INTERIM GEOLOGIC MAP OF THE WELLSVILLE QUADRANGLE, CACHE COUNTY, UTAH

by

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INTRODUCTION

Location

The Wellsville 7.5 minute quadrangle is located in the southwestern portion of Cache County, Utah, at the foot of the Wellsville Mountains, approximately 23 miles (37 km) south of the Utah-Idaho border.

Geographic and Physiographic Features

The major geographic features in the quadrangle are the towns of Wellsville and Mendon, Utah. Wellsville is located in the south central portion, and Mendon is in the northwest portion of the quadrangle. Also, the small town of College Ward is on the east central margin.

The Little Bear River, Logan River, and the Wellsville Mountains are the outstanding physiographic features. The Little Bear River runs from the southeast border to the north-central border of the quadrangle where it joins the Logan River that flows from the northeastern corner of the quadrangle. There are many smaller tributaries that drain into the Little Bear and the Logan Rivers; the two largest are Hyrum Slough and Spring Creek. From the Wellsville Mountains in the southwest, other intermittent streams flow into the Little Bear River, usually during the spring runoff periods.

The lowest point in the quadrangle is 4,405 feet (1,343 m) above sea level which occurs near the confluence of the Little Bear and Logan Rivers, and the highest area is 8,720 feet (2,660 m) in the Wellsville Mountains in the southwestern corner of the quadrangle.

In the southwest quarter of the quadrangle is the high-angle West Cache normal fault which extends along the east side of the Wellsville Mountains of the Wasatch Range. To the east of the quadrangle, approximately 10 miles (16 km), is the Bear River Range which is the eastern boundary of Cache Valley. Cache Valley is a graben filled by alluvium from the bordering mountain ranges. These are typical features of the Basin and Range province which are located to the west and north of the Wellsville quadrangle (Fennerman, 1917).

The eastern boundary of the Basin and Range province in this area would be better placed at the foot of the Bear River Range. At this point, the structural features change. To the east of the Bear River Range, the Wyoming-Utah overthrust is the dominant feature extending to the north and south; whereas, to the west, the classic Basin and Range structural features of sediment-filled valleys bounded by high-angle normal faulting is the dominant geologic feature. Changing the province boundary to the foot of the Bear River Range would place all of Cache Valley in the Basin and Range province and agree more accurately with the geologic structures.

Previous Investigations

The earliest geologic description pertaining to features in the Wellsville quadrangle was supplied by the Hayden Survey in 1871, where he described the Wahsatch (sic) Mountains north of Ogden, Utah (Hayden 1973, p. 192-207). An extensive exploration was reported by Hague and Emmons who explored the southern half of Cache Valley during the Fortieth Parallel Survey in 1877. Gilbert (1890) also referenced Cache Valley when describing Lake Bonneville.

Most of the Paleozoic formations were named by Richardson (1913, 1941). Mansfield (1927) studied and described the Paleozoic formations of Cache Valley in southern Idaho. Williams (1948, 1958) subsequently conducted extensive geologic surveys of the Logan 30 minute quadrangle (U.S. Geological Survey) and published a geologic atlas of Utah in which he described the Cache Valley area. In 1962, Williams continued his investigations of Cache Valley and recorded details of Lake Bonneville sediments in southern Cache Valley. Stokes (1963) completed a geologic investigation and mapped much of northwestern Utah. More recently, Hintze (1973) described the whole state's geology in Geologic History of Utah. In 1988, he published an updated version of that volume.

Structure

Cache Valley is a graben bounded on the east and west by high angle normal faults. On the west side, the West Cache Fault is expressed at the foot of the Wellsville Mountains, and the East Cache Fault is located at the foot of the Bear River Range on the east. Within the quadrangle, the West Cache Fault (commonly referred to as the Wellsville Fault; Williams, 1948, 1958, 1962; Beer, 1967; Bjorklund and McGreevy, 1971) runs roughly northwest-southeast (Green, 1977). It is located immediately east and at the foot of the

Wellsville Mountains and is down-thrown to the east. Williams (1962, figure 40) shows the West Cache Fault to lie along the contact between the Bonneville Gravel (Qlg) and the Wellsville Mountain front. In an earlier publication, Williams (1948) stated that the only direct evidence of the Wellsville Fault occurs in sections 32 and 33, T. 11 N., R. 1 W. In those locations, he observed a block of Tertiary Wasatch Formation (map unit Tg) that was faulted against the Wells Formation (now identified as the Oquirrh Formation). The physiographic expression of the Wellsville Mountains and the triangular faceting of the mountain front suggest that the West Cache Fault is located in the position described by Williams (1962). However, the Utah Geological and Mineral Survey (Mark Jensen, personal communication, September 1989) indicated the fault would be better placed valley-ward from the Wellsville Mountain front.

To the west of the West Cache Fault in sections 19, 30, and 31, T. 11 N., R. 1 W., there is a normal fault zone located midway between the West Cache fault and the Wellsville Mountain crest which creates a small graben. This fault zone parallels the West Cache Fault and extends for approximately 3 miles (4.6 km). Within the graben, the sediments at the south end are higher in elevation and younger in age (Tertiary, Salt Lake Group) than those on the hill immediately to the east (Pennsylvanian-Permian Oquirrh Group) on the adjacent fault block. The presence of Salt Lake Group sediments indicate the West Cache fault was post-Salt Lake in age. If the West Cache Fault formed prior to the deposition of the Salt Lake Group, then the Salt Lake Group sediments would be missing in the graben. Also, the graben probably formed at the same time as the West Cache Fault, or the Salt Lake Group sediments would have been eroded away. Since Lake Bonneville sediments were never deposited higher than 5,100 feet (1,554 m) above sea level and no Lake Bonneville sediments are found associated with the Salt Lake Group sediments in the graben, then the graben must have been higher in elevation at the time the Lake Bonneville sediments were deposited. Consequently, the West Cache fault was formed sometime between the deposition of the Salt Lake Group and the Lake Bonneville Alloformation, making it Pliocene-early Pleistocene in age.

