INTERIM GEOLOGIC MAP OF THE HENEFER QUADRANGLE, MORGAN AND SUMMIT COUNTIES, UTAH

by

James C. Coogan[1,2]

[1] *Geology Program, Western State College, Gunnison, Colorado 81231*
[2] *now Exploration Manager, PETRO MATAD LLC, Suite 409, NIC Bldg, Amar Street 8, Ulaanbaatar 210646, Mongolia*

Disclaimer

This geologic map was funded by the Utah Geological Survey and U.S. Geological Survey, National Cooperative Geologic Mapping Program, through USGS STATEMAP award numbers 96HQAG01521, 97HQAG01797, and 98HQAG2067. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

OPEN-FILE REPORT 576
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources
2010

SUMMARY

The Henefer and Heiners Creek quadrangles are located southeast of Ogden and northeast of Salt Lake City, Utah (figure 1). The major geographic features in and near the quadrangles are the Weber River (Henefer Valley), Lost Creek, and Echo Canyon drainages. Echo Canyon and Henefer Valley are major railroad and interstate highway transportation corridors. The quadrangles are geologically significant for the exposures of Late Cretaceous and early Tertiary synorogenic conglomerates related to the Cordilleran orogeny (DeCelles, 1994; Yonkee and others, 1997). These conglomerates are in the Frontier (Dry Hollow and Chalk Creek Members), Henefer, Echo Canyon, Weber Canyon, Evanston (Hams Fork Member), and Wasatch Formations and are related to uplift along frontal thrusts, uplift due to reactivation of thrusts, and uplift of hinterland areas (Wasatch culmination). The Kelvin Formation is the only bedrock unit older than the Frontier Formation that is exposed in these quadrangles and no bedrock units younger than the Wasatch Formation are exposed. Age control in these and adjacent quadrangles is supplied by extensive sampling by Coogan and palynological dating by Gerry Waanders, as well as work by the U.S. Geological Survey and Chevron U.S.A., Inc. (in particular Jacobson and Nichols, 1982) (see tables 1 and 2). Quaternary map units are stream and terrace deposits, alluvial-fan deposits, colluvium, and landslide and slump deposits; the latter deposits are the most significant Quaternary units in the quadrangle because of the potential threat to the transportation corridors. The booklets for the two quadrangles are the same because the geology is nearly the same in each quadrangle.

The timing of the folding and faulting in the area is complex. The roughly north-south-trending, broad folds in the Wasatch Formation in this and adjacent quadrangles are likely due to emplacement of the Hogsback thrust, with a leading edge to the east in Wyoming (see Yonkee and others, 1997). The Stevenson syncline formed after deposition of the Echo Canyon Conglomerate (deposited during emplacement of the Crawford thrust sheet) and prior to deposition of the latest Cretaceous Evanston Formation (see figure 2), possibly during early movement on the Absaroka thrust system (see Yonkee and others, 1997, figure 30) and likely at the same time as the Coalville anticline (see Lamerson, 1982, p. 320-321). This syncline is mostly in subsurface in the map areas, so the hinge-zone trace is poorly constrained. The south part of the Crawford thrust fault is concealed in the Henefer quadrangle, so its location is uncertain. The location of the southwest end of the Crawford thrust, as mapped here, is based on the inferred northern extent of the Preuss salt welt that is thickest in East Canyon southwest of the Henefer quadrangle (see Lamerson, 1982, p. 325); salt and thrust movement interacted such that the thrust "dies out" into the salt. The inferred northern extent of the Preuss salt welt is placed at the northern ends of normal faults in the Devils Slide and Henefer quadrangles. The age of the roughly north-south trending faults in the Frontier and Evanston Formations in the Heiners Creek quadrangle is unknown and might be related to the broad folding or to the emplacement of the Absaroka or Medicine Butte thrust systems, and/or later Cenozoic extension. The roughly north-south-trending normal faults on the west margin of the Henefer quadrangle are

likely due to later, post-thrust Cenozoic extension. In particular some offset is due to late Eocene and Oligocene relaxation (collapse) of the Cordilleran fold-and-thrust belt (see Constenius, 1996). This is indicated by Norwood Formation fill to the southwest in the East Canyon graben (see Bryant, 1990). Miocene and younger Basin-and-Range extension may have also occurred along the East Canyon graben to the southwest in the Devils Slide quadrangle (see faults in Quaternary-Tertiary deposits in Coogan and King, 2001). Alternatively, these scarps, as well as the faults in the Henefer quadrangle, may be from dissolution of the salt welt under East Canyon; see Lamerson (1982, p. 325), and Yonkee and others (1997, figure 28-B) for more on the salt welt.

These are the first detailed geologic maps of these entire quadrangles. Coogan mapped both the bedrock and surficial deposits, and created a cross section that is simplified as figure 2. Jon K. King (Utah Geological Survey) made changes and additions to surficial deposit mapping, and wrote an earlier version of this summary. Previous relatively detailed mapping in the area was by graduate students (Trexler, 1955; Madsen, 1959; Benvegnu, 1963), and all have planimetric base maps, even Trexler's (1966) later publication of his dissertation. The clay pit and stockpile disturbances that post-date September 1986, when the aerial photographs used to produce this map were taken, are shown in brown and were drawn from 2006 orthophotographs.

MAP UNIT DESCRIPTIONS

(all units are not exposed in each quadrangle)

QUATERNARY

Qa1, Qa2, Qa3, Qa4, Qa5

Alluvium, undivided (Holocene and Pleistocene) - Sand, silt, clay, and gravel in stream and alluvial-fan deposits; composition depends on source area; numbers indicate relative age with 1 being the youngest and used for alluvium along present-day drainages; Qa2 and Qa3 are about 20 feet (6 m) and 40 to 60 feet (12-18 m) above active drainages, respectively; Qa4 and Qa5 are still higher (more than 80 feet [25 m] above active streams); Qa1 and Qa2 are Holocene, Qa3 may be graded to the Provo shoreline of late Pleistocene Lake Bonneville, and Qa4 may be graded to Bonneville shoreline of Lake Bonneville; Qa5 deposits may be related to Bull Lake glaciation (~130-150 ka) or be 300 to 600 ka old (after Coogan and King, 2006, table 1); 0 to 20 feet (0-6 m) thick.

Number suffixes for alluvium (Qa, Qat, Qaf) in the Henefer and Heiners Creek quadrangles are not equivalent to those used to the north in the Lost Creek drainage by Coogan (2004a-b); Qa2-3 here appears to include Qaty of Coogan (2004a-b) and be about 40 feet (12 m) above active drainages; Qa4 and Qa5 here appear to be Qa3 and Qao of Coogan (2004a-b), respectively, at 80-100 feet (12-30 m) and 100 to 120 feet (30-36 m) above active drainages. Qa5 here and in the Lost Creek drainage (see Coogan, 2004a-b) both appear to be 160 feet (50 m) or more above active drainages. Also, alluvial deposits

of the same age do not appear to be as high above active drainages in Morgan Valley, compare Qab and Qap in Coogan and King (2006) to Qa4 (graded to Bonneville shoreline?) and Qa3 (graded to Provo shoreline) in this report; so the correlations may be in error.

Qal Stream and floodplain alluvium (Holocene) - Sand, silt, clay, and gravel in channels and floodplains; composition depends on source area; 0 to 20 feet (0-6 m) thick.

Qat2, Qat3

Stream-terrace alluvium (Holocene and Pleistocene) - Sand, silt, clay, and gravel in terraces above floodplains; numbers indicate relative age with 2 being the youngest; Qat2 is lowest Holocene terraces; Qat3 may be terraces graded to Provo shoreline of late Pleistocene Lake Bonneville; 0 to at least 20 feet (0-6+ m) thick.

Four distinct terrace levels are present along Weber River in Henefer Valley in the Henefer and Devils Slide quadrangles. The lowest/youngest is 20 to 40 feet (6-12 m) above drainages (Qat2 and Qa2). The next older terraces are 40 to 80 feet (12-24 m) (Qat3 and Qa3 =?Qap) and 80 to 160 feet (24-49 m) (part of Qa4 =?Qab) above drainages. The oldest terraces (part of Qa5) are greater than 160 feet (49 m) above drainages.

Qafy, Qaf3

Alluvial-fan deposits (Holocene and late Pleistocene) - Mostly sand, silt, and gravel that is poorly stratified and poorly sorted; includes debris flows, particularly in drainages and at drainage mouths (fan heads); mostly younger fans that impinge on present-day floodplains and divert active streams, and/or overlie low terraces; probably post-Lake Bonneville, mostly Holocene, in age; lone older fan is mapped southwest of Henefer as Qaf3 based on height at least 60 feet (18 m) above Weber River (see Qa3); generally less than 40 feet (12 m) thick.

Qac Alluvium and colluvium (Holocene and Pleistocene) - Includes stream and fan alluvium, colluvium, and, locally, mass-movement deposits; some deposits are “perched” on benches 80 feet (25 m) and more above present-day drainages like Left Fork of Heiners Creek, Heiners Creek quadrangle, and Harris Canyon, Henefer quadrangle; 0 to 20 feet (0-6 m) thick. Note in particular drainages “choked” by sediment from unit Keh in Heiners Creek quadrangle.

Qc Colluvium (Holocene and Pleistocene) - Mostly slopewash and soil creep; composition depends on local bedrock; generally less than 20 feet (6 m) thick and typically not mapped where less than 6 feet (2 m) thick.

Qct Colluvium and talus (Holocene and Pleistocene) - Angular debris at the base of and on steep, typically unvegetated slopes; mapped in steep-walled canyon along Interstate Highway 80 in southeast part of Henefer quadrangle; less than 20 feet (6 m) thick and

typically not mapped where less than 6 feet (2 m) thick.

Qm Mass-movement deposits, undivided (Holocene and Pleistocene) - Includes slides, slumps, flows, colluvium, talus, and alluvium that is mostly composed of debris flow deposits; map unit contains talus along steep-walled canyons; mapped in Heiners Creek quadrangle where several mass-movement processes contribute to deposits and mapping separate, small, intermingled areas of different kinds of mass-movements is not possible at map scale; composition depends on local sources; 0 to 40 feet (12 m) thick.

Qmc Landslide and colluvial deposits, undivided (Holocene and Pleistocene) - Mapped where landslides are difficult to distinguish from colluvium (slopewash and soil creep) and where mapping separate, small, intermingled areas of landslide and colluvial deposits is not possible at map scale; locally includes talus and debris flows; typically mapped where landslides are thin ("shallow") and include slumps and flows; also mapped where the blocky or rumpled morphology that is characteristic of landslides and slumps has been diminished ("smoothed") by slopewash and soil creep; composition depends on local sources; 0 to 40 feet (12 m) thick.

Qms, Qmsh, Qmso

Landslide deposits (Holocene and Pleistocene) - Poorly sorted clay- to boulder-sized material derived from steep local source terrain; includes slump and flow deposits; composition depends on local sources; generally characterized by hummocky topography, head and internal scarps, and chaotic bedding in displaced bedrock; morphology becomes subdued with age and fluidity of deposits; divided into historical and older deposits (Pleistocene) where possible (suffixes h and o, respectively); thickness highly variable; locally, unit involved is shown in parentheses, typically unit Keh is involved in older mass movements. Qmsh are only mapped in Heiners Creek quadrangle. Qmso age based on downslope ends of most of these older slides being "perched" about 300 feet (120 m) or more above present drainages; deposits this high above present drainages in Morgan Valley are >730 ka old (Coogan and King, 2006). Qms and Qmso queried where bedrock may be in place.

