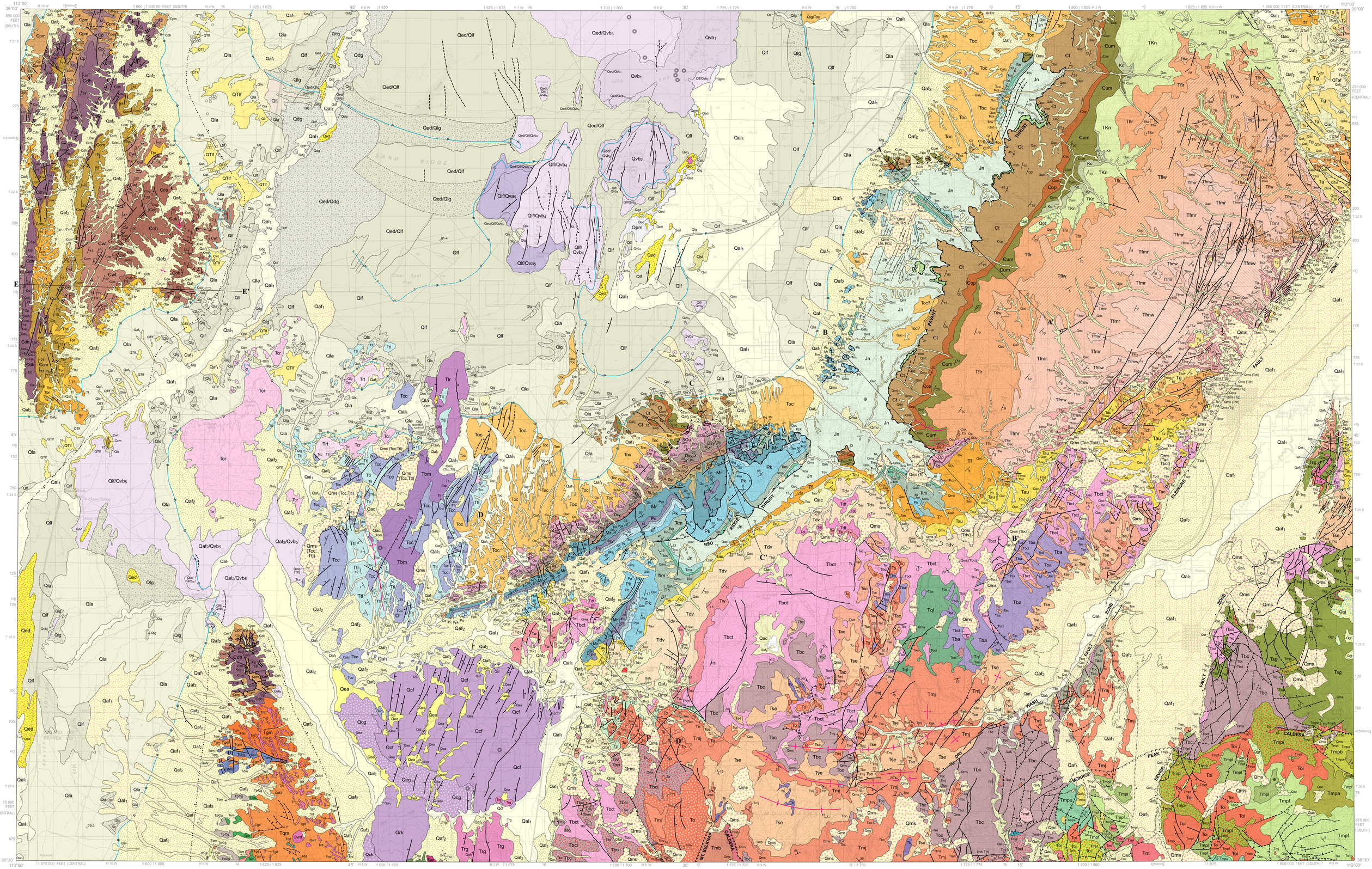

SCALE 1:100,000
Contour interval 40 meters
Supplementary contour interval 10 meters

2 1 0 2 4 6 8 10 Kilometers

2 1 0 2 4 Miles

Base from U.S.G.S. Richfield 30' x 60' quadrangle, 1980

13°00'
231 MILS

2002 MAGNETIC DECLINATION AT CENTER OF SHEET

GEOLOGIC MAP OF THE RICHFIELD 30' x 60' QUADRANGLE, SOUTHEAST MILLARD COUNTY AND PARTS OF BEAVER, PIUTE, AND SEVIER COUNTIES, UTAH

by

Lehi F. Hintze[1,2], Fitzhugh D. Davis[2], Peter D. Rowley[3], Charles G. Cunningham[4], Thomas A. Steven[4], and Grant C. Willis[2]

2003

[1]Brigham Young University [2]Utah Geological Survey [2]Geologic Mapping, Inc. [4]U.S. Geological Survey

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Plate 1 of 2
Utah Geological Survey Map 195

Utah Geological Survey
a division of
Utah Department of Natural Resources
***in cooperation with* U.S. Geological Survey**
National Cooperative Geologic Mapping Program
Statemap Agreement No. 00HQAG0109

GIS compilation: Basia Matyjasik, Angela Wadman (UGS), and Jeremiah B. Workman (USGS)
Cartographer: James W. Parker
Project Manager: Jon K. King