The Wellsville Mountains are a horst that dips eastward and are bounded on the east by the West Cache Fault and on the west by the Wasatch Fault. Oviatt (1985, 1986a) and

Smith and Bruhn (1984) refer to the Wellsville Mountains as the Wellsville Mountain homocline and state that the dips are generally 25 to 60 degrees in a northeastern direction. Within the Wellsville Mountains, along the southwestern portion of the mapped area, the dip was found to be 25 to 79 degrees in a northeasterly direction and the strike is generally north 55 degrees west. Oviatt (1986a) further states that these mountains are the northeastern extent of the Absaroka ramp-anticline that was formed by Sevier orogenic thrusting, and, associated with this thrusting, is a series of northeast-trending strike-slip faults. These strike-slip faults generally have small separation and are interpreted as tear faults that resulted from thrusting during the Sevier orogeny (Williams, 1948; Oviatt, 1985, 1986a). Allmendinger, and others, (1984) state the thrusting in the Wellsville area is probably Jurassic in age.

Within the quadrangle, northeast-trending, strike-slip faults are inferred to lie in the major canyons along the east side of the Wellsville Mountains. They are characterized by small changes in strike and dip on either side of the canyons and probably formed zones of weakness along which stream erosion and downcutting has occurred. The Sevier orogeny thrusted the Absaroka allochthonous block eastward, creating strike-slip, stress-relief faults. After the thrusting, the extensional Wasatch and West Cache normal faults occurred, uplifting the Wellsville Mountains.

STRATIGRAPHY

Rocks ranging in age from Mississippian to late Quaternary are exposed in the Wellsville quadrangle. The most extensive outcrops of Mississippian rock are in the canyons west of the town of Wellsville, but talus is extensive and reliable stratigraphic sections could not be measured. In the same area, Pennsylvanian rocks are present which Oviatt (1986a) reported a thickness of approximately 4,588 feet (1,399 m).

Lower Tertiary gravel rests unconformably on the Paleozoic rocks and is exposed along the western margin of Cache Valley. Williams (1962, p. 133) indicates that the Lower Tertiary gravel are overlain by younger Tertiary rocks of the Salt Lake Group, which in turn are overlain by Quaternary deposits of Lake Bonneville. With the quadrangle, these are exposed east of the Wellsville Mountains.

Mississippian System

Rocks of the Mississippian System are confined to a few small areas along the southwestern boundary of the quadrangle where the Lower Great Blue Formation (Mgl) crops out. This unit is composed of medium- to dark-gray, thin- to thick-bedded, fossiliferous and oolitic limestone. In the mapped area, it forms steep slopes with abundant talus. The Upper Great Blue Formation, which normally would have a basal contact with the Lower Great Blue Formation, was not observed. It apparently has been faulted out or covered with colluvium

Pennsylvanian-Permian System

The Pennsylvanian rocks in the Wellsville Mountains have been called both the Wells Formation and the Oquirrh Formation. Williams (1962, p. 132) described the Wells Formation as being composed of alternating beds of light brown sandstone and gray limestone. Earlier, in his 1958 publication, he designated the same sequence of beds along the western margin of Cache Valley as the Oquirrh Formation. Since then, others have used the Oquirrh as a group name and identified formational names and breaks based on fusulinid and conodont identification (Davis and Webster, 1987; Driese, and others, 1984). In the mapped area, the Oquirrh Group is not well exposed, being covered with talus and abundant plant material, making formation boundaries uncertain at best. The only exception is the basal West Canyon Limestone Formation (Pow) of the Oquirrh Group. The West Canyon Limestone bears a macrofossil fauna consisting mostly of brachiopods, corals, and byrozoans (Hintze, 1988). Oviatt (1986a) mentions that this formation commonly contains chert and conformably underlies the Oquirrh Formation. Limestones of the West Canyon Formation were found in the southeasternmost corner of the quadrangle.

The remainder of the Oquirrh Group are not described by formation in this paper due to the lack of outcrops. The Pennsylvanian-Permian section will be referred to as the Oquirrh Group (PPo).

In the Wellsville quadrangle, the Oquirrh Group is exposed with outcrops occurring along ridges and the steeper slopes. It typically forms talus slopes of alternating bands of limestone and sandstone rubble. The outcrops are fine grained, medium gray fossiliferous limestones with layers of calcareous sandstones that weather light-brown, yellow-brown, or orange-brown. Fossils found in the Oquirrh Formation within the Wellsville quadrangle include crinoids, horn corals, bryozoans, brachiopods, and fusilinids. Oviatt (1986a) gives an extensive list of fossil genera identified in the Oquirrh Group in the Wellsville Mountains in the adjacent Honeyville quadrangle.

Tertiary System (Tg, Tl)

The Tertiary System nomenclature in Cache Valley is presently in dispute. Formerly, two Tertiary units were mapped in the Wellsville quadrangle, the Eocene Wasatch and the Mio-Pliocene Salt Lake Group. Previous workers (Williams, 1948, 1958; Smith, 1953; Adamson, 1955; Adamson, and others, 1955; Beus, 1958) defined the Wasatch as a red iron-stained gravel deposit lying unconformably between the older Pennsylvanian Oquirrh Group and the younger Mio-Pliocene Salt Lake Group, inferring an Eocene age. The Salt Lake Group was described as a tuffaceous lacustrine gravel deposit. Oviatt (1986a, 1986b) described these two Tertiary units in descriptive, generic terms. He stated that gravel of the Eocene Wasatch and the Salt Lake Group are indistinguishable and both may have red-iron staining. He further indicated that sediments, previously mapped as Eocene Wasatch, interfinger with late Tertiary lacustrine deposits in the Cutler Dam quadrangle. Furthermore, the Wasatch Formation underlies and overlies the type section of the Collinston Conglomerate of the Salt Lake Group and would, therefore, be essentially time equivalent to the Mio-Pliocene Salt Lake Group. Outcrops in the mapped area are not sufficient to resolve the present conflict. Consequently, previously identified Wasatch is mapped as undifferentiated Tertiary gravel (Tg).

