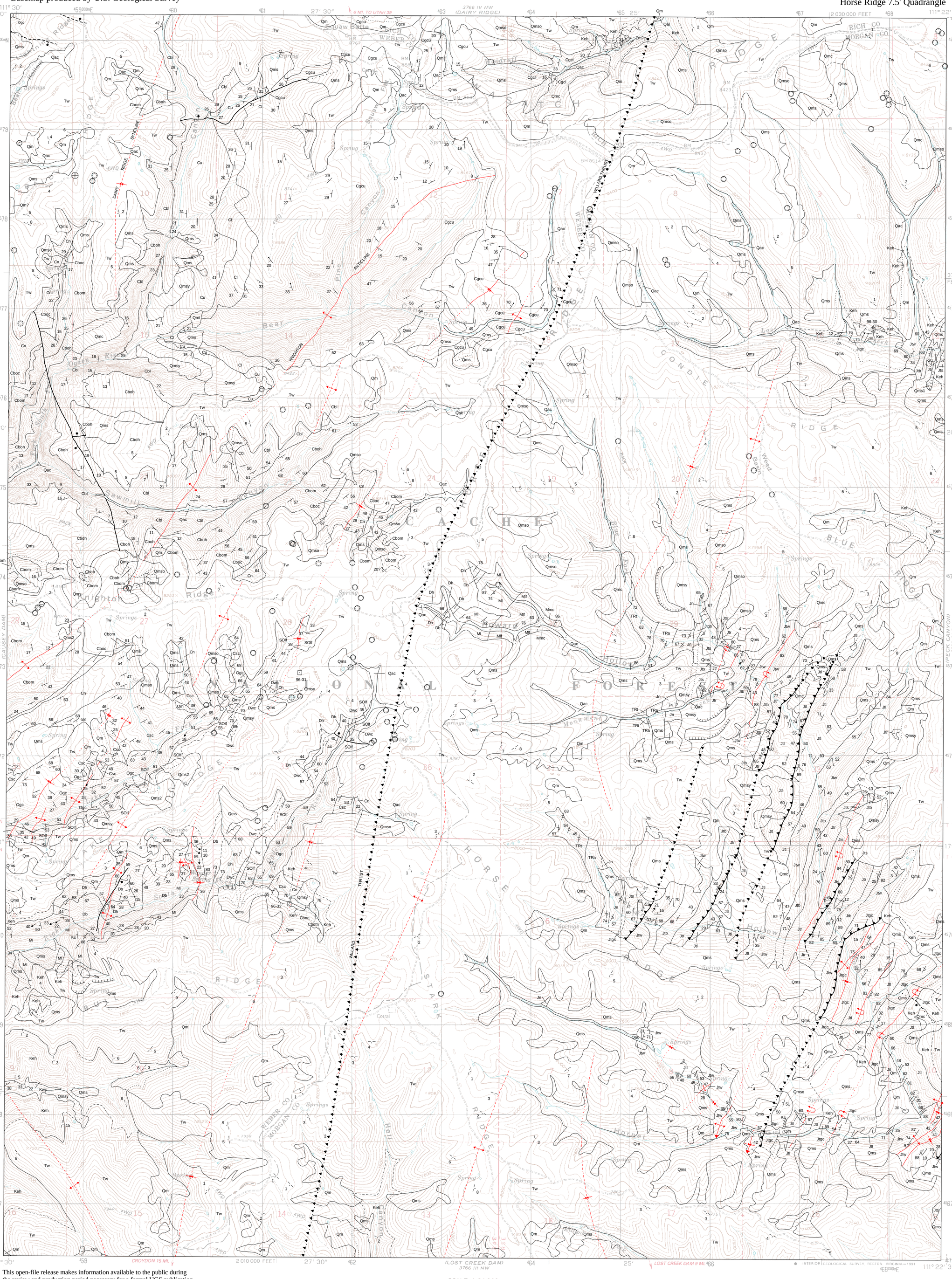
Basemap produced by U.S. Geological Survey

Open-File Report 480
Interim Geologic Map of the
Horse Ridge 7.5' Quadrangle



This open-file release makes information available to the public during the review and production period necessary for a formal UGS publication. The map may be incomplete and possible inconsistencies, errors, and omissions have not been resolved. While the document is in the review process, it not may conform to UGS standards; therefore it may be premature for an individual or group to take action based on its contents. The Utah Department of Natural Resources, Utah Geological Survey, makes no warranty, expressed or implied, regarding the suitability of this product for a particular use. The Utah Department of Natural Resources, Utah Geological Survey, shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to claims by users of this product.
For use at 1:24,000 scale only. The UGS does not guarantee accuracy or completeness of the data.

This geologic map was funded by the Utah Geological Survey and the U.S. Geological Survey, National Cooperative Geologic Mapping Program through U.S. Geological Survey STATEMAP award number 98HQAG2067.

GN MN 0°17' 5 MILS 14° 249 MILS
UTM GRID AND 1991 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000
1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

UTAH
QUADRANGLE LOCATION

ROAD CLASSIFICATION
Unimproved dirt

INTERIM GEOLOGIC MAP OF THE HORSE RIDGE QUADRANGLE, MORGAN, RICH, AND WEBER COUNTIES, UTAH

by JAMES C. COOGAN

2006

HORSE RIDGE, UTAH
41111-C4-TF-024
1991
DMA 3766 IV SW-SERIES V897

INTERIM GEOLOGIC MAP OF THE HORSE RIDGE QUADRANGLE, LEADING MARGIN OF WILLARD THRUST SHEET, MORGAN, RICH, AND WEBER COUNTIES, UTAH

BY

JAMES C. COOGAN
Department of Geology
Western State College
Gunnison, Colorado 81231

2006

Open-File Report 480

Utah Geological Survey
a division of
Utah Department of Natural Resources
in cooperation with U.S. Geological Survey
STATEMAP Agreement No. 98HQAG2067

This open-file release makes information available to the public during the review and production period necessary for a formal UGS publication. The information may be incomplete and possible inconsistencies, errors, and omissions have not been resolved. While the document is in the review process, it may not conform to UGS standards; therefore it may be premature for an individual or group to take actions based on its contents.

The Utah Department of Natural Resources, Utah Geological Survey, makes no warranty, expressed or implied, regarding the suitability of this product for a particular use. The Utah Department of Natural Resources, Utah Geological Survey, shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to claims by users of this product.

For use at 1:24,000 scale only. The UGS does not guarantee accuracy or completeness of the data.

