceous matrix and minor ash beds. Outcrops are rare except near the base of the section where calcareous cementation and ash beds are more abundant. Clasts consist of Cambrian limestone (undifferentiated) (~55%), Cambrian St. Charles Fm. (Lower Worm Creek member) (~15%), Ordovician Swan Peak Quartzite (~13%), reworked Salt Lake Fm. (~7%), and negligible amounts of chert and lower Paleozoic and Neoproterozoic quartzites. Distinguished from Tslc by the relative lack of chert and Cambrian St. Charles Formation (Upper Worm Creek Member). The basal contact is placed above the highest occurrence of unadulterated tephra of the underlying Cache Valley Member. Thickness measured from outcrop exposure to be >2000 ft. (733m).

Tscv **SALT LAKE FORMATION (CACHE VALLEY MEMBER)(MIDDLE LACUSTRINE UNIT)(Early Miocene to Middle Miocene)**- Gray to white, sometimes green, calcareous cemented, locally silicified, primary and reworked ash with interbedded limestone. Ash beds are planar bedded (3mm) with larger scale bounding surfaces spaced 1-2m. Cliff-forming outcrops are exposed along the east-side of Marsh Creek (Sec. 16, T.12S, R.37E) and in ephemeral stream cuts. Reworked ash beds contain dark, silt to sand-sized mineral fragments, increasing in abundance near the top and bottom of the section. Limestone interbeds are white, micritic, thin (10-20cm),and interbedded with ash beds. The basal contact is placed above the highest occurrence of interbedded conglomerate and ash of the underlying lower conglomerate member. Thickness measured from outcrop exposure to be >2800 ft. (1026m).

Tslc **SALT LAKE FORMATION (LOWER CONGLOMERATE UNIT) (Early Miocene)**- Interbedded gray to white, slope-forming, sub-rounded pebble to cobble conglomerate (0.5-20cm) in a sandy tuffaceous matrix with minor interbedded ash beds. Clasts consist of Cambrian limestone (undifferentiated) (~43%), Cambrian St. Charles Fm. (Lower Worm Creek member)(~23%), Ordovician Swan Peak Quartzite (~7%), reworked Salt Lake Fm. (~3%), chert (~22%), and negligible lower Paleozoic and Proterozoic quartzites. Distinguished from Tsuc by the relative abundance of chert and stratigraphic position. Tslc lies unconformably above the Cambrian Bloomington Formation. Thickness measured from outcrop exposure to be >2200ft. (807m).

Tslcl **SALT LAKE FORMATION(LOWER CONGLOMERATE UNIT LIMESTONE BED) (Early Miocene)**- Tan, rhizolith-bearing, intraclastic, fenestral, micritic limestone. Weathers distinctive blue-purple. The marker bed is observed in most sections of the lower unit ~275m from the base. Thickness measured from outcrop exposure to be <6 ft. (2m).

Sl **LAKETOWN DOLOMITE (Middle- Upper Silurian)** – Medium to thick-bedded, light-gray, chert-bearing , medium to coarse-grained, fossiliferous dolomite (Biek et al., 2001). Present at Yago Creek along the northern border of the field area, but obscured by riparian vegetation. Laketown Dolomite is assumed to be stratigraphically overlying the Ordovician Fish Haven Dolomite in the field area, which is supported by mapping to the north (Crane, 2000). Thickness 820 –1148ft. (250-350m) (Oriel, 1965; Schwarze, 1959).

Oth **FISH HAVEN DOLOMITE (Upper Ordovician)** – Medium to dark purple-gray, coarse crystalline, thick-bedded, bioclastic dolostone. Thickness 1050 ft. (320m) (Crane, 2000).