The Tg units rest unconformably on the Pennsylvanian-Permian Oquirrh Group. Williams (1948) reports the thickness of this unit in the Junction Hills to the north of the Wellsville Mountains ranges from 0 to 530+ feet (0 to 162+ m). Deposits in the Wellsville quadrangle consist of moderately to poorly sorted, rounded to subangular pebbles with a matrix of coarse red-to-gray sand. The pebble-sized sediments that make up the Tg units in the mapped area are predominantly limestones with small amounts of red-to-white calcareous siltstones. In the Red Slide area (SW¼, NW¼, SW¼, section 33, T. 11 N., R. 1 W.), this unit is well lithified and may represent exposures of the Wasatch Formation.

One exposure in the NE¼, SW¼, NE¼, section 30, T. 11 N., R. 1 W., is a small unit of what appears to be sediments of the Salt Lake Group (Tl). This unit is composed of white and gray-white tuffaceous gravel containing mica and fresh water molluscan fossils. Due to plant cover, the relationship of this exposure with the surrounding Tertiary gravel is not clear, and, in this case, has not been separated from the Tertiary gravel unit (Tg).

In the mapped area, the Salt Lake Group was identified in two excavations near the town of Mendon, one in the Mendon gravel pit, north of Mendon, and the other in a small excavation on the south side of Mendon, west of State Highway 23. In both of these exposures, the basal Collinston Formation of the Salt Lake Group (Tl) may occur. The sediments are composed of a light-gray or olive-gray to yellow-gray tuffaceous gravel. They are similar to the units measured by Adamson (1955) and identified as the Collinston in a road cut along U.S. Highway 89, approximately 3 miles (4.8 km) northwest of Mendon. The slopes west of the town of Mendon have a distinctive whitish color due to the underlying tufaceous gravel of the Salt Lake Group.

Quaternary System

Lake Bonneville Alloformation: Sedimentation in the Great Basin indicates four major lake levels associated with Lake Bonneville history (Currey, and others, 1984a). the earliest level is the Stansbury level. It occurred approximately 23,000 to 20,000 years before the present (yr B.P.) and reached an elevation of about 4,500 feet (1,372 m) above sea level. Following the Stansbury (16,000 to 14,500 yr B.P.), the lake rose to the highest Bonneville level at approximately 5,090 feet (1,551 m) in the Wellsville quadrangle. After the lake reached this level, it dropped 350 feet (107 m) in a catastrophic event known as the Bonneville Flood (14,500 yr B.P.). This flood occurred through Red Rock pass (between the towns of Preston and Downey in southeastern Idaho) into the Snake River. The flood event dropped the lake level to 4,740 feet (1,445 m) where the Provo shoreline features developed (14,500 to 13,5000 yr B.P.). The last major level to occur was the Gilbert stillstand event. this occurred approximately 10,500 yr B.P. at 4,250 feet (1,295 m) and is not present in Cache Valley.

Hunt, and others, (1953) recognized one additional Lake Bonneville level that he called the Alpine level. The Alpine was defined as the level occurring between the Provo and the Bonneville levels and predates the Stansbury level, making it the oldest recognized Bonneville unit occurring in the Lake Bonneville basinal area. Hintze (1988, p. 88) suggested the Alpine level may be related to the pre-Wisconsin Little Valley Lake Cycle of Lake Bonneville occurring 130 to 160 thousand years ago. To the south in Utah Valley, Bissell (1963) inferred the existence of an unconformity between the Alpine and Bonneville Formation. In addition, Currey, and others, (1984b) and Scott, and others, (1983) reported the Alpine Formation to be greater than 100,000 years B.P. or less than 25,000 years B.P. Consequently, the term Alpine Formation has been applied to two or more different units within the Bonneville basinal area. Due to this misapplication, Oviatt, and others, (1987) inferred that the term Alpine should either be redefined or dropped from usage.

The Bonneville Group in Cache Valley was previously subdivided into three units: the aforementioned Alpine, the Bonneville, and the Provo Formations (Hunt, and others, 1953). They defined the Alpine Formation as the oldest deposits of clay, silt, sand, and gravel of Lake Bonneville below the Bonneville shoreline and above the Provo shoreline. The Lake Bonneville Alloformation was defined as the gravel deposited while the lake stood at its highest level. Exposures of the Bonneville Group in the mapped area grade from silt to sand to gravel along the highest Bonneville shoreline. In the mapped area, the Bonneville shoreline was found to be at an elevation of 5,160 feet (1,570 m) and the Provo shoreline at 4,780 feet (1,454 m). Accordingly, the Lake Bonneville Alloformation is approximately 380 feet (116 m) thick, while the thickness of the Provo Formation is unknown since the lower boundary of the Provo Formation is not exposed in the mapped area.

Presently, the formations of the Lake Bonneville Group are described as the Lake Bonneville Alloformation (Currey, and others, 1987b). In accordance with Allostratigraphic terminology as defined in the 1983 North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature [NACSN], 1983), the term Bonneville Alloformation supersedes the older formational terminology. The lower bounding discontinuity of the Lake Bonneville Alloformation is the Promontory and Fielding Geosol (Oviatt, and others, 1987, figure 2), formed while the upper discontinuity was still forming. Further subdivision of the Lake Bonneville Alloformation requires more extensive investigation of definitive bounding discontinuities which is beyond the scope of the present paper. Consequently, sedimentation of the Lake Bonneville Alloformation will be described genetically.

Gravel of the Lake Bonneville Alloformation (Qlg)

The best exposures of the gravel in the Lake Bonneville Alloformation are in two gravel pits west of Wellsville. One gravel pit is located in the NW¼ of section 3, T. 10 N., R. 1 W., at an elevation of 4,630 feet (1,410 m), and the other is located in the NE¼ of section 4, T. 10 N., R. 1 W., at an elevation of 4,800 feet (1,463 m). The gravel exhibits significant graded bedding repeated numerous times, possibly associated with minor transgression-regression events as Lake Bonneville rose to the Bonneville level. These sequences consist of cobbles on the bottom fining upward to very coarse sand and pebbles in discrete units, 12 to 18 inches (30 to 46 cm) thick. The rock fragments are subround-to-subangular with a matrix of sand and silt. Many of the coarser materials are white in color due to calcium carbonate residues. The loose materials are mined by cutting away the southern end of a terrace, exposing a cross-sectional view of the terrace sediments. Migrating bars and shoreline features formed these terraces which occur in varying numbers parallel to the mountain front. The terraces decrease in elevation until they reach the silts and clays of the valley floor. Sediments within these terraces tend to dip eastward (valley-ward).