Plate 2 of 2

Utah Geological Survey Map 195

GEOLOGIC MAP OF THE RICHFIELD 30' x 60' QUADRANGLE, SOUTHEAST MILLARD COUNTY AND PARTS OF BEAVER, PIUTE, AND SEVIER COUNTIES, UTAH

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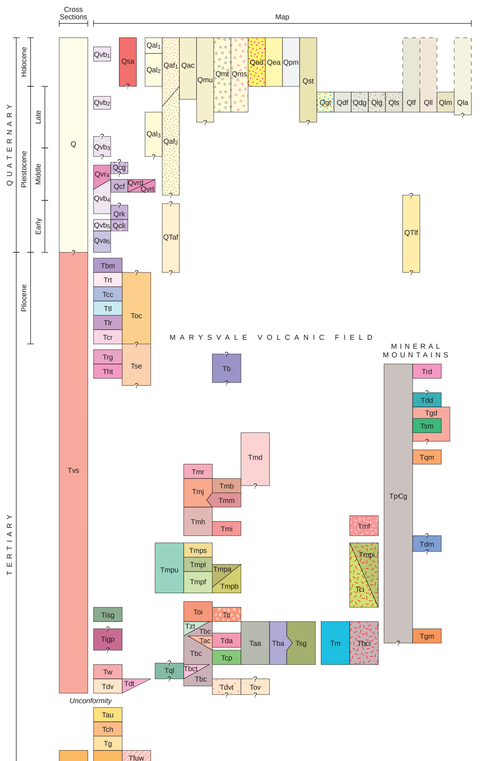
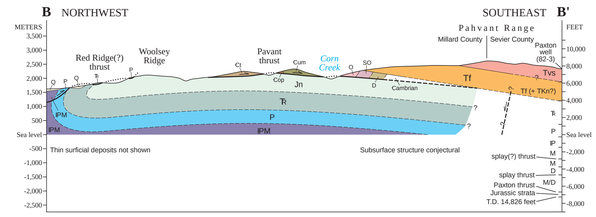
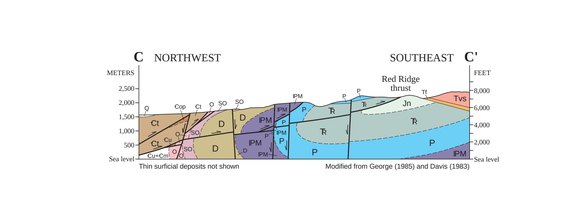
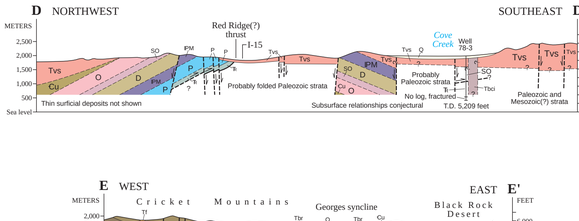
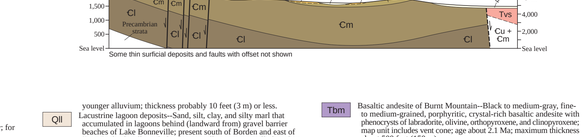
CORRELATION OF GEOLOGIC UNITS