Qh Human disturbance (Historical) - Obscures original deposits by cover or removal; only larger disturbances are shown; includes right-of-way along Interstate Highway 80 and Union Pacific Railroad and low dams such as along Heiners Creek; also includes clay pits and a clay stockpile in Henefer quadrangle, some of which post-date the 1984 aerial photographs used to map the geology in these quadrangles.

TERTIARY

Tw Wasatch Formation (Eocene and uppermost Paleocene) - Typically red sandstone, siltstone, mudstone, and conglomerate, with local minor gray limestone and marlstone; lighter shades of red, yellow/tan, and light gray more common in uppermost part; total

thickness at least 4500 feet (1370 m) southwest of Henefer (after Mann, 1974); thickness varies locally due to relief on basal erosional surface. Paleocene (P5-P6) age based on palynology in Nichols and Bryant (plate 2 in Bryant, 1990). See Jacobson and Nichols (1982) for Paleocene (P) biozones based on palynology and P5-P6 sample P2833-1,2 in Wasatch Formation in Porcupine Ridge quadrangle.

Twc Basal conglomerate of Wasatch Formation (Paleocene) - Red-orange- and tan-weathering, cobble conglomerate; mainly containing Proterozoic and Cambrian quartzite clasts (DeCelles, 1994); forms prominent cliffs along the western tributaries of Lost Creek in and near Henefer quadrangle; 0 to 400 feet (0-120 m) thick.

CRETACEOUS

Keh Hams Fork Member of Evanston Formation (Upper Cretaceous-Maastrichtian/Campanian) - Light-gray, brownish-gray, and tan sandstone, conglomeratic sandstone, and quartzite- and chert-pebble conglomerate, variegated gray, greenish-gray, and red mudstone; member coarsens downward and northwestward into basal conglomerate (unit Kehc); member thickens to north from 300 feet (90 m) at Echo Canyon Junction (to south of these quadrangles) to 1200 feet (365 m) to north in Lost Creek Dam quadrangle (Coogan, 2004b); Lamerson (1982, p. 321) reported 757 feet (230 m) thickness in middle Echo Canyon; may be as much as 1600 feet (500 m) thick near Thirtyfive Canyon, Heiners Creek quadrangle, but dip of beds uncertain; unconformably truncated and locally absent beneath Wasatch Formation in Henefer quadrangle.

Named Hams Fork Conglomerate Member by Oriel and Tracey (1970) but conglomerate in name is dropped in the Ogden 30x60-minute quadrangle because unit is mostly sandstone and mudstone.

Kehc Basal conglomerate of Hams Fork Member (Upper Cretaceous) - Tan and gray, cobble to boulder conglomerate with minor interbedded gray, carbonaceous mudstone; conglomerate contains >80% Proterozoic and Cambrian quartzite clasts, but locally contains clasts of Triassic and Jurassic sandstone and rare Precambrian crystalline basement clasts (DeCelles, 1994); appears more than ~360 feet (110 m) thick and thickest along South Fork of Heiners Creek, with base not exposed; appears to pinch out in lower Echo Canyon to south in Coalville 7.5-minute quadrangle (Coogan, unpublished mapping); based on topographic contours parallel to strike, appears about 150 to 300 feet (45-90 m) thick in upper Toone Canyon, Henefer quadrangle; to north thickness varies in the Crawford thrust footwall from about 300 feet (90 m) in Toone Canyon, Lost Creek Dam quadrangle (Coogan, 2004b) to about 115 feet (35 m) in Francis Canyon quadrangle (Coogan, 2004a). DeCelles and Cavazza (1999) show about 150 feet (45 m) at Sawmill Creek [Canyon], Henefer quadrangle. Carbonized plant remains, as well as fossil freshwater bivalves and gastropods are present in basal mudstone in middle Echo Canyon (Crawford, 1979).

Kwc Weber Canyon Conglomerate (Upper Cretaceous-Campanian/late Santonian) - Red, gray, and tan, boulder to cobble conglomerate with minor sandstone and mudstone interbeds;

locally exposed within a growth syncline above the buried Crawford thrust trace in upper Toone Canyon, northeast Henefer quadrangle, with base not exposed; clasts are from the Tintic Quartzite, Weber Quartzite, Nugget Sandstone, Lodgepole Limestone, Park City Formation, and Twin Creek Limestone (DeCelles, 1994); to north in Lost Creek Dam and Francis Canyon quadrangles and southwest near Devils Slide contains progressive intraformational unconformities; about upper 400 feet (120 m) exposed in Toone Canyon, Henefer and Lost Creek Dam quadrangles; at least 1900 feet (580 m) thick to west near Devils Slide (after DeCelles, 1994), where it forms prominent cliffs.

Kec Echo Canyon Conglomerate (Upper Cretaceous-Santonian/Coniacian) - Likely penetrated in Champlin 475-Amoco A1 exploration borehole (API 43-043-30004) in Henefer quadrangle and shown as undivided (Kec) on figure 2. Folded with underlying Cretaceous strata in Stevenson syncline, so lacks marked angular unconformity with Henefer Formation (compare dips across Kel-Khen contact in Heiners Creek quadrangle). Combined Kwc-Kec thickness to north in Amoco-Marathon 1A well, Francis Canyon quadrangle, is about 3600 feet (1100 m) (API 43-029-30006, Utah DOGM log and well files); so Kec likely more than 3000 feet (900 m) thick there and thickening to south. Shown in axis of syncline on figure 2 as thicker than 1740 feet (530 m) exposed to east and the 3000 feet (900 m) penetrated to north, because figure 2 is based on seismic data. The geophysical logs of the Champlin 475-Amoco A1 exploration hole in the Henefer quadrangle indicate the hole bottomed in conglomeratic strata, but it is not certain that the bottom was in the targeted Henefer Formation (Utah DOGM log and well files), or was still in the Echo Canyon Conglomerate. The upper Henefer Formation is a conglomerate in this area. Based on exposures and the geophysical logs, Jon K. King (UGS, verbal communication, August, 2010) estimates that about 3100 feet (945 m) of Echo Canyon Conglomerate was penetrated in this borehole.

Keu Upper member - Red, massive, very thick bedded, pebble to boulder conglomerate, minor gray and tan sandstone and gray mudstone; conglomerate clasts are dominated by sandstone and quartzite derived from Jurassic, Triassic, and upper Paleozoic strata of the Durst Mountain/Devils Slide block above the Crawford thrust (DeCelles, 1994); more specifically, clasts in upper member are dominantly from Weber Quartzite, with noticeable clasts of red Ankareh and Preuss Formations, of Nugget Sandstone, and of micritic Twin Creek Limestone (DeCelles, 1994); 790 feet (240 m) thick in Echo Canyon.

Kel Lower member - Light-gray and tan, pebble to boulder conglomerate, light-gray to tan sandstone and pebbly sandstone, and minor varicolored mudstone; conglomerate clasts include sandstone and quartzite from Jurassic and upper Paleozoic formations, up to 20% limestone clasts mainly derived from Mississippian strata, as well as distinctive Cambrian and Proterozoic quartzites of the Willard thrust sheet (DeCelles, 1994); more specifically clasts in lower member are from Weber, Park City, Nugget, Twin Creek, Preuss, Lodgepole and Humbug Formations and have Proterozoic quartzite clasts (DeCelles, 1994); 950 feet (290 m) thick in Echo Canyon.

Khen Henefer Formation (Upper Cretaceous-Coniacian/Turonian?) - Tan and gray, coarse-

grained to conglomeratic sandstone, cyclically interbedded with gray mudstone, shale, and carbonaceous mudstone; non-marine; DeCelles (1994, figure 5) shows upper 50 meters (165 ft) in southwest Henefer quadrangle as pebble to cobble conglomerate beds with mudstone/shale interbeds; coarsens upward and westward, so dominantly resistant, thick-bedded, yellow-weathering, bioturbated sandstone to east in upper Echo Canyon underlain by light-colored mudstone/shale; marker bed mapped at this change in Heiners Creek quadrangle; up to 2500 feet (760 m) thick; DeCelles (1994) noted local conglomerate at top of Henefer Formation with clasts from Frontier, Kelvin, Preuss, Twin Creek, Nugget, Ankareh, Gartra/Higham, Park City, and Weber Formations (clasts of the last two formations might actually be recycled from older Cretaceous conglomerates).

Near Coalville reportedly 2450 to 2500 feet (745-760 m) (Hale, 1960, 1962, 1976) and 2410 to 2525 feet (735-770 m) thick (Trexler, 1966), but top not exposed in Hale's reports and 300 feet (90 m) at top covered in Trexler's report. Eardley (1944) named unit but had huge thickness for it because he included some Kelvin and Frontier Formation strata in his Henefer unit (the Wanship Formation of Williams and Madsen (1959) is actually upper Frontier Formation [Kfum of this report]).

Frontier Formation (Upper Cretaceous-Coniacian/Turonian/Cenomanian) - Gray shale, mudstone, and siltstone, light-gray to tan to brown sandstone and conglomeratic sandstone, and carbonaceous shale; marine and non-marine; about 4500 feet (1370 m) total thickness in area derived from addition of member thicknesses; about the same overall thickness (< about 4670-5130 feet [1425-1560 m]) exposed to the south near Coalville (see Trexler, 1966); however member thicknesses and conglomerates are highly variable and reported total thickness in subsurface is up to approximately 8000 feet (2440 m) (see Hale, 1960, average 7850 feet [2390 m]). Divided into three units in figure 2, Kfum-upper Frontier members, Kfo-Oyster Ridge Member, and Kflm-lower Frontier members. Following the members used by Hale (1960; 1962), units mapped in the Henefer and Heiners Creek quadrangles include:

Kfu Upper part - Gray to yellowish-gray, calcareous, fine-grained sandstone interbedded with gray, calcareous shale mapped in Henefer quadrangle; probably lateral equivalent of Upton Sandstone, Judd Shale, Meadow Creek Sandstone Members, and, possibly, the upper part of the Dry Hollow Member of the Coalville area, and lateral equivalent of these members and the Grass Creek Member in the Huff Creek area, Castle Rock quadrangle; about 1100 feet (335 m) thick near Henefer. Upton Sandstone is Coniacian (molluscan fossil zone 27), as is capping sandstone of Dry Hollow Member, near Coalville (Molenaar and Wilson, 1990).

Kfg Grass Creek Member - Gray calcareous shale mapped in the Heiners Creek quadrangle; poorly exposed; about 235 feet (72 m) thick in the Huff Creek area, Castle Rock quadrangle, just to east.

Kfd Dry Hollow Member - Tan and reddish-gray, very thick bedded, cobble conglomerate mapped east of Henefer; conglomerate includes clasts of Cambrian(?) and Upper Paleozoic quartzite, Mississippian limestone, Mesozoic sandstone and siltstone, and chert; conglomerate zone thins markedly southward from over 1200 feet (365 m) in

Harris Canyon to 520 feet (160 m) at Bald Rock Canyon. Still farther south near Coalville, Hale (1960, 1962) reported this member contains only 40 to 100 feet (12-30 m) of conglomerate overlain by 880 feet (270 m) of silty shale, sandstone, and lenses of conglomerate, 90 feet (27 m) of carbonaceous rocks, and capped by 200 feet (60 m) of cliff-forming white sandstone. Conglomerate likely related to movement on the Willard thrust sheet (Yonkee and others, 1997).

In the Heiners Creek quadrangle, the capping resistant sandstone, mapped as Kfdu along Green Creek, is less than ~300 feet (90 m) thick; south of Green Creek the Dry Hollow member is mapped as undivided (Kfd) and the lower less-resistant part of the member is mapped as Kfdl. The capping sandstone thins to the east.