The shoreline deposits consist mainly of coarse gravel derived from Tertiary gravels and fragments of the Oquirrh and Great Blue Formations exposed on the eastern slopes of the Wellsville Mountains. Additional sediments may have come from alpine glacial moraines in Shumway, Bushy, and Pine Canyons of the Wellsville Mountains (Church, 1943). Williams (1962) suggested these glacial sediments were deposited as moraines that were later sorted, reworked, and incorporated into the Lake Bonneville shoreline deposits. However, Oviatt (1986a) indicated these glaciers were small and probably did not extend below 6,000 feet (1,828 m) in elevation. Seasonal floods may have eroded terminal moraine sediments, depositing them as alluvial fans along the pediment of the Wellsville Mountains where Lake Bonneville shoreline processes reworked them with the other sediments along the mountain front. In the mapped area glacial sediments were not observed, possibly because they have been reworked or because of the abundant plant and colluvial cover.

In sections 1, 11, and 12, T. 10 N., R. 1 W., is an exposure of sand and gravel of the lower part of the Bonneville Cycle called the Sterling Bar (Qlg). Only the northern part of this bar is the Wellsville quadrangle. The sediments that make up the Sterling Bar are composed of sand and fine gravel which were swept westward from the Provo delta (Williams, 1962) of the Blacksmith Fork Canyon (located on the southeast side of Cache Valley in the Bear River Range).

West of the town of Mendon, gravels of the Tertiary Salt Lake Formation were exposed to the processes of Lake Bonneville. These are being classified as undifferentiated lacustrine deposits (Qlu) (Ti). These sediments compose a thin veneer of Tertiary Salt Lake Formation sediments of tuffaceous, white, gray-white gravel reworked by Lake Bonneville. Underlying this veneer is the Tertiary Salt Lake Formation. In excavations near the town of Mendon, this formation occurs a few feet below the surface.

Lacustrine Silt and Clay of the Lake Bonneville Alloformation (Qli)

The silts and clays are the most extensive sediments of the Lake Bonneville Alloformation in Cache Valley. They are mainly found in the valley at a lower elevation than the Lake Bonneville Alloformation gravel. They represent suspended sediments that settled from the lake water onto the lake bottom. Outcrops of these sediments are restricted mainly to the banks of the Little Bear River, Logan River, their tributaries, and in excavations such as in the Wellsville Gravel Pit (see Gravel of the Lake Bonneville Alloformation above). Along the eastern edge of the Lake Bonneville Alloformation gravel, the clays onlap and interfinger with the Lake Bonneville sand and gravel. This relationship is clearly exposed on the southeastern edge of the terrace in the lower Wellsville gravel pit.

In the northern portion of the mapped area, the ground-water-table level is almost on the surface. Bjorklund and McGreevy (1971) mention that the high water level impedes the downward movement of water applied to the surface, thereby increasing the waterlogged condition. They further state that in order for agriculture to occur, these sediments are drained. This effects the Qli, Qat, and Qal sediments in the valley along the Little Bear River, the Logan River, and their tributaries.

Post-Lake Bonneville Deposits (Qaf_1, Qal, Qcu, Qac)

The streams of the Wellsville Mountain front have trenched the Lake Bonneville shoreline features, redepositing the gravel of the Lake Bonneville Alloformation as alluvial fans (Qaf_1). Within the mapped area, this is exhibited at the mouths of several canyons along the eastern edge of the Wellsville Mountains (Pine, Bushy, Shumway, Gibson, Bird, and Deep Canyons).

Currently, sediments are being transported and deposited by the Logan River, Bear River, and their tributaries (Qal). As these rivers meander, they erode the river valley deeper and leave terrace deposits (Qat) composed of fine grained silt and clay in abandoned flood plain and channels that are older but geographically higher than the present stream valley deposits. The Little Bear River and Logan River flood on a regular basis; consequently, the landscape and location of the river channels change each year. The confluence between the Logan River and Little Bear River is the lowest area in the quadrangle where muds and silts are currently being deposited. Also, seasonal intermittent streams located along the pediment of the Wellsville Mountains are moving and depositing sediments composed of silt to gravel (Qac).

Additional post-Lake Bonneville sediments are located along the western edge of the quadrangle and are composed of colluvium and avalanche debris (Qcu) from outcrops along the steep-sided canyons. In the middle to upper reaches of Pine Canyon, the present stream has cut downward approximately 15 feet (4.6 m) into the colluvium. The colluvium exhibits minor amounts of bedding and is composed of ungraded angular fine to cobble limestone fragments that may represent reworked glacial till.

In Wide Canyon west of the town of Wellsville and in sections 20 and 29, T. 11 N., R. 1 W., is stream alluvium (Qa) where Lake Bonneville sediments have been reworked by seasonal floods into relatively flat, low relief slopes.

Mass Movements

Pre-Lake Bonneville Mass Movements (Qms_2 and Qaf_2)

On the hills west and northwest of the town of Wellsville are several landslides that pre-date Lake Bonneville. One such slide E½, section 33, T. 11 N., R. 1 W., is composed of

Tertiary red pebble conglomerates. Locally, the south side of this slide is referred to as the "Red Slide" (Qms_2) (Tg) due to its distinctive red color. The pre-Lake Bonneville age of this slide is indicated by the onlap of Lake Bonneville shoreline sediments.