SUMMARY

The Horse Ridge and adjacent Dairy Ridge quadrangles are located northeast of Ogden, Utah and southeast of Logan, Utah in the southern Bear River (Monte Cristo) Range in Cache, Morgan, Rich, and Weber Counties, Utah. The range is the source of snow-melt runoff used in Utah and Idaho, and is largely unpopulated. Geologically the quadrangles are on the leading edge of the Willard thrust sheet, the western and older of several such sheets in the "overthrust" belt of Utah, Idaho, and Wyoming (Coogan, 1992; Royse, 1993). Strata on this leading edge of the thrust sheet are noticeably thinner and lithologically different than on the trailing edge of the thrust sheet, as exposed near Ogden and on the west side of the Bear River Range near Logan (Coogan, 1992; Yonkee and others, 1997). Specifically, Proterozoic strata lack the key marker beds present in the Huntsville area, making correlations suspect. In the Dairy Ridge quadrangle, the leading edge of the Willard thrust sheet is marked by Proterozoic and Cambrian Geertsen Canyon Quartzite juxtaposed against Permian and Pennsylvanian strata of a thrust sliver and Triassic strata. In the Horse Ridge quadrangle, the Willard thrust fault is concealed by the Tertiary Wasatch Formation. Proterozoic to Mississippian strata of the Willard thrust sheet are exposed west of the topographic divide that is also the Weber-Morgan County line, while complexly folded and thrust-faulted Triassic and Jurassic strata are exposed east of the divide in Morgan County. After much discussion, the concealed trace of the Willard thrust is shown on the Horse Ridge geologic map west of the previously unrecognized Devonian and Mississippian strata in Howard Hollow, Morgan County. The Willard thrust was placed to the west because these upper Paleozoic strata are not overturned like the thrust sliver in the Dairy Ridge quadrangle, despite apparent thicknesses that are atypical for these strata.

Other geologic features of importance in these quadrangles are the karstified surface exposed in the northwest part of the Dairy Ridge quadrangle, exposures of latest Cretaceous conglomerate, and structures in the Wasatch Formation. The karst surface is more noticeable to the west in Cache County and is developed on gently dipping and faulted lower Paleozoic carbonate strata in the Monte Cristo Range. This surface likely extends beneath Wasatch Formation cover in the Horse Ridge and Dairy Ridge quadrangles as well as in the remainder of the Monte Cristo Range. These geologic conditions and typically abundant snow pack in the Monte Cristo Range provide for potential recharge of karstic carbonate aquifers. The latest Cretaceous Hams Fork Member of the Evanston Formation and Weber Canyon Conglomerate are related to tectonics in the overthrust belt, and provide clues to the timing and locations of uplift in Utah (DeCelles, 1994; Yonkee and others, 1997). The Dairy Ridge syncline in and east-west-trending normal faults cutting the Wasatch Formation are indicative of Eocene (Hogsback) thrusting in Wyoming (Yonkee and others, 1997) and/or Oligocene relaxation (collapse) of the Cordilleran fold-and-thrust belt (Constenius, 1996).

MAP UNIT DESCRIPTIONS

for the Horse Ridge and Dairy Ridge 7.5' quadrangles
(all units are not exposed in each map area)

QUATERNARY

Qal Stream and floodplain alluvium (Holocene) -- Sand, silt, clay, and gravel in channels and floodplains; composition depends on source area; locally includes fan alluvium in canyons; in Horse Ridge quadrangle only present along Woodruff Creek; 0 to 20 feet (0-6 m) thick.

Qaf Alluvial-fan deposits (Holocene) -- Mostly sand, silt, and gravel that is poorly stratified and poorly sorted; deposited mainly by debris flows in drainages and at drainage mouths; only mapped in Dairy Ridge quadrangle; generally less than 40 feet (12 m) thick.

Qac Alluvium and colluvium (Quaternary) -- Includes stream and fan alluvium, colluvium, and, locally, small mass-movement deposits; 0 to 20 feet (0-6 m) thick.

Qc Colluvium (Quaternary) -- Includes slopewash and soil creep; composition depends on local bedrock; only mapped in Dairy Ridge quadrangle; generally less than 20 feet (6 m) thick.

Qm Mass-movement deposits, undivided (Quaternary) -- Includes slides, slumps, and flows, as well as lessor colluvium and talus; mapped on steep slopes where several mass-movement processes may contribute to deposit; composition depends on local sources; 0 to 40 feet (12 m) thick.

Qmc Mass-movement and colluvial deposits, undivided (Quaternary) -- Includes landslide, slump, slopewash, and soil creep; mapped in areas of subdued morphology where separate mapping of mass movement and colluvial deposits is not possible; composition depends on local sources; 0 to 40 feet (12 m) thick.

Qms, Qmsy, Qms1, Qms2, Qmso
Slides and slumps (Quaternary) -- Poorly sorted clay- to boulder-sized material derived from steep local source terrain; generally characterized by hummocky topography, head and internal scarps, and chaotic bedding in displaced bedrock; locally includes flow deposits; morphology becomes subdued with age; divided into younger (Holocene) and older deposits (suffixes y and o, respectively) where possible; Holocene subdivided into Qms1 and Qms2 (1 is younger) where possible in the Horse Ridge quadrangle; thicknesses highly variable.

Qmt Talus deposits (Holocene) -- Angular debris on and at the base of steep slopes; only mapped north of Bear Canyon in the Horse Ridge quadrangle and along Utah highway 39

in the Dairy Ridge quadrangle; 0 to 20 feet (0-6 m) thick.

Qmr Rockfall deposits (Quaternary) – Unsorted, angular pebble- to boulder-sized carbonate-rock debris; located in north part of Dairy Ridge quadrangle; thickness uncertain.

TERTIARY

Tw Wasatch Formation (Eocene and uppermost Paleocene) -- Typically red sandstone, siltstone, mudstone, and conglomerate with minor gray limestone and marlstone locally; lighter shades of red, yellow/tan, and light gray are also present locally; total thickness up to 4500 feet (1370 m) to south near Henefer; in the Horse Ridge and Dairy Ridge quadrangles the Wasatch rocks are absent to at least 400 to 600 feet (0-180 m) thick, possibly thinning northward, with the thicknesses estimated by elevation differences between pre-Wasatch rocks exposed in drainages and the crests of gently dipping Wasatch Formation on adjacent ridges; thicknesses vary locally due to considerable relief on erosional surface below the Wasatch.