Osp **SWAN PEAK QUARTZITE (Middle Ordovician)** – White, occasionally pink, massive, well-sorted, fine-grained (0.2mm), cliff-forming, vitreous quartz arenite. Grain boundaries are commonly undistinguishable. Boulder-covered slopes are common. The top 50m is pervasively brecciated, weathered grayish-pink to orange with abundant liesegang banding. Distinguished from Camelback Mountain Quartzite by its higher degree of sorting and finer grain-size. The basal contact is placed above the last occurrence of limestone of the Garden City Formation. Thickness measured from outcrop exposure to be 1150 ft. (350m).

Ogc **GARDEN CITY FORMATION (Middle and Lower Ordovician)** – Blue-gray, medium to coarse-crystalline, fine to medium-bedded, fossiliferious limestone. Intraformational, flat-pebble conglomerate clasts (1.0-7.0cm) and cm-scale tan-red silt interbeds are abundant in the lower 250m. Bioturbation, trilobite and brachiopod fossil hash, and black chert are common in the top 100m. Weathers light gray, with tan silty interbeds (often red) typically protruding from surrounding limestone. Large, flat-topped, free-standing outcrops are common. Distinguished from the Bloomington Formation by its fossiliferous character, and the presence of chert and intraformational conglomerate. The basal contact is placed above the uppermost massive, gray dolomite bed of the St. Charles Formation. Thickness measured from outcrop exposure to be 1425 ft. (435m).

Csc **ST. CHARLES FORMATION (UPPER MEMBER)(Lower Ordovician and Upper Cambrian)** – Medium and light gray, medium-crystalline, massive, interbeded dolomite and limestone. Black chert is observed in some localities. Brecciation is common in dolomite interbeds. Distinguished from the overlying Garden City Formation by the presence of dolomite, lack of intraformational conglomerate, and paucity of silty interbeds. The basal contact is placed above the highest sandstone bed of the underlying Worm Creek Member. Thickness measured from outcrop exposure to be1000 ft. (305m)

Csw **ST. CHARLES FORMATION (LOWER WORM CREEK MEMBER)(Upper Cambrian)** – Light-gray to dominately tan, fine to medium-grained, arkosic sandstone and quartzite, with minor interbedded limestone. Feldspar grains are weathered and commonly iron-stained. Rare planar-bedded, gray, fine-grained quartzites are present in isolated localities. Limestone beds are thin (<1m), sandy, and discontinuous. The basal contact is placed above the last occurrence of unbedded limestone of the underlying Nounan Formation. Thickness measured from outcrop exposure to be 450 ft. (137m)

Cn **NOUNAN FORMATION (Upper and Middle Cambrian)** - Light-gray, fine to coarse-crystalline, massive, interbedded limestone and dolomite, and minor siltstone. Oolitic limestone and brown micaceous siltsone is common in the lower 50m. Outcrops typically form cliffs and free-standing rounded pinnacles. Dolostone and limestone are distinctly unbedded and distinguished from the St. Charles Formation (upper member) by its pale color and outcrop form. The basal contact is placed above the highest well-bedded limestone of the Bloomington Formation above which unbedded limestone is dominant. Thickness measured from outcrop exposure to be1000 ft (305m).

Cbo **BLOOMINGTON FORMATION(Middle Cambrian)** – Light to medium gray, well-bedded, fine-grained, oolitic limestone. Silty interbeds are abundant, becoming red near the top of the section (generally observed in float). Green, oblate calcareous-cemented limestone nodules and shale beds (observed elsewhere), are rarely exposed. Limestone forms low-relief outcrops that often control the strike of ridges. Limestone is similar in appearance to the Garden City Formation, but is distinguished by a lack of fossils and intraformational conglomerate. The basal contact is placed above the highest occurrence of massive Oncoid-bearing limestone of the underlying Blacksmith Limestone. Thickness measured from outcrop exposure to be 1600 ft. (487m).