In E½, section 19 and NW¼, section 29, T. 11 N., R. 1 W., are two remnants of another pre-Lake Bonneville slide that exposed the underlying Oquirrh Formation. This slide is composed of Tertiary gravel and alluvium derived from the Oquirrh Formation. Lake Bonneville shoreline processes, sheet erosion, and agricultural practices have eroded the majority of the slide, leaving the remnants (Qms_2) (Tg).

Approximately one mile (1.6 km) southwest of Mendon are massive rounded hills of alluvial-fan materials deposited prior to the time at which Lake Bonneville stood at the Bonneville level (Qaf_2). These have been shaped by seasonal streams and the actions of Lake Bonneville. The alluvial sediments are composed mainly of cobbles, gravel, and finer materials mostly derived from Oquirrh Formation limestones and sandstones. Lake Bonneville shoreline features are superimposed on the toe of these fans along their valley-ward edges.

Lake Bonneville and Post-Lake Bonneville Mass Movements (Qms, Qms_1)

There are several landslides between Mendon and Wellsville that are contemporaneous with, or younger than, Lake Bonneville. The largest is a rock slide approximately one mile long and one-quarter mile wide that extends across the Lake Bonneville alluvial surface in parts of sections 21, 28, and 29, T. 11 N., R. 1 W., (Qms). It appears to have resulted from either undercutting of Tertiary gravel on the steep mountain front when the lake stood at the Bonneville level, or soil failure during an earthquake, or a combination of both.

One small slump is located in the NE¼, section 4, T. 10 N., R. 1 W., (Qms). It has occurred in the Lake Bonneville Alloformation gravel along the northern edge of Wide Canyon. One or some combination of three possible processes explain this feature: (1) lower silts and clays were undercut by canyon streams during seasonal floods; (2) instability of underlying sediments, probably from abnormally high ground water levels; or (3) soil integrity failed because of earthquake activity.

ECONOMIC GEOLOGY

The most important economic deposits in the Wellsville quadrangle are the lacustrine sand and gravel deposited by Lake Bonneville. There are approximately six square miles with thicknesses of as much as 400 feet (122 m) of these lacustrine sediments. The town of Wellsville presently mines Lake Bonneville deposits immediately west of town, and a few locations on private lands have also produced minor amounts of Lake Bonneville gravel.

Mineralization has been found along numerous faults around Cache Valley (Arrington, 1956; Heikes, 1920). A few have produced lead, zinc, copper, and small amounts of gold and silver. Within the Wellsville quadrangle, mineralization was not observed. One excavation north of the Red Slide area (SW¼, NW¼, SW¼, section 33, T. 11 N., R. 1 W.) along the West Cache fault zone originally may have been a prospect pit. It is now filled with water that is used by livestock and wildlife. No oil or gas wells have been drilled in the Wellsville quadrangle, and sources of hydrothermal activity were not observed.

Limestone and dolomite deposits, to the east of the quadrangle, in the Bear River range, have been exploited for cement and building stones, many of which are in various local public and private buildings (Williams, 1958). While limestone deposits are present in the Wellsville quadrangle in the Wellsville Mountains, they have not been mined or quarried.

GEOLOGIC HAZARDS

Geologic hazards in the Wellsville quadrangle occur in three forms: (1) mass movements associated with landslides and creep activity; (2) seismic activity associated with the numerous faults in and around Cache Valley; and (3) a combination of (1) and (2) during earthquakes.

The most imminent danger is from landslides. Numerous large slides have occurred along the Wellsville Mountain front. Many of these pre-date the occurrence of Lake Bonneville as is shown by the presence of lake shore features on the slides. These slides may have occurred as a result of seismic activity. Any future seismic activity may be expected to cause additional movement along these older slides as well as create new ones.

Green (1977) reported that faults in Cache Valley have a potential for causing earthquakes measuring as much as 7.7 to 8.4 on the Richter scale. He also stated that an earthquake along the West Cache Fault may have a maximum credable Richter magnitude of 7.5. In 1962, Cache Valley experienced an earthquake of approximately 5.6 on the Richter scale with an epicenter located west of the town of Logan (Green, 1977). Minor seismic activity continues intermittently. If an earthquake of large magnitude were to occur, ground shaking would take place throughout the quadrangle with surface rupture, varying degrees of liquefaction, and ground failure. Liquefaction occurs where fine grained lacustrine sediments dominate and the water table is high (Nichols and Buchanan-Banks, 1974).

A critical earthquake along the West Cache Fault has the potential for loss of life and serious economic consequences to the towns of Wellsville and Mendon. As an example, the Wellsville culinary water storage tank is located within 80 feet (24 m) of an accessory fault associated with the West Cache fault (Green, 1977). If an earthquake were to occur, the tank might rupture and leave the town without a culinary water supply. The Wellsville dam (located within the city limits) and public buildings are also at risk. Green (1977) reported that schools were not located with regard to nearby seismic hazards and older buildings may not be able to withstand appreciable ground shaking.

Along the west side of the quadrangle, man-made structures are commonly located on the regressional benches of Lake Bonneville. The benches are mainly sand and gravel that are usually well suited for construction. However, along benches with steep slopes erosion and minor landslides are common (Green, 1977). In particular, south of the town of Mendon, a recent subdivision is being built on a regressional bench of unconsolidated lacustrine sediments with slopes approaching 25 to 30 degrees. Additional weight on top and undercutting of the steep hill sides for construction purposes may cause these sediments to become unstable and begin to move.

Within the valley area of the quadrangle, the water level is high causing problems with flooding. Also, the Little Bear River and Logan River change courses yearly. Any construction within their meander belts or in areas of high ground water levels may be adversely affected. These problems are most likely to occur during the annual flood cycles associated with the spring thaw.

REFERENCES

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, 22 p.

Allmendinger, R.W., Miller, D.M., and Jordan, T.E., 1984, Known and inferred Mesozoic deformation in the hinterland of the Sevier Belt, northwest Utah, Utah Geological Association Publication 13, p. 21-34.

Arrington, Leonard, J., 1956, Transition to the Modern Era, *in* Ricks, Joel E., History of a Valley, chapter 9.

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

Beer, P.B., 1967, Ground-water hydrology of southern Cache Valley Utah: Ph.D., Dissertation, University of Utah, 203 p.

