Interim Geologic Map of the Curlew Valley Drainage Basin, Box Elder County, Utah, and Oneida and Cassia Counties, Idaho

Compiled by: Hugh A. Hurlow
Utah Geological Survey
2004

EXPLANATION

Contact

Faults

Normal - dashed where inferred or approximately located, dotted where concealed; ball and bar on downthrown side

Low-angle normal - dashed where inferred or approximately located, dotted where concealed; teeth on upper plate

Thrust - dashed where inferred or approximately located, dotted where concealed; teeth on upper plate

Displacement sense uncertain; dashed where inferred or approximately located, dotted where concealed

Folds

Anticline, showing plunge direction

Overturned anticline, showing plunge direction

Syncline, showing plunge direction

Overturned syncline, showing plunge direction

Shoreline of Lake Bonneville - b = Bonneville, p = Provo, g = Gilbert, s- Stansbury; no letter = intermediate

Petroleum-exploration well - plugged and abandoned - see table 2; letter keyed to "Map ID" column

Radiometric age sample location - see table 1; number keyed to "Map ID" column

Strike and dip of bedding

Strike and dip of overturned bedding

Strike and dip of foliation

Map Units

Quaternary

Qaly	Younger stream alluvium
Qlam	Alluvial and lacustrine mud
Qafy	Younger alluvial-fan deposits
Qac	Alluvium and colluvium
Qae	Alluvium and eolian deposits
Qes	Eolian sand
Qms	Landslide and slump deposits
Qmtc	Talus and colluvium
Qla	Alluvial and lacustrine deposits
Qla/Ts	Alluvial and lacustrine deposits over Salt Lake Formation
Qlfg, Qlfp, Qlfb	Lacustrine silt and marl
Qlsg, Qlsp, Qlsb	Lacustrine sand
Qlsgg, Qlsgp, Qlsgb	Lacustrine sand and gravel
Qlgg, Qlgp, Qlgb	Lacustrine gravel
Qlgp/PIPo	Lacustrine gravel over Oquirrh Group
Ql	Lacustrine deposits, undivided
Qel	Eolian loess
Qel/Qafo	Eolian loess over older alluvial fan deposits
Qafo	Older alluvial-fan deposits
Qafo/Ts	Older alluvial-fan deposits over Salt Lake Formation
Qb	Basalt

The last letters of the map symbols for lacustrine deposits represent the stage of Lake Bonneville during which the deposit formed: b - Bonneville, p- Provo, g - Gilbert

Quaternary and Tertiary

QTaf	Alluvial-fan deposits

Tertiary

Trd	Rhyolite and dacite
Ta2	Pediment alluvium
Tb, Tbc	Basalt - Tb, flows; Tbc, cinder cone
Ta1	Alluvium
Tt	Tuff
Ts	Salt Lake Formation
Tc	Conglomerate and sedimentary breccia

Permian

Plsd	Limestone, calcareous sandstone, and dolomite
Oquirrh Group	
Pod	Sandstone and siltstone

Permian and Pennsylvanian

Oquirrh Group

PIPox	Unit x- bioclastic limestone
PIPoc	Unit c- sandy to silty limestone and calcareous sandstone to siltstone
PIPobc	Units b and c, undivided
PIPos	Sandstone and quartzite
PIPo	Oquirrh Group, undivided

Pennsylvanian

Oquirrh Group

IPob	Unit b- sand to silty limestone and calcareous sandstone to siltstone
IPoa	Unit a- cherty limestone
IPolsd	Limestone and dolomite

