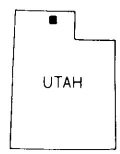
GEOLOGIC MAP OF THE CUTLER DAM QUADRANGLE, BOX ELDER AND CACHE COUNTIES, UTAH

By Charles G. Oviatt



UTAH GEOLOGICAL AND MINERAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
MAP 91 **1986**

GEOLOGIC MAP OF THE CUTLER DAM QUADRANGLE, BOX ELDER AND CACHE COUNTIES, UTAH

By Charles G. Oviatt [1]

INTRODUCTION

The Cutler Dam quadrangle comprises an area between the Wellsville Mountains, which constitute the northern end of the Wasatch Range, and Clarkston Mountain, which marks the southern end of the Malad Range. This area is near the eastern margin of the Basin and Range Province in the foreland of the Sevier orogenic belt. The quadrangle area includes the gorge of the Bear River, referred to as Cutler narrows, where the river passes through the southern part of the Junction Hills. Altitudes in the quadrangle range from about 4230 feet (1289 m) in the Bear River Valley to over 6100 feet (1859 m) in the Wellsville Mountains. The drainage divide between Cache Valley and the Bear River Valley traverses the eastern third of the quadrangle.

A number of thesis maps have covered parts or all of the Cutler Dam quadrangle. These include the maps of Hanson (1949), Beus (1958), Maw (1968), and Sprinkel (1976). Regional mapping by Williams (1948, 1958, 1962), and Doelling (1980) also touched on portions of the Cutler Dam quadrangle. Gravity surveys by Peterson (1974) and Peterson and Oriel (1970) extended into the Cutler Dam area. A number of important papers on the Salt Lake Formation or Group have discussed localities in the Cutler Dam quadrangle. These include Chamberlin and Berry (1933), Yen (1947), Swain (1947), Brown (1949), Adamson (1955), Adamson, Hardy, and Williams (1955), Williams (1964), and McClellan (1977).

STRATIGRAPHY

Introduction

Rocks ranging in age from Middle Ordovician to late Quaternary are exposed in the Cutler Dam quadrangle. The most extensive outcrops of Paleozoic rocks are in the Cutler narrows area where Upper Ordovician, Silurian, and Lower Devonian rocks are exposed, but here the rocks are extensively fractured and faulted, and reliable stratigraphic sections cannot be measured. Therefore, the thicknesses of the Paleozoic rocks reported in this report are mostly inferred from better known sections in the adjacent Honeyville quadrangle to the south in the Wellsville Mountains (Oviatt, 1986).

Upper Tertiary gravels and lacustrine marls, limestones, and claystones, formerly referred to as the Salt Lake Formation or Group overlie the Paleozoic strata and are in turn overlain by Quaternary deposits which are especially thick throughout the quadrangle except in the westernmost parts. Lake Bonneville covered most of the quadrangle during its highest stages, and sediments deposited in Lake Bonneville and in a pre-Bonneville lake are exposed along the Bear River west of Cutler Dam.

Ordovician System

The Ordovician System is represented by the Garden City Formation, the Swan Peak Formation, and the Fish Haven Dolomite, none of which are well exposed in the quadrangle. Only one tiny outcrop of the Garden City Formation (Ogc) has been observed in the quadrangle, directly above the Provo Shoreline about one mile north of Cache Butte. The limestones in this outcrop are medium gray, silty, and include intraformational limestone conglomerate. The Garden City is over 1300 feet (396 m) thick in the Wellsville Mountains but less than 100 feet (30 m) of the formation is exposed in this one small outcrop.

Outcrops of the Swan Peak Formation (Osp) are more extensive than those of the Garden City but also are limited

[1] Currently: Department of Geology, Kansas State University, Manhattan, Kansas; formerly Mapping Geologist, UGMS.

to incomplete sections. Only part of the upper Eureka member (Oaks et al., 1977) is exposed, and fragments of the middle quartzite member containing fucoidal markings can be found in the float. In most outcrops, quartzites of the Swan Peak are highly fractured or brecciated. The uppermost part of the Swan Peak and the contact with the overlying Fish Haven Dolomite are exposed along the north shore of Cutler Reservoir. The Swan Peak is about 380 feet (116 m) thick in the Wellsville Mountains.

The Fish Haven Dolomite consists of dark-gray, medium-grained dolomite containing colonial corals. Its upper contact with the Laketown Dolomite, which is marked regionally by abundant *Thalassinoides* in the uppermost Fish Haven (Sheehan and Schiefelbein, 1984), could not be confidently located in the Cutler Dam quadrangle. Therefore, the Fish Haven and the lower part of the Laketown were mapped as one unit (OS). In the Wellsville Mountains the Fish Haven is about 200 feet (61 m) thick.

Silurian System

The lower part of the Laketown Dolomite consists of dark-gray, medium-grained dolomite similar to the Fish Haven. The upper part, however, which is mapped as a separate unit (Slu), consists of light- to medium-gray, coarse-grained dolomite in the lower part and dark- to medium-gray, medium-grained dolomite similar to the lower Laketown in the uppermost part. Colonial corals such as *Halysites* are common in the upper part of the upper Laketown. In the Wellsville Mountains, the Laketown Dolomite is about 1100 feet (335 m) thick. Small isolated outcrops of medium- to dark-gray dolomite in the Cutler narrows area are mapped as lower Laketown and Fish Haven, although some of them could be upper Laketown.

Devonian System

Overlying the Laketown is the Water Canyon Formation, which in the Cutler Dam quadrangle consists of two mappable units. The lower unit (Dwl) consists of light-gray, laminated, very finely crystalline dolomite containing no fossils. It is correlative with the Card Member of the Water Canyon Formation of Williams and Taylor (1964). The upper unit (Dwu) consists of orange to tan fine-grained dolomitic sandstone in its lower part and white to light-gray finely crystalline dolomite in its upper part, and locally contains fish-bone fragments. This upper map unit is correlative with the Grassy Flat Member of the Water Canyon Formation of Williams and Taylor (1964). In the Wellsville Mountains the Water Canyon Formation is 1285 feet (392 m) thick.

Dark-gray dolomite of the Hyrum Formation (Dh) is exposed in the east face of Cache Butte directly east of the quadrangle. The Hyrum occurs in the Cutler Dam quadrangle in only one small area on Cache Butte.

An outcrop of silty dolomite and thin beds of siltstone in the northern part of the quadrangle are mapped as the Beirdneau Formation (Db), although this assignment is tentative because of the small size of the exposure. The Beirdneau reaches a maximum thickness of 345 feet in the Wellsville Mountains but is considerably thicker (1000 feet, 305 m) in the Bear River Range (Williams, 1971).

Mississippian System

The Lodgepole Limestone (Ml) is the only Mississippian formation exposed in the Cutler Dam quadrangle. The single small outcrop in the Junction Hills consists of medium-gray fossiliferous limestone, but less than 100 feet (30 m) of stratigraphic thickness of the Lodgepole is exposed. In the Wellsville Mountains the Lodgepole Limestone is 970 feet (296 m) thick.

Pennsylvanian and Permian Systems

Two small isolated outcrops of sandy limestone along the northern quadrangle boundary and one area in the south are mapped as the Oquirrh Formation (PPo). Several hundred feet of stratigraphic thickness of the Oquirrh Formation are exposed in the northern outcrops but no fossils were observed. The Oquirrh Formation is over 2600 feet (792 m) thick in the northern Wellsville Mountains.

Tertiary System

Unconformably overlying the Paleozoic rocks is an extensive sequence of upper Tertiary rocks referred to in previous reports and maps of this area as the Salt Lake Formation or Salt Lake Group. The Cutler Dam quadrangle includes parts of the type areas of two of the formations in the Salt Lake Group of Adamson et al. (1955) — the Collinston Conglomerate and the Cache Valley Formation. However, in this report these names are avoided for reasons discussed below, and descriptive or generic map units are used.