Bissell, H.J., 1963, Lake Bonneville - geology of southern Utah Valley, Utah: U.S. Geological Survey Professional Paper 257-B, p. 101-130.

Bjorklund, L.J., and McGreevy, L.J., 1971, Groundwater resources of Cache Valley, Utah, and Idaho, State of Utah Department of Natural Resources, Technical Publication 36, 61 p.

Church, V., 1943, Pleistocene glaciation of Wellsville Mountains, Utah: Utah Academy of Science Proceedings, v. 23, no. 2, p. 8-9.

Currey, D.R., Atwood, G., and Mabey, D.R., 1984a, Major levels of Great Salt Lake and Lake Bonneville: Utah Geological and Mineralogical Survey, Map 73.

Currey, D.R., Oviatt, C.G., and Czarnomski, J.E., 1984b, Late Quaternary Geology of Lake Bonneville and Lake Waring: Utah Geological Association Publication 13, p. 227-237.

Davis, L.E., and Webster, G.D., 1987, Conodont biostratigraphy of the Lake Point Limestone and recognition of the Mississippian-Pennsylvanian boundary and a potential Morrowan stratotype: Geological Society of America Abstracts with Programs, v. 19, p 269.

Driese, S.G., Carr, T.R., and Clar, D.L., 1984, Quantitative analysis of Pennsylvanian shallow-water conodont biofacies, Utah and Colorado: Geological Society of American Special Paper 196, p. 233-250.

Fenneman, Nevin M., 1917, Physiographic divisions of the United States: Association of American Geographers, v. 6, p. 9-98.

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

Green, Robert Kenneth, 1977, A study of geologic hazards and geotechnical input for selected critical facilities - Cache Valley, Utah: M.S. Thesis, Utah State University, 107 p.

Hague, Arnold, and Emmons, S.F., 1877, Descriptive geology, U.S. Geological Exploration, 40th Parallel (King), v. 2, 890 p.

Hayden, F.W., 1873, 6th Annual Report of the Territories Embracing Portions of Montana, Idaho, Wyoming and Utah: U.S. Geological Survey, 844 p.

Heikes, H.W., 1920, Ore deposits of the Hyrum-Paradise region, *in* Ore Deposits of Utah: U.S. Geological Survey Professional Paper 111, p. 217-218.

Hintze, Lehi F., 1973, Geologic history of Utah: Brigham Young University Geology Studies, v. 20, no. 3, 181 p.

______, 1988, Geologic history of Utah: Brigham Young University Geology Studies Special Publication 7, 202 p.

Hunt, C.B., Varnes, H.D., and Thomas, H.E., 1953, Lake Bonneville - Geology of northern Utah Valley, Utah: U.S. Geological Survey Professional Paper 257-B, p. 11-47.

Mansfield, G.R., 1927, Geography, geology and mineral resources of a part of southeastern Idaho: U.S. Geological Survey Professional Paper 152, 453 p.

Nichols, D.R., and Buchanan-Banks, J.M., 1974, Seismic hazards and land-use planning: U.S. Geological Survey Circular 690, 38 p.

North American Commission on Stratigraphic Nomenclature (NACSN), 1983, North American Stratigraphic Code: American Association of Petroleum Geologist Bulletin v. 20, p. 841-875.

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.

______, 1986a, Geologic map of the Honeyville quadrangle, Box Elder and Cache Counties, Utah: Utah Geological and Mineralogical Survey Map 88, scale 1:24,000.

______, 1986b, Geologic map of the Cutler Dam quadrangle, Box Elder and Cache Counties, Utah: Utah Geological and Mineralogical Survey Map 91, scale 1:24,000.

Oviatt, C.G., McCoy, W.D., and Reider, R.G., 1987, Evidence for shallow early or middle Wisconsin-age lake in the Bonneville Basin, Utah: Quaternary Research, v. 27, p. 248-262.

Richardson, G.B., 1913, Paleozoic section in northern Utah: American Journal of Science, 4th Series, v. 36, p. 406-416.

______, 1941, Geology and mineral resources of the Randolph quadrangle, Utah-idaho: U.S. Geological Survey, Bulletin 923, 54 p.

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.

Smith, Neal, 1953, Tertiary stratigraphy of northern Utah and southeastern Idaho: Intermountain Association of Petroleum Geologists, Fourth Annual Field Conference, p. 73-77.

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.

Stokes, W.L., 1963, Geologic map of northwestern Utah: Project of College of Mines and Mineral Industries, University of Utah, scale 1:250,000.

Williams, J.S., 1948, Geology of the Paleozoic rocks, Logan quadrangle, Utah: Geological Society of America Bulletin 59, no. 11, 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, p. 131-152.