Pennsylvanian and Mississippian

IPMmc	Manning Canyon Formation

Mississippian

Mgb	Great Blue Limestone

Devonian

Dj	Jefferson Formation

Ordovician

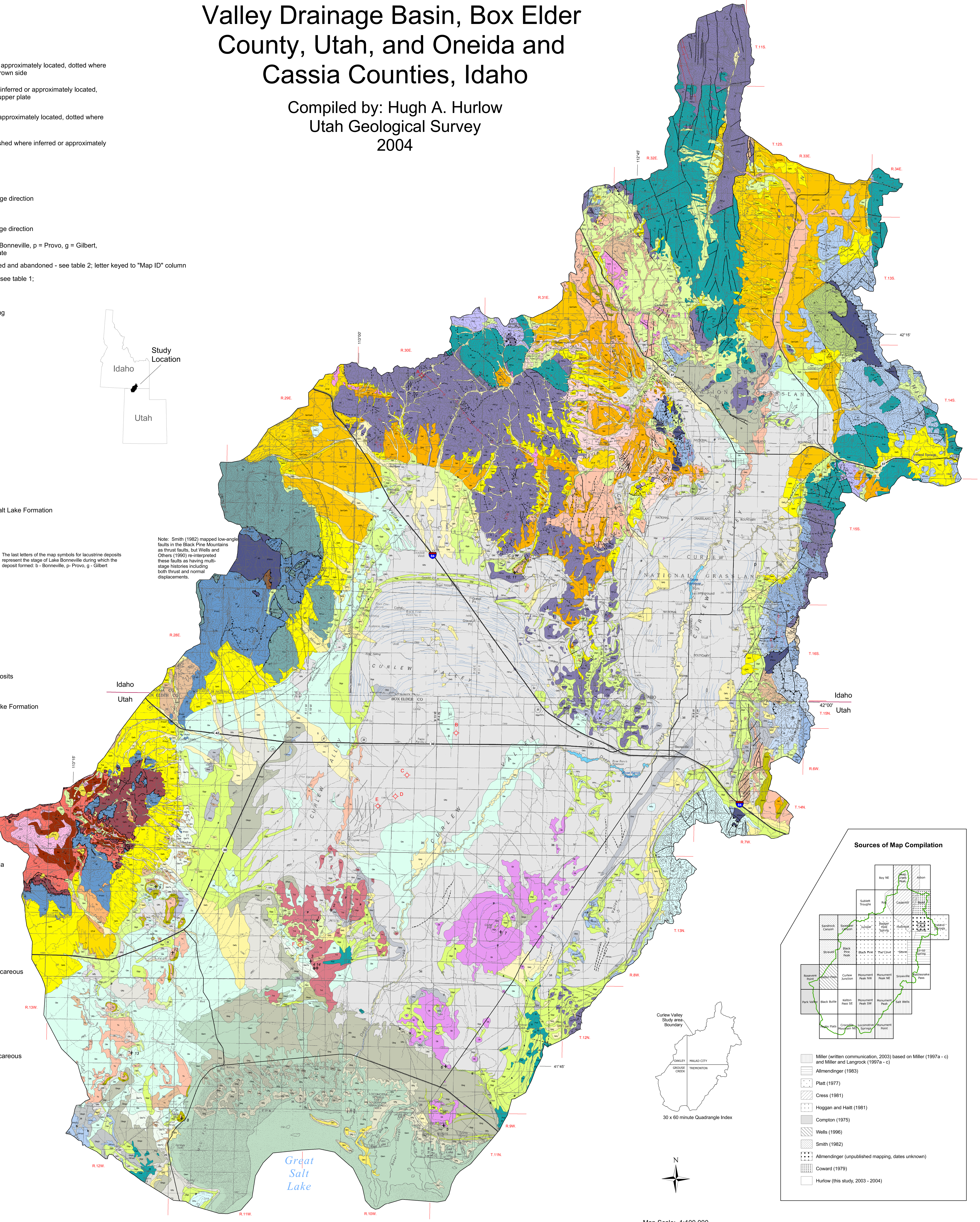
Omq	Marble and quartzite, undivided

Proterozoic

Pqs	Quartzite and schist, undivided

Archean

Ami	Metamorphosed intrusive rocks
As	Metasedimentary rocks



Sources of Map Compilation

- Miller (written communication, 2003) based on Miller (1997a - c) and Miller and Langrock (1997a - c)
- Allmendinger (1983)
- Platt (1977)
- Cress (1981)
- Hoggan and Haitt (1981)
- Compton (1975)
- Wells (1996)
- Smith (1982)
- Allmendinger (unpublished mapping, dates unknown)
- Coward (1979)
- Hurlow (this study, 2003 - 2004)

30 x 60 minute Quadrangle Index

Map Scale: 1:100,000

0 2.5 5 7.5 10 Miles

0 2.5 5 7.5 10 Kilometers

GIS and Cartography by Matt Butler, Kami Bremser, and DeDe Halseth

Base map from U.S. Geological Survey
Tremonton, Grouse Creek, Malad City, and Oakley
30 x 60 minute quadrangles
UTM Projection (zone 12)
North American Datum 1927

UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

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Hugh A. Hurlow

August 2004

Utah Geological Survey, 1594 W. North Temple, PO Box 146100, Salt Lake City, Utah 84114-6100; ph: 801-537-3300; fax 801-537-3400**; www.geology.utah.gov.**

Project Manager: Grant Willis

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Disclaimer

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DESCRIPTION OF MAP UNITS

Sources include the author's field observations, Compton (1975), Yancey and others (1980), Hoggan and Haitt (1981), Allmendinger (1983), Wells (1996), Miller (1997a-c), and Miller and Langrock (1997a-c).

QUATERNARY

Alluvial Deposits

Qaly **Stream deposits** (Holocene) **–** Well- to moderately sorted gravel, sand, silt, and clay deposited in stream channels, terraces, and flood plains; many deposits are present in ephemeral drainages but are too small to show at this scale; up to about 30 feet (9 m) thick.

Qafy **Alluvial-fan deposits** (Holocene to ?late Pleistocene) **–** Moderately to poorly sorted boulders, gravel, sand, and silt deposited by debris-flow and sheet-wash processes; forms fan-shaped deposits at the mouths of canyons and smaller drainages, at the interface between bedrock-dominated mountains and adjacent basins, and at the mouths of smaller drainages within topographic basins; up to 100 feet (30 m) thick.

Qafo **Older alluvial-fan deposits** (Pleistocene and Holocene) – Moderately to poorly sorted pebble to boulder gravel, sand, and silt deposited by debris-flow and sheet-wash processes; forms broad, coalesced fan-shaped deposits emanating from the mouths of major drainages where they intersect topographic basins; deeply incised by younger streams; at least 100 feet (30 m) thick, but may be substantially thicker locally.

Eolian Deposits

Qes **Eolian sand and silt** (Holocene) – Well-sorted, fine-grained sand to silt that forms small dunes in topographically low areas, stands of trees, or on the leeward sides of small hills; variably stabilized by vegetation; mapped chiefly along the east margin of the Raft River Mountains and the south margin of the Wildcat Hills; up to about 3 feet (1 m) thick.

Qel **Eolian loess** (Holocene to late Pleistocene) –Light-brown silt with variable amounts of intermixed fine-grained sand and clay; mantles older surficial deposits and bedrock in topographic lows along the margins of mountain ranges; most extensive deposits are in northern Juniper Valley and in the foothills of the Sublett Mountains northeast of Stone Valley; up to about 6 feet (2 m) thick.

Lacustrine Deposits

All lacustrine deposits shown on this map were deposited in Pleistocene Lake Bonneville and Holocene Great Salt Lake. The last letter in the map symbol refers to the lake stage during which the deposit formed: g -- Gilbert stage of Great Salt Lake [10.9-10.3 ka, shoreline at 4250 feet (1294 m)]; p – Provo stage of Lake Bonneville [14.5-14.0 ka, highest shoreline at 4800 to 4750 feet (1263-1448 m)]; b – Bonneville stage of Lake Bonneville [15.0-14.5 ka, highest shoreline at 5180 feet (1579 m), secondary shoreline at 5150 feet (1570 m)]. Stage names, ages, and shoreline elevations are from Oviatt and others (1992).

Qlfg, Qlfp, Qlfb

Lacustrine silt and marl (Pleistocene) – Silt is tan to yellow-tan, laminated to well-layered where exposed, and contains variable amounts of clay; locally contains beds of sand, pebbly sand, and gravel less than about 1 foot (0.3 m) thick. Marl is white to pale-brown, and contains abundant ostracodes and sparse dropstones; lower part typically white and laminated, upper part white to pale brown; locally contains beds of sand, pebbly sand, and gravel less than about 1 foot (0.3 m) thick; includes "reworked marl" unit of Miller (1997a-c) and Miller and Langrock (1997a-c); thickness varies from about 0 to 40 feet (0-12 m), depending on local pre-lacustrine topography.

Qlsg, Qlsp, Qlsb

Lacustrine sand (Pleistocene) **–** Tan to brown, well-sorted, fine-grained sand deposited on beaches, offshore bars, and a broad delta plain west of Rose Ranch Reservoir; thickness about 30 feet (10 m) or less.

Qlsgg, Qlsgp, Qlsgb

Lacustrine sand and gravel (Pleistocene) – Tan to pale-gray, well-sorted, fine-grained sand and interbedded pebble gravel, deposited on beaches, offshore bars, and as thin mantles on slopes adjacent to shorelines cut on moderate to steep bedrock slopes; well-defined, planar, gently to moderately inclined bedding, only locally exposed; thickness about 30 feet (10 m) or less.

Qlgg, Qlgp, Qlgb

Lacustrine gravel (Pleistocene) – Pale-gray, well-sorted pebble to cobble gravel with variable amounts of sand in discrete beds or as matrix, deposited on beaches, offshore bars, and as thin mantles on slopes adjacent to shorelines cut on moderate to steep bedrock slopes; where exposed in gravel pits, characterized by well-defined, planar, gently to moderately inclined bedding; thickness about 100 feet (30 m) or less.

