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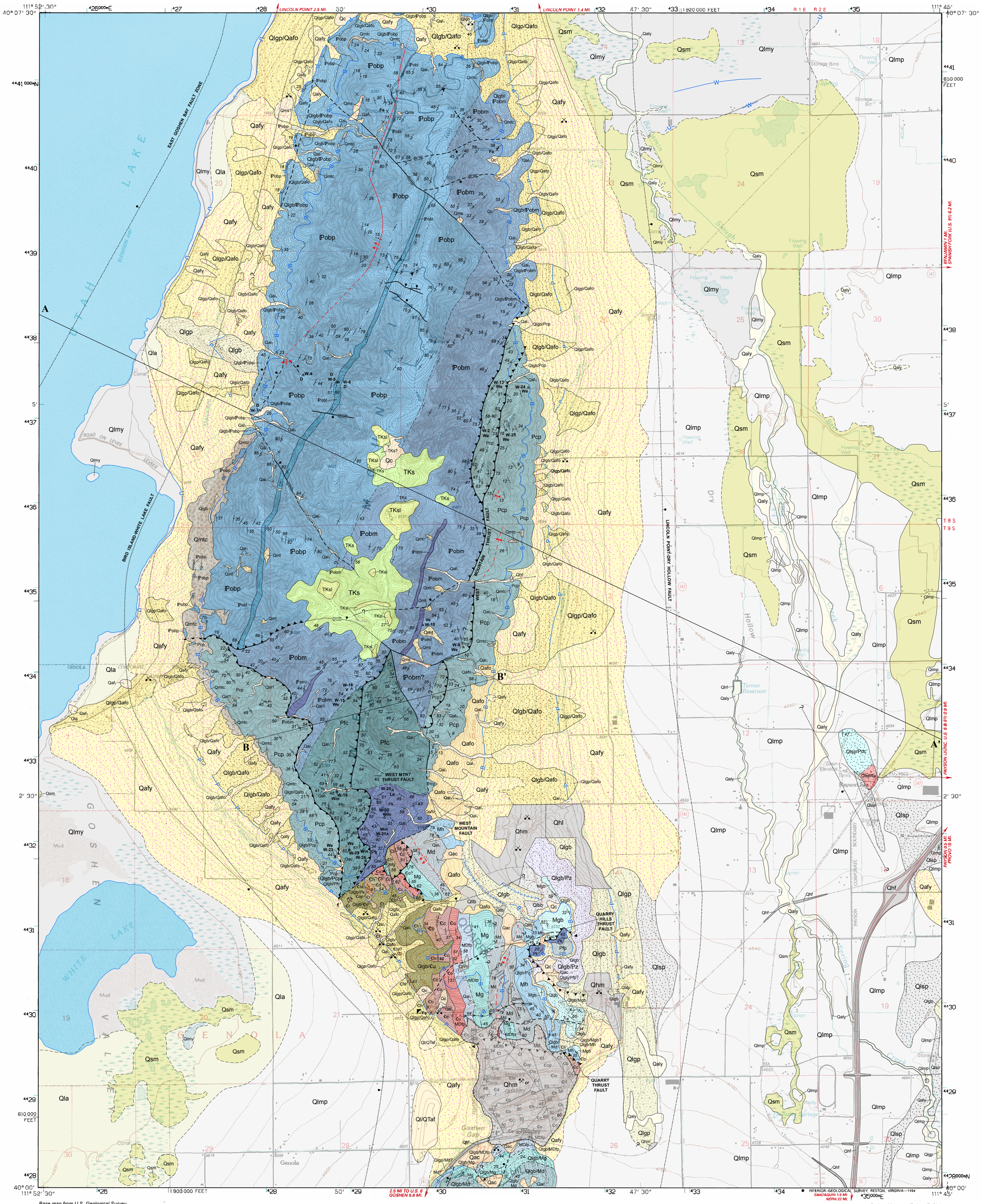

Base map from U.S. Geological Survey, West Mountain Quadrangle, 1994

North American Datum of 1927, UTM Zone 12 North
Quarry Hills is an unofficial geographic name.