Cbl **BLACKSMITH LIMESTONE (Middle Cambrian)** – Medium to dominantly dark gray, thick-bedded to massive, fine-crystalline, mottled limestone. Oncoids and trilobite fossil hash are common. Tan silty interbeds are rare. Locally, outcrops weather light-gray and form rounded dip slopes. The basal contact is placed above the highest occurrence of interbedded shale and limestone. Thickness measured from outcrop exposure to be 1550 ft. (472m)

Clb **LEAD BELL SHALE (Middle Cambrian)** – Divided into two informal members, a bottom claystone and siltstone member (150m) and an upper interbedded limestone and siltstone member (250m). Lower claystone and siltstone are typically fissile slope-formers that are green to dominantly tan to brown. Siliciclastic interbeds in the upper member are tan to green, and decrease in frequency and width upsection. Limestones are light-gray, locally oolitic, and thick-bedded. Outcrops form moderate-relief, flat-topped, limestone stripes indicative of the interbedded nature of the unit. The basal contact is placed above the last occurrence of silty limestone of the Twin Knob Limestone, above which shale beds are overwhelmingly dominate. Thickness measured from outcrop exposure to be1150 ft. (350m).

Ctk **TWIN KNOB LIMESTONE (Middle Cambrian)** – Interbedded siltsone and bioclastic limestone. Siltstone interbeds are tan, fissile slope-formers. Limestone is distinctive blue-gray and contains discontinuous tan and red wispy silt lenses. Differential weathering of the silty limestone gives the strata a mottled appearance and abrasive texture. Outcrops form low-relief angular ledges on the top and overhangs above siltstone interbeds. The basal contact is placed above the last occurrence of quartzite. Thickness measured from outcrop exposure to be 300 ft. (91m).

Gsp **SEDGWICK PEAK QUARTZITE (Lower Cambrian)** – Green to pink-brown, thick-bedded, moderately-sorted (0.06- 0.25mm), limonite-bearing, sugary quartzite and minor interbedded limestone. Limonite blebs (0.5-1.5mm) give hand samples a distinctive speckled pattern. Outcrops are typically weathered dark-red to brown. The basal contact is placed above where shales of the Windy Pass Argillite become overwhelmingly dominant. Thickness measured from outcrop exposure to be 560 ft. (170m).

Cwp **WINDY PASS ARGILLITE (Lower Cambrian)** – Green to tan, sandy shale. Mudstone is fissile, rich in medium-grained quartz sand (30%), micaceous (usually muscovite), and forms benches. The basal contact is placed above the highest occurrence of quartzite of the Camelback Mountain Quartzite. Thickness measured from outcrop exposure to be 250 ft. (76m)

CZcm **CAMELBACK MOUNTAIN QUARTZITE (Lower Cambrian and Neoproterozoic)** - White to pink-tan, thick-bedded to massive, medium to coarse-grained, moderate to well-sorted, locally conglomeratic quartzite. Distinctive brown weathering rinds penetrate the outer 1cm of hand samples and outcrops in most localities. Distinguished from the Sedgwick Peak Formation by lack of limonite stains and unique weathering rinds and from the Swan Peak Quartzite by being coarser-grained, and more poorly-sorted. The basal contact with the underlying Mutual Formation is placed at the first occurrence of pink quartzite pebble conglomerate (not everywhere observed) of that unit, or above where channelized gravel conglomerate is absent. Thickness measured from outcrop exposure to be 1570 ft. (479m)

Zm **MUTUAL FORMATION (Neoproterozoic)** – Pink to dominantly maroon, cross-bedded, moderately to poorly-sorted, channelized, conglomeratic quartzite and minor interbedded red argillite. Clasts in scour-and-fill structures have a maximum grain size of 2cm and are composed of intraformational quartzite and argillite. A distinct pink quartzite pebble conglomerate marks the top of the section. Distinguished from the overlying Camelback Mountain Quartzite by the lack of sorting, larger grain size, and maroon color. Thickness 1200 ft. (366m) in the Malad Summit quadrangle to the southwest (Link 1982).