Ql **Lacustrine deposits, undivided** (Pleistocene) – Gravel, sand, and silt, mapped where deposits are interbedded or intermixed at scales too fine to show on map; thickness about 100 feet (30 m) or less.

Mass-movement deposits

Qms **Landslide and slump deposits** (Holocene to ?Pleistocene) – Poorly sorted debris ranging from large blocks to silt, deposited principally by rotational slides; thickness about 30 to 50 feet (10-15 m).

Qmtc **Talus and colluvium** (Holocene to ?Pleistocene) – Poorly sorted debris ranging from large blocks to silt, deposited by block fall, slope wash, and creep processes on steep to moderate slopes, chiefly below mesa-forming basalt outcrops; up to about 10 feet (3 m) thick.

Mixed-environment deposits

Qac **Alluvial and colluvial deposits** (Holocene to ?Pleistocene) – Poorly sorted, boulder- to silt-size, locally derived debris deposited on gentle to moderate slopes and in swales and small drainages by fluvial, slope wash, and creep processes; up to about 20 feet (6 m) thick.

Qae **Alluvial and eolian deposits** (Holocene to ?Pleistocene) – Fine-grained eolian sand re-worked by and/or intermixed with stream or alluvial-fan deposits at a scale too fine to separate on the map; up to about 30 feet (10 m) thick.

Qla **Lacustrine and alluvial deposits** (Holocene to Pleistocene) **–** Moderately to well-sorted gravel, sand, silt, and clay deposited in lacustrine environments, re-worked by ephemeral streams and/or slope wash, and intermixed with deposits formed from these processes; mapped adjacent to major stream channels and on the flanks of mountain slopes having lacustrine deposits; gradational with adjacent undisturbed lacustrine deposits; mapped where linear texture associated with shoreline processes is significantly disrupted or obscured by stream channels and/or slope wash, as seen on aerial photographs; forms a thin mantle on underlying lacustrine deposits; up to 3 feet (1 m) thick.

Qlam **Lacustrine and alluvial mud** (Holocene to Pleistocene) **–** Well-sorted clay and silt deposited by ephemeral streams on flats immediately north of Great Salt Lake; composed chiefly of re-worked lacustrine clay and silt; may include some lacustrine mud from Holocene highstands of Great Salt Lake; maximum thickness about 3 feet (1 m).

Stacked-unit deposits

Qafo/Ts

Older alluvial-fan deposits over Salt Lake Formation – Older alluvial-fan deposits overlying discontinuously exposed Salt Lake Formation; mapped on northwestern flank of North Hansel Mountains, and in the central Sublett Mountains in the northwest part of the map area.

Qel/Qafo

Eolian loess over older alluvial-fan deposits – Older alluvial-fan deposits mantled by up to 3 feet (1 m) of pale-tan to brown eolian loess; alluvial-fan deposits are moderately sorted, moderately to well-bedded pebble to cobble gravel exposed where ephemeral streams have incised through the loess; mapped along range margins where fan morphology is clearly visible on aerial photographs but deposits present on the surface are predominantly loess.

Qla/Ts

Lacustrine and alluvial deposits over Salt Lake Formation – Lacustrine deposits reworked by alluvial processes and intermixed and overlain by alluvial deposits that form a mantle up to 6 feet (2 m) thick on Salt Lake Formation; Salt Lake Formation is discontinuously exposed in stream bottoms, south-facing slopes of stream canyons, and along ridge crests.

Qlgp/PlPo

Lacustrine gravel over Oquirrh Group – Lacustrine gravel deposited during the Provo stage of Lake Bonneville, that forms a thin mantle over discontinuously exposed Oquirrh Group rocks.

Qb **Basalt –** Brown- to black-brown-weathering, dark-gray to black on fresh surfaces, variably vesicular flow rock containing fine- to medium-grained, subhedral plagioclase, olivine, and pyroxene phenocrysts in various relative abundances, in an aphanitic groundmass; forms three shield volcanoes from Cedar Hill south to Locomotive Springs, with progressively decreasing radius and summit elevation. Miller and others (1995) reported K-Ar whole-rock ages of 1.16 ± 0.08 Ma, 0.72 ± 0.15 Ma, and 0.44 ± 0.10 Ma for the northern, central, and southern shields, respectively (table 1). A water well 2.8 miles (4.5 km) northeast of the crest of Cedar Hill penetrated 523 feet (160 m) of basalt; flow thickness is probably much greater below central cone areas and tapers outward.

QUATERNARY AND TERTIARY

QTaf **Alluvial-fan deposits –** Moderately to poorly sorted pebble to cobble gravel; bedding not exposed; clasts consist of metamorphic rocks exposed in the Raft River Mountains on south flank of Raft River Mountains, and of Oquirrh Group rocks on east flank of Black Pine Mountains; eroded and deeply dissected by active drainages; up to about 400 feet (120 m) thick.

unconformity

TERTIARY

Trd **Rhyodacite** (Pliocene) – Pale- to medium- gray or pinkish-gray welded ash-flow tuff composed of flow-banded to structureless, cryptocrystalline to glassy groundmass containing sparse pyroxene and plagioclase phenocrysts and pebble-sized spherules composed of gray, white, and pinkish-gray devitrified glass, pumice or black glass. Miller and others (1995) reported K-Ar ages of 4.4 ± 1.1 Ma on plagioclase from rhyodacite and 2.1 ± 0.06 Ma on sanidine from rhyolite from the Wildcat Hills (table 1). At least 200 feet (60 m) thick.

Ta2 **Pediment gravel** (Pliocene) **–** Subangular to subrounded, locally derived cobble to pebble gravel, grading to diamictite; deposited by alluvial processes on broad, smooth erosional surfaces; locally includes a silty or tuffaceous matrix; up to 250 feet (75 m) thick.

unconformity

Tb, Tbc

Basalt (Pliocene to Miocene) – Brown- to brown-black-weathering, dark-gray to black on fresh surfaces, variably vesicular, aphanitic groundmass with medium- to fine-grained subhedral phenocrysts of olivine and plagioclase; up to about 300 feet (100 m) thick; Tbc is a cinder cone in the south-central Sublett Mountains west of Stone Reservoir. Fiesinger (written communication, 2004) reported the following K-Ar whole-rock ages for Tertiary basalt from various parts of the map area (table 1): 5.0 ± 0.4 to 8.6 ± 0.8 Ma for flows and a dike in the southwestern part of the map area; 4.9 ± 0.4 Ma for a flow in the Wildcat Hills (not differentiated on plate 1); 14.7 ± 0.5 and 14.9 ± 0.5 Ma for flows at Rattlesnake Pass, along Interstate 84 about 3 miles (4.8 km) east of the map area; and 12.6 ± 0.5 and 13.1 ± 0.5 Ma for flows of Table Mountain in the west-central Sublett Mountains. Miller and others (1995) reported K-Ar whole-rock ages for basalt flows from the Wildcat Hills of 3.6 ± 0.1 and 4.9 ± 0.1 (table 1).