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SCALE 1:24,000

1 — 1/2 — 0 — 1 MILE

1000 — 0 — 1000 — 2000 — 3000 — 4000 — 5000 — 6000 — 7000 FEET

1 — .5 — 0 — 1 KILOMETER

CONTOUR INTERVAL 20 FEET

12°20′
TRUE NORTH
MAGNETIC NORTH

APPROXIMATE MEAN DECLINATION, 2009

GEOLOGIC MAP OF THE WEST MOUNTAIN QUADRANGLE, UTAH COUNTY, UTAH

by

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2009

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Field mapping by author, October-November 2005 and April 2006
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QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

1. Soldiers Pass
2. Lincoln Point
3. Provo
4. Goshen Valley North
5. Spanish Fork
6. Goshen
7. Santaquin
8. Payson Lakes

ADJOINING 7.5′ QUADRANGLE NAMES

INTRODUCTION

Within the West Mountain quadrangle, West Mountain and part of Goshen Hill separate Utah Valley (east) and Goshen Valley (west). The south arm of Utah Lake extends into Goshen Valley, and White Lake and the village of Genola are also located in the valley. On the Utah Valley side of West Mountain are Spring and Beer Creeks and part of Payson city. Interstate 15 crosses the southeast corner of the quadrangle (figure 1, plate 1).

West Mountain is a range block about 8 miles (13 km) long by 1 to 2 miles (2-3 km) wide in the northeast Great Basin. Most of the mountain consists of Permian and Pennsylvanian marine sedimentary strata (Nolan, 1950; Swanson, 1952; White, 1953) capped by probable Late Cretaceous and early Tertiary synorogenic deposits. The southern quarter of the mountain (herein informally referred to as the Quarry Hills) consists largely of Mississippian, Devonian, and Cambrian sedimentary strata (Swanson, 1952; Schindler, 1952, Elison, 1952; White, 1953). West Mountain was deformed by Late Cretaceous to early Tertiary contractional folding and faulting of the Sevier orogeny (DeCelles, 2004), a subsequent extensional collapse (relaxation) event (Constenius and others, 2003), and late Tertiary to Holocene Basin-and-Range extension (Zoback and others, 1981).

A major transverse structural zone separates the Quarry Hills from the remainder of West Mountain. Both parts of the mountain were folded into an eastward-overturned (reclined) anticline and were faulted. The transverse zone, herein referred to as the West Mountain fault, was originally mapped as the West Mountain thrust by Brigham Young University (BYU) students (Swanson, 1952; Elison, 1952; White, 1953), and later called the Inez tear fault by H.T. Morris of the U.S. Geological Survey (Morris and Shepard, 1964; Morris, 1983). Due to poor exposures, the nature of the fault remains unclear and will require further detailed structural evaluation; it could be a tear fault, oblique thrust ramp, reverse fault covering an oblique thrust ramp, or a normal fault.

There are several other significant faults in West Mountain. The West Mountain thrust fault places Pennsylvanian over Permian strata along the eastern flank of the mountain; an oblique thrust ramp or tear fault appears to splay from it (sections 3 and 4, T. 9 S., R. 1 E.), and the West Mountain thrust (or a separate thrust) continues southward to the West Mountain fault. A low-angle normal fault exists on the southwest flank of the mountain north of the transverse zone. South of the transverse zone are two major thrust faults. The Quarry Hills thrust fault is a substantial structural feature that places Mississippian on Permian strata (cutting out Manning Canyon Shale and Oquirrh Group strata), and may be an oblique thrust ramp. Gravity data (Cook and others, 1997) indicate that a range-bounding fault is present on the east side of West Mountain (Lincoln Point-Dry Hollow fault), and I infer one on the west side (Bird Island-White Lake fault). The faults bounding West Mountain may link with faults that reportedly underlie Utah lake (Brimhall and others, 1976; Solomon and Biek, 2008).

Utah and Goshen Valleys are mostly covered by Quaternary deposits related to the Bonneville lake cycle (Oviatt and others, 1992), as well as by some younger deposits of Utah Lake and other surficial processes. Two of the four major shorelines of Lake Bonneville are present along the mountain-valley margins—the Bonneville and Provo shorelines. In addition, the highstand shoreline of Utah Lake is present (table 1).