CRETACEOUS

Evanston Formation (Paleocene and Upper Cretaceous-Maastrichtian/Campanian)

Keh Hams Fork Member (Upper Cretaceous) -- Light-gray, brownish-gray, and tan sandstone, conglomeratic sandstone, and quartzite- and chert-pebble conglomerate, and variegated gray, greenish-gray, and red mudstone; to the south contains dark-gray, carbonaceous shale and coal in upper part (Coogan, 2004a, b); up to 450 feet (140 m) thick in southwestern Horse Ridge quadrangle where the member markedly coarsens to cobble conglomerate dominated by Cambrian and Proterozoic quartzite clasts; thins to absence to north and west along regional angular unconformity (northwestern Horse Ridge and western Dairy Ridge quadrangles were areas of high paleotopography); overlies the Weber Canyon Conglomerate with angular unconformity along the Right Fork of South Ogden River.

Kwc Weber Canyon Conglomerate (Upper Cretaceous-Campanian/late Santonian) - Tan and gray conglomerate; mainly comprises cobbles of Mississippian Lodgepole Limestone (75-100%) with lesser amounts of Cambrian and Proterozoic quartzites and Paleozoic sandstone cobbles; only exposed along the Right Fork of South Ogden River in southwestern Horse Ridge quadrangle; clasts were derived from a paleotopographic ridge developed on the Lodgepole Limestone to the west in the adjacent Causey Dam quadrangle; only about 300 feet (90 m) exposed.

WILLARD THRUST SHEET (Miogeoclinal/basin sequence of Coogan, 1992)

MISSISSIPPIAN

Ml Lodgepole Limestone (Mississippian-Osagean and Kinderhookian) -- Dark-gray, thin-bedded, lime micrite to wackestone, locally cherty; top not exposed in Horse Ridge and Dairy Ridge quadrangles; structurally thickened in Horse Ridge quadrangle; about 900 feet (275 m) thick to west in Causey Dam quadrangle (see Mullens, 1969).

DEVONIAN

Db Beirdneau Sandstone (Upper Devonian) -- Tan, reddish-tan and yellowish-gray sandstone, siltstone, and sandy dolomite and limestone; base not exposed in Dairy Ridge quadrangle and structurally thickened in Horse Ridge quadrangle; thickens southward from about 245 to 500 feet (77-150 m) in adjacent Monte Cristo Peak and Causey Dam quadrangles (see Smith, 1961; Mullens, 1969).

Dh Hyrum Dolomite (Upper and Middle Devonian) -- Dark- to medium-brownish-gray, coarsely crystalline dolomite; weathers distinctive, chocolate-brown color; 500 to 675 feet (150 to 205 m) thick.

Dwc Water Canyon Formation (Lower Devonian) -- Thin- to medium-bedded, reddish-tan and gray siltstone and light-gray to light-tannish-gray, very light-gray- to white-weathering, very thick-bedded to thinly laminated, finely crystalline dolomite; Hansen (1964) measured 168.5 feet (51.4 m) and estimated another 30 feet (9 m) were eroded to the north in the Curtis Ridge quadrangle; estimate 100 to 150 feet (30 to 45 m) thick in Horse Ridge and Dairy Ridge quadrangles.

SILURIAN AND ORDOVICIAN

SOlf Laketown and Fish Haven Dolomites, undivided -- Dark- to light-gray, cherty dolomite; thins southward from 600 feet (180 m) in northern Dairy Ridge quadrangle to 360 feet (110 m) thick in southern Horse Ridge quadrangle; mapped separately only in northwest Dairy Ridge quadrangle.

Sl Laketown Dolomite (as mapped Silurian and Ordovician) -- Dark- to light-gray, thick- to very thick-bedded, cherty dolomite; about 500 feet (150 m) thick.

ORDOVICIAN

Ofh Fish Haven Dolomite (Ordovician) -- Dark-gray, thick- to very thick-bedded dolomite with white chert as small nodules; commonly with dull-medium-gray to light-gray mottling on weathered surfaces; forms resistant ridge where distinguishable from more recessive dolomites at the base of the overlying Laketown Dolomite; Hansen (1964) measured 128 feet (39.0 m) to the north in the Curtis Ridge quadrangle; about 100 feet (30 m) thick in northwest Dairy Ridge quadrangle. Unconformably overlies Garden City Formation with Swan Peak Quartzite missing.

Ogc Garden City Formation (Ordovician) -- Dark-gray to gray, thin- to medium-bedded, silty

limestone; intraformational, flat-pebble conglomerate common in lower half; weathers light-bluish-gray with yellow-weathering, wavy, silt layers; forms resistant ridges; commonly structurally thickened; exhibits faint, axial-planar cleavage where mesoscopically folded; Hansen (1964) measured 1280 feet (390 m) in a composite section to the north in the Curtis Ridge quadrangle; thins southward from about 1050 feet (320 m) thick along Sugar Pine Creek, Dairy Ridge quadrangle, to about 700 feet (213 m) thick in southern Horse Ridge quadrangle.

ORDOVICIAN AND CAMBRIAN

Εsc St. Charles Formation (Ordovician and Upper Cambrian) -- Dark-gray, medium- to thick-bedded dolomite, weathers very dark gray with medium-gray, crude laminae and mottling; contains subordinate medium-gray, very thick- to thick-bedded dolomite; light-gray, tannish-gray weathering, thin-bedded, silty limestone present above basal Worm Creek Member; includes extremely thin (0-10 ft [0-3 m]) Worm Creek Quartzite in Horse Ridge quadrangle; Hansen (1964) measured 595 feet (181 m) in a faulted section to the north in the Curtis Ridge quadrangle, but suggested the thickness was 1100 feet (335 m); thins southward from 700 feet (215 m) thick along Sugar Pine Creek, Dairy Ridge quadrangle, to about 500 feet (150 m) thick in Horse Ridge quadrangle.

Εsw Worm Creek Quartzite (Upper Cambrian) -- Tannish-gray, medium-bedded, cross-bedded quartzite; interbedded with light-tannish-gray, silty limestone; thins southward from about 75 feet (25 m) thick where mapped in northern Dairy Ridge quadrangle to nothing in Horse Ridge quadrangle.

CAMBRIAN

Εn Nounan Formation (Middle and Upper Cambrian) -- Medium-gray, very thick- to thick-bedded dolomite; with subordinate dark-gray, medium- to thick-bedded dolomite that weathers very dark gray with medium-gray, crude laminae and mottling; Hansen (1964) measured 1025 feet (312.5 m) to the north in the Curtis Ridge quadrangle, while Gardiner (1974) measured 801 foot (244 m) thickness in Sugar Pine Canyon, Dairy Ridge quadrangle; thins southward from 800 feet (265 m) thick along Sugar Pine Creek, Dairy Ridge quadrangle, to 675 feet (205 m) thick in Horse Ridge quadrangle.