Ta1 **Alluvium** (Miocene to ?Pliocene) – Pebble to cobble gravel deposited in alluvial-fan and stream environments; mapped below Tertiary basalt flows; poorly exposed; up to 215 feet (65 m) thick.

Tt **Tuff** (Miocene to Pliocene) – This map unit includes several different tuff units mapped by Hoggan and Haitt (1981) and Cress (1981). In the Sublett Mountains, Hoggan and Haitt (1981) mapped vitric air-fall tuff containing glass shards and lithic fragments; pinkish-gray vitric ash-flow tuff containing some lithic fragments; white to gray air-fall and water-lain tuff, locally well-bedded, composed principally of glass shards; gray to pink, rhyolitic, densely welded tuff with basal vitrophyre and phenocrysts of sanidine and pyroxene; and gray, friable, rhyolitic, vitric, poorly welded ash-flow tuff containing columnar jointing. In the southwestern Deep Creek Mountains, Cress (1981) included the Tuff of Arbon Valley and two air-fall tuffs in the upper member of the Salt Lake Formation. The Tuff of Arbon Valley is brown-weathering, buff-gray fresh, moderately welded to non-welded ash-flow tuff including a matrix of pumice and devitrified glass and phenocrysts of sanidine, smoky quartz, and biotite (see Trimble and Carr [1976] for a more complete description). The air-fall tuff is poorly exposed, brown-weathering, light-gray fresh, poorly to well-bedded, re-worked, and devitrified (Cress, 1981). About 0 to 50 feet (15 m) thick.

Ts **Salt Lake Formation** (Miocene to ?early Pliocene) – Sandstone, conglomerate, tuffaceous sandstone, tuffaceous siltstone and mudstone, rare lacustrine dolomite, and water-lain tuff deposited in alluvial and lacustrine environments. The Salt Lake Formation is discontinuously exposed in four main parts of the study area: the western margin of the North Hansel Mountains, the southern Deep Creek

Mountains, the eastern Raft River Mountains, and the southwestern part of the map area. Exposures are typically along south-facing walls of stream gullies and canyons; many small, discontinuous exposures are found near those depicted on plate 1 but are too small to include on the map. The Salt Lake Formation likely covered much of the study area during deposition and forms a substantial part of the basin fill below the fault-bounded valleys. The Salt Lake Formation was deposited from about 13 to 5 Ma in Cache Valley, about 50 miles (80 km) east of the study area (Janecke and others, 2003; Oaks and others, 1999); no ages have been determined from within the map boundaries. In the southern Deep Creek Mountains diamictite of the Salt Lake Formation underlies the tuff of Arbon Valley.

In the North Hansel Mountains, the Salt Lake Formation consists chiefly of tan to pale-gray, moderately sorted, medium- to fine-grained, poorly bedded tuffaceous sandstone; other rock types include well-sorted pebble gravel deposited in stream channels; pale-tan to brown, structureless diamictite deposited as mudflows; and moderately sorted, medium-grained, well-bedded tuffaceous sandstone consisting almost entirely of pale- to medium- gray glass shards. Exposures are along the lower western margin of the range in the footwall of the range-bounding fault. The Salt Lake Formation along the margin of the Hansel Mountains is at least 700 feet (210 m) thick, but is difficult to determine due to poor exposure and lack of exposed bedding planes.

In the southern Deep Creek Mountains, the Salt Lake Formation includes diamictite that is tan to brown, poorly sorted, structureless, contains subangular to angular pebbles composed of Oquirrh Group and volcanic rocks, and is about 650 feet (200 m) thick (Cress, 1981). Exposures are chiefly along stream gullies and road cuts on the southern and southwestern flanks of the range. Cress (1981) mapped a gravel member of the Salt Lake Formation along the margins of the southern Deep Creek Mountains; that unit along the eastern range margin is reinterpreted as Quaternary-Tertiary alluvial-fan deposits in this report. Cress (1981) included basalt flows and siliceous tuff in the Salt Lake Formation; those units are separated from the Salt Lake Formation and included in units Tb and Tt, respectively, in this report.

In the eastern Raft River Mountains and in the southwestern part of the map area, the Salt Lake Formation includes pale-gray to yellowish- or greenish-gray, well- to poorly sorted, well- bedded, fine to coarse tuffaceous sandstone; moderately to well-sorted, moderately to poorly bedded conglomerate containing rounded pebbles of Oquirrh Group and Paleozoic metasediments identical to those exposed in the Raft River Mountains; pale-green-gray, well-bedded tuffaceous siltstone to mudstone; pale-tan to yellow-tan, fine-grained, medium-bedded, unfossiliferous dolomite; and pale- to medium-gray, moderately to well-sorted, moderately to poorly bedded tuffaceous sandstone consisting primarily of glass shards. The thickness of the Salt Lake Formation in this area is difficult to determine accurately due to discontinuous exposure but is at least 1700 feet (520 m) (Wells, 1996).

unconformity

Tc **Conglomerate and sedimentary breccia** (?Oligocene)– Brown to reddish-brown, moderately to poorly sorted, structureless to weakly cross-bedded, clast-supported pebble to cobble conglomerate grading to sedimentary breccia; clasts are angular to subrounded and consist entirely of sandstone, limestone, and chert derived from the Oquirrh Group; likely deposited in alluvial-fan or colluvial-slope environments in the hanging wall of an east-side-down normal fault in the eastern foothills of the Raft River Mountains; age uncertain but inferred to be Oligocene, the time of extensive normal faulting in the eastern Raft River Mountains (Wells and others, 2000); at least 500 feet (150 m) thick.

unconformity

PERMIAN

Plsd **Limestone, sandstone, and dolomite –** Light-gray to tan, well-sorted, fine-grained, well-bedded calcareous sandstone; buff-tan, fine-grained, poorly bedded, sandy, variably fossiliferous dolomite; medium- to dark-gray bedded chert; and medium-gray, fine-grained, poorly bedded limestone; deposited in shallow-marine environments; contains Early Permian (Leonardian) conodonts (Yancey and others, 1980); about 2300 feet (700 m) thick, but top not exposed in study area.

Oquirrh Group

The Oquirrh Group consists of interbedded calcareous sandstone and siltstone, sandy to silty limestone, bioclastic limestone, and cherty limestone deposited in shallow to medium depth (up to 1300 feet [400 m]) marine environments in the Oquirrh basin of early Pennsylvanian to early Permian age (Armstrong, 1968; Jordan and Douglass, 1980). The map area is situated in the northern part of the Oquirrh basin. The total thickness of the Oquirrh Group in the study area is approximately 10,000 to 13,500 feet (3000-4100 m).