The Quarry Hills part of West Mountain contains Keigley Quarry, which supplied limestone and dolomite to the former Geneva Steel plant near Orem from about 1943 to 1998; the quarry is now operated by Staker & Parson Companies as a source of aggregate. The city of Payson owns landfill and gravel pit operations on the northeast side of the Quarry Hills.

This map is part of ongoing work by the Utah Geological Survey to complete a regional-scale map of the Provo 30' x 60' quadrangle (figure 2).

MAP UNIT DESCRIPTIONS

QUATERNARY

Alluvial Deposits

Qal_1 — **Level-1 stream alluvium** (upper Holocene) – Moderately sorted sand, silt, clay, and pebble to boulder gravel deposited in stream channels; grades down drainage to upper part of younger alluvial fan deposits (Qafy) and is equivalent to the upper part of younger alluvial deposits (Qaly); locally includes small alluvial-fan and colluvial deposits; mapped in ephemeral washes of West Mountain; 0 to 20 feet (0-6 m) thick.

Qaly — **Younger alluvial deposits** (Holocene) – Moderately sorted sand, silt, clay, and local pebble gravel deposited in stream channels and flood plains; mapped along several drainages within Utah Valley; grades to spring and marsh deposits (Qsm); thickness probably less than 20 feet (<6 m).

Qaf_1 — **Level-1 alluvial-fan deposits** (upper Holocene) – Poorly to moderately sorted, clay- to boulder-size sediment deposited principally by debris flows at the mouths of active drainages; equivalent to the younger part of Qafy, but mappable because Qaf1 forms smaller, isolated fans; thickness probably less than 20 feet (<6 m).

Qafy — **Younger alluvial-fan deposits** (Holocene to upper Pleistocene) – Similar in composition to Qaf_1; coalesced and individual alluvial fans emanating from West Mountain and spilling over or cutting through older alluvial fan deposits (Qafo); thickness unknown but likely several tens of feet.

Qafo — **Older alluvial-fan deposits** (upper to lower? Pleistocene) – Similar to younger alluvial-fan deposits (Qafy), but forms a deeply dissected alluvial apron truncated by, and therefore predating, the Bonneville shoreline; upper parts of fans locally receive younger sediment from minor washes; thickness unknown but likely several tens of feet.

Spring Deposits

Qsm — **Spring and marsh deposits** (Holocene) – Silt and clay with local sand that is locally organic rich; present in low-lying areas of Utah Valley and Goshen Valley; grades to younger alluvial deposits (Qaly), but not present in distinct channels; thickness probably 0 to 10 feet (0-3 m).

Lacustrine Deposits

Qlmy — **Younger lacustrine silt and clay and marsh deposits** (Holocene to upper Pleistocene) – Silt, clay, and minor fine-grained sand deposited along the margin of Utah Lake (table 1); locally organic rich, locally forms gravelly beaches and berms; includes areas of spring and marsh deposits (Qsm) and mixed lacustrine and alluvial deposits (Qla) difficult to show at map scale; thickness probably 0 to 20 feet (0-6 m).

Deposits of the regressive (Provo) phase of the Bonneville lake cycle are identified with the last map symbol letter "p", and deposits of the transgressive (Bonneville) phase of the Bonneville lake cycle are identified with the last map symbol letter "b". Refer to Currey and Oviatt (1985), Oviatt and others (1992), and Oviatt (1997) for information on timing of the Bonneville lake cycle; also see table 1. Crittenden (1963) and Currey (1982) provided regional data on shoreline elevations, and for the highest beach ridge in section 15, T. 9 S., R. 1 E., of 5,125 feet (1,563 m) and 5,123 ± 3 feet (1,562 ± 1 m), respectively.