The oldest Tertiary deposits consist of gravel unconformably overlying Paleozoic rocks. Two lower gravel units are recognized, Tgu and Tg_2. Tgu consists of fan gravels resting on the upper dolomite of the Water Canyon Formation in one small outcrop along the West Side Canal about 0.6 miles (0.9 km) west of Cutler Dam (section A-A'). It apparently underlies Tertiary fine-grained lacustrine beds and is distinguished from Tg_2 by the lithology of the angular clasts. Tgu clasts are composed of locally derived dolomite fragments from the Silurian and Devonian rocks, and Tg_2 clasts are composed of sandstone, siltstone, limestone, and chert, all probably derived from the Oquirrh Formation and therefore transported relatively long distances. Tg_2 is locally iron oxide stained, and occurs as gravelly float in isolated localities. In most places it appears to overlie Paleozoic rocks but is rarely exposed in outcrops.

Overlying Tg_2, and locally interfingering with it, are lacustrine limestones, marls, claystones, and tuffaceous sandstones collectively mapped as Tl. Tl has been previously referred to as the Cache Valley Formation of the Salt Lake Group (Adamson et al., 1955). Tl has yielded abundant fossils in the Cutler Dam quadrangle, including mollusks (Chamberlin and Berry, 1933; Yen, 1947), ostracodes (Swain, 1947), plants (Brown, 1949), fish (McClellan, 1977), and mammals (P.H. McClellan, 1984, personal communication). The paleontology and paleoecology of Tl in the Cutler Dam/Cache Valley area has been extensively reviewed by McClellan (1977).

In the Cutler Dam quadrangle, Tl is widely distributed at the surface over most of the eastern two-thirds of the map area. Below the Bonneville Shoreline it occurs as isolated outcrops in gullies or road cuts where the thin mantle of Quaternary lacustrine sediment has been removed. Above the Bonneville Shoreline, slightly more resistant beds of Tl are locally exposed along ridge crests, but over most of the area the presence of Tl must be inferred from the composition of the surficial float materials.

An upper gravel unit, Tg_1, overlies and interfingers with Tl and Tg_2 in the southern part of the map area. Tg_1 and Tg_2 are separated by the lithologies of their clasts, and to some extent by grain size and rounding. Tg_2 consists of subrounded to angular clasts derived from the Oquirrh Formation. Tg_1 clasts are generally coarser-grained, subangular to well rounded, and include exotic lithologies. The most distinctive exotic clasts are well rounded, light-colored pebbles, cobbles, and boulders of porphyritic rhyolite or rhyodacite. Thin-section and hand-specimen descriptions of the rhyolite (M.A. Siders, UGMS, written communication, 1984) do not match those from any known outcrops of volcanic rocks in this area (D.W. Fiesinger, Utah State University, oral communication, 1984). Other exotic clasts include large, well-rounded boulders and cobbles of brown chert and tan sandstone.

In the Cutler Dam quadrangle, Tg_2 overlies the Oquirrh Formation in the northern part of the Wellsville Mountains, and it overlies other Paleozoic bedrock units farther north in the quadrangle. Tg_1 overlies both the Oquirrh Formation and Tg_2, and also overlies and intertongues with Tl. Tl overlies the older gravel unit (Tg_2) and apparently also interfingers with it. All three of these units are regarded as late Tertiary in age on the basis of the following arguments.

Previous workers (Williams, 1948; Adamson, 1955; Adamson, Hardy, and Williams, 1955; Beus, 1958; and Sprinkel, 1976) have mapped two separate Tertiary gravel units in the Wellsville Mountains, however, the units were defined differently. Some of the red iron-stained gravels were previously mapped as part of the Wasatch Formation and all other gravels were regarded as the Collinston conglomerate of the Salt Lake Group (Adamson, Hardy, and Williams, 1955). These usages are abandoned in this report for the following reasons: (1) The "Wasatch" gravels in the past were distinguished on the basis of their redness, yet when examined carefully the red gravels are lithologically indistinguishable from gravels previously mapped as "Collinston" but which are not red. In addition, some of the gravels previously mapped as "Collinston" are red. Thus, the redness has been inconsistently applied as a mapping criterion. (2) There is no evidence that any of the gravel deposits in the Wellsville Mountains are Eocene in age, which would be required for correlation with the Wasatch Formation. Because the gravel deposits previously mapped as Wasatch are lithologically similar to gravels that interfinger with late Tertiary lacustrine deposits (Tl), it is more reasonable to regard all the gravel deposits as late Tertiary in age. (3) The Honeyville quadrangle includes much of the type area of the Collinston conglomerate, which has been regarded as the basal gravel of the Salt Lake Group (Adamson, Hardy, and Williams, 1955). However, gravels previously mapped as Collinston (Tg_1) both overlie and interfinger with late Tertiary lacustrine deposits (Tl) that were previously mapped as the Cache Valley Formation of the Salt Lake Group (Adamson, Hardy, and Williams, 1955).

Therefore, the stratigraphic terms Wasatch, Collinston, Cache Valley, and Salt Lake are avoided in this report. Thus, Tg_2 includes deposits previously mapped as Wasatch and part of what has been previously mapped as Collinston. Tg_1 includes part of what has been previously mapped as Collinston. Tl is essentially equivalent to the Cache Valley Formation, although the interpretation in this report of its stratigraphic relationships with the gravel units differs from previous interpretations.

Quaternary System

Quaternary sediments in the Cutler Dam area consist of lacustrine, mass-wasting, and alluvial deposits. A striking feature of the geomorphology of the Cutler Dam quadrangle is the course of the Bear River through Cutler narrows. The Bear River flows westward from Cache Valley through the narrow gorge cut in Paleozoic rocks of the Junction Hills, into the Bear River Valley, and ultimately to Great Salt Lake. The Bear River has flowed into the Great Salt Lake basin only in late Quaternary time (Bright, 1963), but an older stream, consisting of the combined waters of the local drainages in Cache Valley, must have flowed through Cutler narrows prior to the diversion of the Bear River. This older stream was superimposed across the Junction Hills structural block in late Tertiary time and gradually became entrenched through the structure as extensional deformation progressed during the Late Tertiary and Quaternary (Hunt, 1982).

Most of the Quaternary deposits in the quadrangle were derived at least partly from the Tertiary rocks and thus resemble them superficially. Careful observations, however, allow one to distinguish between the Quaternary and Tertiary units.

Fine-grained deposits of Lake Bonneville and of a pre-Bonneville lacustrine cycle are exposed in slump scarps and canal banks along the Bear River and are mapped together as Qls_2. Localities where pre-Bonneville lacustrine deposits are exposed are indicated on the map (localities A, B, C, D, E, and F). The older lacustrine deposits are referred to as the "alloformation of Cutler Dam" and they bear a moderately developed buried soil referred to as the "geosol of Fielding." At locality C, pre-Bonneville lacustrine gravel, which bears a strongly developed calcic soil, may have been deposited during an older lacustrine cycle (Little Valley cycle of Scott et al., 1983).

A radiocarbon date of greater than 36,000 years B.P. (Beta - 9845) on wood from an excavation at locality D, and amino acid analyses on mollusk shells from this locality and others, suggest that the "alloformation of Cutler Dam" was deposited during early to middle Wisconsin time (about 65,000 to 40,000 years B.P.; Oviatt et al., 1985). Marginal lacustrine deposits of the "alloformation of Cutler Dam" containing mollusks and bones of a trumpeter swan (Feduccia and Oviatt, 1986) at localities C and E suggest that the early to middle Wisconsin lake rose no higher than about 4400 feet (1341 m) in altitude.