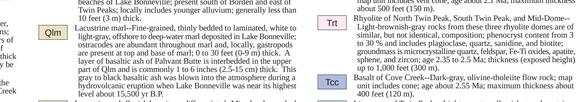












LITHOLOGIC COLUMN

AGE	MAP SYMBOL	UNIT	THICKNESS Feet	THICKNESS Meters	SCHEMATIC COLUMN	OTHER INFORMATION
QUATERNARY	Q-various	Alluvial, eolian, glacial, and Lake Bonneville deposits	0-300±	0-90±		
	Qvb$_1$	Basalt of Ice Springs	0-200	0-60		6607-4,000? years old
	Qvb$_2$	Basalt of Tabernacle Hill	0-200	0-60		14,320 yrs B.P.
	Qvb$_3$	Basalt of Pahvant Butte	0-100	0-30		
	Qvrs, *Qvrt, Qvrd	Rhyolite of White Mountain and Mineral Mountains	0-120	0-40		0.4 and 0.5 Ma, respectively
	Qcg,Qcf	Basaltic andesite of Cedar Grove (cg), Cove Fort (cf)	0-800	0-250		0.3 and 0.5 Ma, respectively
	Qvb$_4$	Basalt of Kanosh, Beaver Ridge and Mineral Mountains	0-300	0-90		0.5 to 0.9 Ma
	*Qrk,*Qck	Basaltic andesite of Red and Crater Knolls	0-200	0-60		~1.0 Ma
	Qvb$_5$,Qvb$_6$	Basalt of Black Rock, Andesite of Beaver Ridge	0-200	0-60		1.0-1.5 Ma
	QTif,QTaf	Fine-grained lake sediments (lf); alluvial-fan deposits (af)	0-1,000	0-300		0.7-2.0 Ma in Sevier Lake
TERTIARY: PLIOCENE	Tbm	Basaltic andesite of Burnt Mountain	0-500	0-150		2.1 Ma
	Trt	Rhyolite of N. Twin Peak, S. Twin Peak, Mid-Dome	-------	-------		2.35-2.5 Ma
	Tcc	Basalt of Cove Creek	0-400	0-120		2.55 Ma
	Tti	Toc: Limestone of Twin Peaks	0-262	0-80		Lacustrine
	Tlr	Basalt of Lava Ridge	0-200	0-60		2.5 Ma
	Tcr	Rhyolite of Cudahy Mine, Rhyodacite of Coyote Hills	0-650	0-200		2.6 & 2.7 Ma
TERTIARY: MIOCENE	Tse	Sevier River Formation	600-1,000	180-300		5 to 14 Ma
	*Trg	Rhyolite of Gillies Hill	-------	-------		~9 Ma
	Tht	Tuff of Holden	0-200?	0-60?		10.5-10.8 Ma?
	*various	Intrusions and gneiss complex in Mineral Mountains	--------			11-25 Ma
	Tqm	Quartz monzonite of Mineral Mountains	Stock			18 Ma
	Tmj	Joe Lott Tuff Member, Mt. Belknap Volcanics	0-400	0-120		19 Ma, from Mt. Belknap caldera
	To	Osiris Tuff	0-200	0-60		23 Ma, from Monroe Peak caldera
	*Tisg, *Tigp	Syenite (sg) and gabbro (gp) of Cedar Grove	Intrusions			~23 Ma
	Tgm	Granodiorite of Mineral Mountains	Stock			25 Ma
	Tac	Tuff of Albinus Canyon	0-650	0-200		25.3 Ma
	Tbct	Three Creeks Tuff Member, Bullion Canyon Volcanics	0-720	0-220		27 Ma
	Tw	Volcanic rocks of Wales Canyon	440	135		
	Tdv	Volcanic rocks of Dog Valley	0-1,200	0-370		~33 Ma
	Tdt	Tuff of Dog Valley	400±	120±		33.6 Ma Ar/Ar
	Tdvt, Tov	Dipping Vat Formation, older volcanic rocks	~600	~180		Age uncertain; Hiatus and unconformity
	Tau	Aurora Formation	0-1,200	0-360		38-40 Ma
	Tch	Crazy Hollow Formation	0-350	0-107		
	Tg	Green River Formation	0-800	0-245		
	Tf-various	Flagstaff Formation	0-3,500	0-1,070		Freshwater limestone, bioturbated
	Tbr	Breccia of Cat Canyon	0-165	0-50		Sandstone and pebble conglomerate
	TKn	North Horn Formation	0-2,500	0-760		
	Ktm	Tectonic melange beneath Pavant thrust plate	0-200	0-60		
CRET.	Kc,Kcg	Canyon Range Conglomerate, Conglomerate of Mineral Mtns.	0-866	0-264		
JUR.	Jn	Navajo Sandstone	2,000±	600±		Eolian, cross-bedded
TRIASSIC	Trcu	Chinle Formation, upper member	69-274	21-83		Clayey, prone to slump
	Trcs	Chinle Formation, Shinarump Conglomerate Member	177-566	54-172		
PERMIAN	Tem	Moenkopi Formation	1,876	572		Ripple marks, marine fossils
	Pk	Kaibab Limestone	1,160	353		Cherty; 497 feet (152 m) thick in subsurface
	Pq	Queantoweap Sandstone	817	249		
	Ppk	Pakoon Dolomite	445	136		
PENN.	IPc	Callville Limestone	538	164		
MISS.	Mr	Redwall Limestone	1,545	471		Fossil corals and gastropods
DEVONIAN	Dc	Cove Fort Quartzite	82-160	25-49		Pinyon Peak Ls equivalent
	Dg	Guilmette Formation	575	175		Stromatoporoids
	Ds	Simonson Dolomite	185	56		
	Dsy	Sevy Dolomite	710	217		Light-gray dolomite
SIL.	SOu	Laketown and Fish Haven Dolomites, undivided	566-1,000	173-300		
	Oe	Eureka Quartzite	150-180	45-55		Orthid brachiopods at top
ORDOVICIAN	Op	Pogonip Group	1,125-1,200	343-350		Intraformational conglomerate
UPPER CAMBRIAN	Ca: Ajax Dolomite	700 ft (210 m)				Top not preserved in map area
	Cox: Opex Formation	390 ft (120 m)				*Tricrepicephalus*
MIDDLE CAMBRIAN	Cum: Upper and Middle Cambrian carbonate rocks	2,400 ft (735 m)				*Eldoradia*
	Cop: Ophir Formation	850 ft (260 m)				*Ehmaniella* *Glossopleura*
LOWER CAMBRIAN	Ct: Tintic Quartzite	est. 3,300 ft (1,000 m)				
PRECAM.	pCg	Banded gneiss in Mineral Mountains				1,750 Ma

OCn	Notch Peak Fm.	100+	30+
Cou	Orr Fm, upper mbrs.	405	122
Cob	Orr Fm, Big Horse Mbr.	656	200
Cwt	Wah Wah Summit - Tripps Fms., undivided	1,420±	433±
Ccm	Limestone of Cricket Mountains	1,970	600
Cw	Whirlwind Fm.	200-265	60-80
Cdh	Dome-Chisholm (Peasely)-Howell Fms.	850±	260±
Cp	Pioche Formation	800±	245±
Cpm	Prospect Mountain Quartzite	4,000+	1,200+

THRUST FAULTED BASE

Paleozoic sequence listed above is part of the paratectonic Pavant thrust plate in the eastern part of the quadrangle.