This map compilation includes nine sources of previous work that use seven different versions of Oquirrh stratigraphy. Reconciling these different versions was challenging. I derived two subdivisions of the Oquirrh Group: one for the majority of the study area, consisting of units lPoa through Pod, based on the section described by Yancey and others (1980) from the northeastern Sublett Mountains; and a second, simpler subdivision, consisting of units lPolsd and PlPos, for the Black Pine and Raft River Mountains based on the work of Smith (1982) and Compton (1975). The latter is necessary due to complex stratigraphy, structure, and metamorphism in those ranges.

The lithologic succession and marker beds described by Yancey and others (1980) are generally present in the Pleasantville, North Hansel, Deep Creek, and Sublett Mountains. Because of potential variations in the ages of contacts, general lithology, and the nature of marker beds among ranges, I chose to assign informal units to the Oquirrh Group for this map rather than retain the formations of Yancey and others (1980). The chart "Correlation of Source-Map Units for Paleozoic and Older Rocks" shows the relations between the formations of Yancey and others (1980), the map units used in this report, and those of previous workers in the study area.

The relation between the stratigraphy described by Miller (1997a-c) and Miller and Langrock (1997a-c) and the section of Yancey and others (1980) is less straightforward, due to relatively sparse age control and structural complexity. Miller's "variable lithology" member (his Pov) of the Oquirrh Group overlies a "sandstone" member (his Pos) in the Sublett and Hansel Mountains in Utah, whereas sandstone (my unit Pod) forms the top of the Oquirrh Group throughout the rest of the study area. Miller's "variable lithology" and "sandstone" members are herein included in unit Pod of the Oquirrh Group (see "Correlation of Source-Map Units for Paleozoic and Older Rocks").

Pod **Oquirrh Group unit d –** Brownish-tan to orange-brown on weathered surfaces, tan to grayish-tan on fresh surfaces, well-sorted, fine- to medium-grained, well-bedded (planar or, rarely, cross-bedded) to structureless, non-calcareous or, less commonly, calcareous sandstone grading to quartzite; forms a thick, monotonous section and is generally poorly exposed; thin beds of buff dolomite and silty, unfossiliferous to coarse-grained, bioclastic limestone are found near the top of the unit; pale-gray, medium-grained, cross-bedded sandstone is found near the middle; fusulinids suggest Early Permian (post-early Wolfcampian to early Leonardian) age (Yancey and others, 1980; R.C. Douglass *in* Allmendinger, 1983); about 2200 to 3300 feet (670-1000 m) thick.

PERMIAN AND PENNSYLVANIAN

PlPo **Oquirrh Group undivided –** Shown where exposures are poor or where previous work is of insufficient detail to assign a unit designation to outcrops.

PlPox **Bioclastic limestone unit of Oquirrh Group –** Medium- to dark-blue-gray, fine- to medium-grained, well-sorted, well- to poorly bedded, bioclastic calcarenite; visible fossil fragments include brachiopod shells, crinoid stems and heads, and coral; variable amounts of dark-gray chert, either bedded or as irregular nodules; mapped in the North Hansel Mountains by Allmendinger (1983) as klippe above Oquirrh Group rocks of similar age; distinguished based on markedly different facies and appearance from rocks in the North Hansel Mountains; age estimated as Early Permian to late Pennsylvanian (Allmendinger, 1983); contains Virgilian fusulinids (R.L. Ballou *in* Allmendinger, 1983); upper contact not exposed, lower contact removed by low-angle faults; up to about 600 feet (300 m) thick.

PlPoc **Oquirrh Group unit c –** Interbedded sandy to silty limestone, calcareous sandstone to siltstone, and rare bioclastic limestone. Sandy to silty limestone includes medium-gray, tan-gray, or yellow-gray, well-bedded, unfossiliferous, silty micrite to calcarenite, and medium-gray, fine- to medium- grained, well-bedded to platy calcarenite with tan- to brown-weathering, fine to medium grained quartz sand that is diffusely distributed or in clearly defined layers. Calcareous sandstone is grayish-tan- to tan-weathering, tan or medium-gray on fresh surfaces, well-sorted, and fine-grained and has well- to poorly defined planar bedding. Calcareous siltstone is medium-gray varying to shades of pink, lavender, or brown, well-sorted, and well-bedded to platy. Bioclastic limestone is medium-blue-gray, well-sorted, medium-grained calcarenite having well-defined bedding and sparse visible fragments of crinoid, brachiopod, coral, and other remains; forms ledges about 3 to 12 feet (1-4 m) thick. The upper contact is marked by an abrupt transition from interbedded limestone and calcareous sandstone and shale, to sandstone of unit Pod; the lower contact is placed at a relatively thick (100 feet [30 m]) group of ledge-forming, variably sandy, well-bedded bioclastic limestone beds. Unit c ranges from about 3800 to over 6000 feet (1160->1830 m) thick and contains Early Permian to Late Pennsylvanian (Virgilian to Wolfcampian) age fusulinids (Hoggan and Haitt, 1981; R.C. Douglass and R.L. Ballou *in* Yancey and others, 1980, and Allmendinger, 1983).

PlPos **Sandstone and siltstone unit of Oquirrh Group –** Tan- to brown-weathering, light-gray to yellowish-gray on fresh surfaces, poorly sorted, well- to moderately bedded, calcareous sandstone grading to siltstone; relatively minor gray-weathering, gray to dark-gray, fine-grained, unfossiliferous silty limestone is interbedded with the sandstone; contains Early Permian to Middle Pennsylvanian (early Wolfcampian to Desmoinesian) conodont, fusulinid, and bryozoan fossils (Smith, 1983); at least 8850 feet (2700 m) thick; mapped in the Black Pine Mountains (Smith, 1982).

PlPobc

Oquirrh Group units b and c undivided – Shown where source map did not differentiate Oquirrh Group sufficiently to assign units b and c.