CZb **BRIGHAM GROUP, UNDIFFERENTIATED (Lower Cambrian-Neoproterozoic)** – Present along the eastern extent of the field area, as noted by Platt and Oriel (1967). Strata include Camelback Mountain Quartzite, Mutual Formation, Inkom Formation, Caddy Canyon Quartzite, and Papoose Creek Formation and overlie the Pocatello Formation. Combined thickness 4300 ft. (1310m) in the Malad Summit and Oxford Peak quadrangles to the southwest (Link, 1982).

Zp **POCATELLO FORMATION, UNDIFFERENTIATED (Neoproterozoic)** – Shown only in cross section, the members of the Pocatello Formation (Upper Scout Mountain and Bannock Volcanic Members) presumably underlie Brigham Group strata within the map area. Thickness is estimated at 6000 feet (1829m)(Link, 1982)

GEOLOGIC HISTORY

The Downey East 7.5' quadrangle and adjacent Neogene basin are located along the southwest margin of the Portneuf Range within southern Marsh Valley, 50 miles south of Pocatello, Idaho and the southern border of the Eastern Snake River Plain. It lies in the northeastern Great Basin region, and is part of the northern Basin and Range Province. Rocks of the southern Portneuf Range include Neoproterozoic fluvial siliciclastic rocks of the Brigham Group through lower Silurian shallow-marine carbonate, mudstone and sandstone (Armstrong and Oriel, 1965; Link, 1982), that are unconformably overlain by strata of the Neogene Salt Lake Formation.

The study area is divided into three structural blocks (DeVecchio, 2002). Neoproterozoic through Silurian strata of the north and east bedrock region, make up the main southern Portneuf Range block, Upper Cambrian through Upper Ordovician strata make up the southwest spur block, and Neogene Salt Lake strata compose the Red Rock sub-basin (RRSB) block. Map scale folds and four fault sets are preserved in these three structural blocks. They include: 1) a NW-WNW-striking, north and south dipping set, 2) a NE-striking, north and south dipping set (typically north dipping), 3) a NW-striking, west dipping set, and an 4) a E-W-striking, north and south-dipping set.

Mesozoic Compressional Deformation

Paleozoic and Neoproterozic strata of the Downey region belong to the hanging wall of the Paris-Putnam thrust of the Idaho-Wyoming thrust belt that experienced east-northeast translation beginning in the Early Cretaceous, ending by the Paleocene (Armstrong and Oriel, 1965; DeCelles et al., 1993; Yonkee, 1997). The southern Portneuf Range is immediately east of the Malad frontal footwall ramp of the Paris thrust which exposes stratigraphically lower rocks of the hanging wall than those exposed west of the ramp (Rodgers and Janecke, 1992). Evidence of Cretaceous compressional deformation in the study area is restricted to a gently folded, steeply inclined, gently plunging anticline, in which strike of bedding changes from NW to NNW, from northwest to southeast, and a north-dipping homocline on the southeast side of the Portneuf Range, shown in cross section B-B'.

Miocene Syntectonic Deposition and Extensional Deformation

The Middle Miocene to Pliocene Salt Lake Formation consists of conglomerate, lacustrine limestone, marl, fluvial and alluvial sediments, intercalated with primary and reworked rhyolitic fallout ash. The basal Salt Lake Formation lies unconformably on Cambrian Bloomington Formation in the RRSB, though to the northeast and southwest it lies on Ordovician and Silurian strata, reflecting Mesozoic folding. The formation is laterally extensive, present throughout SE Idaho and N Utah and accumulated in response to local and regional subsidence associated with early extension of the northern Basin and Range Province (Trimble and Carr, 1963; Perkins et al., 1998; Janecke et al., 2002). Janecke and Evans (1999) propose that the Salt Lake Formation in the Cache Valley region formed in the hanging wall of the Bannock Detachment System that experienced WSW extension from ~12 to <4 Ma (Janecke et al., 2002).