Just east of Heiners Creek quadrangle, in Huff Creek area, Castle Rock quadrangle, member contains light-yellowish-gray, fine-grained, calcareous sandstone in upper 70 feet (21 m); gray-brown and tan, calcareous siltstone and shale in middle part; and interbedded lenses of light-gray, coarse-grained sandstone and chert- and quartzite-pebble conglomerate in lower 100 feet (30 m); total thickness in Huff Creek area is about 550 feet (168 m).

Kfo Oyster Ridge Sandstone Member - Light-yellow- to orange-gray, fine-grained, calcareous sandstone with local pebble layers and disarticulated pelecypod shells; thins northward in the Henefer quadrangle from 260 to140 feet (80-43 m). Age is Turonian (molluscan fossil zone 19) near Coalville (Molenaar and Wilson, 1990).

Kfac Allen Hollow and Coalville Members - Gray, calcareous shale in upper part; and medium-bedded, light-yellow-gray, calcareous sandstone with interbedded carbonaceous shale and coal in lower part; poorly exposed; 550 to 625 feet (168-190 m) thick where exposed in Henefer quadrangle. Allen Hollow and Coalville Members are Turonian (molluscan fossil zone 19 and 18, respectively) near Coalville (Molenaar and Wilson, 1990).

Kfcc Chalk Creek Member - Red and tan-gray, very thick-bedded, cobble conglomerate east of Henefer; conglomerate includes clasts of Cambrian(?) and upper Paleozoic quartzite, Mississippian limestone, Mesozoic sandstone and siltstone, and chert; conglomerate thickens markedly northward from 460 (140 m) feet thick at Bald Rock Canyon to about 1960 feet (600 m) thick in Harris Canyon; 3150 feet (960 m) thick to south at Coalville (Hale, 1960). Conglomerate likely related to movement on the Willard thrust sheet (Yonkee and others, 1997).

Kfl Lower member - Gray to red, coarse-grained, medium-bedded sandstone with discontinuous chert- and quartzite-pebble conglomerate beds; interbedded with red, tan, and gray mudstone and siltstone; some yellowish-gray, fine-grained, calcareous sandstone and gray, calcareous siltstone in lower part; equivalent to lower Chalk Creek, Spring Canyon, and Longwall Sandstone members of the Coalville area; Spring Canyon Member contains thin coal beds near Coalville; about 850 feet (260 m) thick near Henefer.

Ka Aspen Shale (lower Cenomanian/Albian) - Not exposed in either quadrangle, but shown on figure 2 and western extent of "pinch-out" is unknown. Champlin 461-Amoco A well in Heiners Creek quadrangle reportedly penetrated 73 feet (22 m) of Aspen (API 43-043-

30059, Utah DOGM well file), and the Aspen is mapped 3 miles (5 km) east of Coalville by Bryant (1990), a location roughly due south of the junction of Heiners and Echo Creeks, Heiners Creek quadrangle. Typically dark-gray, fissile, siliceous shale and silty shale with teleost fish scales; about 300 feet (90 m) thick where exposed to east on southeast flank of Porcupine Ridge, Porcupine Ridge quadrangle. Age is early Cenomanian (molluscan fossil zone 2) near Coalville (Molenaar and Wilson, 1990).

Kk Kelvin Formation (Lower Cretaceous-Albian/Aptian) - At least 5700 feet (1740 m) thick near Henefer, with base not exposed (this report); and to southwest about 6000 feet (1800 m) thickness penetrated in Richins well in East Canyon graben, though dip not known (see API 43-043-30256, Utah DOGM well and log files). Benvegnu (1963) reported thickness of 4425 feet (1350 m) on northwest limb of Stevenson Canyon Syncline. Upper part mainly light-gray, tan and light-reddish-gray, coarse-grained, cross-bedded sandstone and pebbly sandstone with abundant chert; interbedded with gray, tan, and minor red and gray-green mudstone and siltstone; up to 2300 feet (700 m) thick to south near Wanship (Eardley, 1944) and overlain by the Aspen Shale (Hale, 1960; Trexler, 1966). Lower third dominantly red-weathering, with red and tan mudstone and siltstone; contains thin, discontinuous beds of nodular, blue-gray and lavender, micritic limestone (Morrison of some workers); gray and red, coarse-grained, pebbly sandstone, with reddish-gray, chert-pebble conglomerate toward base; up to 700 feet (210 m) thickness exposed (Eardley, 1944), but not clear where this thickness is exposed in his map area.

JURASSIC (NOT EXPOSED, but Jsp may be present in shallow subsurface west of normal fault on west margin of Henefer quadrangle. For other subsurface units exposed just to the west in the Devils Slide quadrangle, see lithologic column). The thicknesses of Twin Creek Limestone and older strata on figure 2 are mostly from boreholes east of the Crawford thrust fault near the Utah-Wyoming border (see figure 1).

Jsp Stump and Preuss Formations

Js Stump Sandstone (Upper and Middle Jurassic) - Pale red, yellow, gray, and gray-green shale and calcareous sandstone; at least locally green and glauconitic; regionally 100 to 250 feet (30-76 m) thick (Pipiringos and Imlay, 1979; Coogan, 2004b).

Jp, Jps Preuss Redbeds (Middle Jurassic) - Red and purple-red sandstone, siltstone, and shale, with salt (halite and anhydrite) near base in subsurface (Jps on figure 2); about 900 feet (270 m) thickness of redbeds exposed to north at Toone Canyon (Coogan, 2004a-b); subsurface thickness to south in East Canyon graben about 900 to 1250 feet (275-380 m) (likely including Stump), with an additional 0 to about 1000 feet (0-300 m) and possibly as much as 6000 to 7500 feet (1800-2300 m) of salt penetrated in Gulf W-1 well (API 43-043-30070) to southwest in East Canyon Reservoir quadrangle, but bed dips uncertain (Lamerson, 1982, p. 325; Utah DOGM well and log files).

Jtc Twin Creek Limestone (Middle Jurassic) - Mostly white- to gray-weathering, shaly limestone with some shale; 2722+ feet (825+ m) total thickness at Devils Slide (Imlay,

1967); subdivided into multiple members at Devils Slide and in Lost Creek drainage (Coogan, 2004a,b) (see lithologic column); subsurface thickness about 1500 to 1900 feet (460-580 m) (Moklestad, 1979; Lamerson, 1982; Lelek, 1982; West and Lewis, 1982).

Jn Nugget Sandstone (Lower Jurassic) - Pale-grayish-orange, pinkish, and locally white, well-cemented, cross-bedded, quartz sandstone; about 1250 to 1360 feet (380-415 m) thick near Devils Slide, and about 1100 feet (335 m) thick to north of Henefer quadrangle (Coogan, 2004b).

TRIASSIC (Surface thickness estimates are from Devils Slide quadrangle and are by Jon K. King, Utah Geological Survey)

TRa Ankareh Formation (Triassic) - Upper red shale, siltstone, and sandstone (Wood Shale Tongue, Stanaker Member or upper member). Middle red, buff and gray, gritty to locally conglomeratic sandstone, with no greenish sandstone or limestone reported (Shinarump of Scott, 1954; Schick, 1955; Gartra of Smith, 1969). Middle unit to the north in the Lost Creek drainage, in contrast to Devils Slide, includes: gray and greenish-gray, micaceous, quartz-granule sandstone at top (Higham Grit); middle greenish-gray, lithic-pebble conglomerate in middle, containing green siltstone clasts and rare fossil wood fragments (Timothy Sandstone Member of Thaynes Formation); and thin (2 feet [0.6 m]), gray and lavender, mottled limestone at base (Portneuf Limestone Member of the Thaynes Formation) (Coogan, 2004a). Lower purple and brownish-red shale, siltstone, and sandstone (Lanes Shale Tongue or Mahogany Member). To east, subsurface thickness 900 to 1050 feet (275-320 m) (Lamerson, 1982; Sprinkel and Chidsey, 1993).

TRt Thaynes Formation (Lower Triassic) - Gray, silty limestone and calcareous shale and siltstone; estimated thickness of 1835 feet (560 m); underlain by an additional approximately 250 feet (75 m) of underlying less resistant, silty limestone and calcareous siltstone of upper tongue of Dinwoody Formation. Subsurface thickness 1430 to 1650 feet (435-500 m) (West and Lewis, 1982; Sprinkel and Chidsey, 1993).

TRwd Woodside Shale and Dinwoody Formation (Lower Triassic) - Woodside Shale is dark-red, sandy shale and siltstone, with some sandstone (this report); an estimated 500 feet (150 m) thick. Dinwoody Formation is greenish-gray and tan, calcareous siltstone and silty limestone (this report); an estimated 300 feet (90 m) thick. Subsurface thickness of combined unit west of Crawford thrust about 1050 to 1160 feet (320-355 m) (Deseret WIU well [API 43-029-30009], Utah DOGM well files and AMSTRAT, 1981); east of Crawford thrust about 900 to 1050 feet (275-320 m) thick at Yellow Creek field (Lamerson, 1982; 4-36 & Urroz wells, [API 49-041-20578 & 49-041-20321] WOGCC); because this is a greater thickness than at Devils Slide, figure 2 unit may include upper tongue of Dinwoody Formation or part of the Franson Member of the Park City Formation.

PERMIAN

Pp Park City and Phosphoria Formations, undivided - Total thickness about 850 feet (260 m); includes: Franson Member of Park City Formation, an interbedded gray to pinkish-gray to dark-gray, vuggy, cherty limestone, with lesser gray shale and calcareous sandstone; dark-gray and black, bedded chert of Rex Chert Member of Phosphoria Formation; Meade Peak Phosphatic Shale Member of Phosphoria, gray limestone, dark-gray to black, phosphatic siltstone and shale, and gray, calcareous sandstone; and Grandeur Member of Park City, light-gray, thick-bedded, dolomitic sandstone with gray chert nodules. Thickness used on figure 2 is closer to that exposed at Devils Slide due to uncertainly about the strata included in the reported subsurface thickness of 675 feet (205 m) west of the Crawford thrust (Deseret WIU well, AMSTRAT, 1981), and thicknesses east of Crawford thrust of 480 to 600 feet (145-180 m) (Lamerson 1982; Sprinkel and Chidsey, 1993; Cave Creek field 846A & Fawcett wells [API 43-043-30100, 43-043-30078], Utah DOGM well files; Yellow Creek field Urroz & 4-36 wells, WOGCC).

Descriptions for the following units shown on figure 2 are modified from Sieverding and Royse (1990) descriptions for Whitney Canyon/Carter Creek field, located north of Evanston, Wyoming, because the exposed counterparts on Durst Mountain to the west of the Henefer and Heiners Creek quadrangles are significantly different (see Coogan and King, 2006). The lack of nearby exposures is also the reason they are not on the lithologic column.

PERMIAN AND PENNSYLVANIAN

PIPw Wells Formation - Upper is very thick bedded to cross-bedded quartzose sandstone separated by thin shale beds; lower is thin-bedded sandstone and shale with some limestone; all sandstone well sorted, fine grained and with quartz overgrowths. Thickness used on figure 2 is intermediate between the Weber Sandstone thickness exposed on Durst Mountain (at least 2500 feet [760 m]) (Coogan and King, 2006) and subsurface thicknesses of about 800 to 920 feet (245-280 m) at Cave Creek field (Weber of Fawcett & 846A wells, Utah DOGM well files).

PENNSYLVANIAN AND MISSISSIPPIAN

IPMa Amsden Formation - Interbedded red shale, siltstone, sandstone and very thick bedded dolomite. Like the Morgan Formation in eastern Utah on the flanks of the Uinta Mountains (see Sadlick, 1957) and on Durst Mountain (see Coogan and King, 2006); but note older age of Amsden. Thickness used on figure 2 is intermediate between the Morgan thickness exposed on Durst Mountain and subsurface thicknesses of ~300 to 425 feet (90-130 m) (Lamerson, 1982; Fawcett & 846A wells of Cave Creek field, Utah DOGM well files; Amsden of Urroz well in Yellow Creek field, WOGCC).