Cambrian rocks above are exposed in the Cricket Mountains (on the Canyon Range thrust plate), and are partially exposed and structurally thinned in the Mineral Mountains

*Unit mostly in Beaver County

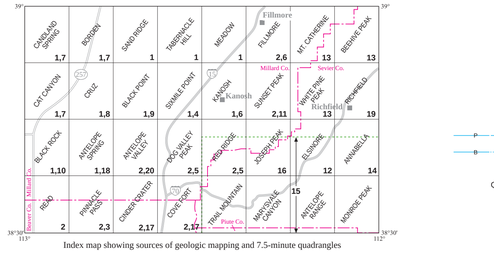
Diagram is schematic-- no fixed thickness scale

NOTE: Ma ages are from K-Ar data and may contain substantial error. Most units are local and thus not superposed on one another. Stacking on this chart is a best estimate. Some thicknesses were estimated from topographic maps.

MARYSVALE VOLCANIC FIELD LITHOLOGIC COLUMN

AGE	MAP SYMBOL	MAP UNIT	THICKNESS Feet	THICKNESS Meters	SCHEMATIC COLUMN	OTHER INFORMATION
MIOCENE	Tb	Basalt flows in northern Tushar Mountains	0-425	0-130		11-13 Ma?
	Tmd	Late rhyolite rocks	----	----		14-19 Ma
	Tmr	Mount Belknap Volcanics: Red Hills Tuff Member	<600	<180		18.9 Ma K-Ar
	Tmj	*Joe Lott Tuff Member	0-400	0-120		Mount Belknap caldera is source
	Tmb	Mount Baldy Rhyolite Member	<2,600	<800		Age uncertain
	Tmm	Middle tuff member	<1,640	<500		Present in upper Tmj
	Tmh	Lower heterogeneous member	230	70		
	Tmf	Fine-grained granite	intrusions			20-21 Ma
	Tmi	Crystal-rich domes and plugs	----	----		
	Tmpi, Tci	Intracaldera intrusions	intrusions			21-22 Ma
	Tmpu: Tmps	Intracaldera rocks, undivided: Sedimentary rocks	200	60		
	Tmpl	Lava flows of Monroe Peak	500	150		21.3 Ma K-Ar
	Tmpa	Volcanic rocks of Sage Flat	200	60		Andesitic
	Tmpf	Lava flows of Monkey Tail Ridge	<500	<150		Dacitic
	Tmpb	Lava flows of Bagley Meadows	650	200		Flows or dome
	Toi, To	*Osiris Tuff (i=intracaldera)	0-1,150+	0-350+		Monroe Peak caldera is source
	Tzt	Zeolite tuff	400	120		24.6 Ma?
	Tsg	Volcanic rocks of Signal Peak	2,100	650		Andesitic
OLIGOCENE	Tda: Tamy Fm.	Antimony Tuff Member, Mt. Dutton Fm.	200	60		25.4 Ma K-Ar
	Tba	Basaltic andesite lava flows	500	150		May be part of unit Tsg
	Tac	*Tuff of Albinus Canyon	0-650	0-200		25.3 Ma
	Tcp	Crystal-poor dacitic lava flows	100-160	30-50		
	Tbc	Bullion Canyon Volcanics	5,000±	1,500+		22-30 Ma
	Tbci	Monzonitic / latitic intrusions	intrusions			23-27 Ma
	Tbct	*Three Creeks Tuff Member	0-720	0-220		27 Ma
	Tql	Quartz latite dome and rhyodacite flow	650	200		Age uncertain

*Also on main lithologic column



Index map showing sources of geologic mapping and 7.5-minute quadrangles

SOURCE LIST FOR GEOLOGIC MAPPING

Surficial Geology

1. Oviatt, C.G., 1991, Quaternary geology of the Black Rock Desert, Millard County, Utah: Utah Geological and Mineral Survey Special Study 73, 23 p., scale 1:100,000; locally modified by L.F. Hintze and F.D. Davis, 1991 and 1992, unpublished mapping for this publication, scale 1:24,000.
2. Davis, F.D., and Hintze, L.F., 1991, 1992, and 1999, unpublished mapping for this publication, scales ~1:50,000 and 1:24,000.