Deposits of Lake Bonneville, which inundated most of the Cutler Dam quadrangle from about 25,000 to 10,000 years B.P., are widespread below the Bonneville Shoreline. Waves generated in the lake reworked the available materials in the shore zone, much of which consisted of Tertiary gravels and lacustrine sediments. The locally derived wave-generated Bonneville sediments, as well as the small deltas of Willow and Cottonwood Creeks, contain large quantities of volcanic ash reworked from the tuffaceous Tertiary lacustrine beds. These locally derived fine-grained deposits are typically white or gray and contrast sharply with the red, fine-grained sediments carried into the area by the Bear River. Red Bear River sediments can be traced in exposures from the delta of the Bear River in the vicinity of Preston, Idaho, downstream to below Bear River City. In the Cutler Dam quadrangle, red Bear River sediments and locally derived white, ashy sediments interfinger in some exposures and provide clues to the history of lake level changes or to changes through time in local sedimentation patterns in Lake Bonneville.

Lacustrine gravel (Qlg) primarily deposited in Lake Bonneville is mapped locally but, over most of the area occupied by the lake, undivided lacustrine sediments (Qlu) are mapped because of the difficulty in determining the lithologic character and thickness of the surficial materials where exposures are widely spaced. Willow Creek and Cottonwood Creek, tributaries of the Bear River, each deposited small deltas (Qds) that have been entrenched following the regression of Lake Bonneville. Cottonwood Creek also deposited a delta at and slightly above the Provo Shoreline.

Lake Bonneville dropped from the Bonneville Shoreline to the Provo Shoreline in less than a year about 15,000 years B.P. during an event known as the Bonneville Flood when the alluvial dam near Red Rock Pass, Idaho, was catastrophically washed out (Gilbert, 1890; Malde, 1968; Currey, 1982). During the flood, all the water between the Bonneville and Provo levels in the main body of Lake Bonneville was discharged through three small passes in the Cutler Dam quadrangle, into Cache Valley, and then out through Red Rock Pass to the Snake River. The flood discharge is estimated at between 35 and 40 million cubic feet per second at a point on the Snake River south of Boise, Idaho (Malde, 1985, p. 31). The combined discharge through the three passes in the Cutler Dam quadrangle must have been close to this amount.

A small pass at Long Divide north of Cutler narrows contains the best geomorphic evidence of the Bonneville flood. At this locality, the flood current scoured gravel from the pass and deposited it on the downstream (east) side as a series of huge gravel bars that have the form of giant, irregular ripples (Qlf). The bars enclose several small closed depressions. Similar scouring and bar deposition by extremely high currents at passes connecting arms of glacial Lake Missoula, as described by Pardee (1943), occurred in response to a rapid lowering of lake levels.

The Bonneville Flood current also flowed eastward through Cutler narrows and must have scoured the walls of the gorge but left no geomorphic evidence in the gorge itself. However, a low hill of Tertiary lacustrine limestone northeast of the narrows was directly in the path of the flood current. An irregularly shaped gravel bar (Qlf) on the lee side of this hill was deposited as the current scoured debris from the upcurrent side and the crest of the hill. Blocks of the soft limestone bedrock were ripped from the crest of the hill by the current to produce isolated depressions, or kolks, measuring about 8 feet (2.4 m) wide in the direction of the current by 15 feet long and 8 feet deep (4.5 x 2.4 m) . The crest of the hill is approximately 100 feet (30.5 m) below the level of the Provo Shoreline and, therefore, was completely submerged during the flood.

The third pass, which is between Cache Butte and the northern end of the Wellsville Mountains, is more open and the flood discharge was much less constricted than in the other two passes. Therefore, the current velocity was lower and less geomorphic work was done. Little or no scour of the pass can be demonstrated, but a shallow depression on the downstream side of the pass may have been produced by a plunge-pool effect.

The youngest Quaternary lacustrine unit in the Cutler Dam quadrangle (Qls_1) consists of sand and gravel underlying a number of terrace remnants along the Bear River. Similar terrace remnants, each having a surface altitude of between 4245 and 4250 feet (1294-1245 m) , are preserved downstream along the Bear River in the Honeyville quadrangle. At locality F along Utah Highway 154 in the Cutler Dam quadrangle, a cutbank of the Bear River exposes about 8 feet (2.4 m) of well rounded, well sorted alluvial gravel overlain by about 9 feet (2.4 m) of sand fining upward into silty sand. The sand unit at this section changes facies laterally to the west into organic-rich mud containing abundant gastropods.

I interpret the remnants of Qls_1 as fluvial-deltaic or estuarine sediments deposited during the Gilbert stage of Lake Bonneville. By about 11,500 years B.P., at the end of the major regressive phase of Lake Bonneville, the lake had dropped to a very low level (Currey and Oviatt, 1985) and the Bear River had entrenched itself into the older lacustrine deposits (Qls_2). About 10,000 years B.P. the lake expanded to the Gilbert shoreline (Currey and Oviatt, 1985), about 4250 feet (1295 m) in this area (Currey, 1982). During the Gilbert stage, a narrow arm of the lake extended up the entrenched Bear River Valley and raised the base level of the river. Sand carried into this arm or estuary of the lake by the Bear River filled the entrenched valley to the level of the lake at 4250 feet (1295 m). As the Gilbert lake dropped in the early Holocene, the Bear River entrenched the estuarine fill and produced the Qls_1 terrace, which does not slope downstream like a fluvial terrace but maintains a constant altitude for about 10 miles (16 km) downstream. Gastropods from the organic-rich mud that grades laterally into the sand at section F yielded a radiocarbon date of 7460 ± 250 years B.P. (Beta 13153).

During the regressive phase of Lake Bonneville, alluvial gravels (Qag) and terrace sediments (Qat_2) were deposited by the Bear River. Sediments underlying a younger river terrace (Qat_1) may have been deposited during the Gilbert stage of Lake Bonneville when the base level for the Bear River was higher than the Holocene average. Floodplain (Qal) and ox-bow lake (Qab) deposits of Holocene age are the youngest deposits of the Bear River. Undifferentiated alluvial and colluvial deposits (Qac) are thick enough to be mapped in a few valleys in the higher parts of the quadrangle and at the mouths of Willow and Cottonwood Creeks. Mass-wasting deposits are discussed below.

STRUCTURE

The Cutler Dam quadrangle is located in the eastern part of the Basin and Range Province and is also in the foreland of the Sevier orogenic belt. Rocks in the quadrangle contain structures caused by both Neogene and Quaternary extensional tectonism and Mesozoic thrusting.

The Junction Hills-Cache Butte structural block is distinctly different in deformational style than the Wellsville Mountains block (Williams, 1948), of which only the northernmost tip extends into the Cutler Dam quadrangle. Lower and Middle Paleozoic rocks in the Junction Hills-Cache Butte block dip to the west-southwest and are cut by numerous north-, northwest-, and east-trending normal faults, most of which dip moderately to steeply to the east or north. In contrast, the Wellsville Mountains are, in large part, a northeast-dipping homocline. Only at the northern end of the mountains do dips swing to the north, northwest, and west (Oviatt, 1986). These relationships, in addition to structures exposed in the Chocolate Peak area in the Honeyville quadrangle (Oviatt, 1985), suggest that the Wellsville Mountains constitute the hanging wall of a younger-over-older thrust fault and that the Junction Hills block is in the foot wall. This thrust fault, which is referred to as the Wellsville thrust (Oviatt, 1985), extends into the Cutler Dam quadrangle. The inferred trace of the fault cannot be mapped north of the northernmost outcrops of Oquirrh Formation in the Wellsville Mountains, but it probably swings eastward beneath the Tertiary rocks in this area. The change in dip at the northern end of the Wellsville Mountains homocline in the Honeyville quadrangle occurs in a lateral ramp-anticline that may be related to a splay of the Absaroka thrust fault (Oviatt, 1985).