Qlgp, Qlgb — **Lacustrine gravel and sand** (upper Pleistocene) – Moderately to well-sorted, moderately to well-rounded, clast-supported pebble to cobble gravel and lesser pebbly sand; thin to thick bedded; typically interbedded with or laterally gradational to sand and silt facies; gastropods common in sandy lenses; locally partly cemented with calcium carbonate; Qlgp deposited below the Provo shoreline; Qlgb deposited below Bonneville shoreline but above the Provo shoreline; forms beach ridges, terraces, bars, and spits; 0 to 50 feet (0-15 m) thick.

Qlsp, Qlsb — **Lacustrine sand and silt** (upper Pleistocene) – Coarse- to fine-grained sand and silt with minor gravel; typically well sorted and laminated in thick beds; gastropods locally common; grades downslope from sandy nearshore deposits to finer grained offshore deposits; shorelines typically poorly developed on this facies; Qlsp deposited below the Provo shoreline; Qlsb deposited below the Bonneville shoreline but above the Provo shoreline; probably less than 30 feet (9 m) thick.

Qlmp — **Lacustrine silt and clay** (upper Pleistocene) – Calcareous silt (marl) with minor clay and fine-grained sand; typically thick bedded; deposited below the Provo shoreline in large areas of Utah Valley and Goshen Valley; contact with distal parts of alluvial fans can be difficult to identify and is based on subtle geomorphic differences; thickness unknown.

Qllb — **Lagoon-fill deposits** (upper Pleistocene) – Lacustrine silt and sand, with minor pebble gravel; deposited in lagoon behind beach-ridge gravel at Bonneville shoreline; probably less than 20 feet (<6 m) thick.

Colluvial Deposits

Qc — **Colluvial deposits** (Holocene to upper Pleistocene?) – Slopewash deposits of clay- to boulder-size, locally derived sediment deposited on upland slopes; generally less than 20 feet (6 m) thick.

Human Disturbance

Qhf — **Fill** (Historical) – Engineered fill along railroad rights-of-way and Interstate 15 in Utah Valley; local earth materials used to construct dams for stock and wildlife watering ponds and berms to divert drainages; several small watering-pond dams not mappable at 1:24,000 scale; thickness 0 to 30 feet (0-9 m).

Qhm — **Mine-dump deposits and disturbed land** (Historical) – Waste rock and overburden from aggregate quarries and gravel pits including the Keigley Quarry, Condie Pit, City of Payson Pit, and other smaller pits; variable thickness.

Qhl — **Landfill** (Historical) – Waste disposal area and cover materials associated with the City of Payson landfill located in NW1/4 section 14, T. 9 S., R. 1 E; variable thickness.

Mass-Movement Deposits

Qms — **Landslide deposits** (Holocene to upper Pleistocene?) – Very poorly sorted, clay- to boulder-size, locally derived material deposited principally by rotational slides and slumps; characterized by slightly to moderately subdued hummocky topography; very locally developed in surficial and Pennsylvanian strata; thickness variable.

Qmt — **Talus deposits** (Holocene to upper Pleistocene?) – Very poorly sorted, angular cobble- and boulder-size debris and finer-grained interstitial sediment deposited principally by rock fall on and at the base of steep slopes; locally grades downslope to colluvial deposits; generally less than 20 feet (<6 m) thick.

Mixed-Environment Deposits

Qac — **Alluvial and colluvial deposits** (Holocene to upper Pleistocene?) – Poorly to moderately sorted, generally poorly stratified, clay- to boulder-size, locally derived sediment deposited in swales, small drainages, and the upper reaches of larger ephemeral streams by fluvial, slopewash, and soil creep processes; generally less than 20 feet (6 m) thick.

Qla — **Lacustrine and alluvial deposits** (Holocene to upper Pleistocene?) – Moderately to well-sorted, fine-grained sand, silt, and clay; grades into silt and clay deposits of the Bonneville Lake cycle (Qlmp); mapped in Goshen Valley; includes areas of spring and marsh deposits (Qsm) and younger lacustrine deposits (Qlmy) difficult to separate at map scale; thickness unknown.

Qmtc — **Talus and colluvium** (Holocene to Pleistocene?) – Very poorly sorted, angular to subangular cobbles and boulders and finer-grained interstitial sediment, deposited principally by rock fall on steep slopes that grade downslope into colluvial deposits; locally includes older colluvium; generally less than 20 feet (6 m) thick.