Bedrock Geology

3. Coleman, D.S., Bartley, J.M., Walker, J.D., Price, D.E., and Friedrich, A.M., 1997, Extensional faulting, footwall deformation and plutonism in the Mineral Mountains, southern Sevier Desert: Brigham Young University Geology Studies, v. 42, part 2, p. 203-233, scale 1:21,300; Walker, J.D., and Bartley, J.M., 1992, unpublished map, scale 1:12,000; and Sibbett, B.S., and Nielson, D.L., 1980, Geology of the central Mineral Mountains, Beaver County, Utah: Earth Science Laboratory, University of Utah Research Institute Report ESL-33 (DOE/ET/28392-40), 42 p., scale 1:24,000.
4. Crosby, G.W., 1959, Geology of the south Pavant Range, Millard and Sevier Counties, Utah: Brigham Young University Geology Studies, v. 6, no. 3, 59 p., scale 1:65,000; modified by L.F. Hintze, 1992, unpublished mapping for this publication, scale 1:24,000.
5. Davis, R.L., 1983, Geology of the Dog Valley-Red Ridge area, southern Pavant Mountains, Millard County, Utah: Brigham Young University Geology Studies, v. 30, part 1, p. 19-36, scale 1:24,000; modified locally by L.F. Hintze, 1992, for this publication, scale ~1:50,000. Mapping of volcanic rocks by L.F. Hintze, 1992 for this publication, scale 1:24,000, with clarification from G.C. Willis, 2001-02, sketch maps; modified from Steven, T.A., and Morris, H.T., 1983, Geologic map of the Cove Fort [15'] quadrangle, west-central Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-1481, scale 1:50,000.
6. George, S.E., 1985, Geology of the Fillmore and Kanosh quadrangles, Millard County, Utah: Brigham Young University Geology Studies, v. 32, part 1, p. 39-62, scale 1:24,000; modified locally by L.F. Hintze for this publication.
7. Hintze, L.F., 1984, Geology of the Cricket Mountains, Millard County, Utah: U.S. Geological Survey Open-File Report 84-683, 14 p., plate 8, map scale 1:24,000; mapping of volcanic rocks by L.F. Hintze for this publication, scale 1:24,000, modified from Crecraft, H.R., Nash, W.P., and Evans, S.H. Jr., 1981, Late Cenozoic volcanism at Twin Peaks, Utah, geology and petrology: Journal of Geophysical Research, v. 86, p. 10,303-10,320, scale 1:200,000.
8. Hintze, L.F., 1990 and 1991, unpublished mapping for this publication, scale 1:24,000.
10. Hintze, L.F., 1991, unpublished mapping for this publication, scale 1:24,000, partly modified from Crecraft, H.R., Nash, W.P., and Evans, S.H. Jr., 1981, Late Cenozoic volcanism at Twin Peaks, Utah, geology and petrology: Journal of Geophysical Research, v. 86, p. 10,303-10,320, scale 1:200,000.
11. Hintze, L.F., 1992, and Hintze, L.F., and Willis, G.C., 1999, unpublished mapping for this publication, scale 1:24,000, partly modified from Hickox, C.W., 1971, Geology of a portion of the Pavant Range allochthon, Millard County, Utah: Houston, Texas, Rice University, Ph.D. dissertation, 67 p., scales 1:63,360 and 1:31,360.
12. Hintze, L.F., 1992, and Hintze, L.F., and Willis, G.C., 1999, unpublished mapping for this publication, scale 1:24,000 and ~1:50,000; modified from Steven, T.A., 1975a, Geologic map of the Monroe NW (Elsinore) quadrangle, west-central Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-1007, scale 1:24,000.
13. Lautenschlager, H.K., 1952, Geology of the central part of the Pavant Range, Utah: Columbus, Ohio State University, Ph.D. dissertation, 188 p., map scale 1:31,680; modified locally using Hickox, C.W., 1971, Geology of a portion of the Pavant Range allochthon, Millard County, Utah: Houston, Texas, Rice University, Ph.D. dissertation, 67 p., scales 1:63,360 and 1:31,360; modified by L.F. Hintze, 1991, and L.F. Hintze and G.C. Willis, 1999, unpublished mapping for this publication, scale 1:24,000.
14. Rowley, P.D., Steven, T.A., and Kaplan, A.M., 1981, Geologic map of the Monroe Peak NE (Annabella) quadrangle, Sevier County, Utah: U.S. Geological Survey Miscellaneous Field Investigations Map MF-1330, scale 1:24,000; partly modified by G.C. Willis, 1999.
15. Rowley, P.D., Cunningham, C.G., Steven, T.A., Workman, J.B., Anderson, J.J., and Theissen, K.M., 2002, Geologic map of the central Marysvale volcanic field, southwestern Utah: U.S. Geological Survey Geologic Investigations Map I-2645A, scale 1:100,000; with clarification locally from Cunningham, C.G., Steven, T.A., Rowley, P.D., Glassgold, L.B., and Anderson, J.J., 1983, Geologic map of the Tushar Mountains and adjoining areas, Marysvale volcanic field, Utah: U.S. Geological Survey Miscellaneous Investigations Map I-1430, scale 1:50,000.
16. Steven, T.A., 1979, Geologic map of volcanic rocks in the Sevier NE (Joseph Peak) quadrangle, west-central Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-1108, scale 1:24,000; and Hickox, C.W., 1971, Geology of a portion of the Pavant Range allochthon, Millard County, Utah: Houston, Texas, Rice University, Ph.D. dissertation, 67 p., scales 1:63,360 and 1:31,360; modified by L.F. Hintze, 1991, and L.F. Hintze and G.C. Willis, 1999, unpublished mapping for this publication, scale 1:24,000.
17. Steven, T.A., and Morris, H.T., 1983, Geologic map of the Cove Fort [15'] quadrangle west-central Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-1407, scale 1:24,000.
18. Whelan, J.A., and Bowdler, James, 1979, Geology of the Antelope Springs quadrangle, Millard County, Utah: Utah Geology, v. 6, no. 2, p. 81-85, scale 1:62,500; and Hintze, L.F., 1991-1992, unpublished mapping for this publication, scale 1:24,000; north end of Mineral Mountains from Coleman, D.S., Bartley, J.M., Walker, J.D., Price, D.E., and Friedrich, A.M., 1997, Extensional faulting, footwall deformation and plutonism in the Mineral Mountains, southern Sevier Desert: Brigham Young University Geology Studies, v. 42, part 2, p. 203-233, scale 1:21,300.
19. Willis, G.C., 1994, Interim geologic map of the Richfield [7.5'] quadrangle: Utah Geological Survey Open-File Report 309, 105 p., scale 1:24,000.
20. Zimmerman, J.T., 1961, Geology of the Cove Creek area, Millard and Beaver Counties, Utah: Salt Lake City, University of Utah, M.S. thesis, 91 p., scale 1:24,000; and Hintze, L.F., 1991, unpublished mapping for this publication, scale 1:24,000, partly modified from Crecraft, H.R., Nash, W.P., and Evans, S.H. Jr., 1981, Late Cenozoic volcanism at Twin Peaks, Utah, geology and petrology: Journal of Geophysical Research, v. 86, p. 10,303-10,320, scale 1:200,000.