The Junction Hills-Cache Butte structural block is cut by many normal faults, most of which downthrow to the east. Only the major faults are mapped, but many smaller faults are evident in the outcrops in Cutler narrows. The normal faults in this area are most likely related to Neogene and Quaternary extensional tectonism because they cut Miocene(?) rocks.

Tertiary lacustrine rocks are generally not well exposed in the Cutler Dam quadrangle but the strikes and dips of isolated outcrops in most of the area are non-uniform. Where extensive exposures are available, such as in the man-made cuts along the West Side Canal, the Tertiary beds are highly deformed by numerous small faults and folds. Some of this deformation probably occurred as the sediments were being deposited both as tectonic faulting and as soft-sediment deformation on a smaller scale. In addition, the Tertiary beds have been faulted since they were deposited. The result is a chaotic structural pattern. However, some generalizations can be made from the available evidence. On the west side of the Junction Hills and Cache Butte the Tertiary lacustrine beds seem to dip generally to the north and west, while on the east they seem to dip to the north and east. In the central Junction Hills the Tertiary beds dip generally to the east. It is unknown what component of these dips is due to the initial dip of the beds and what components are due to tectonic deformation, penecontemporaneous soft-sediment deformation, and deformation related to Quaternary mass wasting.

The Wasatch fault, which is well developed south of the quadrangle, is poorly developed in the Cutler Dam area. There is no evidence at the surface for late Quaternary offset along this fault, and its position is inferred from the available geologic evidence and scant geomorphic evidence. The northern end of the Collinston segment of the Wasatch fault (Schwartz and Coppersmith, 1984) coincides with the northern end of the Wellsville Mountains structural block, which is marked by the northern mappable limit of the Wellsville thrust fault. Many of the other segment boundaries south of this area in the Wasatch fault zone coincide with Mesozoic or older structural features (Smith and Bruhn, 1984).

A fault north of Cache Butte in the west Cache fault zone shows conclusive evidence of late Quaternary offset. The fault is exposed in a stream cut in the NW¼ NE¼ sec. 1, T. 12 N., R. 2 W. In this exposure, the fault strikes N 5° W and dips between 35° and 45° E. The basal transgressive gravel of the Bonneville Alloformation is offset about 8 feet (2.4 m) by the fault and there is evidence for multiple pre-Bonneville displacement events. On the west, or upthrown, side of the fault, the Bonneville beds directly overlie Tertiary lacustrine beds dipping about 10° E. On the downthrown side, however, the Bonneville beds overlie a sequence of over 20 feet (6 m) of fine-grained alluvial fill containing multiple calcic soil horizons, all of which presumably overlie Tertiary strata. Two other faults in this area are expressed similarly on aerial photographs and may also offset Bonneville sediments.

ECONOMIC GEOLOGY

Sand and gravel are probably the most important economic resources in the Cutler Dam quadrangle. Quaternary lacustrine gravel deposits are widespread and have not been extensively exploited. The best gravel occurs in places where waves in Lake Bonneville reworked Tertiary gravels or Paleozoic rocks, particularly the Oquirrh Formation (e.g., SW¼ sec. 15, T. 12 N., R. 2 W.; SW¼ NW¼ sec. 22, T. 12 N., R. 2 W.; C. sec. 21, T. 12 N., R. 2 W.). Gravel composed of clasts of Tertiary lacustrine rocks is less desirable because many of the clasts of soft limestone or claystone flake apart when they are wetted and dried.

A prospect pit in the Laketown Dolomite in the NE¼ SW¼ sec. 35, T. 13 N., R. 2 W. shows slight oxidation of the rocks but no significant mineralization. Another prospect pit in partially silicified dolomite of the Beirdneau Formation in the SE¼ SW¼ sec. 15, T. 13 N., R. 2 W. might be worthy of further investigation if the silicification and associated mineralization proved to be more extensive in the subsurface. No other areas of mineralization have been noted in the quadrangle.

Tertiary oolitic limestone has been quarried on a small scale at several localities in the quadrangle, presumably for building stone (including: NE¼ sec. 14, T. 13 N., R. 2 W.; NE¼ sec. 22, T. 13 N., R 2 W.; SE¼ sec. 17, T. 12 N., R. 2 W.). Another small quarry in Laketown Dolomite in the SW¼ sec. 35, T. 13 N., R. 2 W. might also have supplied a small amount of building stone.

GEOLOGIC HAZARDS

The greatest immediate geologic hazard in the Cutler Dam quadrangle is from landslides and slumps along the bluffs of the Bear River (Qms). During the wet years of 1983 and 1984 the Hammond Main Canal along the southeast bluff of the Bear River was damaged by small slumps and mudflows in the Quaternary lacustrine deposits. The Tertiary lacustrine deposits are also susceptible to slumping. Landslides have occurred naturally along the bluff of the river in post-Bonneville time as a result of ground water discharge through the incompetent sediments, but the hazard has increased due to the oversteepened slopes that were created when the canal was constructed. Continuing landslide problems probably can be avoided only be moving the canal away from the river bluff.

Older landslides in the Cutler Dam quadrangle include an enormous pre-Bonneville landslide (Qms) in the Tertiary lacustrine deposits on the west slope of the Junction Hills. The landslide complex includes huge headscarps and closed depressions in the Junction Hills and low hummocky topography that extends westward for several miles to the western boundary of the quadrangle. Bonneville sediments overlie the lower parts of the landslide and the Bonneville and Provo Shorelines are cut into its upper parts.

Smaller landslides in the Tertiary lacustrine rocks (Qms) are common in the Junction Hills and Cache Butte areas. Some of them are associated with the Bonneville or Provo Shorelines and were probably generated as wave erosion oversteepened the slopes.

A significant geologic hazard exists for potential earthquakes generated by movement in the Wasatch and west Cache fault zones. There has been surface rupture in post-Bonneville time along the west Cache fault zone, and the Wasatch fault has ruptured the surface a few miles south of the quadrangle near Honeyville also in post-Bonneville time. Earthquakes could recur along either fault zone.

Two large lateral-spread landslides (Qml) composed of lacustrine gravel in the southwest corner of the quadrangle are overlain by Bonneville lacustrine deposits below an approximate altitude of 4440 feet (1353 m). Shorelines are well developed below this altitude on the surface of the southern lateral spread. These lateral spreads are similar to several others in the adjoining Honeyville quadrangle, all of which have shorelines and lacustrine deposits on their surfaces below about 4440 feet (1353 m). This suggests that they were all generated by an earthquake between 13,000 and 12,000 years B.P. when Lake Bonneville was about 4440 feet (1353 m) in its regressive phase. The lateral spreads would have been generated by liquifaction of the water-saturated gravel and are unlikely to occur in the absence of a large lake.

ACKNOWLEDGMENTS

D.M. Miller and J. P. McCalpin reviewed the map and manuscript and provided helpful comments for their improvement. In addition I wish to thank the following people for their help in various ways: B. J. Albee, A. J. Feduccia, D. W. Fiesinger, R. M. Forester, G. A. Izett, J. H. Madsen, P. H. McClellan, W. D. McCoy, R. G. Reider, M. A. Siders, G. R. Smith, and D. A. Sprinkel.

REFERENCES CITED

Adamson, R. D., 1955, The Salt Lake Group in Cache Valley, Utah and Idaho: M.S. thesis, Utah State University, 59 p.

Adamson, R. D., Hardy, C. T., and Williams, J. S., 1955, Tertiary rocks of Cache Valley, Utah and Idaho: Utah Geological Society Guidebook no. 10, p. 1-22.

Beus, S. S., 1958, Geology of the northern part of Wellsville Mountain, northern Wasatch Range, Utah: M.S. thesis, Utah State University, 84 p.