Bloomington Formation (Middle Cambrian)

Εboc Calls Fort Shale Member -- Olive-gray to tan-gray, thin-bedded, micaceous shale and argillite with minor, thin-bedded, dark-gray, silty limestone; 75 to 125 feet (25 to 40 m) thick.

Εbom Middle limestone member -- Dark-gray, thick- to thin-bedded limestone with tan-, yellow-, and red-weathering, wavy, silt layers; contains subordinate olive-gray and tan-gray, thin-bedded, micaceous shale and argillite; thickens southward from 425 feet (130 m) thick along Sugar Pine Creek, Dairy Ridge quadrangle, to 850 feet (260 m) along Sawmill Canyon, Horse Ridge quadrangle.

Εboh Hodges Shale Member -- Olive-gray to tan-gray, thin-bedded, micaceous shale and argillite and thin- to thick-bedded, dark-gray limestone with tan-, yellow-, and red-

weathering, wavy, silt layers; thickens southward from 410 feet (125 m) thick along Sugar Pine Creek, Dairy Ridge quadrangle, to 600 feet (180 m) thick along Sawmill Canyon, Horse Ridge quadrangle.

Єbl Blacksmith Dolomite (Middle Cambrian) -- Medium-gray, very thick- to thick-bedded, coarsely crystalline dolomite; forms cliffs and ridges; thickens southward from 600 feet (180 m) thick along Sugar Pine Creek, Dairy Ridge quadrangle, to about 760 feet (230 m) thick in northwestern Horse Ridge quadrangle.

Єu Ute Formation (Middle Cambrian) -- Gray to dark-gray, thin- to thick-bedded limestone with tan-, yellow-, and red-weathering, wavy, silt layers, and olive-gray to tan-gray, thin-bedded, micaceous shale and argillite; and minor, medium-bedded, gray to light-gray dolomite; about 450 feet (137 m) thick.

Єl Langston Dolomite (Middle Cambrian) -- Dark-gray to gray-brown, sandy dolomite in upper part and bright-red shale and tan, dolomitic sandstone in lower part; about 200 to 250 feet (60 to 75 m) thick.

CAMBRIAN AND PROTEROZOIC

Geertsen Canyon Quartzite (Middle and Lower Cambrian and possibly upper Proterozoic) -- Total thickness about 3200 feet (975 m); contact between members partly based on purplish color of upper part of lower member, so contact may shift in quartzite and is uncertain in Sawmill and Hansen Canyons, southern Dairy Ridge quadrangle.

Єgcu Upper member – Tan, white, and light-gray, medium- to coarse-grained, cross-bedded, thick-bedded quartzite; base of upper part is marked by a resistant, light-colored quartzite with quartz-pebble conglomerate containing white and pink quartz and rare jasper clasts; incompletely exposed, so thickness uncertain.

Єgcl Lower member – Typically conglomeratic and feldspathic; in these quadrangles contains a purplish upper part and a light-colored lower part; thickness about 600 to 1300 feet (180-400 m) (calculated from outcrop pattern, dip, topography), thickening northward in Dairy Ridge quadrangle.

PROTEROZOIC (Inkom Formation missing; compare to Crittenden and others, 1971)

Zb Browns Hole Formation (upper Proterozoic) – Brownish to purplish red (hematitic), mostly volcanic sandstone with some argillite; interval between Єgcl and Zm?c outcrops covered in Horse Ridge quadrangle; 20 to 200 feet (6-60 m) thick.

Zm?c Mutual(?) Formation and Caddy Canyon Quartzite (upper Proterozoic) -- Reddish, pink, tan, and light-gray, thick-bedded, locally vitreous quartzite, and conglomeratic and feldspathic quartzite; the upper part of this quartzite is darker colored, but because the Inkom is not present, the dark part may or may not be the Mutual Formation; total exposed thickness about 725 to 1300 feet (220-400 m) (calculated from outcrop pattern, dip, topography), apparently thickening northward (or underlying argillitic strata mapped

as Zkc? pinches out northward); base truncated by Willard thrust where Zkc? not mapped.

Zkc? Kelley Canyon Formation? (upper Proterozoic) -- Interbedded gray quartzite and reddish and greenish gray argillite mapped in Dairy Ridge quadrangle; because Caddy Canyon grades downward with increasing argillite into Kelley Canyon, the map unit may be part of either formation and is queried; up to about 300 feet (90 m) thick, with base truncated by Willard thrust.

CRAWFORD THRUST SHEET - FOOTWALL OF WILLARD THRUST (Outer shelf sequence of Coogan, 1992)

JURASSIC

Jp Preuss Redbeds (Middle Jurassic) -- Red sandstone, mudstone and shale, with anhydrite and halite near the base in subsurface sections; exposed along upper Lost Creek in Horse Ridge quadrangle where only the basal 200 feet (60 m) are exposed. Combined unit of Preuss and overlying Stump Formation is about 1000 feet (300 m) thick to the south at Toone Canyon, Lost Creek Dam quadrangle (Coogan, 2004b). About 250 feet (76 m) thickness of Stump Formation exposed to the east at Watton [now Walton] Canyon, Birch Creek Reservoirs quadrangle (Pipiringos and Imlay, 1979).

Twin Creek Limestone (Middle Jurassic) -- Mostly white- to gray-weathering, shaley limestone with some shale; 2722+ and 2600+ feet (830+ and 790+ m) thick to south at Devils Slide and to east at Watton [now Walton] Canyon/Birch Creek (Meachum Ridge and Birch Creek Reservoirs quadrangles), respectively (Imlay, 1967), top truncated by thrust fault at Devils Slide. Descriptions are from Coogan (2004b); see Imlay (1967, p. 23, 38-39, 41, 47, and 52) for detailed descriptions of Sliderock, Boundary Ridge, Watton Canyon, Leeds Creek, and Giraffe Creek Members, respectively, at Walton Canyon/Birch Creek

Jtgc Giraffe Creek Member -- Gray, greenish-gray, and tannish-gray, calcareous sandstone and lime grainstone; forms ridges; about 225 feet (70 m) thick. Atypically limestone-poor and pebbly to east at Watton Canyon (see Imlay, 1967).

Jtl Leeds Creek Member -- Light-gray, thin- to very thick-bedded, soft, clay-rich micritic limestone with tan silt partings; locally exhibits bedding-normal, pencil cleavage; forms barren scree-covered slopes; 1000 to 1200 feet (300-365 m) thick.