MAP AND CROSS-SECTION SYMBOLS

CONTACT-- Dashed where location inferred; queried where speculative on cross sections

NORMAL FAULT-- Dashed where location inferred; dotted where concealed; queried where existence uncertain; bar and ball on downthrown side; arrows show relative movement on cross section

STEEPLY DIPPING FAULT-- Sense of motion not known or complex; dashed where location inferred; dotted where concealed

NORMAL FAULT-- Inferred and delineated from gravity data; concealed; bar and ball on downthrown side

TEAR FAULT-- High-angle fault with strike-slip offset; dashed where location inferred; dotted where concealed; arrows show relative movement on map

THRUST FAULT-- Dashed where location inferred; dotted where concealed; barbs on upper plate; arrows show relative movement on cross sections

ATTENUATION FAULT -- Younger over older rocks with strata thinned and cut out between; present in Mineral Mountains; barbs on upper plate

CALDERA MARGIN-- Dashed where location inferred; dotted where concealed; hachures on downthrown side; mostly topographic boundary of caldera.

DETACHMENT RELATED TO MASS MOVEMENTS--Dashed where location inferred; present on west side of Pahvant Range (where Navajo Sandstone has crept downslope on underlying Chinle)

LINEAMENT -- Shown west of White Sage Flat, may be concealed fault trace

FOLD AXES -- Dotted where concealed (arrows on axes show plunge)

anticline

syncline

overturned anticline

ESCARPMENT AT HEAD OF SLUMP/SLIDE AREA

STRIKE AND DIP OF BEDDING--

inclined

vertical

overturned

horizontal

STRIKE AND DIP OF PLANAR FEATURES IN ASH-FLOW TUFF

DEEP EXPLORATION WELL-- map symbol on left, cross section symbol on right

SINKHOLE (in QTif)

VOLCANIC VENT/CINDER CONE

SHORELINES-- dashed where inferred; dotted where concealed; queried where conjectural

Provo shoreline of Lake Bonneville-- queried where uncertain

Bonneville shoreline of Lake Bonneville

Qtf/QTaf Indicates thin cover of the first unit overlying the second unit

Qms (℞c) Indicates unit(s) involved in mass movement

DESCRIPTION OF GEOLOGIC UNITS

Q Quaternary surficial units, undivided--On cross sections only; for included units see correlation chart and descriptions.

Qal$_1$, **Qal$_2$** Alluvium, late Holocene--Youngest alluvium in channels, floodplains, and low terraces of the Sevier River, Beaver River, Chalk Creek, Corn Creek, Cove Creek, and other large streams; includes overbank and marsh deposits in abandoned meanders of the Sevier River; consists of silt, silt and clay, and lenses of gravel; silt in lower Pahvant Valley; less than 100 feet (30 m) thick along Sevier River; mostly 0 to 20 feet (0-6 m) thick, but may be thicker locally.

Qal$_3$ Alluvium, middle and early Holocene--Sand, silt, and clay in the floodplain of Cove Creek, isolated remnants in the valleys of Chalk Creek and Corn Creek sand and gravel near Fillmore and Kanosh (respectively), along a stream near White Sage Flat, in the Pahvant Range foothills along East Creek, and south of the Sevier River southwest of Elsinore; 0 to 30 feet (0-9 m) thick.

Qal$_4$ Alluvium, pre-Lake Bonneville--Silt, sand, and pebble to boulder gravel in faulted and tilted terraces along Sevier River southwest of Elsinore; 0 to 40 feet (0-13 m) thickness exposed; age uncertain, might be Holocene.

Qvb$_1$ Younger alluvial-fan deposits--Poorly sorted silt, sand, and pebble, cobble, and boulder gravel deposited by streams, sheetwash, debris flows, and flash floods on alluvial fans, and in canyons and mountain valleys above the Bonneville shoreline; includes colluvium in canyons and mountain valleys; on flanks of Mineral Mountains is mostly pebble-and gravel-size, locally including larger cobbles and boulders; mostly pre-Lake Bonneville in age, but locally includes younger material; up to 200 feet (60 m), or more, in thickness.

Qvb$_2$ Alluvium and colluvium, undifferentiated--Alluvial and colluvial deposits that consist of flavally reworked coarse-grained colluvium and/or alluvium with a significant colluvial component; also includes talus; generally 0 to 50 feet (0-15 m) thick, but may be thicker locally.