Bright, R. C., 1963, Pleistocene Lakes Thatcher and Bonneville southeastern Idaho: Ph.D. dissertation, University of Minnesota, 292 p.

Brown, R. W., 1949, Paleobotany — Pliocene plants from Cachee (sic) Valley, Utah: Journal of the Washington Academy of Science, v. 39, p. 224-229.

Chamberlin, R. V., and Berry, E., 1933, Mollusks of the Pliocene deposits at Collinston, Utah: Nautilus, v. 27, p. 25-29.

Currey, D. R., 1982, Lake Bonneville: Selected features of relevance to neotectonic analysis: U.S. Geological Survey Open-File Report 82-1070, 30 p.

Currey, D. R., and Oviatt, C. G., 1985, Durations, average rates, and probable causes of Lake Bonneville expansions, stillstands, and contractions during the last deep-lake cycle, 32,000 to 10,000 years ago, *in* Kay, P. A., and Diaz, H. F., eds., Problems of and prospects for predicting Great Salt Lake levels: Papers from a conference held in Salt Lake City, March 26-28, 1985: Center for Public Affairs and Administration, University of Utah, p. 9-24.

Doelling, H. H., 1980, Geology and mineral resources of Box Elder County, Utah: Utah Geological and Mineral Survey Bulletin 115, 251 p.

Feduccia, A. J., and Oviatt, C. G., 1986, in press, A trumpeter swan from the Pleistocene of Utah: Great Basin Naturalist, v. 46, no. 3.

Gilbert, G. K., 1890, Lake Bonneville: U.S. Geological Survey Monograph 1, 438 p.

Hanson, A. M., 1949, Geology of the southern Malad Range and vicinity in northern Utah; Ph.D. dissertation, University of Wisconsin, Madison, 128 p.

Hunt, C. B., 1982, The anomalous transverse canyons of the Wasatch Range, *in* Nielson, D. L., ed., Overthrust belt of Utah: Utah Geological Association Publication 10, p. 81-89.

Malde, H. E., 1968, The catastrophic late Pleistocene Bonneville Flood in the Snake River Plain, Idaho: U.S. Geological Survey Professional Paper 596, 52 p.

Malde, H. E., 1985, Raft trip through the Snake River Birds of Prey area to view canyon-filling volcanics and lake beds of the Pleistocene River: Rocky Mountain Section, Geological Society of America, 38th Annual Meeting, Boise, Idaho, Guidebook, 48 p.

Maw, G. G., 1968, Lake Bonneville history in the Cutler Dam quadrangle, Cache and Box Elder Counties, Utah: M.S. thesis, Utah State University, 58 p.

McClellan, P. H., 1977, Paleontology and paleoecology of Neogene freshwater fishes from the Salt Lake beds, northern Utah: M.A. thesis, Berkeley, University of California, 243 p.

Oaks, R. Q., Jr., James, W. C., Francis, G. G., Schulingkamp, W. J. II, 1977, Summary of Middle Ordovician stratigraphy and tectonics, northern Utah, southern and central Idaho: Wyoming Geological Association, Twenty-Ninth Annual Field Conference Guidebook, p. 101-118.

Oviatt, C. G., 1985, Preliminary notes on the Paleozoic stratigraphy and structural geology of the Honeyville quadrangle, northern Wellsville Mountains, Utah: Utah Geological Association Publication 14, p. 47-54.

Oviatt, C. G., 1986, Geology of the Honeyville quadrangle, Box Elder and Cache Counties, Utah: Utah Geological and Mineral Survey Map 88, scale 1:24,000.

Oviatt, C. G., McCoy, W. D., and Reider, R. G., 1985, Quaternary lacustrine stratigraphy along the lower Bear River, Utah: Evidence for a shallow early Wisconsin lake in the Bonneville basin: Geological Society of America Abstracts with Programs, v. 17, no. 4, p. 260.

Pardee, J. T., 1942, Unusual currents in glacial Lake Missoula, Montana: Geological Society of America Bulletin, v. 53, p. 1569-1599.

Peterson, D. L., 1974, Bouguer gravity map of part of the northern Lake Bonneville basin, Utah and Idaho; U.S. Geological Survey Miscellaneous Field Studies Map MF-627, scale 1:250,000.

Peterson, D. L., and Oriel, S. S., 1970, Gravity anomalies in Cache Valley, Cache and Box Elder Counties, Utah, and Bannock and Franklin Counties, Idaho, *in* Geological Survey Research 1970: U.S. Geological Survey Professional Paper 700-C, p. C114-C118.

Schwartz, D. P., and Coppersmith, K. J., 1984, Fault behavior and characteristic earthquakes: Examples from the Wasatch and San Andreas fault zones: Journal of Geophysical Research, v. 89, no. B7, p. 5681-5698.

Scott, W. E., McCoy, W. D., Shroba, R. R., and Rubin, M., 1983, Reinterpretation of the exposed record of the last two cycles of Lake Bonneville, western United States: Quaternary Research, v. 20, p. 261-285.

Sheehan P. M., and Schiefelbein, D. R. J., 1984, The trace fossil *Thalassinoides* from the Upper Ordovician of the eastern Great Basin: Deep burrowing in the Early Paleozoic: Journal of Paleontology, v. 58, no. 2, p. 440-447.

Smith, R. B., and Bruhn, R. L., 1984, Intraplate extensional tectonics of the eastern Basin-Range: Inferences on structural style from seismic reflection data, regional tectonics, and thermal-mechanical models of brittle-ductile deformation: Journal of Geophysical Research, v. 89, no. B7, p. 5733-5762.

Sprinkel, D. A., 1976, Structural geology of Cutler Dam quadrangle and northern part of Honeyville quadrangle, Utah: M.S. thesis, Utah State University, 58 p.

Swain, F. M., 1947, Tertiary non-marine Ostracoda from the Salt Lake Formation, northern Utah: Journal of Paleontology, v. 21, p. 518-528.

Williams, J. S., 1948, Geology of the Paleozoic rocks, Logan quadrangle, Utah: Geological Society of America Bulletin, v. 59, p. 1121-1163.

———1958, Geologic atlas of Utah: Cache County: Utah Geological and Mineralogical Survey Bulletin 64, 98 p.

———1962, Lake Bonneville: Geology of southern Cache Valley, Utah: U.S. Geological Survey Professional Paper 257-C, 152 p.

———1964, The age of the Salt Lake Group in Cache Valley, Utah-Idaho: Utah Academy of Science, Arts, and Letters Proceedings, v. 41, p. 269-277.

———1971, The Beirdneau and Hyrum Formations of north-central Utah: Smithsonian Contributions to Paleobiology, no. 3, p. 219-229.

Williams , J. S., and Taylor, M. E., 1964, The Lower Devonian Water Canyon Formation of northern Utah: University of Wyoming Contributions to Geology, v. 3, no. 2, p. 38-53.

Yen, T. C., 1947, Pliocene fresh-water mollusks from northern Utah: Journal of Paleontology, v. 21, p. 268-277.

UTAH GEOLOGICAL AND MINERAL SURVEY

606 Black Hawk Way
Salt Lake City, Utah 84108-1280

THE UTAH GEOLOGICAL AND MINERAL SURVEY is one of eight divisions in the Utah Department of Natural Resources. The UGMS inventories the geologic resources of Utah (including metallic, nonmetallic, energy, and ground-water sources); identifies the state's geologic and topographic hazards (including seismic, landslide, mudflow, lake level fluctuations, rockfalls, adverse soil conditions, high groundwater); maps geology and studies the rock formations and their structural habitat; provides and disseminates educational materials concerning the geology of Utah; and provides information to decisionmakers at local, state, and federal levels.