Stacked-Unit Deposits

Consist of a thin cover of deposits of the Bonneville lake cycle (first unit) overlying various surficial deposit or bedrock units (second unit). See overlying and underlying unit descriptions for details, except for Ql/QTaf, Qlsp/Tu, and Qlsp/Pdc. Queried bedrock units indicate uncertain correlation due to structural complications and limited exposures.

Qlgp/Qafo, Qlgb/Qafo — **Lacustrine gravel and sand over older alluvial-fan deposits** (upper Pleistocene/upper to lower? Pleistocene) – Veneer of predominantly coarse-grained lacustrine deposits overlying older alluvial-fan deposits on West Mountain piedmont slopes; closely spaced shorelines common on lacustrine cover deposits; lacustrine deposit thickness probably less than 20 feet (3 m).

Ql/QTaf — **Lacustrine deposits over oldest alluvial-fan deposits** (upper Pleistocene/lower Pleistocene? to Pliocene?) – Veneer of coarse- to fine-grained lacustrine deposits overlying high-level alluvial-fan deposits in two areas west of Goshen Gap. Alluvial-fan deposits contain predominantly quartzite and carbonate clasts, locally with volcanic clasts; clasts are poorly sorted, subangular to subrounded boulders, cobbles, and pebbles in a matrix of sand and silt (also see Elison, 1952); previously mapped as fanglomerate by Elison (1952) and White (1953), but later mapped as Provo-level gravel by Bissell (1963); up to about 60 feet (20 m) exposed, but total thickness unknown.

Qlsp/Tu — **Lacustrine sand and silt over Tertiary strata** (upper Pleistocene/Pliocene? or Miocene?) – One exposure, in railroad cut on south side of hill near Payson Station, of up to about 3 feet (1 m) of sand and silt likely of the regressive (Provo) phase of Lake Bonneville overlying conglomerate. Conglomerate consists of pebbles, cobbles, and boulders (to 1 foot [0.3 m] in diameter) of subrounded quartzite, dark-gray limestone, and a few igneous clasts in a matrix of very pale orange to orange, calcareous sand and grit; conglomerate unit locally contains travertine and freshwater limestone; conglomerate has slight east dip; previously assigned to the Salt Lake Formation by Bissell (1948, 1963) and White (1953); age unknown, assumed to be post-Oligocene; exposed thickness of Tertiary strata about 20 feet (6 m), but total thickness is unknown.

Qlsp/Pdc — **Lacustrine sand and silt over Diamond Creek Sandstone** (upper Pleistocene/Lower Permian) – One area near Payson Station of up to about 3 feet (1 m) of sand and silt likely of the regressive (Provo) phase of Lake Bonneville overlying the Diamond Creek Sandstone. Sandstone in small, unmapped exposure is light red to very pale orange, fine grained, friable to well indurated, and cross-bedded; bedding varies from thin and medium to indistinct; Diamond Creek Sandstone age from Baker and Williams (1940) and Morris and Lovering (1961); exposed sandstone thickness is approximately 150 to 200 feet (45-60 m) (White, 1953); regional thickness of Diamond Creek up to about 1000 feet (300 m) (Baker, 1947; Hintze, 1962).

Qlgb/Pk — **Lacustrine gravel and sand over Kirkman Formation** (upper Pleistocene/Lower Permian) – Veneer of predominantly coarse-grained lacustrine deposits overlying Kirkman Formation in West Mountain; surficial deposit thickness probably less than 20 feet (6 m).

Qlgb/Pfc — **Lacustrine gravel and sand over Freeman Peak and Curry Peak Formations** (upper Pleistocene/Lower Permian) – Veneer of predominantly coarse-grained lacustrine deposits overlying undivided Freeman Peak and Curry Peak Formations in West Mountain; surficial deposit thickness probably less than 20 feet (6 m).