Qvs$_m$ Mass movements, undivided--Masses of soil, sand, rock, and boulders that have moved downslope under the influence of gravity; includes soil creep, slopewash, talus, and fan alluvium, and locally slides and slumps; 0 to 100 feet (0-30 m) thick. Includes dissected older deposits on and near Bull Claim Hill southeast of Richfield.

Qms Mass movements, talus--Poorly sorted, angular rock rubble with minor fine-grained interstitial material on and at the base of steep slopes in the Pahvant Range; only the largest deposits can be shown at map scale; thickness less than 100 feet (30 m).

Qms Mass movements, slides and slumps--Volcanic and sedimentary rock masses that have slumped and slid downslope, commonly on softer, underlying rocks; small isolated slides or slumps are present in many mountainous areas, but are too small to show at 1:100,000 scale; up to 250 feet (75 m) thick.

Qed Eolian dunes--Chiefly parabolic, longitudinal, and barchan sand dunes that are active and not stabilized by vegetation; composed of well-sorted, fine-grained quartz sand; also gypsum dunes in the vicinity of White Mountain and silt dunes downwind from playas and alluvial fans; 3 to 35 feet (1-10 m) thick.

Qea Eolian and alluvial deposits, mixed--Interbedded and mixed windblown and alluvial sand and silt in the volcanic terrain west of Cove Fort; 3 to 20 feet (1 to 6 m) thick.

Qpm Playa mud--Laminated, silty, fine sand, silt, and clayey silt infused with various salts, gypsum, and calcium carbonate; thickness probably 20 feet (6 m) or less.

Qst Spring travertine--Cellular to dense and banded, spring-deposited travertine in southern Pahvant Valley and in White Sage Flat, siliceous spring deposits near Roosevelt Hot Springs in Beaver County, and calcareous spring deposits south of Joseph and east of Monroe in Sevier County; 0 to 90 feet (0-30 m) thick.

Qsa Altered material--White, porous aggregates of opaline silica, gypsum, native sulfur, and alunite; and jarosite and argillic alteration of andesite produced by acid leaching; related to geothermal system; located near Cove Fort in Hickman (Cove Fort) and likely Pleistocene and Holocene in age; thickness unknown; only the largest areas, exposed in a pit, is mapped; up to 105 feet (33 m) thick in this pit.

Qtf Glacial till--Unsorted mixtures of clay, silt, sand, and angular pebbles, cobbles, and boulders in Pahvant Range; includes lateral and other moraines and outwash on Sevier Plateau; probably late Wisconsin (Pinedale) in age; up to 200 feet (60 m) thick.

Qdf Underflow-fan deposits--Thin-bedded to laminated, calcareous silt and sand interbedded with fine-grained, tan to light-gray sands; deposited in the Lake Bonneville delta of the Beaver River south of Borden; 0 to more than 30 feet (0-10+ m) thick.

Qdg Deltaic sand and gravel--Silty, fine- to coarse-grained sand and gravel deposited by the Beaver River in Lake Bonneville and then distributed by waves and currents; 0 to 24 feet (0-7 m) thick.

Qlg Lacustrine gravel--Silty, fine- to coarse-grained sand and gravel in shore zone deposits of Lake Bonneville; 0 to 30 feet (0-9 m) thick.

Qls Lacustrine sand--Fine- to coarse-grained sand, marly sand, and pebbly sand deposited in shore zone of Lake Bonneville as beaches, spits, and offshore bars; 0 to 30 feet (0-9 m) thick.

Qlf Fine-grained lacustrine deposits--Tan to light-gray, calcareous silts that are deep-water sediments of Lake Bonneville; locally includes younger alluvium; thickness probably 10 feet (3 m) or less.

Qlm Lacustrine lagoon deposits--Sand, silt, clay, and silty marl that accumulated in lagoons behind spits and offshore bars in Bonneville beaches of Lake Bonneville; present south of Borden and east of Twin Peaks; locally includes younger alluvium; generally less than 10 feet (3 m) thick.

Qlm Lacustrine marl--Fine-grained, thinly bedded to laminated, white to light-gray, offshore to deep-water marl deposited in Lake Bonneville; ostracodes are abundant throughout marl and, locally, gastropods are present at top and base of marl; 0 to 30 feet (0-9 m) thick. A layer of basaltic ash of Pahvant Butte is exposed near the upper part of Qlm and is commonly 1 to 6 inches (2.5-15 cm) thick. This gray to black basaltic ash was blown into Lake Bonneville during a hydrovolcanic eruption when Lake Bonneville was near its highest level about 15,500 yr B.P.

Qla Lacustrine and alluvial deposits, undifferentiated--Mixed and reworked gravelly lacustrine and alluvial deposits on piedmont slopes; grades from pebbly sand and silt to sandy pebble gravel; generally 0 to 12 feet (0-4 m) thick, but may be thicker locally.

Qvb$_1$ Basalt of Ice Springs--Contains 2 % phenocrysts and has a greater glass content than other basalts in the Black Rock Desert; estimated to be between 4,000 and 660 years old; may be as much as 200 feet (60 m) thick.