PENNSYLVANIAN

lPob **Oquirrh Group unit b** -- Interbedded sandy to silty limestone, calcareous sandstone to siltstone, and rare bioclastic limestone; lithology is essentially identical to unit c; contains late to Early Pennsylvanian (late Atokan to Virgilian) fusulinids (R.L. Ballou and R.C. Douglass *in* Allmendinger, 1983); about 1600 to 2750 feet (490-840 m) thick.

lPoa **Oquirrh Group unit a –** Medium- to pale-gray to blue-gray, fine- to medium-grained, well-bedded to structureless, typically thick bedded (3 feet [1 m]), variably fossiliferous, variably cherty or sandy limestone; contains Middle to Early Pennsylvanian (Atokan to early Desmoinesian) age fusulinids (R.L. Ballou and R.C. Douglass *in* Allmendinger, 1983); well-bedded, fine-grained, calcareous sandstone increasingly common near top of section; upper contact placed above last prominent limestone ledge; lower contact placed below last prominent bed of cherty limestone; about 1300 to 1450 feet (400-440 m) thick.

lPolsd

Limestone, sandstone, and dolomite member of Oquirrh Group – Limestone is dark- to light-gray weathering, gray on fresh surfaces, dense to fine-grained, sugary textured, well-bedded to structureless, in beds up to 18 feet (6 m) thick, locally silty to sandy; dolomite is light- to dark-gray, dense to fine-grained crystalline, structureless, forming ledges up to about 60 feet (20 m) high, and as blocks or irregular masses interbedded in limestone; sandstone is brown, calcareous, fine-grained, and grades to quartzite; contains Middle to Early Pennsylvanian (Desmoinesian to Missourian) coral, conodont, and fusulinid fossils (Smith, 1983); mapped in Black Pine and eastern Raft River Mountains; total unit thickness about 3500 (1070 m) thick.

PENNSYLVANIAN AND MISSISSIPPIAN

lPMmc

Manning Canyon Shale – Dark-gray to black, fine-grained, well-bedded shale and mudstone; metamorphosed and deformed to scaly, olive-brown argillite in North Hansel Mountains; contains beds of gray, brown, and olive-tan, planar or cross-bedded, subarkosic quartzite in beds 1 to 20 feet (0.3-6 m) thick; upper and lower contacts removed along low-angle faults; total thickness unknown due to poor exposure and structural disruption; approximately 2200 to 6000 feet (670-1800 m) thick.

MISSISSIPPIAN

Mgb **Great Blue Limestone –** Medium- to dark-blue-gray, medium- to fine-grained, well-bedded to structureless, variably cherty and fossiliferous calcarenite; upper contact cut out by low-angle faults, and lower contact not exposed; about 3000 feet (910 m) exposed.

DEVONIAN

Dj **Jefferson Formation –** Medium- to pale-gray weathering, light- to dark-gray on fresh surfaces, medium-grained, sugary textured, thin-bedded to structureless dolomite comprising about 65 percent of the formation; gray to pale-gray, fine-grained, sugary textured limestone (25 percent); fine-grained calcareous sandstone and quartzite (10 percent); 900 feet (275 m) exposed.

ORDOVICIAN

Omq **Marble and quartzite, undivided –** Calcitic marble, dolomitic marble, sandy dolomitic to calcitic marble, quartzite, micaceous schist, and vitreous white quartzite; comprises several map units shown by Wells (1996) but grouped together here for simplicity; mapped in the eastern Raft River Mountains, structurally below the main low-angle normal fault that separates unmetamorphosed, upper-plate rocks from metamorphosed and highly deformed middle- and lower-plate rocks; these units are the metamorphosed equivalents of well-known Ordovician stratigraphic units in eastern Nevada and western Utah; the total thickness of this combined unit is 0 to about 650 feet (0-200 m), but this value bears little relationship to the stratigraphic thickness of unmetamorphosed equivalents.

unconformity

PROTEROZOIC

Pqs **Quartzite and schist –** Basal pebble- to cobble-quartzite-clast metaconglomerate, white muscovite quartzite containing thin beds of muscovite schist, dark-brown to dark-gray quartz-muscovite-biotite-feldspar schist, platy muscovite quartzite with interlayered muscovite schist and marble, pelitic schist with characteristic metamorphic mineral assemblage of staurolite + biotite + garnet + muscovite +

plagioclase + quartz, or muscovite + quartz + kyanite ± staurolite ± garnet ± zoisite; unit includes several formations mapped individually by Compton (1975) and Wells (1996) but mapped together here for simplicity; total thickness ranges from about 600 to 2000 feet (180-610 m), but this value bears little relation to stratigraphic thickness due to extensive deformation and metamorphism.

unconformity

ARCHEAN

Ami **Metamorphosed igneous rocks –** Includes metamorphosed mafic and granitic igneous rocks that intrude the Archean schist unit (Compton, 1975; Wells, 1996); mafic rocks are dark-green, dark-gray, or black, structureless, medium-grained, gneissic to schistose amphibolite composed of hornblende, andesine, quartz, and zoisite; granitic rocks are adamellite (monzogranite) in composition, medium to coarse grained, equigranular to porphyritic, and composed of plagioclase, quartz, potassium feldspar, biotite, and muscovite, with minor amounts of garnet, zircon, and apatite; dated at about 2.5 Ga by the Rb-Sr isochron method (see references in Wells, 1996).

As **Schist –** Light-brown to medium-gray weathering, fine-grained, biotite-muscovite-feldspar schist with conspicuous quartz veins; 400 feet (120 m) thick.

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Table 1. *Radiometric K-Ar ages from Curlew Valley study area.*

Map ID	Source[1]	Sample[2]	Latitude	Longitude	UTM Northing	UTM Easting	Location	Rock Type	Material Dated	Age (Ma)
1	M	M93WI-40	41°50'43"	113°01'32"	4634368	331834	Wildcat Hills	Rhyolite	Sanidine	2.1 ± 0.06
2	M	M93WI-37	41°51'09"	113°00'48"	4635146	332868	Wildcat Hills	Rhyodacite	Plagioclase	4.4 ± 1.1
3	M	M93WI-43	41°49'03"	113°01'50"	4631294	331346	Wildcat Hills	Basalt	Whole Rock	3.6 ± 0.1
4	M	AD/WH/91-7	41°48'51"	113°02'01"	4630930	331083	Wildcat Hills	Basalt	Whole Rock	4.9 ± 0.4
5	M	M87LS-135	41°42'23"	112°54'29"	4618724	341247	Locomotive Springs	Basalt	Whole Rock	0.44 ± 0.1
6	M	M89CV-44	41°44'52"	112°54'24"	4623317	341465	middle shield	Basalt	Whole Rock	0.72 ± 0.15
7	M	M89CV-43	41°50'25"	112°51'33"	4633500	345637	Cedar Hill	Basalt	Whole Rock	1.16 ± 0.08
8	F	AD/TM/88-6	41°42'33"	113°08'37"	4619493	321655	Table Mountain	Basalt	Whole Rock	5.7 ± 0.6
9	F	AD/BB/88-7	41°51'56"	113°10'21"	4636918	319691	NW of Black Butte	Basalt	Whole Rock	8.6 ± 0.8
n/a[3]	F	AD/RP/91-1	41°53'48"	112°32'59"	4639251	371443	Rattlesnake Pass	Basalt	Whole Rock	14.7 ± 0.5
n/a[3]	F	AD/RP/91-2	41°53'43"	112°33'16"	4639104	371048	Rattlesnake Pass	Basalt	Whole Rock	14.9 ± 0.5
10	F	AD/TM/91-3	42°05'01"	112°51'15"	4660534	346667	Table Mountain ID	Basalt	Whole Rock	12.6 ± 0.5
11	F	AD/TM/91-4	42°05'02"	112°51'11"	4660473	346626	Table Mountain ID	Basalt	Whole Rock	13.1 ± 0.5
12	F	AD/PV/91-5	41°49'16"	113°09'20"	4631948	320973	South of Black Butte	Basalt	Whole Rock	6.1 ± 0.4
13	F	AD/KV/91-6	41°45'09"	113°11'26"	4624403	317872	Basalt dike	Basalt	Whole Rock	5.0 ± 0.4
14	F	AD/WH/91-7	41o48'51"	113o02'01"	4630930	331083	Wildcat Hills	Basalt	Whole Rock	4.9 ± 0.4

Notes
1. M = Miller and others (1995), F = Fiesinger (written communication, 2004).
2. Sample number listed in source publication.
3. Sample location is about 3 miles (4.8 km) east of the study area.