Jtw Watton Canyon Member -- Dark-gray, lime micrite and wackestone and minor oolite packstone; forms prominent ridges; locally exhibits bedding-normal, stylolitic, spaced cleavage; about 400 feet (120 m) thick.

Jtb Boundary Ridge Member -- Gray, very thick-bedded, ridge-forming, oolitic, lime grainstone to wackestone beds in middle and upper part that separate red and purple siltstone and gray, silty limestone beds in middle and lower part; 100 to 250 feet (30-75 m) thick. Imlay (1967) noted middle part is mostly limestone at Birch Creek.

Jtr Rich Member -- Light-gray, thin- to very thick-bedded, soft, clay-rich, micritic limestone

in upper part; gray, lime wackestone in lower part; locally exhibits bedding-normal, pencil cleavage; forms barren, scree-covered slopes; about 500 feet (150 m) thick.

Jts Sliderock Member -- Dark-gray, very thick-bedded lime wackestone in upper part and dark-gray, pelecypod and crinoid grainstone in lower part; forms small ridges; 100 to 227 feet (30-70 m) thick. Imlay (1967) noted middle part of variegated siltstone and shaly sandstone at Birch Creek.

Jtgs Gypsum Spring Member -- Red siltstone and sandstone, and gray, vuggy dolomite, with anhydrite in subsurface; up to 208 feet (65 m) thick. Imlay (1967) stated the carbonate was limestone and noted cherty limestone.

Jn Nugget Sandstone (Lower Jurassic) -- Pale-grayish-orange, pinkish, and locally white, well-cemented, cross-bedded, quartz sandstone; about 1100 and 1500 feet (305-460 m) thick to south at Toone Canyon, Lost Creek Dam quadrangle and in Devils Slide quadrangle, respectively (Madsen, 1959; Coogan, 2004b; Eardley, 1944).

TRIASSIC

TRa Ankareh Formation; Higham Grit; and Timothy Sandstone and Portneauf Limestone Members of Thaynes Formation, undivided (Triassic) – Descriptions for each subunit are listed below; structurally thinned to about 700 feet (215 m) beneath the Willard thrust; mapped in Horse Ridge quadrangle and in areas of poor exposure in Dairy Ridge quadrangle. Subdivided where possible in the Dairy Ridge quadrangle into:

TRaw Wood Shale Tongue of the Ankareh Formation (Upper Triassic) -- Bright orange-red shale, siltstone and sandstone; locally micaceous; structurally thinned beneath the Willard thrust; regional thickness about 500 feet (150 m) (Coogan, 2004a).

TRht Higham Grit and Timothy Sandstone Member of the Thaynes Formation (Triassic) -- Gray and greenish-gray, micaceous, quartz-granule sandstone at top (Higham); greenish-gray, lithic-pebble conglomerate below, containing green siltstone clasts and rare fossil wood fragments (Timothy); structurally thinned beneath the Willard thrust; regional thickness about 200 feet (60 m) (Coogan, 2004a).

TRtp Portneuf Limestone Member of Thaynes Formation – Gray and lavender, mottled micritic limestone with gray chert; about 50 to 100 feet (15-30 m) thick.

TRal Lanes Tongue of the Ankareh Formation (Lower Triassic) -- Purple and brownish-red shale, siltstone, and sandstone; structurally thinned beneath the Willard thrust; regional thickness about 450 feet (140 m) (Coogan, 2004a).

TRt Thaynes Formation, undivided (Lower Triassic) – Brownish-gray, thin-bedded, calcareous siltstone; gray, thin-bedded, silty shale; and thin- to medium-bedded, gray, fossiliferous limestone in upper and lower part. Separated by a resistant ridge of gray, very thick- to medium-bedded, fossiliferous limestone in middle part; mapped in Horse Ridge quadrangle and in areas of poor exposure in Dairy Ridge quadrangle. Subdivided where possible in the Dairy Ridge quadrangle into:

TRtu Upper calcareous siltstone member – Brownish-gray, thin-bedded, calcareous siltstone and thin-bedded, gray, fossiliferous limestone; includes poorly exposed, gray, thin-

bedded, silty shale in lower part, middle shale member of Kummel (1954); structurally thinned beneath the Willard thrust to about half its regional thickness of about 1150 feet (350 m) (J.C. Coogan, Western State College, Colorado, written communication, email, March 30, 2005).

TRtml Middle limestone member – Gray, very thick- to medium-bedded, fossiliferous limestone; forms prominent ridge; about 110 feet (33 m) thick.

TRtls Lower shale member -- Gray to brownish-gray, thin-bedded, calcareous siltstone to silty shale; structurally thinned beneath the Willard thrust; regional thickness about 375 feet (115 m) (Coogan, 2004a).

TRtll Lower limestone member – Gray to grayish-brown, thick- to thin-bedded, fossiliferous limestone; *Meekoceras* ammonite zone at base; about 200 feet (60 m) thick.

Dinwoody and Woodside Formations (only exposed in Dairy Ridge quadrangle) – To north in Idaho, these units intertongue (Kummel, 1954).

TRdu Upper tongue of Dinwoody Formation (Lower Triassic) – Greenish-gray and tan, calcareous siltstone and silty limestone; thickness about 250 feet (75 m) where it is probably structurally thinned beneath the Willard thrust.

TRw Woodside Formation (Lower Triassic) -- Dark-red, sandy shale and siltstone, with some sandstone; structurally thinned beneath the Willard thrust; estimate 500 to 800 feet (150-245 m) thick at Devils Slide (from unpublished mapping by author and cross section in Mullens and Laraway, 1964); about 700 to 750 feet (215-230 m) thick in subsurface to northeast in Birch Creek fold belt, with upper tongue of Dinwoody likely included in Thaynes (see Utah Department of Oil, Gas and Mining American Quasar no. 23-1 Putnam and Sohio Birch Creek 14-B well files and logs).

TRd Dinwoody Formation (Lower Triassic) -- Greenish-gray and tan, calcareous siltstone and silty limestone; structurally thinned beneath the Willard thrust; to south at Devils Slide about 200 to 500 feet (60-150 m) thick (after Cheney and Sheldon, 1959; Mullens and Laraway, 1964; unpublished mapping by author); about 325 feet (100 m) thick to northeast in subsurface in Birch Creek fold belt (see Utah Department of Oil, Gas and Mining American Quasar no. 23-1 Putnam and Sohio Birch Creek 14-B well files and logs).