MISSISSIPPIAN

Mm Madison Group, Mission Canyon (Brazer) Formation and Lodgepole Limestone - Thick-bedded dolomite and limestone, with shale and siltstone unit at base; basal strata at least

locally include Cottonwood Canyon Member of Madison/Lodgepole Formation (Mississippian) and Devonian Leatham Formation; subsurface thicknesses are about 1150 to 1500 feet (350-460 m) (Lamerson, 1982) and 1600 feet (490 m) (Fawcett well of Cave Creek field, Utah DOGM well files and AMSTRAT).

DEVONIAN

Dd Darby Formation - Calcareous shale, sandstone, and very thick bedded dolomite; sometimes called the Three Forks and Jefferson Formations in area; similar to Beirdneau and Hyrum formations on Durst Mountain (see Coogan and King, 2006); subsurface thicknesses are about 500 to 650 feet (150-200 m) (Lamerson, 1982).

ORDOVICIAN

Ob Bighorn Dolomite - Gray, finely crystalline, very thick bedded dolomite with diverse fossils; subsurface thicknesses are about 600 feet (180 m), and though thrust truncated (Lamerson, 1982), are about the 600 feet (180 m) exposed in Wyoming (Rubey and others, 1975) north of the area shown in figure 1. Ordovician missing on Durst Mountain (see Coogan and King, 2006).

CAMBRIAN

Cg Gallatin Limestone and Gros Ventre Formation - Thin-bedded, silty limestone, oolitic limestone (Gallatin), and shale (Gros Ventre); subsurface thickness east of Crawford thrust is a maximum of about 1250 feet (380 m) above regional thrust fault (decollement) (Lamerson, 1982) shown on bottom of figure 2. Gallatin mostly limestone like the Maxfield Limestone on Durst Mountain and about the same thickness (~300 feet [90 m]) (see Coogan and King, 2006); Gros Ventre is shale over limestone over shale like the Ophir Formation on Durst Mountain, which is about 440 to 725 feet (135-220 m) thick (see Coogan and King, 2006).

Cf Flathead Sandstone - Arkosic; subsurface thickness not known but may be more than exposed thickness of 280 feet (85 m) reported by Shaw and DeLand (1955), because the Tintic Quartzite, which occupies the same stratigraphic interval on Durst Mountain, is about 1000 feet (300 m) thick (see Coogan and King, 2006).

REFERENCES

Cited

AMSTRAT, 1981, Amstrat log D-4948, Amoco Production Company No. 1 Deseret Working Interest Unit: Casper, Wyoming, American Stratigraphic Company, oversize folded strip [on file at Utah Geological Survey Core Research Center].

Benvegnu, C.J., 1963, Stratigraphy and structure of the Croydon-Henefer, Grass Valley area,

Morgan and Summit Counties, Utah: Salt Lake City, University of Utah, M.S. thesis, scale 1:31,680.

Bryant, Bruce, 1990, Geologic map of the Salt Lake City 30' x 60' quadrangle, north-central Utah, and Uinta County, Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I-1944, scale 1:100,000.

Constenius, K.N., 1996, Late Paleogene extensional collapse of the Cordilleran foreland fold and thrust belt: Geological Society of America Bulletin, v. 108, p. 20-39.

Coogan, J.C., 2004a, Interim geologic map of the Francis Canyon quadrangle, Lost Creek drainage, Morgan, Rich and Summit Counties, Utah: Utah Geological Survey Open-File Report 425, 10 p., 1 plate, scale 1:24,000.

Coogan, J.C., 2004b, Interim geologic map of the Lost Creek Dam quadrangle, Lost Creek drainage, Morgan and Weber Counties, Utah: Utah Geological Survey Open-File Report 426, 10 p., 1 plate, scale 1:24,000.

Coogan, J.C., and King, J.K., 2001, Progress report geologic map of the Ogden 30' x 60' quadrangle, Utah and Wyoming, year 3 of 3: Utah Geological Survey Open-File Report 380, 33 p., scale 1:100,000.

Coogan, J.C., and King, J.K., 2006, Interim geologic map of the Durst Mountain quadrangle, Morgan and Weber Counties, Utah: Utah Geological Survey Open-File Report 498, scale 1:24,000, 29 p.

Crawford, K.A., 1979, Sedimentology and tectonic significance of Late Cretaceous-Paleocene Echo Canyon and Evanston synorogenic conglomerates of the north-central Utah thrust belt: Madison, University of Wisconsin-Madison, M.S. thesis, 143 p. [Notes distinct conglomerate in Echo Canyon Conglomerate that is Weber Canyon Conglomerate of DeCelles, 1994.]

DeCelles, P.G., 1994, Late Cretaceous-Paleocene synorogenic sedimentation and kinematic history of the Sevier thrust belt, northeast Utah and southwest Wyoming: Geological Society of America Bulletin, v. 106, p. 32-56.

DeCelles, P.G., and Cavazza, W., 1999, A comparison of fluvial megafans in the Cordilleran [northeast Utah and southwest Wyoming] (Upper Cretaceous) and modern Himalayan foreland basin systems: Geological Society of America Bulletin, v. 111, p. 1315-1334.

Eardley, A.J., 1944, Geology of the north-central Wasatch Mountains, Utah: Geological Society of America Bulletin, v. 55, p. 819-894, plate 1 scale 1:125,000.

Hale, L.A., 1960, Frontier Formation-Coalville, Utah, and nearby areas of Wyoming and Colorado, *in* McGookey, D.P. and Miller, D.N., Jr., editors, Overthrust belt of southwestern Wyoming and adjacent areas: Wyoming Geological Association, 15th Annual Field Conference Guidebook, p. 136-146.

Hale, L.A., 1962, Frontier Formation-Coalville Utah, and nearby areas of Wyoming and Colorado, *in* Enyert, R.L., and Curry, W.H., III, editors, Symposium on Early Cretaceous rocks of Wyoming and adjacent areas: Wyoming Geological Association, 17th Annual Field Conference Guidebook, p. 211-220.

Hale, L.A., 1976, Geology of the Coalville anticline, Summit County, Utah, *in* Gilmore-Hill, J., editor, Symposium on geology of the Cordilleran hingeline: Rocky Mountain Association of Geologists, p. 381-386, and plate.

Jacobson, S.R., and Nichols, D.J., 1982, Palynological dating of syntectonic units in the Utah-Wyoming thrust belt, The Evanston Formation, Echo Canyon Conglomerates, and Little Muddy Creek Conglomerate, *in* Powers, R.B., editor, Geologic studies of the Cordilleran thrust belt: Denver, Rocky Mountain Association of Geologists, v. 2, p. 735-750. [also dated Henefer Formation in Echo Canyon]

Lamerson, P.R., 1982, The Fossil Basin area and its relationship to the Absaroka thrust fault system, Surface geologic map of the Fossil Basin area, southwestern Wyoming and adjacent Utah, *in* Powers, R.B., editor, Geologic studies of the Cordilleran thrust belt: Rocky Mountain Association of Geologists, p. 279-340, plates 1-A, 1-B, scale 1:200,000, cross sections - plates 4, 5, 10, and 11, scale ~1:50,000, figure 27, scale 1:100,000.

Madsen, J.H., Jr., 1959, Geology of the Lost-Echo Canyon area, Morgan and Summit Counties, Utah: Salt Lake City, University of Utah, M.S. thesis, 65 p., scale 1:31,680.

Mann, D.C., 1974, Clastic Laramide sediments of the Wasatch hinterland, northeast Utah: Salt Lake City, University of Utah, M.S. thesis, 112 p.

Molenaar, C.M., and Wilson, B.W., 1990, The Frontier Formation and associated rocks of northeastern Utah and northwestern Colorado: U.S. Geological Survey Bulletin 1781-M, 21 p., 1 plate.

Oriel, S.S., and Tracey, J.I., Jr., 1970, Uppermost Cretaceous and Tertiary stratigraphy of Fossil Basin, southwestern Wyoming: U.S. Geological Survey Professional Paper 635, 56 p.

Pipiringos, G.H., and Imlay, R.W., 1979, Lithology and subdivisions of the Jurassic Stump Formation in southeastern Idaho and adjoining areas: U.S. Geological Survey Professional Paper 1035-C, 25 p.

Sadlick, Walter, 1957, Regional relations of Carboniferous rocks of northeastern Utah, *in* Seal, O.G., Jr., editor, Guidebook to the geology of the Uinta Basin: Intermountain Association of Petroleum Geologists 8th annual field conference guidebook, p. 56-77, 1 plate.

Schick, R.B., 1955, Geology of the Morgan-Henefer area, Morgan and Summit Counties, Utah: Salt Lake City, Utah, University of Utah, M.S. thesis, 60 p., scale 1:31,680.

Scott, F.W., 1954, Regional physical stratigraphy of the Triassic in a part of the eastern Cordillera: Seattle, University of Washington, Ph.D. dissertation, 142 p.

Smith, H.P., 1969, The Thaynes Formation of the Moenkopi Group, north-central Utah: Salt Lake City, University of Utah, Ph.D. dissertation, 378 p., 13 plates.

Trexler, D.W., 1955, Stratigraphy and structure of the Coalville area, northeastern Utah: Baltimore, Maryland, Johns Hopkins University, Ph.D. dissertation, 143 p., scale 1:45,000?.

Trexler, D.W., 1966, The stratigraphy and structure of the Coalville area, northeastern Utah: Golden, Colorado School of Mines, Professional Contribution no. 2, scale 1:45,000. [used stratigraphy from his 1955 dissertation, ignoring Hale, 1960, 1962]

Utah DOGM, various dates, Well and log files: Utah Department of Natural Resources, Division of Oil, Gas and Mining records, variously paginated, accessed at http://oilgas.ogm.utah.gov/Data_Center/LiveData_Search/files.htm http://oilgas.ogm.utah.gov/Data_Center/LiveData_Search/logs.htm

Williams, N.C., and Madsen, J.H., Jr., 1959, Late Cretaceous stratigraphy of the Coalville area, Utah, *in* Williams, N.C., editor, Guidebook to the geology of the Wasatch and Uinta Mountains transition area: Intermountain Association of Petroleum Geologists Tenth Annual Field Conference, p. 122-125.

Yonkee, W.A., DeCelles, P.G., and Coogan, J.C., 1997, Kinematics and synorogenic sedimentation of eastern frontal part of the Sevier orogenic wedge, northern Utah: Brigham Young University Geology Studies, v. 42, part 1, p. 355-380.

Cited for subsurface information

Lelek, J.J., 1982, Anschutz Ranch East field, northeast Utah and southwest Wyoming, *in* Powers, R.B., editor, Geologic studies of the Cordilleran thrust belt: Rocky Mountain Association of Geologists, v. 2, p. 619-631.

Moklestad, T.C., 1979, Yellow Creek field *in* Wyoming oil and gas fields symposium, Greater Green River Basin: Wyoming Geological Association, p. 426-427.

Rubey, W.W., Oriel, S.S., and Tracey, J.I., Jr., 1975, Geology of the Sage and Kemmerer 15-minute quadrangles, Lincoln County, Wyoming: U.S. Geological Survey Professional Paper 855, 18 p., 2 plates, scale 1:62,500.

Shaw, A.B., and DeLand, C.R., 1955, Cambrian of southwestern Wyoming, *in* Green River Basin: Wyoming Geological Association 10th annual field conference guidebook, p. 38-42.