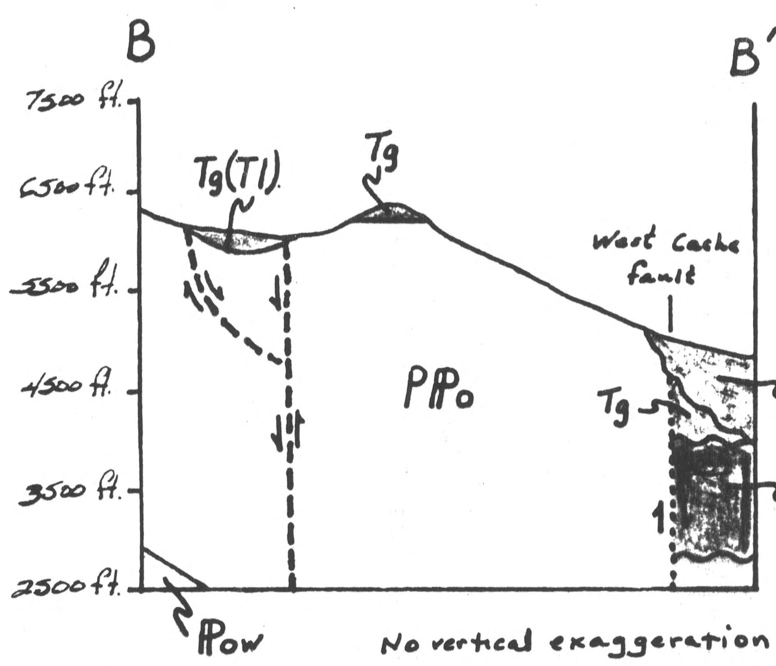
INTERIM GEOLOGIC MAP OF THE WELLSVILLE QUADRANGLE, CACHE COUNTY, UTAH

by

Karl S. Barker and Steven W. Barker

Utah Geological Survey Contract Report 93-2 April 1993

Plate 2



SYSTEM	SERIES	FORMATION		SYMBOL	LITHOLOGY	THICKNESS (feet)	
Quaternary	Recent	Flood plain deposits of the Little Bear and Logan Rivers		Qal, Qat		?	
Quaternary	Pleistocene	Bonneville Alloformation		Qlu, Qlg, Qli		0 to 380 +	
Tertiary	Mio-Pliocene	Upper Tertiary alluvial lacustrine and Valley fill deposits of the Salt Lake formation		Tl		0 to 1160+	
Tertiary	Mio-Pliocene	Tertiary Gravel		Tg		0-530+	
PERMIAN / PENNSYLVANIAN	Lower / Upper / Middle	Oquirrh Formation		PPo		4500(?)	
PENNSYLVANIAN	Lower	West Canyon Limestone		IPow		395	
MISSISSIPPIAN	Chesterian	Great Blue Formation	Upper	Mgu		475	1025
MISSISSIPPIAN	Chesterian	Great Blue Formation	Lower	Mgl		550	
MISSISSIPPIAN	Meramecian	Humbug Formation		Mh		820	
MISSISSIPPIAN	Osagean	Deseret Limestone		Md		91	
MISSISSIPPIAN	Kinderhookian	Lodgepole Limestone		Ml		970	
DEVONIAN	Upper	Beirdneau Formation		Db		0-346	
DEVONIAN	Middle	Hyrum Formation		Dh		490	
DEVONIAN	Lower	Water Canyon Formation	Upper	Dwcu		454	1285
DEVONIAN	Lower	Water Canyon Formation	Middle	Dwcm		403	
DEVONIAN	Lower	Water Canyon Formation	Lower	Dwcl		428	

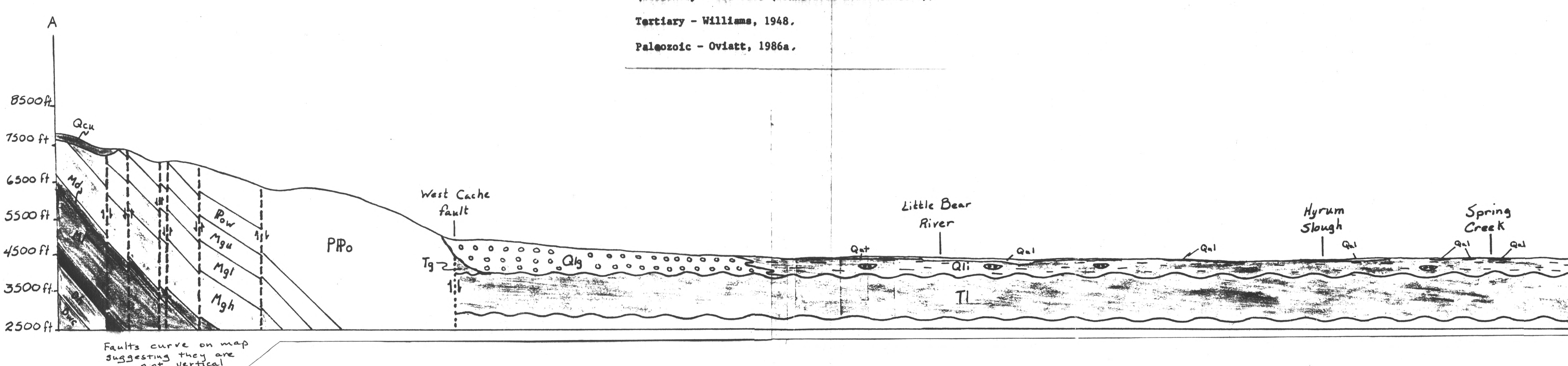
Quaternary - see text (Bonneville Alloformation).

Tertiary - Williams, 1948.

Paleozoic - Oviatt, 1986a.