The oldest phase of extension, beginning ~12 Ma (Janecke et al., 2002, Kruger et al., 2002) in the Downey area is characterized by NW-striking faults (set 1) and deposition of the Salt Lake Formation. Remnants of set 1 faults are preserved as isolated hanging wall blocks in grabens and horsts of younger set 2 faults on the southern Portneuf Range block. The basal conglomerate unit of the Salt Lake Formation (Tslc) likely formed in response to inception of tectonism and accumulated quickly in a rapidly subsiding basin. Tephra dates from the middle unit (Tscv) constrains lacustrine deposition of the Salt Lake Formation from 11.8 Ma to 9.5 Ma (Perkins et al., 1998) in southern Marsh Valley. The upper conglomerate unit in the RRSB likely accumulated from ~9.5 to ~4.5 Ma and records a time of decreased accommodation and integration of Neogene basins.

The second extensional deformational event is characterized by set 2 faults that strike NE and are laterally continuous through the southern Portneuf block and Salt Lake strata of the RRSB. These faults typically have offsets on the order of 10- 100 m. Fault set 2 likely formed during Late Miocene time, perhaps in response to down-warping of the Snake River Plain and detumescence of the Yellowstone Hotspot plateau to the north (McQuarrie and Rodgers, 1998; Janecke et al., 2000).

Plio-Pleistocene Peneplanation and Extensional Deformation

With cessation of the early phases of tectonism and a decrease in accommodation, infilling by the fluvial upper conglomerate unit (Tsuc) of the Salt Lake Formation likely overfilled basins to the tops of the intervening ranges (Ore, 1982; Rodgers et al., 2003). Ordovician bedrock highs were beveled and Salt Lake strata were graded to a northward flowing master stream (Link et al., 1999). Lag concentrate of resistant Ordovician Swan Peak Quartzite boulders likely accumulated on pediment surfaces adjacent to buried or nearly buried Basin and Range mountains (Ore, 1999).

Renewed tectonism during Plio-Pleistocene time and displacement on the NW-striking, Portneuf Range-front fault (Set 3) led to subsequent down cutting and abandonment of formerly graded surfaces. Strath terraces (Sec. 6 and 29, T.11S., R.38E.) were isolated and Neogene basin fill of the footwall (Sec. 15, T.12S., R.38E.) was incised. Break-up of the footwall by left-stepping of the range-front fault to the Marsh Creek Headwaters fault vertically offset strath terraces (1200ft) and led to back-filling of incised valleys (QTg) of the nascent hanging wall by lag boulders of Swan Peak Quartzite and locally derived basalt.

Fault set 4 includes the NW-striking fault that cuts Qfg1 west of Marsh Creek, north of Red Rock Pass, and an extensional anticline-syncline pair. The set is restricted to the SW spur and the region of overlap between the Portneuf Range-front fault and the Marsh Creek Headwaters fault. These faults are interpreted to reflect local deformation associated with development of a synthetic accommodation zone and break up of the relay ramp between the faults.

Bonneville Flood

Red Rock Pass (Sec.20, T.12S., R.38E.) is the site of the 14.5 ka alluvial dam failure of pluvial Lake Bonneville (O'Connor, 1993). Flood outwash flowed northwest along the path of the modern channel of Marsh Creek, scouring Quaternary fan gravels immediately north of the breakout and exposing outcrops of the underlying Salt Lake Formation. Approximately 5.5 km upstream the channel widens and floodwaters deposited boulders (up to 3 m) of Salt Lake Formation and locally derived detritus removed from the alluvial dam.

REFERENCES CITED

Armstrong, F.C., and Oriel, S.S., 1965, Tectonic Development of the Idaho-Wyoming thrust belt: American Association of Petroleum Geologists Bulletin, v. 49, p. 1847-1866.

DeCelles, P. C., Pile, H. T., Coogan, J. C., 1993, Kinematic history of the Meade thrust based on provenance of the Beehler conglomerate at Red Mountain, Idaho, Sevier thrust belt: Tectonics, vol. 12, No. 6, p. 1436-1450.