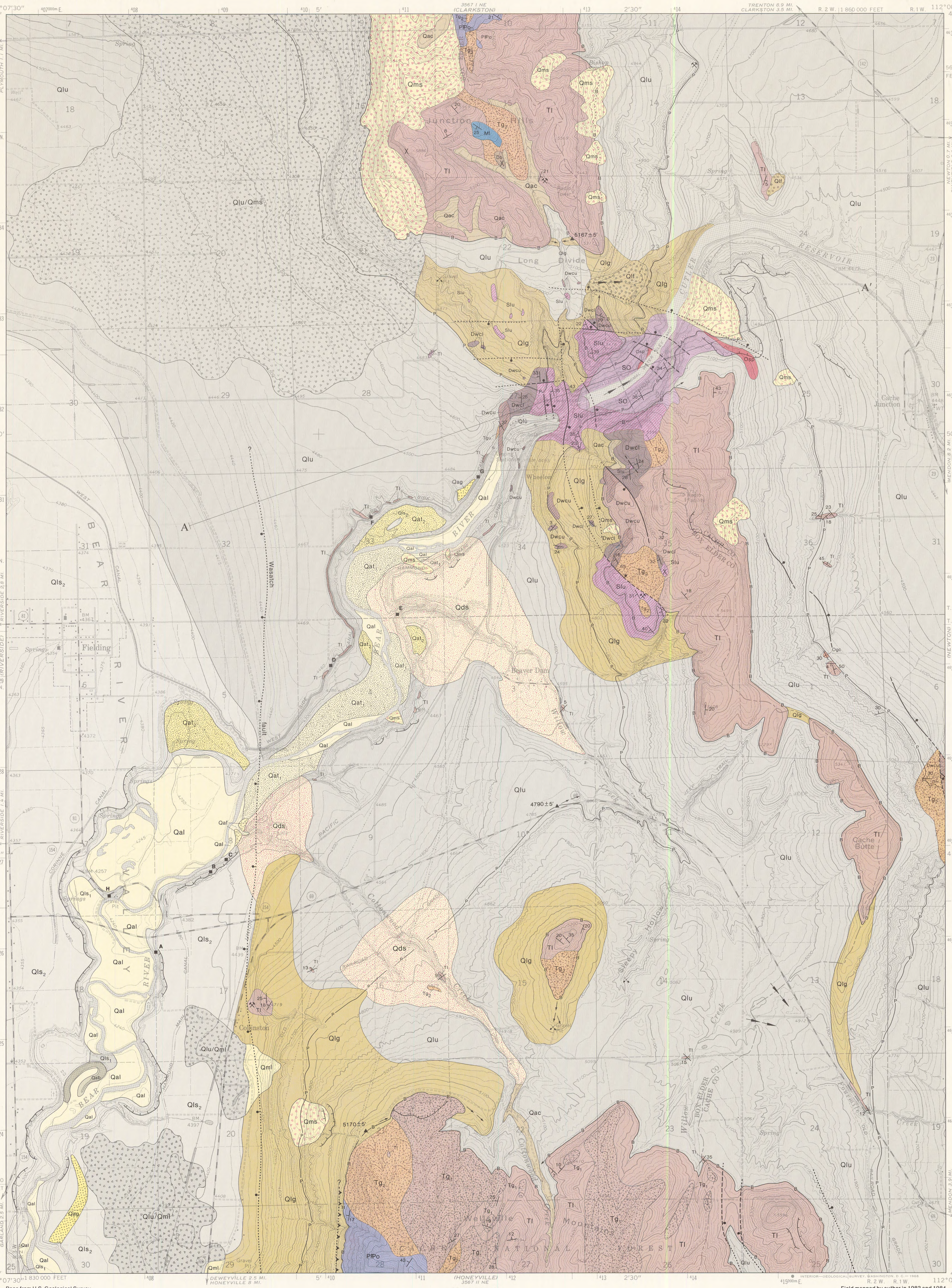
THE UGMS is organized into five programs. Administration provides support to the programs. The Economic Geology Program undertakes studies to map mining districts, to monitor the brines of the Great Salt Lake, to identify coal, geothermal, uranium, petroleum and industrial minerals resources, and to develop computerized resource data bases. The Applied Geology Program responds to requests from local and state governmental entities for site investigations of critical facilities, documents, responds to and seeks to understand geologic hazards, and compiles geologic hazards information. The Geologic Mapping Program maps the bedrock and surficial geology of the state at a regional scale by county and at a more detailed scale by quadrangle.

THE INFORMATION PROGRAM distributes publications, and answers inquiries from the public and manages the UGMS library. The UGMS Library is open to the public and contains many reference works on Utah geology and many unpublished documents about Utah geology by UGMS staff and others. The UGMS has begun several computer data bases with information on mineral and energy resources, geologic hazards, and bibliographic references. Most files are not available by direct access but can be obtained through the library.

THE UGMS PUBLISHES the results of its investigations in the form of maps, reports, and compilations of data that are accessible to the public. For future information on UGMS publications, contact the UGMS Sales Office, 606 Black Hawk Way, Salt Lake City, Utah 84108-1280.

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES
UTAH GEOLOGICAL AND MINERAL SURVEY

Published and sold by
UTAH GEOLOGICAL AND MINERAL SURVEY
Genevieve Atwood, Director
606 Black Hawk Way
Salt Lake City, Utah 84108

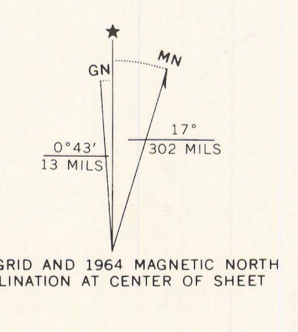


Base from U.S. Geological Survey, Cutler Dam Quadrangle, 1964

Field mapped by author in 1983 and 1984
J. Parker, Cartographer

SCALE 1:24 000

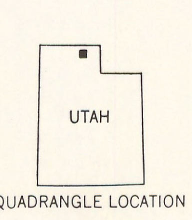
CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL



UTM GRID AND 1964 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

GEOLOGIC MAP OF THE CUTLER DAM QUADRANGLE, CACHE AND BOX ELDER COUNTIES, UTAH

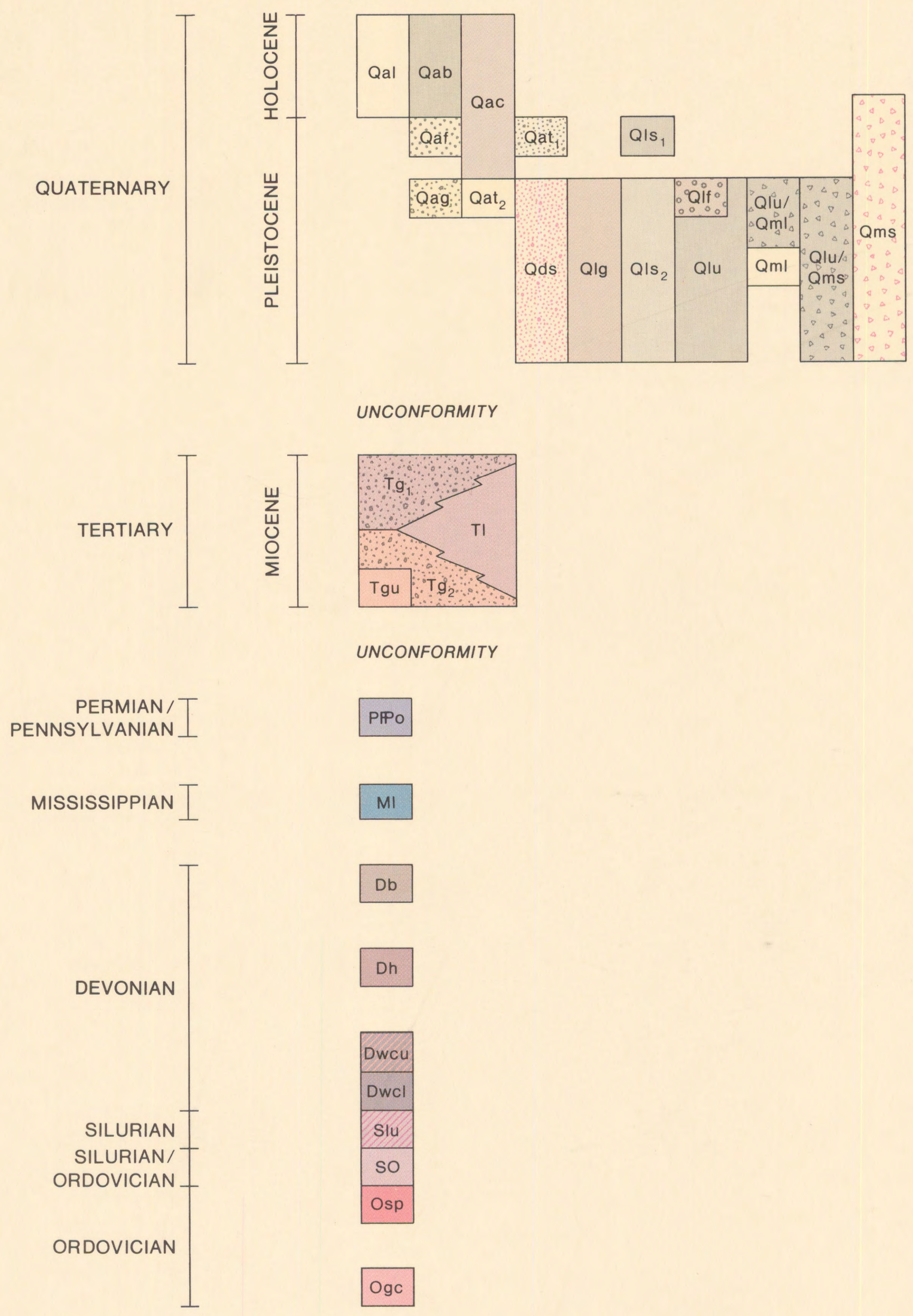
by
C. G. Oviatt
Utah Geological and Mineral Survey



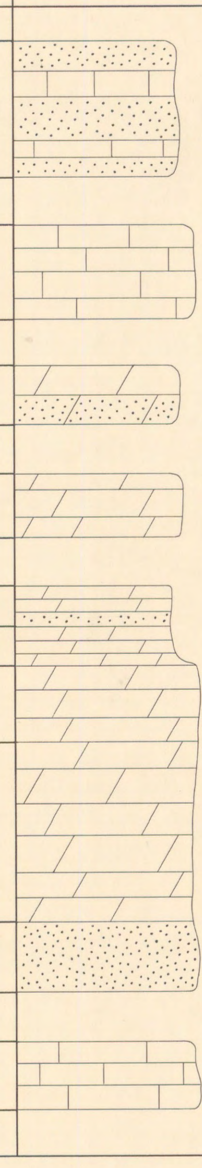
QUADRANGLE LOCATION

1986

CORRELATION OF MAP UNITS



FORMATION	SYMBOL	THICKNESS (feet)[1]	LITHOLOGY
Oquirrh Formation	PPo	(4500?)	
Lodgepole Limestone	Ml	(970)	
Beirdneau Formation	Db	(345)	
Hyrum Formation	Dh	(490)	
Water Canyon Formation, upper	Dwcu	300	
Water Canyon Formation, lower	Dwcl	300+	
upper Laketown Dolomite	Slu	700	
Fish Haven and lower Laketown Formations, undivided	SO	1500	
Swan Peak Formation	Osp	(380)	
Garden City Formation	Ogc	(1330)	



[1] Numbers in parentheses are thicknesses from the Honeyville quadrangle (Oviatt, 1986); numbers without parentheses are thicknesses estimated from cross section A-A'.

DESCRIPTION OF MAP UNITS

- **Qal** Alluvium—*fine-grained to gravelly, of flood plains and channels*
- **Qab** Ox-bow lake deposits—*fine-grained, organic-rich*
- **Qac** Alluvium of small ephemeral streams and colluvium derived from adjacent slopes
- **Qaf** Alluvial-fan deposits—*at the mouth of Cottonwood Creek*
- **Qag** Alluvial gravel—*of late Pleistocene Bear River, fills paleochannels in* Qls_2
- **Qlf** Bar gravel—*deposited during the Bonneville Flood*
- **Qlg** Lacustrine gravel and sand—*shore-zone deposits of Lake Bonneville and possibly pre-Bonneville lakes*
- **Qls_1** Lacustrine sand, silt, and clay—*deposited during Gilbert stage of Lake Bonneville*
- **Qls_2** Lacustrine sand, silt, and clay—*Bonneville and pre-Bonneville in age*
- **Qlu** Undifferentiated lacustrine deposits
- **Qlu/Qml** Thin lacustrine deposits overlying lateral-spread deposits
- **Qlu/Qms** Undifferentiated lacustrine deposits overlying landslide deposits
- **Qml** Lateral-spread deposits—*composed of Qlg, stabilized and non-hazardous*
- **Qms** Landslide deposits—*derived from Qlg or from Tertiary gravel or lacustrine deposits*
- **Qds** Deltaic sand and other fine-grained sediments, minor gravel—*deposited in Lake Bonneville by Willow and Cottonwood Creeks*
- **Qat_1** Thin alluvial strath-terrace deposits—*probably the same age as* Qls_1
- **Qat_2** Thin alluvial strath-terrace deposits—*deposited during regressive phase of Lake Bonneville*
- **Tgu** Fanglomerate—*angular to subrounded locally derived alluvium*
- **Tg_1** Gravel deposits—*includes both locally derived clasts of Paleozoic rocks and exotic clasts of silicic volcanic rocks*
- **Tg_2** Gravel deposits—*clasts locally derived and generally finer-grained and more angular than* Tg_1
- **Tl** Lacustrine deposits—*marl, oolitic limestone, and volcanic ash*
- **PPo** Oquirrh Formation—*sandstone with interbedded sandy limestone and limestone*
- **Ml** Lodgepole Limestone—*medium to dark gray limestone, fossiliferous*
- **Db** Beirdneau Formation—*medium to light gray dolomite, and orange dolomitic sandstone and siltstone*
- **Dh** Hyrum Formation—*dark to medium gray dolomite*
- **Dwcu** Upper Water Canyon Formation—*light gray to white dolomite and orange dolomitic sandstone, locally contains fish-bone fragments*
- **Dwcl** Lower Water Canyon Formation—*light gray laminated dolomite, nonfossiliferous*
- **Slu** Upper Laketown Dolomite—*light to medium-gray, coarsely crystalline dolomite, and dark-gray medium-grained dolomite, contains colonial corals*
- **SO** Lower Laketown Dolomite and Fish Haven Dolomite, undifferentiated—*dark- to medium-gray dolomite*
- **Osp** Swan Peak Formation—*white to purple quartzite*
- **Ogc** Garden City Formation—*limestone, silty limestone, intraformational limestone conglomerate, fossiliferous*

MAP SYMBOLS

CONTACT
Dashed where approximately located

FAULTS
Dashed where approximately located; dotted where concealed

43

High- to moderate-angle fault; bar and ball on downthrown side, dip indicated

Buried trace of thrust fault, triangles on upper plate

30

STRIKE AND DIP OF BEDS

B

BONNEVILLE SHORELINE
Dashed where approximately located; arrow indicates direction of longshore transport and gravel spit growth

P

PROVO SHORELINE
Dashed where approximately located; arrow indicates direction of longshore transport and gravel spit growth