Qvb$_2$ Basalt of Tabernacle Hill--Fine-grained holocrystalline basalt with olivine and plagioclase in a groundmass made opaque by submicroscopic opaque grains; geography of the lava during its eruption into Lake Bonneville; radiocarbon age 14,320 ± 90 yr B.P.; maximum thickness about 200 feet (60 m).

Qvb$_3$ Basalt of Pahvant Butte--Basalt flows of probable late and/or middle Pleistocene age; K-Ar dated as 0.031 to 0.22 Ma; 0 to about 100 feet (30 m) thick.

Qvb$_4$ Basaltic andesite of Cedar Grove--Dark-gray to black, porphyritic basaltic andesite with phenocrysts of plagioclase, clinopyroxene, orthopyroxene, and olivine; forms small cones and lava flows; maximum thickness about 200 feet (60 m); age about 0.3 Ma.

QVrs$_4$ Rhyolite dome of White Mountain--Black obsidian and devitrified felsite with spherulites and lithophysae; about 120 feet (40 m) high; age about 0.4 Ma.

Qcf Basaltic andesite of Cove Fort--Dark-gray to black, vesicular to dense basaltic andesite containing small phenocrysts of plagioclase, pyroxene, magnetite, olivine, and sparse corroded quartz in a felted to glassy matrix; age about 0.5 Ma; maximum thickness about 800 feet (250 m).

Qvrd Rhyolite of Mineral Mountains, dome--Tan perlitic glassy dome, commonly pumiceous and brecciated and containing scattered black obsidian fragments; northernmost of several similar domes in the Mineral Mountains; age 0.54 Ma.

Qvrt Rhyolite of Mineral Mountains, tuff--White to tan, poorly consolidated tuff vented from nearby rhyolite dome in Mineral Mountains; less than 100 feet (30 m) thick; probably same age as nearby rhyolite dome (Qvrd).

Qvb$_5$ Basalt of Black Rock--Red-weathering, vesicular basalt with large plagioclase phenocrysts and small phenocrysts of olivine and clinopyroxene in a microcrystalline matrix; age 0.67 Ma; locally exposed in a pit 25 feet (7.5 m) deep in the Black Rock desert of Kanosh.

Qvb$_6$ Basalt of Beaver Ridge--Consists of older flow series, dated at 0.9 Ma, of diabasic basalts about 80 feet (24 m) thick, and younger series, dated at 0.5 Ma, of similar composition but fine-grained to aphanitic, and about 50 feet (37 m) thick.

Qvb$_4$ Basalt of Mineral Mountains--Dark-gray, vesicular basalt that forms two spatter cones and flow remnants on northeast end of the Mineral Mountains; dated at 0.9 Ma; cones about 200 feet (60 m) high.

Qrk Basaltic andesite of Red Knoll--Dark-gray to black, dense to vesicular, with various salts, gypsum, and calcium carbonate; thickness probably 20 feet (6 m) or less.

Qck Basaltic andesite of Crater Knoll--Dark-gray to black, porphyritic basaltic andesite lava flows similar to Qrk; 40 to 45 % phenocrysts, mostly labradorite and andesine; glassy to finely crystalline groundmass, containing microlites of plagioclase, pyroxene, olivine(?), and opaque minerals; vents (2 miles (3 km) south of the Mineral Mountains and west of Cove Fort; age 1.0 Ma; thickness in map area less than 100 feet (30 m).

Qvb$_5$ Basalt of Black Rock--Dark-gray, vesicular basalt composed of about 40% small zoned plagioclase phenocrysts, with lesser phenocrysts of orthopyroxene, olivine, and Fe-Ti oxides; age about 1.0-1.3 Ma; maximum thickness about 200 feet (60 m).

Qvs$_5$ Andesite of Beaver Ridge--Dark-gray, crystal-poor andesite characterized by abundant small phenocrysts of plagioclase, and pyroxene crystals; age about 1.5 Ma; thickness about 200 feet (60 m) thick.

QTif Fine-grained lacustrine deposits of Sevier Desert--Brown and light-olive-gray, calcareous, lacustrine silt and silty clay with minor sand; offshore to deep-water sediments; Pliocene to middle Pleistocene in age; 0 to 872 or more feet (0-265+ m) thick; contains sinkholes.

QTaf Quaternary-Tertiary alluvial-fan deposits--Poorly sorted silt, sand, and gravel, including boulders, in Dog Valley, upper Cove Creek, and in northeast corner of map area; locally has a calcic soil with a stage IV carbonate morphology (so early Pleistocene age) near the top of the deposit; 0 to 300 feet (0-90 m), or more, thick.

Tvs Tertiary volcanic and sedimentary units, undivided--On cross sections only; for included units see correlation chart and descriptions.

Tbm Basaltic andesite of Burnt Mountain--Black to medium-gray, fine- to medium-grained, porphyritic, crystal-rich basaltic andesite with phenocrysts of labradorite, olivine, orthopyroxene, and clinopyroxene; map unit includes vent cone; age about 2.1 Ma; maximum thickness about 500 feet (150 m).

Trt Rhyolite of North Twin Peak, South Twin Peak, and Mid-Dome--Light-brownish-gray rocks from these three

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GEOLOGIC MAP OF THE RICHFIELD 30′ X 60′ QUADRANGLE, SOUTHEAST MILLARD COUNTY AND PARTS OF BEAVER, PIUTE, AND SEVIER COUNTIES, UTAH

by

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