PERMIAN (only exposed in Dairy Ridge quadrangle)

Park City and Phosphoria Formations (Permian)

Ppfr Franson Member of Park City Formation and Rex Chert Member of the Phosphoria Formation -- Interbedded dark-gray, thick-bedded, vuggy, cherty limestone and dark-gray and black bedded chert; about 300 feet (90 m) thick in incomplete thrust-truncated section along Woodruff Creek.

Ppm Meade Peak Phosphatic Shale Member of the Phosphoria Formation -- Gray limestone, dark-gray to black, phosphatic siltstone and shale, and gray, calcareous sandstone; 100 to 300 feet (30 to 90 m) thick along Woodruff Creek; thickness variation caused by

structural thickening and attenuation beneath the Willard thrust.

Ppg Grandeur Member of Park City Formation -- Light-gray, thick-bedded, dolomitic sandstone with gray chert nodules; about 300 feet (90 m) thick along Woodruff Creek.

PERMIAN AND PENNSYLVANIAN (only exposed in Dairy Ridge quadrangle)

IPw Wells Formation (Lower Permian and Pennsylvanian) -- Light-gray to tannish-gray, very thick-bedded, cross-bedded, fine-grained sandstone; about 1050 feet (320 m) thick, but the Wells is overturned and the base is truncated by the Willard thrust.

MISSISSIPPIAN (only exposed along Howard Hollow in Horse Ridge quadrangle)

Mmc Monroe Canyon Limestone (Mississippian-Chesterian and Meramecian) -- Tannish-gray, fossiliferous, vuggy, sandy dolomite; top not exposed, incomplete section about 1200 feet (365 m) thick, considerably (4x) thicker than near Laketown on the Willard thrust sheet (see Sandberg and Gutshick, 1979), but comparable to thicknesses in Idaho and top truncated by unconformity at Laketown (see Sando and others, 1981).

Mlf Little Flat Formation (Mississippian-Meramecian and Osagean) -- White to light-tan, light-orange to tan weathering, fine-grained, calcareous sandstone; 970 feet (295 m) thick, slightly (~15%) thicker than near Laketown on the Willard thrust sheet (see Sandberg and Gutschick, 1979).

Ml Lodgepole Limestone (Mississippian-Osagean and Kinderhookian) -- Dark-gray, thin-bedded, lime micrite to wackestone, locally cherty; 1300 feet (395 m) thick, but likely structurally thickened (notice upright and overturned dips on map and 900 foot thickness on Willard thrust sheet); 770 foot (235 m) thickness reported in the Crawford Mountains (see Sandburg and Gutschick, 1979).

DEVONIAN (only exposed along Howard Hollow in Horse Ridge quadrangle)

Db Beirdneau Sandstone (Upper Devonian) -- Tan, reddish-tan and yellowish-gray sandstone, siltstone, and sandy dolomite and limestone; one bed of brownish-gray dolomite resembling Hyrum Dolomite in middle part; 175 feet (55 m) thick, similar to the 190 foot (58 m) thickness reported in the Crawford Mountains (Sandberg and Gutschick, 1979). This is part of the Darby using terminology of Coogan (1992, figures 30 and 31) for the Crawford thrust sheet, and might better be called the Three Forks Formation (see Johnson and others, 1991).

Dh Hyrum Dolomite (Upper and Middle Devonian) -- Dark- to medium-brownish-gray and gray, coarsely crystalline dolomite; weathers distinctive, dark-chocolate brown; approximately 725 feet (220 m) thick, but base not exposed; greater thickness than Hyrum on Willard thrust sheet in this quadrangle (675 feet [205 m]) and proximity to concealed Willard thrust implies structural thickening. This is part of the Darby using terminology of Coogan (1992, figures 30 and 31) for the Crawford thrust sheet, and might better be called the Jefferson Formation (see Johnson and others, 1991).

REFERENCES CITED

Cheney, T.M., and Sheldon, R.P., 1959, Permian stratigraphy and oil potential, Wyoming and Utah, *in* Williams, N.C., editor, Guidebook to the geology of the Wasatch and Uinta Mountains: Intermountain Association of Petroleum Geologists Tenth Annual Field Conference, p. 90-100.

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., 1992, Thrust systems and displacement transfer in the Wyoming-Idaho-Utah thrust belt: Laramie, University of Wyoming, Ph.D. dissertation, 240 p., 17 plates. [Chapter 3 published as Structural evolution of piggyback basins in the Wyoming-Idaho-Utah thrust belt, in Link, P.K., Kuntz, M.A., and Platt, L.B., editors, Regional geology of eastern Idaho and western Wyoming: Geological Society of America Memoir 179, p. 55-81]

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., 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.

Crittenden, M.D., Jr., Schaeffer, F.E., Trimble, D.E., and Woodward, L.A., 1971, Nomenclature and correlation of some upper Precambrian and basal Cambrian sequences in western Utah and southeastern Idaho: Geological Society of America Bulletin, v. 82, p. 581-602.

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.

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.

Hansen, S.C., 1964, Geology of the southwestern part of the Randolph [30'] quadrangle, Utah-Wyoming [Curtis Ridge 7.5', Utah]: Logan, Utah State University, M.S. thesis, 50 p., scale 1:24,000?, microfiche.

Imlay, R.W., 1967, Twin Creek Limestone (Jurassic) in the Western Interior of the United States: U.S. Geological Survey Professional Paper 540, 105 p.

Johnson, J.G., Sandberg, C.A. and Poole, F.G., 1991, Devonian lithofacies of western United States, *in* Cooper, J.D., and Stevens, C.H., editors, Paleozoic paleogeography of the western United States II: Los Angeles, California, Pacific Section, Society of Economic Paleontology and Mineralogy, p. 83-105.

Kummel, B., 1954, Triassic stratigraphy of southeastern Idaho and adjacent areas: U.S. Geological Survey Professional Paper 254-H, 194 p.

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

Mullens, T.E., 1969, Geologic map of the Causey Dam quadrangle, Weber County, Utah: U.S. Geological Survey Geologic Quadrangle Series Map GQ-790, scale 1:24,000.

Mullens, T.E., and Laraway, W.H., 1964, Geology of the Devils Slide quadrangle, Morgan and Summit Counties, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-290, scale 1:24,000.

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.

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.

Sandberg, C.A., and Gutschick, R.C., 1979, Guide to conodont biostratigraphy of Upper Devonian and Mississippian rocks along the Wasatch Front and Cordilleran hingeline, Utah: Brigham Young University Geology Studies, v. 26, part 3, p. 107-134.