Sieverding J.L., and Royse, Frank, Jr., 1990, Whitney Canyon-Carter Creek field- U.S.A., western Wyoming thrust belt, Wyoming, *in* Structural traps III, Tectonic fold and fault traps: American Association of Petroleum Geologists Treatise of Petroleum Geology, Atlas of Oil and Gas Fields, 29 p.

Sprinkel, D.A., and Chidsey, T.C., Jr., 1993, Jurassic Twin Creek Limestone, *in* Hjellming, C.A., editor, Atlas of major Rocky Mountain gas reservoirs: New Mexico Bureau of Mines and Mineral Resources, p. 76.

West, Judy, and Lewis, Helen, 1982, Structure and palinspastic reconstruction of the Absaroka thrust, Anschutz Ranch area, Utah and Wyoming, *in* Powers, R.B., editor, Geologic studies of the Cordilleran thrust belt: Rocky Mountain Association of Geologists, p. 633-639.

WOGCC, various dates, well logs and formation tops: Wyoming Oil and Gas Conservation Commission website, accessed at http://wogcc.state.wy.us.

General

Bryant, Bruce, 1990, Geologic map of the Salt Lake City 30' x 60' quadrangle, north-central Utah, and Uinta County, Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I-1944, scale 1:100,000, with palynological data by Bryant, Bruce and Nichols, D.J. - plate 2.

DeCelles, P.G.,1988, Lithologic provenance modeling applied to the Late Cretaceous synorogenic Echo Canyon Conglomerate, Utah - A case of multiple source areas: Geology, v. 16, p. 1039-1043. [details are in DeCelles, 1994]

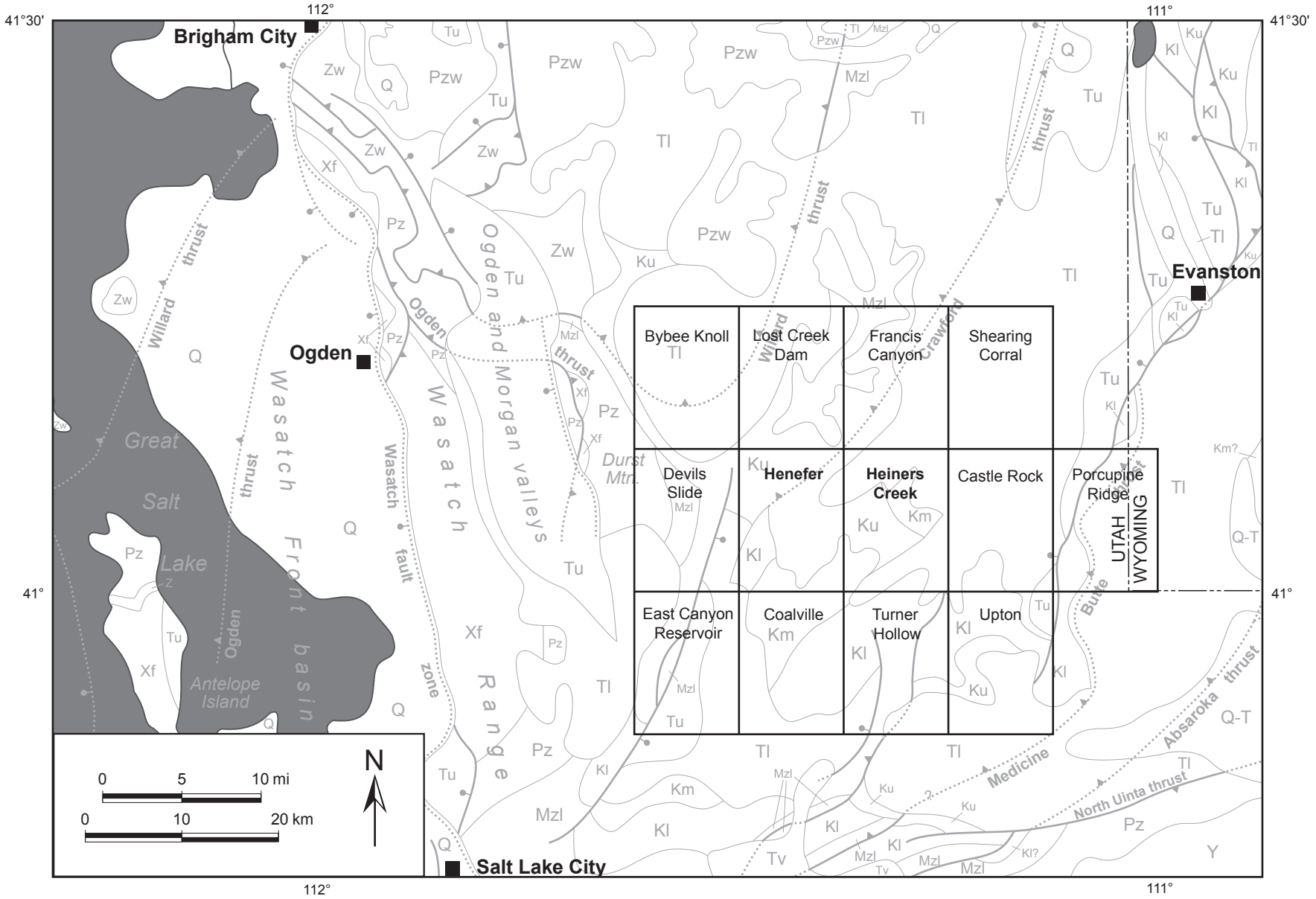
Mullens, T.E., 1971, Reconnaissance study of the Wasatch, Evanston, and Echo Canyon Formations in part of northern Utah: U.S. Geological Survey Bulletin 1311-D, 31 p.

Nichols, D.J., and Ott, H.L., 1978, Biostratigraphy and evolution of the *Momipites-Caryapollenites* lineage in the early Tertiary in the Wind River Basin, Wyoming: Palynology v. 2, p. 93-112.

Nichols, D.J., and Ott, H.L., 2006, Neotypes for Paleocene species in the *Momipites-Caryapollenites* pollen lineage: Palynology v. 30, p. 33-41.

Royse, Frank, Jr., 1993, An overview of the geologic structure of the thrust belt in Wyoming, northern Utah, and eastern Idaho, *in* Snoke, A.W., Steidtmann, J.R., and Roberts, S.M., editors, Geology of Wyoming: Geological Survey of Wyoming Memoir no. 5, p. 273-311, 2 plates. [cross section through Coalville area]

Schmitt, J.G., 1982, Origin and sedimentary tectonics of Upper Cretaceous Frontier Formation conglomerates in the Wyoming-Idaho-Utah thrust belt: Laramie, University of Wyoming Ph.D. dissertation, 225 p. [includes Coalville area, mostly about conglomerate in Dry Hollow Member]



Q Quaternary deposits
Tu Tertiary, upper
Tl Tertiary, lower
Tv Tertiary volcanics
Ku Cretaceous, upper
Km Cretaceous, middle
Kl Cretaceous, lower
Mzl Mesozoic, lower
Pz Paleozoic
Pzw Paleozoic, Willard thrust sheet
Zw Late Proterozoic, Willard thrust sheet
Xf Farmington Canyon Complex

Figure 1. Generalized geologic map (modified from Yonkee and others, 1997), showing Henefer and Heiners Creek quadrangles (in bold), as well as adjacent quadrangles and quadrangles noted in text.

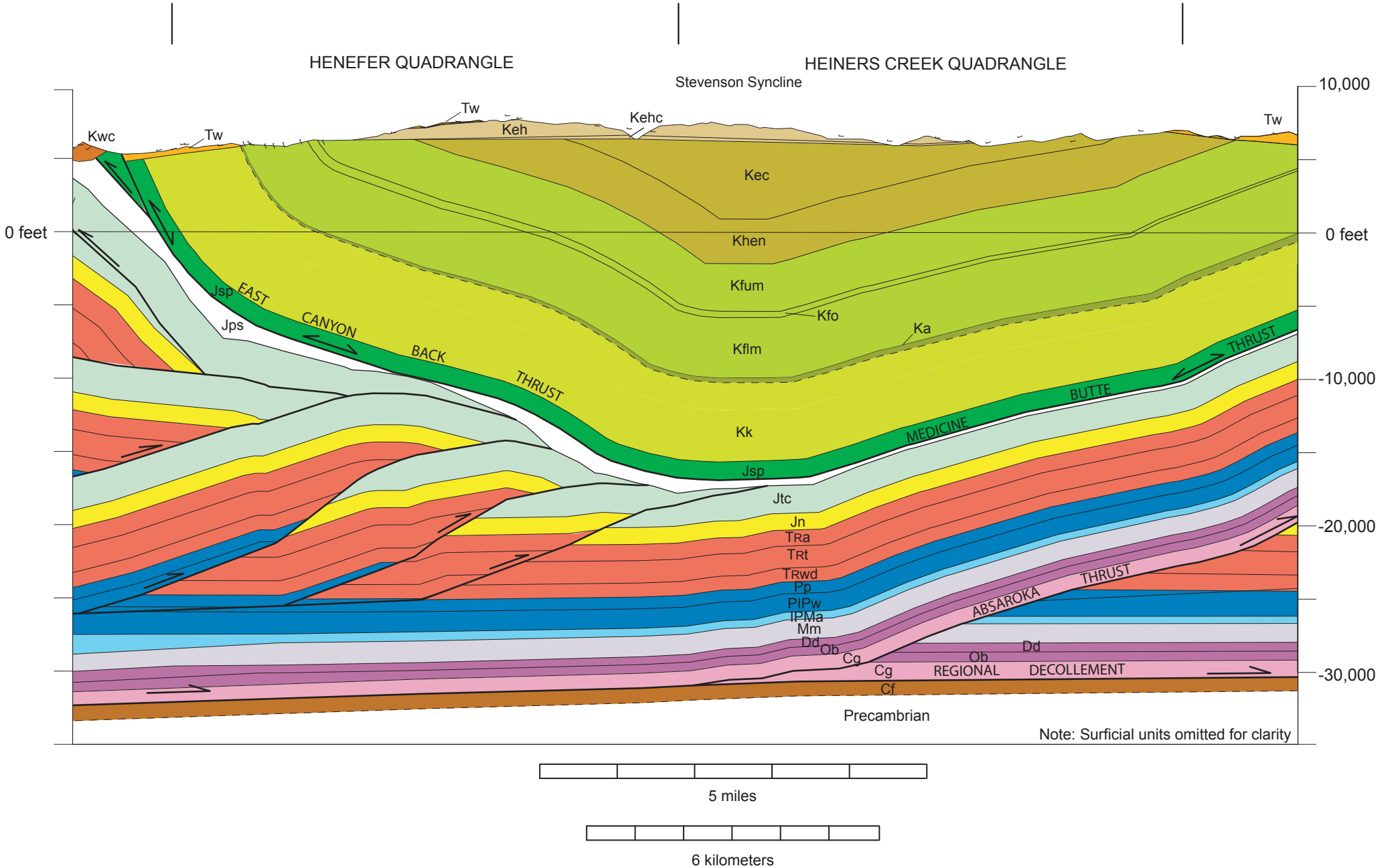
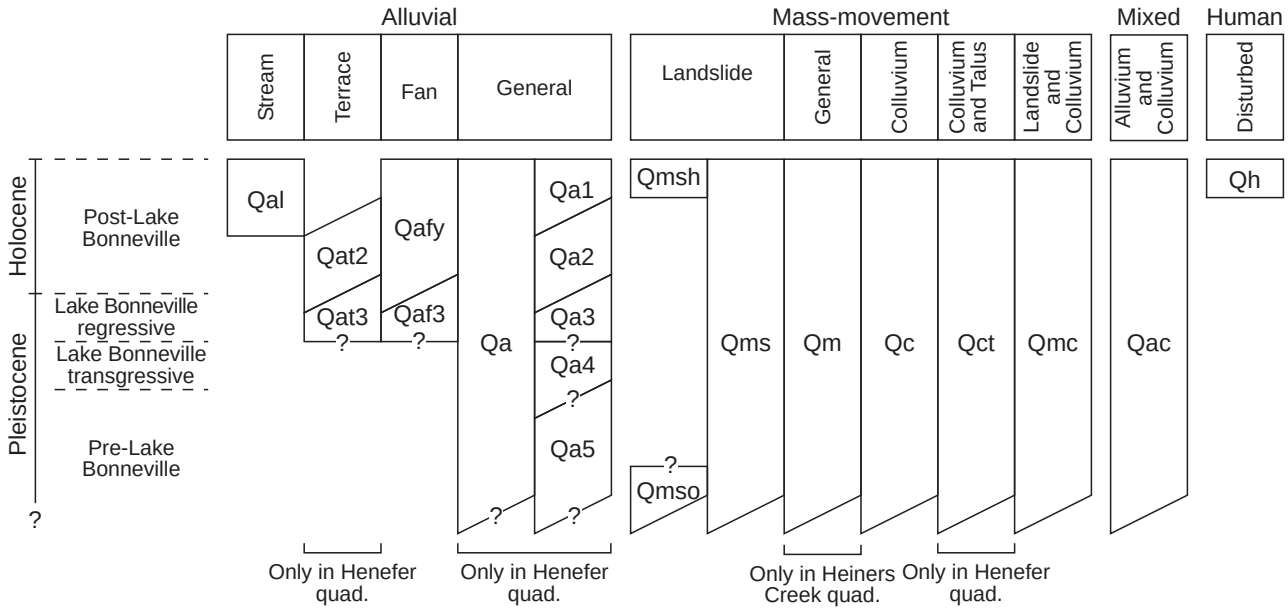
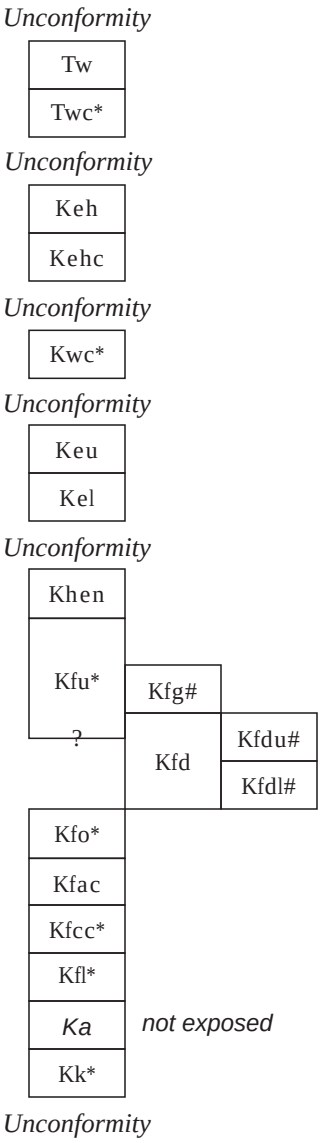