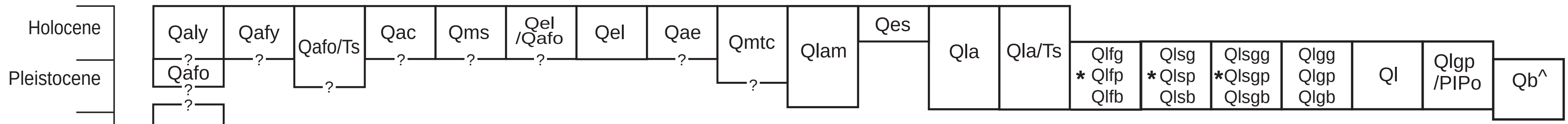
Table 2. *Records of petroleum-exploration wells in Curlew Valley map area*[1].

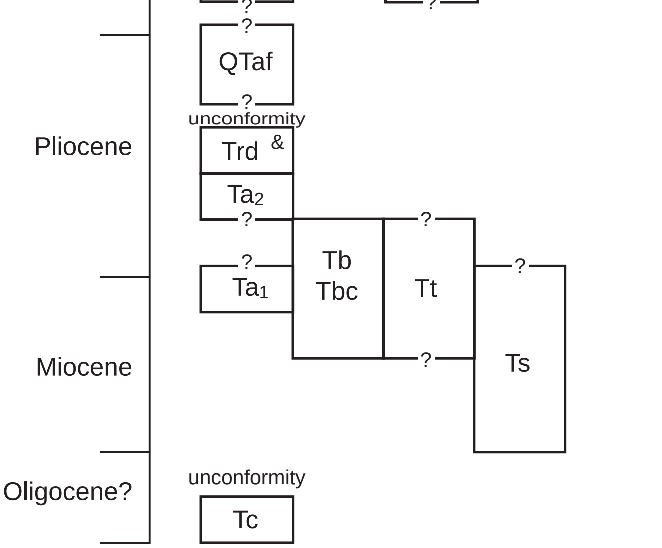
Map ID	Township, Range, Section	Spot[2]	Completion Date	Operator	Well Name	Wellhead Elev. (ft)	Total Depth (feet)
A	14 S 30 W 10	3250 FSL 152 FWL	2/12/1951	UTAH SOUTHERN OIL COMPANY	1 JUNIPER	5840	12,841
B	14 N 9 W 6	1980 FNL 660 FEL	04/27/1956	UTAH SOUTHERN OIL COMPANY	2 FEDERAL	4420	7569
C	14 N 10 W 14	1998 FNL 1863 FEL	12/01/1954	UTAH SOUTHERN OIL COMPANY	GOVT-GABRIELSON	4408	4767
D	14 N 10 W 23	1980 FNL 660 FWL	12/01/1954	UTAH SOUTHERN OIL COMPANY	1 KEELER	4394	4760
E	14 N 10 W 22	891 FSL 1940 FWL	01/13/1956	UTAH SOUTHERN OIL COMPANY	1 FEDERAL	4412	6465
F	13 N 11 W 25	2210 FNL 330 FEL	10/08/1946	STANFORD PETROLEUM	1 FONNS BECK	5325	730

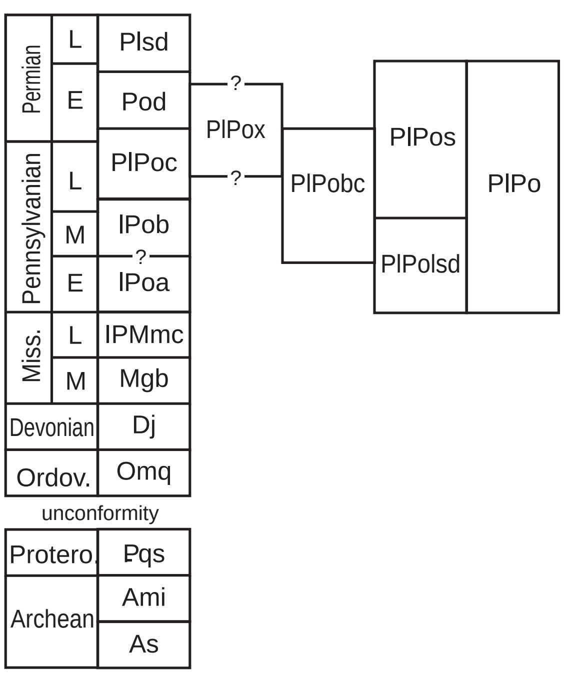
Notes

1. Data from Utah Division of Oil, Gas and Mining
2. Well location within section is given in feet from south (FSL) or north (FNL), and from west (FWL) or east (FEL) section-boundary lines.

CORRELATION OF MAP UNITS







Notes:

* Lacustrine sediments are denoted by the last letter in the map symbol according to the lake stage during which they were deposited: g – Gilbert stage of the Great Salt Lake [10.9-10.3 ka, shoreline at 4,250 feet (1,294 meters)]; p – Provo stage of Lake Bonneville [14.5-14.0 ka, highest shoreline at 4,800-4,750 feet (1,263-1,448 meters)]; b – Bonneville stage of Lake Bonneville [15.0 - 14.5 ka, highest shoreline at 5,180 feet (1,579m); secondary shoreline at 5,150 feet (1,570 meters)]; Stage names, ages, and shoreline elevations from Oviatt and others (1992).

^ K-Ar whole-rock ages are 1.16 $\pm$ 0.08 Ma for the Cedar Hill (northern) shield, 0.72 $\pm$ 10.15 Ma for the middle shield, and 0.44 $\pm$ 0.10 Ma for the Locomotive Springs (southern) shield (table 1; Miller and others, 1995).

& K-Ar ages range from 2.1 $\pm$ 0.06 Ma on sanidine from rhyolite, to 4.9 $\pm$ 0.4 Ma on whole-rock basalt (table 1; Miller and others, 1995).