Qlgb/Pfp? — **Lacustrine gravel and sand over Freeman Peak Formation?** (upper Pleistocene/Lower Permian) – Veneer of predominantly coarse-grained lacustrine deposits overlying Freeman Peak Formation? in West Mountain; surficial deposit thickness probably less than 20 feet (6 m).

Qlgb/Pcp — **Lacustrine gravel and sand over Curry Peak Formation** (upper Pleistocene/Lower Permian) – Veneer of predominantly coarse-grained lacustrine deposits overlying Curry Peak Formation in West Mountain; surficial deposit thickness probably less than 20 feet (6 m).

Qlgb/IPobm — **Lacustrine gravel and sand over Bingham Mine Formation of Oquirrh Group** (upper Pleistocene/Upper Pennsylvanian) – Veneer of predominantly coarse-grained lacustrine deposits overlying Bingham Mine Formation in West Mountain; surficial deposit thickness probably less than 20 feet (6 m).

Qlgb/IPobp — **Lacustrine gravel and sand over Butterfield Peaks Formation of Oquirrh Group** (upper Pleistocene/Middle to Lower Pennsylvanian) – Veneer of predominantly coarse-grained lacustrine deposits overlying Butterfield Peaks Formation in West Mountain; surficial deposit thickness probably less than 20 feet (6 m).

Qlgb/Md — **Lacustrine gravel and sand over Deseret Limestone** (upper Pleistocene/Upper and Lower Mississippian) – Veneer of predominantly coarse-grained lacustrine deposits overlying Deseret Limestone in Goshen Hill, south of State Route 141; surficial deposit thickness probably less than 20 feet (6 m).

Qlgb/Mg — **Lacustrine gravel and sand over Gardison Limestone** (upper Pleistocene/Lower Mississippian) – Veneer of predominantly coarse-grained lacustrine deposits overlying bedrock unit in Goshen Hill; surficial deposit thickness probably less than 20 feet (6 m).

Qlgb/MDfp — **Lacustrine gravel and sand over Fitchville Formation and Pinyon Peak Limestone** (upper Pleistocene/Lower Mississippian and Upper Devonian) – Veneer of predominantly coarse-grained lacustrine deposits overlying bedrock unit in Goshen Hill; surficial deposit thickness probably less than 20 feet (6 m).

Qlgb/Cu — **Lacustrine gravel and sand over undivided Cambrian strata** (upper Pleistocene/Upper to Lower Cambrian) – Veneer of predominantly coarse-grained lacustrine deposits overlying undivided Cambrian strata in West Mountain; surficial deposit thickness probably less than 20 feet (6 m).

Qlgb/Pz — **Lacustrine gravel and sand over undivided Paleozoic strata** (upper Pleistocene/Paleozoic) – Veneer of predominantly coarse-grained lacustrine deposits overlying undivided Paleozoic strata in West Mountain; surficial deposit thickness probably less than 20 feet (6 m).

Unconformity

TERTIARY-CRETACEOUS

TKs — **Tertiary-Cretaceous strata** (Paleocene? to Upper Cretaceous?) – Moderate-reddish-orange mudstone, gray to light-brown conglomerate, and light-brown limestone; conglomerate contains subangular to subrounded pebbles, cobbles, and boulders of quartzite and limestone with small fragments of black chert; generally forms slopes with local conglomerate and limestone ledges; caps the upper part of West Mountain between Hill 6797 and West Mtn 2 triangulation station (Hill 6904); queried where uncertain designation in E1/2 section 33, T. 8 S., R. 1 W.; previously mapped as the North Horn Formation (White, 1953), and may correlate to part of North Horn Formation, Uinta Formation, unnamed sandstone and conglomerate unit, or Tibble Formation (Constenius and others, 2006); age unknown, but estimate based on mapping of similar synorogenic strata in region (Constenius and others, 2006), samples of mudstone and limestone were barren for palynomorphs; exposed thickness 0 to 200 feet (0-60 m); regionally this conglomeratic strata is up to 2500 feet (760 m) thick (Hintze, 1962; Constenius and others, 2006; Solomon and others, 2007).