Figure 2. Simplified cross section of the Henefer and Heiners Creek quadrangles, Morgan and Summit Counties, Utah. See text booklet for unit symbols.

Quaternary correlation chart - Henefer and Heiners Creek quadrangles



Bedrock correlation chart - Henefer and Heiners Creek quadrangles



*=only in Henefer quadrangle

#=only in Heiners Creek quadrangle

Lithologic column - Henefer and Heiners Creek quadrangles

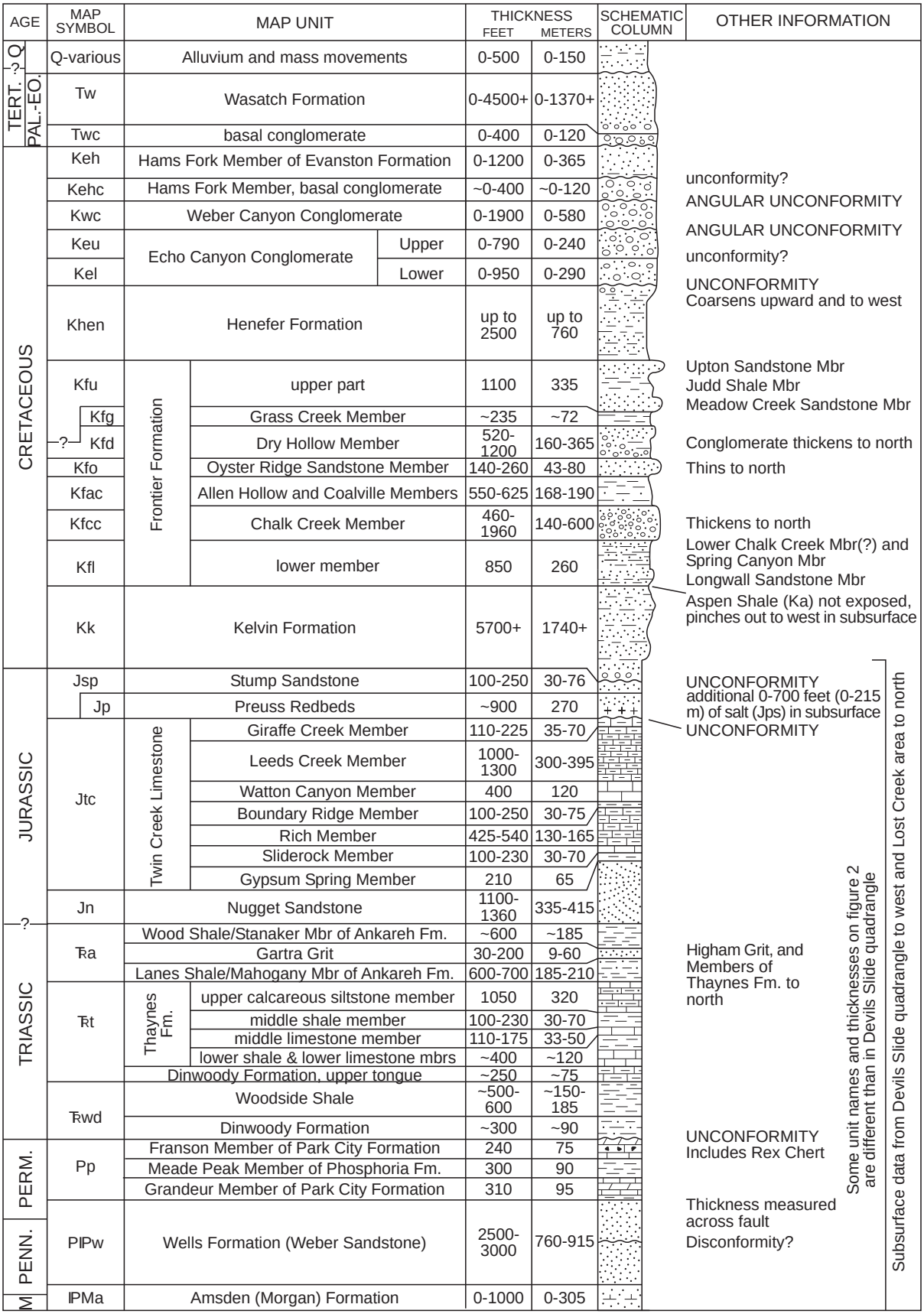


Diagram is schematic - no fixed thickness scale

Table 1. Palynology samples from Ogden 30'x60' quadrangle, ages by Waanders for Utah Geological Survey in 1996-1999.

SAMPLE #	recovery	comment	age	map unit	7.5' QUAD	SPOT LOCATION
96-1		need better loc	Albian or older		Castle Rock	T3N-R7E
96-2		need better loc	Middle Cretaceous		Castle Rock	T3N-R7E
96-3a			Paleocene, P4	Tw	Porcupine Ridge	sec 21, T4N-R8E
96-4			Cretaceous?	Tw-Twc contact	Porcupine Ridge	T4N-R8E
96-5a			Paleocene, P3/P4	Twc	Porcupine Ridge	sec 19, T4N-R8E
96-6	barren			Twc	Porcupine Ridge	sec 19, T4N-R8E
96-7			Cretaceous?	Keh	Heiners Creek	T4N-R6E
96-8			indeterminate	Keh-Kehc contact	Heiners Creek	T4N-R6E
96-9?		plotted on map				
96-10			indeterminate	Kehc	Heiners Creek	4N-
96-11a	barren			basal Keh	Heiners Creek	sec 17, T4N-R6E
96-12	barren			Keh-Kehc contact	Heiners Creek	4N-
96-13			Cretaceous	Keh	Heiners Creek	T4N-R6E
96-14			Cretaceous	Khen	Heiners Creek	T4N-R6E
96-15a	barren			Tw	Heiners Creek	sec 22, T4N-R6E
96-16			Middle? Cretaceous	Khen	Heiners Creek	4N-
96-17			indeterminate	Kku	Wahsatch	sec 26, T14N-R121W
96-18	barren			Twc	Wahsatch	sec 3, T13N-R121W
96-19			Eocene, but P6 or younger	Twc	Porcupine Ridge	T3N-R7E
96-20			indeterminate	Kku	Porcupine Ridge	T3N-R7E
96-21			indeterminate		Castle Rock	T3N-R7E
96-22		see 99-21	Eocene?, P3	Kku	Porcupine Ridge	
96-23		see 99-20	Late Cretaceous	Ka	Porcupine Ridge	
96-24a			Maastrichtian	Keh	Henefer	sec 19, T4N-R5E
96-25a		need better loc	Santonian? To Cenomanian?		Henefer	sec 23, T4N-R4E
96-26			Cretaceous	Keh	Henefer	T4N-R6E
96-27			Albian or older	Kk, upper	Henefer	T3N-R7E
96-28a	barren			Keh	Henefer	sec 14, T4N-R4E
96-29a			indeterminate	Keh	Peck Canyon	sec 14, T7N-R5E
96-30a			Maastrichtian	Tw-Keh contact	Horse Ridge	sec 16, T7N-R5E
96-31a			indeterminate	Tw	Horse Ridge	sec 26, T7N-R4E
96-32a			Santonian to Coniacian?	Keh	Horse Ridge	sec 2, T6N-R4E
96-33a		see 99-22	indeterminate	Tw	Meachum Ridge	sec 34, T9N-R5E
96-35sup	barren				Dairy Ridge	1200fsl, 1900fwl sec 30, T9N-R5E
96-36a			Maastrichtian	Keh	Lost Creek Dam	sec 36, T6N-R4E
96-40a			Maastrichtian	Keh	Francis Canyon	sec 10, T6N-R5E
96-41a			Campanian	Kehc	Francis Canyon	sec 11, T5N-R5E
96-42a	barren			Kehc	Lost Creek Dam	sec 21, T5N-R5E
96-43sup	barren				Devils Slide	250fsl, 2050fel sec 19, T4N-R4E
96-46a	barren				Devils Slide	sec 18, T4N-R4E

Table 1. Palynology samples from Ogden 30'x60' quadrangle, ages by Waanders for Utah Geological Survey in 1996-1999.