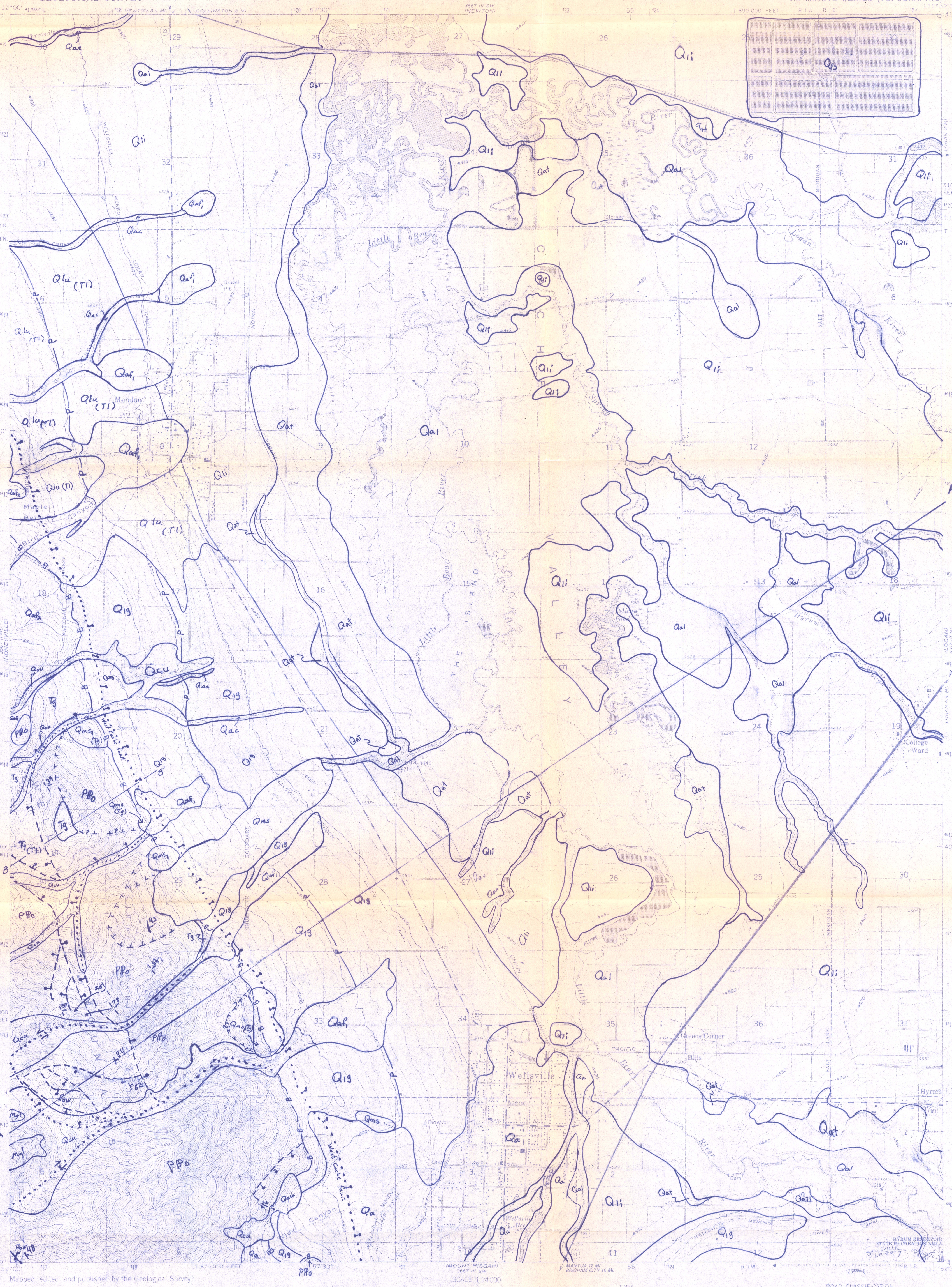
DESCRIPTION OF MAP UNITS
WELLSVILLE, 7.5 MINUTE QUADRANGLE

Qa	Post-Lake Bonneville alluvium and slope wash gravel and sands.
Qaf_1	Post-Lake Bonneville alluvium formed of boulders, gravels, sand, and clays deposited on the eastern pediment of the Wellsville Mountains by intermittent streams.
Qaf_2	Alluvial fan deposits of boulders, gravel, sands, and clays of pre-Lake Bonneville. Particles are predominantly limestones and sandstones of the Oquirrh Formation.
Qal	Alluvium, fine grained to gravelly; flood plain and channel deposits of the Little Bear River, Logan River, and their tributaries.
Qat	Terraces of the Little Bear River. Composed of fine grained silt and clay to gravelly channel sediments deposited by the Little Bear River.
Qcu	Colluvial deposits, composed of talus materials.
Qfs	Sewage treatment ponds.
Qlg	Lacustrine gravel to silts of the Provo and Bonneville Formations, deposited by Lake Bonneville shoreline processes.
Qli	Lacustrine deposits of silt and clay deposited by Lake Bonneville.
Qlu (Tl)	Undifferentiated lacustrine deposits. Tufaceous, white, gray-white, gravel of the Tertiary Salt Lake Formation reworked by Lake Bonneville.
Qms	Landslide, post-Lake Bonneville, composed of Oquirrh Formation limestones and sandstones.
Qms_1	Landslide, pre-lake Bonneville, composed of Tertiary conglomerates and Oquirrh Formation limestones and sandstones.
Tg	Tertiary conglomerates and gravel, previously assigned to Eocene Wasatch Formation. Consists of moderately to poorly sorted conglomerates with a matrix of red to gray sands. Pebbles are predominantly limestones with small amounts of red to white calcareous siltstones.
Pow	West Canyon Formation composed of medium-gray cherty limestones. (Basal formation of the Oquirrh Group).
PPo	Oquirrh Group, light brown, red to yellow sandstones, sandy limestones, and light-gray to medium-gray limestones with fossils occurring commonly.
Mgu	Upper Great Blue (not exposed in the quadrangle - symbol used on cross-section).
Mgl	Lower Great Blue Formation, medium-gray to dark-gray fossiliferous limestone.
Mh	Humbug Formation (not exposed in the quadrangle - symbol used on cross-section).
Md	Deseret Limestone (not exposed in the quadrangle - symbol used on cross-section).
Ml	Lodgepole Limestone (not exposed in the quadrangle - symbol used on cross-section).
Db	Beirdneau Formation (not exposed in the quadrangle - symbol used on cross-section).
Dh	Hyrum Formation (not exposed in the quadrangle - symbol used on cross-section).
Dwc	Water Canyon Formation (not exposed in the quadrangle - symbol used on cross-section).



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WELLSVILLE QUADRANGLE
UTAH–CACHE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1956 and planetable surveys 1962

Polyconic projection. 1927 North American Datum
10,000-foot grid based on Utah coordinate system, north zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

Fine red dashed lines indicate selected fence lines

To place on the predicted North American Datum 1983 move the projection lines 11 meters north and 65 meters east as shown by dashed corner ticks

There may be private inholdings within the boundaries of the National or State reservations shown on this map

UTM GRID AND 1986 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Revisions shown in purple and woodland compiled from aerial photographs taken 1981 and other source data. This information not field checked. Map edited 1986

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
U. S. Route — State Route

INTERIM GEOLOGIC MAP OF THE WELLSVILLE QUADRANGLE, CACHE COUNTY, UTAH

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Utah Geological Survey Contract Report 93-2 April 1993

Plate 1

WELLSVILLE, UTAH
41111–F8–TF–024

1962
PHOTOREVISED 1986
DMA 3667 III NW–SERIES V897