Sando, W.J., Sandberg, C.A., and Gutschick, R.C., 1981, Stratigraphic and economic significance of Mississippian sequence at Georgetown Canyon, Idaho: American Association of Petroleum Geologists Bulletin, v. 65, p. 1433-1443.

Smith, R.B., 1965, Geology of the Monte Cristo [Peak quadrangle] area, Bear River Range, Utah: Logan, Utah State University, M.S. thesis, scale 1:24,000.

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.

OTHER REFERENCES

Gale, H.S., and Richards, R.W., 1910, Preliminary report on the phosphate deposits in southeastern Idaho and adjacent parts of Wyoming and Utah: U.S. Geological Survey Bulletin 430, p. 526-529. (Woodruff Creek area., Dairy Ridge quadrangle)

Hintze, L.F., 1959, Ordovician regional relationships in north central Utah and adjacent area, *in* Williams, N.C., editor, Guidebook to the geology of the Wasatch and Uinta Mountains transition zone: Intermountain Association of Petroleum Geologists, Tenth Annual Field Conference, p. 45-53. (missing Swan Peak Quartzite)

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.

Kienast, V.A., 1985, Structural geology of eastern part of Dairy Ridge quadrangle and western part of Meachum Ridge quadrangle, Utah: Logan, Utah State University, M.S. thesis, 41 p., scale 1:12,000.

Swanson, R.W., Carswell, L.D., Sheldon, R.P., and Cheney, T.M., 1956, Stratigraphic sections of the Phosphoria Formation, 1953: U.S. Geological Survey Circular 375, p. 30. (Sugar Pine Creek [Woodruff Creek area], Dairy Ridge quadrangle)

MAP SYMBOLS

for the Horse Ridge and Dairy Ridge 7.5' quadrangles

(all map symbols are not present on each map)

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

Normal Fault, bar and ball on downthrown side, dashed where approximately located, dotted where concealed.

Thrust Fault, teeth on upper plate, dotted where concealed.

Anticline Axis, dashed where approximately located, dotted where concealed, arrow shows plunge.

Syncline Axis, dashed where approximately located, dotted where concealed, arrow shows plunge.

Overturned Anticline Axis, dotted where concealed, arrow shows plunge.

Overturned Syncline Axis, dotted where concealed, arrow shows plunge.

Mass-Movement Scarp

54 75 Strike and Dip of Bedding

Upright (top known on right)

65 49 Overturned (top known on right)

Horizontal

8 Determined by Photogrammetry (upright)

75 Strike and Dip of Cleavage

40 Bearing and Plunge of Minor Fold

57 Strike and Dip of Joint - Determined by photogrammetry and only in northwest part of Dairy Ridge quadrangle

Sinkhole

96-36 Sample Location and Number

Horse Ridge and Dairy Ridge Quadangles - Lithologic Column

WILLARD THRUST SHEET

AGE	MAP SYMBOL	MAP UNIT			THICKNESS FEET	THICKNESS METERS	SCHEMATIC COLUMN	OTHER INFORMATION
MISS.	Ml	Lodgepole Limestone			~900	~275		Fossiliferous
DEV.	Db	Beirdneau Sandstone			245-500	77-150		Thins to north
	Dh	Hyrum Dolomite			500-675	150-205		
	Dwc	Water Canyon Formation			100-150	30-45		
S.	SOlf: Sl	Laketown Dolomite			~500	~150		
ORD.	SOlf: Ofh	Fish Haven Dolomite			~100	~30		Swan Peak Quartzite missing
	Ogc	Garden City Formation			700-1,050	215-320		Thins to south Intraformational conglomerate
CAMBRIAN	Ꞓsc	St. Charles Formation			500-700	150-215		Thins to south
	Ꞓsw	Worm Creek Quartzite Mbr			0-75	0-25		Absent to south
	Ꞓn	Nounan Formation			675-800	205-265		Thins to south
	Ꞓboc	Bloomington Formation	Calls Fort Shale Member		75-125	25-40		Intraformational conglomerate
	Ꞓbom	Bloomington Formation	Middle limestone member		425-850	130-260		Thins to north
	Ꞓboh	Bloomington Formation	Hodges Shale Member		410-600	125-180		Thins to north
	Ꞓbl	Blacksmith Dolomite			600-760	180-230		Limestone in places
	Ꞓu	Ute Formation			~450	~140		
	Ꞓl	Langston Dolomite			200-250	60-75		
	Ꞓgc: Ꞓgcu	Brigham Group	Geertsen Canyon Quartzite	Upper member	~3200: ?	~975: ?		Middle portion covered
	Ꞓgc: ?	Brigham Group	Geertsen Canyon Quartzite	?				Thickens northward
PROTEROZOIC	Ꞓgc: Ꞓgcl	Brigham Group	Geertsen Canyon Quartzite	Lower member	~3200: 600-1300	~975: 180-395		Purplish upper part; feldspathic; light-colored lower part
	Zb	Brigham Group	Browns Hole Formation		20-200	6-60		Covered in Horse Ridge quad.
	Zm?c	Brigham Group	Mutual(?) Formation and Caddy Canyon Quartzite		725-1300	220-395		Purple to pink upper part may be Mutual Formation Some feldspar locally
	Zkc?	Kelley Canyon Formation?			0-300	0-90		Argillite and quartzite; may be basal Caddy Canyon; base not exposed