SAMPLE #	COMMENTS
96-1	immediately below Oyster Ridge Mbr. Age revised to Cenomanian to Albian based on assemblages in 98-5 and 98-12
96-2	above Oyster Ridge Mbr
96-3a	Nichols and Ott (1978) - P4. 150-200 ft above base of main body of Wasatch Fm. Jkk notes location much farther above base
96-4	contaminants or recycled. Also plotted on attitude sheet
96-5a	best fit Nichols and Ott (1978) - P3/P4. **TOO OLD** Also plotted on attitude sheet
96-6	also plotted on attitude sheet
96-7	
96-8	originally thought to be 8 ft above Evanston-Echo Canyon Fm contact
96-9?	
96-10	originally thought to be Keu
96-11a	originally thought to be cong in Keh
96-12	
96-13	
96-14	originally thougth to be basal Khen or uppermost Kf
96-15a	
96-16	originally thougth to be basal Khen or uppermost Kf, stratigraphically a couple feet below 96-14
96-17	also plotted on attitude sheet
96-18	also plotted on attitude sheet
96-19	Nichols and Ott (1978) - P6 or younger. Also plotted on attitude sheet
96-20	also plotted on attitude sheet
96-21	
96-22	Eocene age is reason for resample. Also plotted on attitude sheet
96-23	Cenomanian or younger age is reason for resample. Jkk notes Kelvin may have been sampled
96-24a	see '98 blueline
96-25a	Echo Canyon Cong
96-26	
96-27	
96-28a	
96-29a	no Kehc here. Also plotted on attitude sheet
96-30a	Hams Fork Mbr. Jkk notes digital contact or sample location is incorrect, but plot on attitude sheet is in Keh
96-31a	also plotted on attitude sheet
96-32a	also plotted on attitude sheet. **TOO OLD**
96-33a	near contact with Keh; also plotted on attitude sheet. Shown as P3 by Jacobson and Nichols (1982, figure 6)
96-35sup	
96-36a	Hams Fork Mbr. Also plotted on attitude sheet
96-40a	Hams Fork Mbr. Also plotted on attitude sheet
96-41a	Hams Fork Mbr. Plotted on attitude sheet
96-42a	plotted on attitude sheet
96-43sup	
96-46a	

Table 1. Palynology samples from Ogden 30'x60' quadrangle, ages by Waanders for Utah Geological Survey in 1996-1999.

SAMPLE #	recovery	comment	age	map unit	7.5' QUAD	SPOT LOCATION
96-47a			indeterminate		Devils Slide	sec 19, T4N-R4E
96-48a			Campanian	Keh	Francis Canyon	sec 31, T6N-R6E
96-50a			Campanian	Kwc	Francis Canyon	sec 10, T5N-R5E
96-51a			Santonian to Cenomanian	Keu-Kel contact	Henefer	sec 9, T3N-R5E
96-52a			Campanian	Keu-Kel contact	Henefer	sec 10, T3N-R5E
97-1mh	barren				McKay Hollow	1800fel, 24230fnl sec 30, T7N-R7E
97-1			indeterminate	Tw	Meachum Ridge	1030fwl, 520fsl sec 22, T9N-R6E
97-2			Maastrichtian	Keh	Dairy Ridge	700fwl, 500fnl sec 16, R8N-R5E
97-3			Maastrichtian	Keh	Dairy Ridge	1780fel, 1910fsl sec 32, R8N-R5E
97-4			Maastrichtian	Keh	Dairy Ridge	1450fwl, 2530fsl sec 33, T8N-R5E
97-5	barren			Tw	Meachum Ridge	720fel, 50fnl sec 13, T8N-R5E
97-6	barren			Tw	Meachum Ridge	1830fwl, 2300fnl sec 4, T8N-R6E
97-7			Late Paleocene, P4/P5	Tw	Meachum Ridge	110fel, 2230fsl, sec 11, T8N-R5E
97-8			Maastrichtian	Keh	Peck Canyon	2240fwl, 1450fsl sec 24, T7N-R5E
97-9		need better loc	Maastrichtian to Campanian		Neponset Res NW	2540fel, 2280fnl sec 23, R8N-R6E
97-11	barren				Henefer	1280fwl, 2310fsl sec. 22, T4N-R4E
97-12	barren			Tw	Meachum Ridge	690fel, 1910fsl sec 8, T8N-R6E
97-13			Paleocene to Eocene, P6 or younger	Tw	Meachum Ridge	500fel, 2380fnl sec 8, T8N-R6E
97-14			indeterminate		Devils Slide	2000fwl, 2000fnl sec. 21, T4N-R4E
97-15		need plot	Tertiary?		Henefer	2690fel, 2210fsl sec. 21, T4N-R4E
97-16			Cenomanian to Albian	upper Kk	Henefer	2080fel, 2190fsl sec. 27, T4N-R4E
97-17		need plot	Cenomanian to Albian		Henefer	1260fwl, 580fsl sec. 15, T4N-R4E
97-18		need plot	Cretaceous		Henefer	750fwl, 910fsl sec. 15, T4N-R4E
97-19			indeterminate		Castle Rock	500fel, 510fsl sec. 11, T4N-R6E
97-20			Maastrichtian to Campanian		Shearing Corral	1550fwl, 2750fsl sec. 22, T5N-R7E
97-21		diverse	Paleocene	need plot	Castle Rock	1870fwl, 3210fnl sec. 32, T5N-R7E
98-1p			Early Cret to Middle Jurassic		Porcupine Ridge	2600fwl, 1450fsl sec 9, T3N-R8E
98-1			Cenomanian to Albian	Kk	Henefer	2580fel, 175fnl sec 16 T4N-R4E
98-2			Cenomanian to Albian	Kk	Henefer	2510fel, 1920fsl sec 9 T4N-R4E
98-3			Cenomanian to Albian	Kfcc, lower	Henefer	2080fwl, 90fnl sec. 10 T4N-R4E
98-4			Cenomanian to Albian	Kfcc	Henefer	2440fel, 80fsl sec 3 T4N-R4E
98-5			Cenomanian to Albian	Kfcc, middle	Henefer	1850fel, 675fnl sec. 10 T4N-R4E
98-6			Turonian or younger	Kfu	Henefer	1500fwl, 200fnl sec 14 T4N-R4E
98-7			Turonian	Kfu	Henefer	880fwl, 200fnl sec. 11 T4N-R4E
98-8			Turonian or younger	Kfu	Henefer	975fwl, 1500fnl sec. 11 T4N-R4E
98-9			Turonian	Kfo-Kfac contact	Henefer	710fel, 2120fsl sec. 10 T4N-R4E
98-10			Turonian	Kfu-Kfd contact	Henefer	50fel, 825fnl sec 10 T4N-R4E
98-11			Turonian	Kfo-Kfac contact	Henefer	950fel, 810fnl sec. 10 T4N-R4E

Table 1. Palynology samples from Ogden 30'x60' quadrangle, ages by Waanders for Utah Geological Survey in 1996-1999.

SAMPLE #	COMMENTS
96-47a	
96-48a	also plotted on attitude sheet
96-50a	also plotted on attitude sheet
96-51a	
96-52a	50ft below 96-51. **SHOULD BE OLDER; SWITCHED?**
97-1mh	upper Wasatch. Typo in fnl
97-1	also plotted on attitude sheet
97-2	no Kehc here. Also plotted on attitude sheet
97-3	no Kehc here. Also plotted on attitude sheet
97-4	no Kehc here. Also plotted on attitude sheet
97-5	also plotted on attitude sheet
97-6	also plotted on attitude sheet
97-7	near contact with Keh. Also plotted on attitude sheet
97-8	no Kehc here
97-9	Jkk notes no Cretaceous exposed in this quad; sample of cutting from Home Canyon borehole?
97-11	
97-12	also plotted on attitude sheet
97-13	also plotted on attitude sheet. Jkk notes above marker bed and sample 97-7
97-14	
97-15	
97-16	
97-17	
97-18	
97-19	
97-20	likely recycled, no Cretaceous exposed in this quadrangle
97-21	
98-1p	Bear River Fm?
98-1	
98-2	
98-3	
98-4	see '98 blueline
98-5	
98-6	
98-7	**MAY BE TOO OLD**
98-8	
98-9	
98-10	**MAY BE TOO OLD**
98-11	

Table 1. Palynology samples from Ogden 30'x60' quadrangle, ages by Waanders for Utah Geological Survey in 1996-1999.

SAMPLE #	recovery	comment	age	map unit	7.5' QUAD	SPOT LOCATION
98-12			Cenomanian to Albian	Kfac	Henefer	1150fel, 825fnl sec. 10 T4N-R4E
98-13	yes	diverse	Late Cret or Early Tert	need plot	Causey Dam	2000fwl, 1000fsl sec. 2 T6N R3E
98-14	yes		Late Cret or Early Tert	need plot	Causey Dam	875fwl, 2500fsl sec. 34 T7N R3E
99-1	barren	100% woody			Browns Hole	2550fwl, 250fnl sec. 31 T7N R3E
99-2	yes	diverse	Maastrichtian	basal Kehc	Heiners Creek	820fwl, 1710fnl sec. 29 T4N R6E
99-3	yes	diverse	Maastrichtian	need plot	Causey Dam	1200fwl, 1200fnl sec. 11 T6N R3E
99-4	yes	diverse	Paleocene?	Keh, upper	Lost Creek Dam	500fwl, 1230fsl sec. 15 T5N R4E
99-5	yes	diverse	Late Cret or Early Tert	Keh	Lost Creek Dam	1220fwl, 650fsl sec. 26 T5N R4E
99-6	barren	100% woody			Henefer	100fel, 1600fsl sec. 33 T5N R4E
99-7	yes		indeterminate	need plot	Devils Slide	1300fel, 810fsl sec. 8 T4N R4E
99-8	barren	100% woody			Devils Slide	1420fel, 210fsl sec. 18 T4N R4E
99-9	barren	100% woody			Devils Slide	1000fwl, 2025fsl sec. 18 T4N R4E
99-10	yes		Late? Cretaceous	need plot	Devils Slide	1570fel, 10fnl sec. 14 T4N R3E
99-11	yes	diverse	probable Jurassic	Jsp	Devils Slide	1825fel, 1440fsl sec. 20 T4N R4E
99-12	barren	100% woody			Henefer	950fel, 1550fsl sec. 14 T4N R4E
99-13	barren	100% woody			Heiners Creek	1310fwl, 1120fnl sec. 5 T3N R6E
99-14	barren	100% woody			Heiners Creek	410fwl, 390fnl sec. 10 T3N R6E
99-15	barren	100% woody			Heiners Creek	2325fel, 2120fsl sec. 33 T4N R6E
99-16	yes	diverse	Early Maastrichtian to Late Campanian	basal Keh	Heiners Creek	2000fwl, 1350fnl sec. 33 T4N R6E
99-17	yes		indeterminate	need plot	Porcupine Ridge	1150fel, 2580fsl sec. 32 T5N R8E
99-18	barren			Kku	Porcupine Ridge	1810fwl, 1100fnl sec. 12 T4N R7E
99-19	barren			Twc	Porcupine Ridge	1790fel, 1050fsl sec. 12 T4N R7E
99-20			Late Albian	Ka	Porcupine Ridge	2100fel, 1200fsl sec. 12 T4N R7E
99-21			Late Albian	Kku	Porcupine Ridge	1575fel, 640fsl sec. 11 T4N R7E
99-22	barren				Meachum Ridge	2375fel, 100fnl sec 34, T9N-R5E

Table 1. Palynology samples from Ogden 30'x60' quadrangle, ages by Waanders for Utah Geological Survey in 1996-1999.