HEAD SCARP OF SLUMP OR SLIDE
Teeth on downdropped side

OTHER SYMBOLS

4790 ± 5'

Estimated altitude of beach-ridge crest of Bonneville or Provo Shoreline

A

Location of measured section in Quaternary lacustrine sediments (see text)

Passes through which water discharged from the main body of Lake Bonneville into Cache Valley during the Bonneville Flood

Prospect — Quarry — Gravel pit

Table 1. Quaternary Fossils from the Cutler Dam Area

Stratigraphic Unit	Ostracodes	Vertebrates	Plants	Moluscs
Bonneville Alloformation	typical "Bonneville" assemblage	*Mammuthus* sp. (mammoth)	wood algae	*Sphaerium* sp. *Lymnaea* sp. *Amnicola* sp. *Fluminicola* sp.
"alloformation of Cutler Dam" (lacustrine)	*Lymnocythere staplini*	*Salmo* sp. (trout)	wood, *Picea* sp. (spruce) needles	*Sphaerium* sp. *Fluminicola* sp.
"alloformation of Cutler Dam" (marginal lacustrine)	----	*Gila atraria* (Utah chub), *Cygnus buccinator* (trumpeter swan), large mammal bones	----	*Lymnaea* sp. *Helisoma* sp. *Valvata* sp.

Thanks to B.J. Albee, A.J. Feduccia, R.M. Forester, J.H. Madsen, Jr., and G.R. Smith for identifications.

Table 2. Amino-Acid Analyses on Mollusks from the Cutler Dam Quadrangle[1]

Stratigraphic unit	measured section	lab number	genus (N)	alloisoleucine/isoleucine Free	Hydrolysate
Bonneville	E	AGL-298	*Amnicola* 3	0.19 ± .01	0.105 ± .005
Bonneville	E	AGL-297[2]	*Sphaerium* 1	0.19	0.11
Bonneville	B	AGL-271	*Lymnaea* 1	0.10	0.06
Bonneville	B	AGL-272	*Amnicola* 2	0.14	0.097 ± .004
Cutler Dam lacustrine facies	E	AGL-295	*Sphaerium* 3	0.21 ± .03	0.15 ± .01
Cutler Dam marginal lacustrine facies	D	AGL-268	*Helisoma* 3	0.184 ± .016	0.110 ± .013
Cutler Dam marginal lacustrine facies	D	AGL-269	*Valvata* 3	0.176 ± .012	0.138 ± .011
Cutler Dam marginal lacustrine facies	D	AGL-270	*Lymnaea* 2	0.157 ± .025	0.122 ± .014
Cutler Dam marginal lacustrine facies	D	AGL-274	*Lymnaea* ? 3	0.203 ± .028	0.136 ± .011

[1] All analyses were run by W.D. McCoy at the Amino Acid Geochronology Laboratory at the University of Massachusetts.

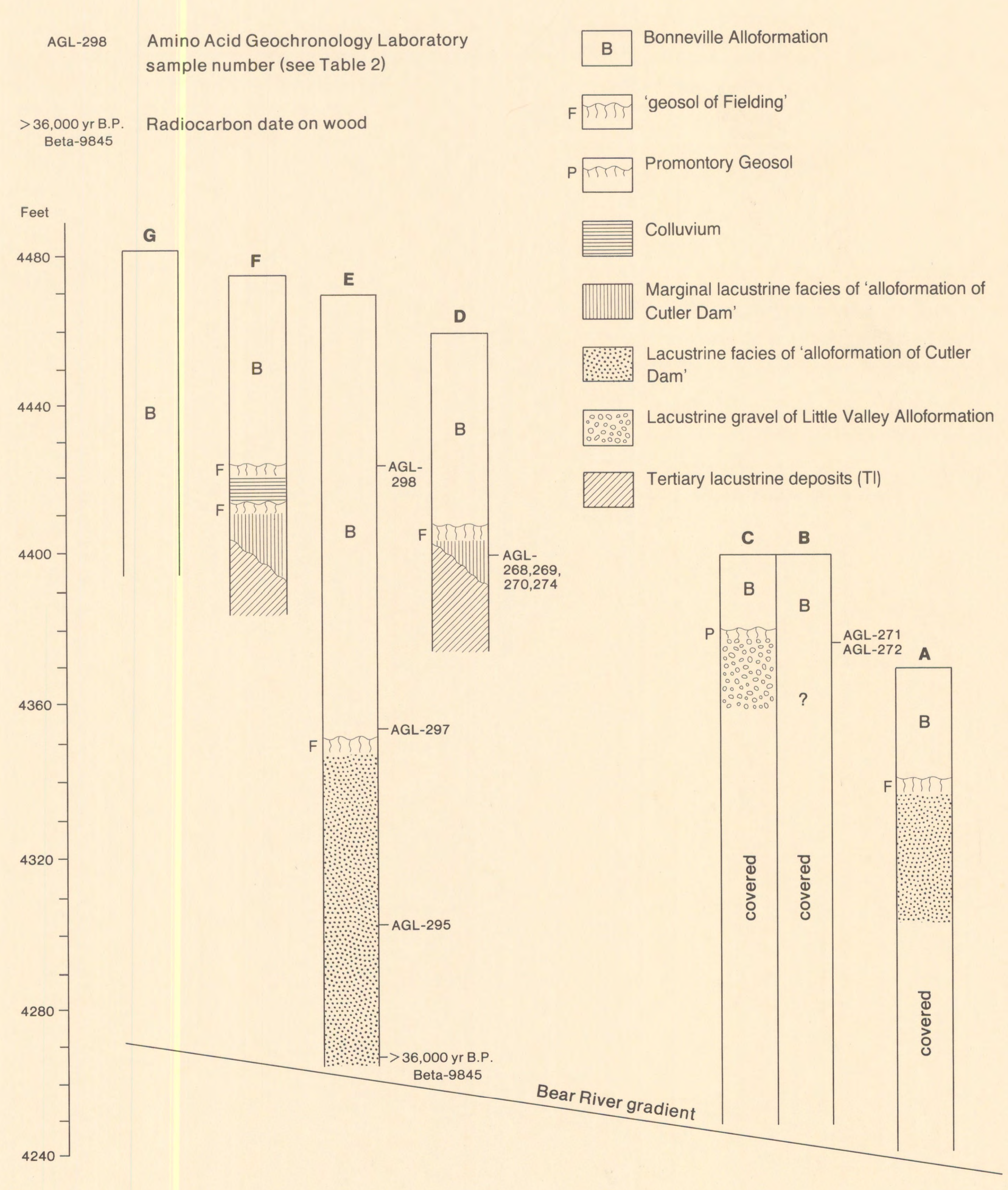
[2] Two shells from this sample had anomalously high alloisoleucine/isoleucine ratios (0.25 - 0.28 in the free fraction and 0.19 in the hydrolysate) and are interpreted as reworked from older deposits

Table 3. Amino-Acid Ratios of Mollusks from Bonneville, Cutler Dam, and Little Valley Deposits[1]

Stratigraphic Unit	*Lymnaea*	*Sphaerium*	*Amnicola*
Bonneville Alloformation (average)	.11	.12	.15
"alloformation of Cutler Dam" (lacustrine)	—	.15	—
"alloformation of Cutler Dam" (marginal lacustrine)	.13	—	—
Little Valley Alloformation (average)	.25-.30	(.25-.30[2])	.32

[1] data are derived from this study and McCoy (1981)

[2] *Sphaerium* shells of Little Valley age have not been analyzed but *Sphaerium* ratios are consistently similar to *Lymnaea* ratios of the same age (W.D. McCoy, personal communication, 1984)



Correlation of Quaternary deposits in measured sections along the Bear River, Cutler Dam quadrangle.