STRATIGRAPHIC COLUMN

Era	Period/ Epoch		Group	Unit	Map	Thickness (feet)	Lithology
Cenozoic	Quaternary	Holocene		Alluvial, mass-movement, and eolian deposits	Qa, Qm, Qe	≤300	
		Pleistocene		Lacustrine deposits of Lake Bonneville	Ql	≤400	
				Basalt	Qb	0 - 600+	
				Alluvial-fan deposits	QTaf	400	
	Pliocene			Rhyodacite	Trd	200+	
				Pediment gravel and alluvium	Ta_2	0 - 250	
				Basalt	Tb, Tbc	300	
	Miocene			Alluvium	Ta_1	0 - 215	
				Tuff	Tt	0 - 50	
				Salt Lake Formation	Ts	1700+	
				Sedimentary breccia and conglomerate	Tc	0 - 500	
Paleozoic	Permian			Limestone, sandstone, and dolomite	Plsd	260 - 2300+	
			Oquirrh Group	Sandstone and quartzite	Pod	2200 - 3300	
	Permian and Pennsylvanian			Sandstone	PlPos	8850	
				Limestone	PlPox	600	
				Sandy limestone, calcareous sandstone and siltstone, and bioclastic limestone	PlPoc	3800 - 6000+	
				Sandy limestone, calcareous sandstone and siltstone, and bioclastic limestone	IPob	1600 - 2750+	
	Pennsylvanian			Cherty and sandy limestone	IPoa	1300- 1445	
				Sandy limestone, dolomite	IPolsd	3500	
				Manning Canyon Shale	IPMmc	2200 - 6000+	
	Mississippian			Great Blue Limestone	Mgb	3000+	
	Devonian			Jefferson Formation	Dj	900+	
	Ordovician			Marble and quartzite	Omq	0 - 650	
Proterozoic				Quartzite and schist	Ꝑqs	600 - 2000	
Archean				Metamorphosed igneous rocks	Ami	450 - 700	
				Schist	As	400	

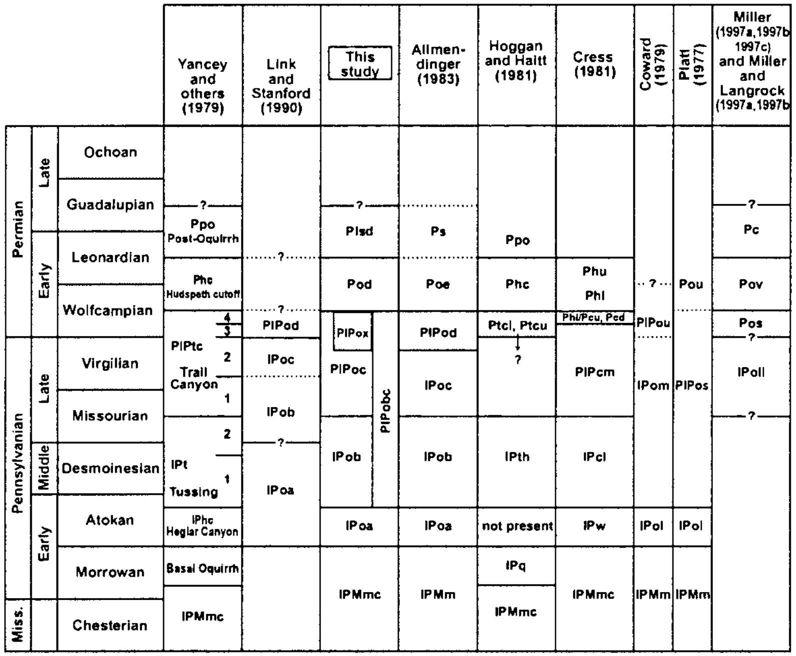
Explanation

Lithology

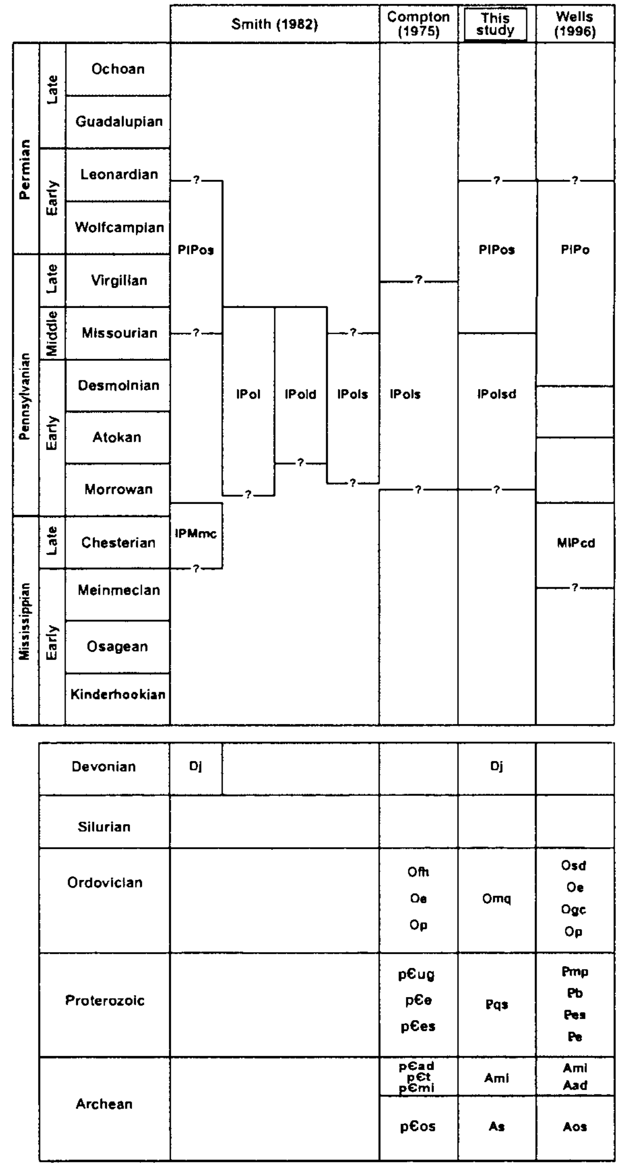
- fine sandstone
- coarse sandstone
- limestone
- limestone-bedded
- limestone-shaley
- conglomerate
- lava flows-basic
- lava flows-silicic
- breccia/tuff
- intrusive rock-silicic
- quartzite
- dolomite
- shale - carbonaceous
- claystone
- cherty limestone
- limestone - sandy
- marble
- schist
- schist and gneiss

CORRELATION OF SOURCE MAP UNITS FOR PALEOZOIC AND OLDER ROCKS

Sublett, Hansel, Pleasantview, Deep Creek, and Hansel Mountains



Raft River and Black Pine Mountains



Map Indices and Sources of Map Compilation