SAMPLE #	COMMENTS
98-12	**MAY BE TOO OLD**
98-13	Lt gy mdstn & intbdd gy sltstn w/ carbncs flecks near uncertain Wasatch-Evanston Fm contact
98-14	yel, grn, rd, & rd-br sltstn & mdstn near uncertain Wasatch-Evanston Fm contact
99-1	Lt yel-gy to wht mdstn near uncertain Wasatch-Evanston Fm contact
99-2	Coaly mdstn & sltstn above basal Evanston oversize clast cgl
99-3	Lt gy mdstn & gy sltstn w/ carbncs flecks below rd mudstn near uncertain Wasatch-Evanston Fm contact
99-4	Gy clystn below tn ss overhang
99-5	Gn-gy clystn, dk gy carbncs mdstn
99-6	Gy clystn between tn ss & cgl ribs. upper Evanston Fm
99-7	Dk gy sltstn w/ cly lam between tn ss ribs. upper Evanston Fm
99-8	Gy-gn mdstn roadcut. Evanston Fm
99-9	Gy-gn clystn roadcut in Evanston Fm. adj to Wasatch fault contact
99-10	Gy-br sltstn to mdstn w/ carbncs flecks
99-11	Gn soft clystn betwn rd-br clystn layers. Prev. mapped as J. Stump-Preuss, poss Wasatch.
99-12	Gy sltstn betwn tn ss & rd sltstn near Evanston-wasatch contact
99-13	Gy carboncs mdstn near Henefer-Evanston Fm contact
99-14	Gy slty clystn beneath tn ss & rd mdstn near Wasatch-Evanston Fm contact
99-15	Gy, gy-gn, tn, & purp mdstn near Henefer-Evanston Fm contact
99-16	Dk gy sli fissile clystn near Henefer-Evanston Fm contact; no Kehc here
99-17	Gn-gy mdstn w/ purp mottling in roadcut. Kelvin Fm
99-18	Br-gy mdstn
99-19	Basal gy mdstn beneath Evanston or Wasatch cgl bed and immediately above K. Aspen-Frontier
99-20	Dk gy fiss sh w/ fish scales. Aspen Fm field ID. Resamp of Ogden 96-23 which was prob contam
99-21	Lt gy mdstn. Resamp of Ogden 96-22 (Eocene) which was prob contam
99-22	Gy mdstn from n. wall of borrow pit above poss Evanston cgl. Resamp of Ogden 96-33 (barren) NOT!

Table 2. Palynology samples from Ogden 30'x60' quadrangle ages from Jacobson and Nichols (1982), Chevron-U.S. Geological Survey

SAMPLE #	recovery	comment	age	map unit	7.5' QUAD	SPOT LOCATION
P3849-4			Paleocene-Eocene?	Tw	Castle Rock	sec 14, T4N-R6E
P3850-2			Paleocene-Eocene? P5-P6	Tw	Castle Rock	sec 11, T4N-R6E
P3043-1			P3	Tw	Meachum Ridge	200fnl, 850fel sec. 33, T9N-R5E
P2833-1,2			P5-P6	Tw-Twc contact	Porcupine Ridge	1000fwl, 3200fsl sec. 33, T5N-R8E
P3903-2			Maastrichtian-upper Campanian	Keh	Devils Slide	nenwnw sec 3, T3N-R3E
P3040-1B			Maastrichtian-upper Campanian	Keh	Lost Creek Dam	150fwl, 1000fnl sec. 17, T5N-R5E
P3041-1			Maastrichtian-upper Campanian	Keh-Kehc contact	Lost Creek Dam	400fsl, 2300fwl sec. 28, T5N-R5E
D6176			Maastrichtian-upper Campanian	guess Keh or Kehc	Francis Canyon	nwnw sec 10 T5N-R5E
D6118A,B			Maastrichtian-upper Campanian	guess Kehc or Kel	Heiners Creek	swsese sec 35, T4N-R5E
D6175			Maastrichtian-upper Campanian	guess Keh or Kehc	Lost Creek Dam	nesesw sec 28 T5N-R5E
D6278A-D			Maastrichtian-upper Campanian	guess Keh or Kehc	Lost Creek Dam	swswnw sec 17 T5N-R5E
D6175			Maastrichtian-upper Campanian	guess Keh or Kehc	Lost Creek Dam	nesesw sec 28 T5N-R5E
P3060-1			Santonian-Coniacian	Khen	Heiners Creek	*nwswne sec 21 T4N-R6E
P3060-3			Santonian-Coniacian	Khen	Heiners Creek	*seswnw sec 21 T4N-R6E
P3060-4			Santonian-Coniacian	Khen	Heiners Creek	*swswnw sec 21 T4N-R6E
P3060-5			Santonian-Coniacian	Khen	Heiners Creek	*nwnwsw sec 21 T4N-R6E
P3060-6			Santonian-Coniacian	Khen	Heiners Creek	*nwsese sec 20 T4N-R6E
P3060-7			Santonian-Coniacian	Khen	Heiners Creek	*nwsese sec 20 T4N-R6E
P3060-8			Santonian-Coniacian	Kel-Khen contact	Heiners Creek	*nwnwsw sec 29 T4N-R6E
P3060-9			Santonian-Coniacian	Kel	Heiners Creek	*nenesw sec 36 T4N-R5E
P3060-10			Santonian-Coniacian	Kel	Heiners Creek	senenw sec 10 T3N-R5E
P3060-13			Santonian-Coniacian	Kel	Heiners Creek	seswse sec 3 T3N-R5E
P3060-14			Santonian-Coniacian	Kel	Heiners Creek	nenwsw sec 2 T3N-R5E
P3060-14A			Santonian-Coniacian	Kel	Heiners Creek	nenwnw sec 2 T3N-R5E
P3060-15			Santonian-Coniacian	Kel	Heiners Creek	*nesese sec 36 T4N-R5E
P3060-16			Santonian-Coniacian	Khen	Heiners Creek	*nwswsw sec 21 T4N-R6E
P3060-16A			Santonian-Coniacian	Khen	Heiners Creek	*nwswsw sec 21 T4N-R6E
P3060-18			Santonian-Coniacian	Khen	Heiners Creek	*nesene sec 21 T4N-R6E
P2826-5			Santonian-Coniacian	Keu or Kel	Heiners Creek?	1500fsl 1600fwl nw1/4 sec 10, T3N-R5E
D6129-1			Santonian-Coniacian	Keu or Kel	Henefer?	e1/2 sec 9 T3N-R5E
D6128-2			Santonian-Coniacian	guess Kel	Henefer?	ne1/4 sec 16 T3N-R5E
D6279A,B			Santonian-Coniacian	Keu or Kel	Heiners Creek?	sec 10 T3N-R5E
P3848-1			Santonian-Coniacian	Khen	Heiners Creek	senwne sec 21 T4N-R6E
P3848-2			Santonian-Coniacian	Khen	Heiners Creek	senwne sec 21 T4N-R6E

Table 2. Palynology samples from Ogden 30'x60' quadrangle ages from Jacobson and Nichols (1982), Chevron-U.S. Geological Survey

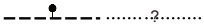
SAMPLE #	COMMENTS
P3849-4	Chevron biostrat study 1060
P3850-2	Chevron biostrat study 1060
P3043-1	(p. 740 and 743, figure 6). Age is Tertiary Evanston, but not mapped here
P2833-1,2	(p. 738 and 744, figure 11)
P3903-2	(p. 740 and 747, figure 19)
P3040-1B	(p. 740 and 747, figure 20)
P3041-1	(p. 740 and 747, figure 20)
D6176	(p. 740 and 747, figure 20)
D6118A,B	(p. 740 and 747, figure 20)
D6175	(p. 740 and 747, figure 20)
D6278A-D	(p. 740 and 747, figure 20)
D6175	(p. 740 and 747, figure 20)
P3060-1	(p. 741 and 749, figure 24). Not Echo Canyon Cong. Location from map in Chevron biostrat study 1060.
P3060-3	(p. 741 and 749, figure 24). Not Echo Canyon Cong. Location from map in Chevron biostrat study 1060.
P3060-4	(p. 741 and 749, figure 24). Not Echo Canyon Cong. Location from map in Chevron biostrat study 1060.
P3060-5	(p. 741 and 749, figure 24). Not Echo Canyon Cong. Location from map in Chevron biostrat study 1060.
P3060-6	(p. 741 and 749, figure 24). Not Echo Canyon Cong. Location from map in Chevron biostrat study 1060.
P3060-7	(p. 741 and 749, figure 24). Not Echo Canyon Cong. Location from map in Chevron biostrat study 1060.
P3060-8	(p. 741 and 749, figure 24). Location from map in Chevron biostrat study 1060.
P3060-9	(p. 741 and 749, figure 24). Location from map in Chevron biostrat study 1060.
P3060-10	(p. 741 and 749, figure 24)
P3060-13	(p. 741 and 749, figure 24)
P3060-14	(p. 741 and 749, figure 24)
P3060-14A	(p. 741 and 749, figure 24)
P3060-15	(p. 741 and 749, figure 24). Location from map in Chevron biostrat study 1060.
P3060-16	(p. 741 and 749, figure 24). Not Echo Canyon Cong. Location from map in Chevron biostrat study 1060.
P3060-16A	(p. 741 and 749, figure 24). Not Echo Canyon Cong. Location from map in Chevron biostrat study 1060.
P3060-18	(p. 741 and 749, figure 24). Not Echo Canyon Cong. Location from map in Chevron biostrat study 1060.
P2826-5	(p. 741 and 749, figure 24). Need better location
D6129-1	(p. 741 and 749, figure 24). Need better location
D6128-2	(p. 741 and 749, figure 24). Need better location
D6279A,B	100m SW of Sawmill Canyon (p. 741 and 749, figure 24). Need better location
P3848-1	(p. 741 and 749, figure 24). Not Echo Canyon Cong. Hilliard-Adaville age-Chevron biostrat study 1060
P3848-2	(p. 741 and 749, figure 24). Not Echo Canyon Cong. Hilliard-Adaville age-Chevron biostrat study 1060

GEOLOGIC SYMBOLS
for Henefer quadrangle

Contact, dashed where approximately located or gradational, dotted where concealed

Contact (brown), extent of newer (2006) clay pit and stockpiles

Lineament, possible ridge of uppermost Chalk Creek Member of Frontier Formation “ghosting” through overlying Wasatch Formation



Normal fault, dashed because approximately located, bar and ball on downthrown side, dotted where concealed, queried where existence is uncertain

Thrust fault, teeth on upper plate, dotted because concealed, queried where location uncertain

Fault on figure 2, arrow indicates direction of movement, double headed arrow indicates reversal of movement due to later normal faulting

Anticline hinge-zone trace, dashed because approximately located, dotted where concealed

Syncline hinge-zone trace, dashed because very approximately located in Sawmill Canyon, dotted where concealed, queried where location uncertain

Monocline (flexure) hinge-zone trace, dashed because approximately located, dotted where concealed

Mass-movement scarp

Strike and Dip

Upright

Upright, top known

Determined by photogrammetry, upright

Determined digitally after mapping by Jon K. King using 3-point calculation on photogrammetrically mapped contact or marker bed, upright (in red)

Oil and gas exploration borehole

Locations of selected palynology samples

this study

Chevron

Utah Geological Survey
a division of
Utah Department of Natural Resources

Plate 1
Utah Geological Survey Open-File Report 576
Interim Geological Map of the Henefer Quadrangle,
Morgan and Summit Counties, Utah

This geologic map was funded by the Utah Geological Survey and U.S. Geological Survey, National Cooperative Geologic Mapping Program, through USGS STATEMAP award numbers 96HQAG01521, 97HQAG01797, and 98HQAG2067. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

UTM GRID AND 1991 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

ROAD CLASSIFICATION
Primary highway, hard surface
Secondary highway, hard surface
Light-duty road, hard or improved surface
Unimproved road
Interstate Route
U. S. Route
State Route

INTERIM GEOLOGIC MAP OF THE HENEFER QUADRANGLE, MORGAN AND SUMMIT COUNTIES, UTAH

by James C. Coogan

2010

HENEFER, UTAH
41111-A4-TF-024

1991

DMA 3766 III SW-SERIES V897