DeVecchio, D.E., 2002, Geologic map of the Downey East quadrangle and regions of the Swan Lake, Oxford, and Cottonwood Peak quadrangles, Bannock County, Idaho: Multiple phases of Miocene to Quaternary extensional tectonics (M.S. thesis): Pocatello, Id., Idaho State University, 103 p.

Janecke, S.U., and Evans, J.C., 1999, Folded and faulted Salt Lake Formation above the Miocene to Pliocene (?) New Canyon and Clifton detachment faults, Malad and Bannock Ranges, Idaho: *in* Hughes, S.S., and Thackray, G.D., eds., Guidebook to the Geology of Eastern Idaho: Idaho Museum of Natural History, p. 71-96.

Janecke, S.U., Perkins, M.E., and Smith, R.B., 2000, Normal fault patterns around the Yellowstone Hot Spot: A new model: Geological Society of America Abstracts with Programs, vol. 32, no. 7, p. A-45.

Janecke, S. U., Carney, S. M., Evans, J. C., Perkins, M. E., Link, P. K., Oaks, Jr. R. Q., Nash, B. P., 2002, Late Miocene-Pliocene detachment faulting and superimposed Pliocene-Pleistocene Basin and Range extension inferred from dismembered rift basins filled with the Salt Lake Formation, southeast Idaho: *in* Raynolds, R., and Flores, R., eds., Cenozoic Paleogeography of the Rocky Mountains: Rocky Mountain Section, SEPM Special Publication, *in press*.

Kruger, J.M., Crane, T.S., Pope, A.D., Perkins, M.E., Link, P.K., 2002, Structural and stratigraphic development of Neogene basins in the Lava Hot Springs and Marsh Valley areas, southeast Idaho, Two phases of extension: *in* Raynolds, R., and Flores, R., eds., Cenozoic Paleogeography of the Rocky Mountains: Rocky Mountain Section, SEPM Special Publication, *in press*.

Link, P.K., Reading, R.W., Godfrey, A.E., and Prevedel, D., 1999, Topographic development of the Snake River Plain, Idaho: *in* Hughes, S.S., and Thackray, G.D., eds., Guidebook to the Geology of Eastern Idaho: Idaho Museum of Natural History, back cover.

McQuarrie, N., and Rodgers, D.W., 1998, Subsidence of a volcanic basin by flexure and lower crustal flow: The eastern Snake River Plain, Idaho, Tectonics, vol. 17, no. 2, p. 203-220.

O'Connor, J. E., 1993, Hydrogeology, Hydraulics, and Geomorphology of the Bonneville Flood: Boulder Colorado, Geological Society of America Special Paper 274, 83 p.

Ore, H.T., 1982, Geologic field guide to Tertiary-Quaternary sediments in the Pocatello region: Northwest Geology. v. 11, p. 31-36.

Ore, H.T. 1999, Topographic and Geomorphic Development of Southeast Idaho: Guidebook to the Geology of Southeast Idaho: *in* Hughes, S.S., and Thackray, G.D., eds., Guidebook to the Geology of Eastern Idaho: Idaho Museum of Natural History, p. 254-255.

Perkins, M.E., E.H. Brown, W.P. Nash, W. McIntosh, and S.K. Williams, 1998, Sequences, age, and source of silicic fallout tuffs in middle to late Miocene basinsof the northern Basin and Range province: Geological Society of America Bulletin, v. 110, p. 344-360.

Rodgers, D.W., Ore, H.T., Bobo, R.T., McQuarrie, N., Zentner, N., 2003, Extension and subsidence of the eastern Snake River Plain, Idaho, *in* Bonnichsen, B., White, C., and McCurry, M., eds., Tectonic and Magmatic Evolution of the Snake River Plain Volcanic Province: Idaho Geological Survey Bulletin 30, *in press*.