Diagram is schematic--- no fixed thickness scale

Horse Ridge and Dairy Ridge Quadrangles - Lithologic Column

CRAWFORD THRUST SHEET

AGE	MAP SYMBOL	MAP UNIT		THICKNESS FEET	THICKNESS METERS	OTHER INFORMATION
Q.	Q-various	Alluvium, colluvium, mass movements		0-100	0-30	UNCONFORMITY
T. P.-E.	Tw	Wasatch Formation		0-600	0-180	Up to 4500 ft (1370 m) thick in area UNCONFORMITY
CRET.	Keh	Hams Fork Member of Evanston Formation		0-450	0-140	MAJOR ANGULAR UNCONFORMITY
	Kwc	Weber Canyon Conglomerate		0-300	0-90	Units above also overlie Willard thrust sheet units
JURASSIC	Jp	Preuss Sandstone		200+	60+	Salt in subsurface
	Jtgc	Twin Creek Limestone	Giraffe Creek Member	~225	~70	UNCONFORMITY
	Jtl		Leeds Creek Member	1000-1200	300-365	
	Jtw		Watton Canyon Member	400	120	
	Jtb		Boundary Ridge Member	100-250	30-75	
	Jtr		Rich Member	~500	~150	
	Jts		Sliderock Member	100-230	30-70	
	Jtgs		Gypsum Spring Member	210	65	
	Jn	Nugget Sandstone		1100-1500	305-460	
? TRIASSIC	Ꞧaw	Ꞧa	Wood Shale Tongue of Ankareh Fm	500	150	
	Ꞧht		Higham Grit and Timothy Ss Mbr of Thaynes Fm	~200	~60	
	Ꞧtp		Portneuf Limestone Mbr of Thaynes Fm	50-100	15-30	
	Ꞧal		Lanes Shale Tongue of Ankareh Fm	~450	~140	
	Ꞧtu	Ꞧt	Thaynes Fm: Upper calcareous siltstone member	~500	~150	Regional thickness structurally thinned to half
	Ꞧtml		Middle limestone member	~110	~33	
	Ꞧtls		Lower shale member	~375	~115	
	Ꞧtll		Lower limestone member	~200	~60	
	Ꞧdu	Upper tongue of Dinwoody Formation		~250	~75	
	Ꞧw	Woodside Shale		~800	~245	
	Ꞧd	Dinwoody Formation		200-500	60-150	UNCONFORMITY
PERM.	Ppfr	Franson Member of Park City Formation		300+	90+	Includes Rex Chert
	Ppm	Meade Peak Member of Phosphoria Fm		100-300	30-90	
	Ppg	Grandeur Member of Park City Formation		~300	~90	
IP	IPw	Wells Formation		1050+	320+	Base truncated by Willard thrust
MISSISSIPPIAN	Mmc	Monroe Canyon Limestone		1200+	365+	Top not exposed
	Mlf	Little Flat Formation		970	295	
	Ml	Lodgepole Limestone		1300	395	Fossiliferous Likely structurally thickened
DEV.	Db	Beirdneau Sandstone		175	55	
	Dh	Hyrum Dolomite		725+	220+	Base not exposed

Not exposed in Horse Ridge quadrangle

Not exposed in Dairy Ridge quadrangle

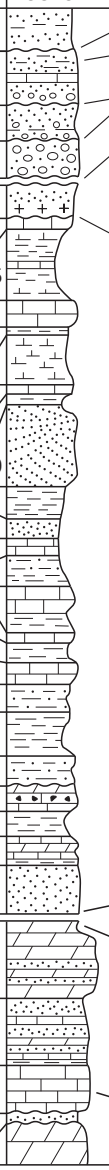
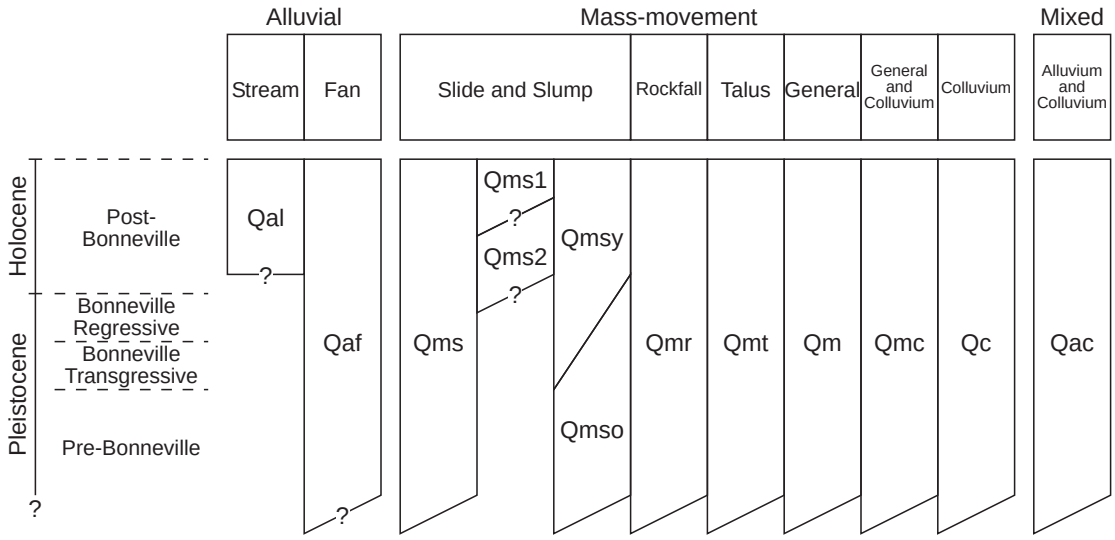
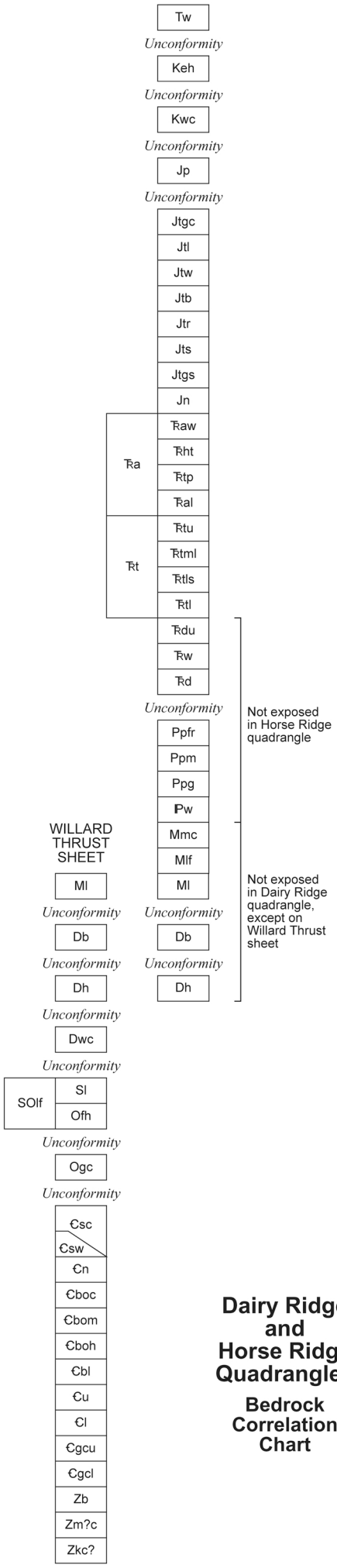


Diagram is schematic--- no fixed thickness scale

Horse Ridge and Dairy Ridge Quadrangles - Quaternary Correlation Chart





Dairy Ridge and Horse Ridge Quadrangles

Bedrock Correlation Chart