Rodgers, D. W., and Janecke, S. U., 1992, Tertiary paleogeographic maps of the western Idaho-Wyoming-Montana thrust belt, *in* Link, P. K., Kuntz, M. M., and Platt, L. B., eds., Regional Geology of Eastern Idaho and Western Wyoming, Geological Society of America Memoir 179, p. 83-94.

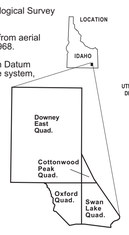
Yonkee, W.A., 1997, Kinematics and mechanics of the Willard thrust sheet, central part of the Sevier orogenic wedge, north-central Utah: Brigham Young University Geology Studies, v. 42, p. 341-354.

Mapped, edited, and published by the Geological Survey
Control by USGS and USC&GS.

Topography by photogrammetric methods from aerial photographs taken 1966. Field checked 1968.

Polyconic projection. 1927 North American Datum
10,000-foot grid based on Idaho coordinate system, east zone.

LOCATION



520,000 FEET
UTM GRID AND 1968 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24,000
0 1/2 1 MILE
1000 0 1000 2000 3000 FEET
0 .5 1 KILOMETER
CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
NATIONAL GEODETIC VERICAL DATUM OF 1929

[1] Department of Geosciences, Idaho State University, Pocatello, Idaho 83209.

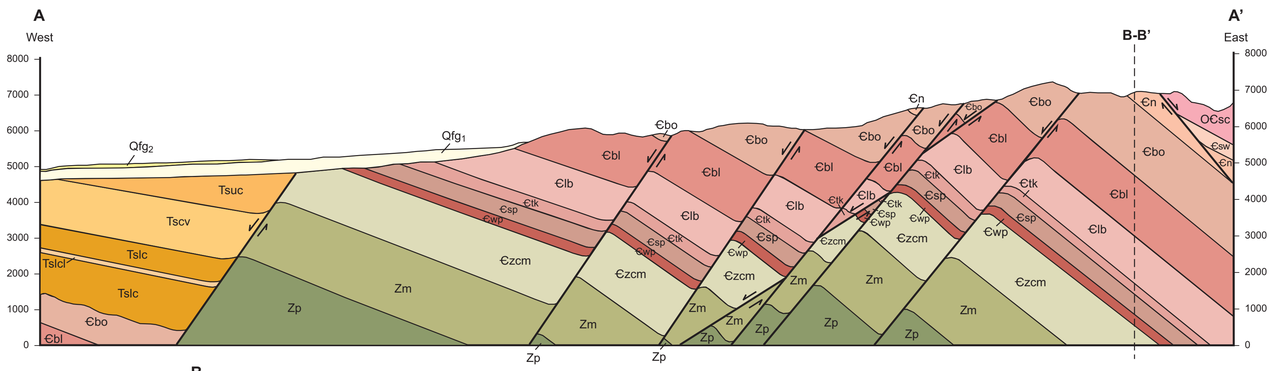
[2] U.S. Geological Survey, Denver, Colorado, Deceased.

Funding provided by the educational component of the U.S. Geological Mapping Program (EdMap) and the Idaho State University Geology Department.

Map modified from DeVecchio, D.E. (2002) [M.S. Thesis]: Idaho State University, Pocatello, Idaho

SYMBOLS

- Unit Contact: dashed where approximately located, dotted where concealed
- Normal fault: bar and ball on hanging wall, dashed where approximately located, dotted where concealed
- Thrust fault: teeth on hanging wall, dashed where approximately located
- 43 — Strike and dip of bedding surfaces
- Plunging anticline, arrow points in the direction of plunge
- Syncline
- Sense of slip indicators for faults in cross-section. Arrow point indicates out-of-page slip. Arrow feathers indicate into-page slip.
- Landslide complex; bedrock formations are shown within complex.



Published and sold by the Idaho Geological Survey
University of Idaho, Moscow, Idaho 83844-3014