TKsl — **Limestone unit of Tertiary-Cretaceous strata** (Paleocene? to Upper Cretaceous?) – Light-brown limestone, weathering to white; mapped separately where thicker and better exposed; oncolitic and algal limestone, locally with sandy and pebbly lenses; medium bedded to indistinctly bedded; forms ledges and small cliffs and weathers to rounded boulders and cobbles; mapped by White (1953) as Flagstaff Limestone; age unknown; 0 to 40 feet (0-12 m) thick.

Major Unconformity

Terminology and subdivision of the Pennsylvanian Oquirrh Formation/Group and associated Permian strata varies by thrust plate and location within the Oquirrh basin (see for example, Welsh and James, 1961; Tooker and Roberts, 1970; Swenson, 1975; Morris and others, 1977; Welsh and Bissell, 1979; Jordan and Douglas, 1980; Hintze, 1988). Differing terminology is applied west and east of Salt Lake and Utah Valleys in probable different thrust sheets (figure 3). A comprehensive regional study has not been conducted. The terminology used herein follows that used in the Oquirrh Mountains (Bingham mining district), where the Oquirrh Group has formally been restricted to Pennsylvanian strata (Welsh and James, 1961; Tooker and Roberts, 1970); however, some Kennecott-Bingham Mine geologists informally included both the Permian (Freeman Peak and Curry Peak) and Pennsylvanian formations (Bingham Mine, Butterfield Peaks, and West Canyon Limestone) in the Oquirrh Group (see Hintze, 1988; Laes and others, 1997). The Pennsylvanian Oquirrh Group and overlying Permian formations (Curry Peak and Freeman Peak) are about 21,900 feet (6700 m) thick in the Oquirrh Mountains (Welsh and James, 1961; Tooker and Roberts, 1970; Swenson, 1975), and the Permian-Pennsylvanian Oquirrh Formation is about 26,000 feet (8000 m) thick near Mt. Timpanogos (Baker and Crittenden, 1961).

The majority of West Mountain is composed of Permian-Pennsylvanian strata previously mapped as the Oquirrh Formation (Permian-Pennsylvanian) and overlying Kirkman Limestone (Permian). Nolan (1950) conducted a stratigraphic study of the Oquirrh Formation on the central part of West Mountain. She measured a section in sections 33 and 34, T. 8 S., R. 1 W. (stated as Wilsons and Long Trail Canyons), and reported a total measurement of 11,040 feet (3370 m) (1950, p. 11, plate IV), but plate III indicates 11,450 feet (3490 m). Swanson (1952) and White (1953) subsequently mapped the Oquirrh Formation on West Mountain as one map unit with little internal structure, and reported a total Oquirrh thickness of 16,200 feet (4900 m). This total thickness includes 11,450 feet (3490 m) attributed to Nolan, an additional 350 feet (110 m) of underlying strata (White, 1953), and an additional 4400 feet (1300 m) of overlying strata attributed to Swanson (White, 1953). Swanson (1952) reportedly measured 5000 feet (1500 m) of section (overlapping Nolan's section by about 600 feet [200 m]), but the location or basis for this measurement was not stated in his thesis. These three studies reported the Oquirrh Formation ranged from Lower Permian (Wolfcampian) to Lower Pennsylvanian (Atokan) (Nolan, 1950; Swanson, 1952; White, 1953). Swanson and White reported that 1000 feet (300 m) of Kirkman Limestone overlay the Oquirrh Formation. The present mapping indicates a thickness of Permian-Pennsylvanian strata (below the Kirkman Formation) of approximately 13,000 feet (4000 m), ranging from Wolfcampian to Desmoinesian. The disparity in thickness estimates between previous work and this study is due to increased understanding of the stratigraphy and structure in West Mountain.

Larson (1977) and Larson and Clark (1978) measured a stratigraphic section of uppermost Pennsylvanian (Virgilian) and Lower Permian (Sakmarian) strata attributed to the Oquirrh Formation on West Mountain totaling 5209 feet (1588 m); this section is only reported as NW, NE and SE quarters of section 34, T. 8 S., R. 1 E.; NW, SW and SE quarters of section 9, NW quarter of section 10, and NW and NE quarters of section 16, T. 9 S., R. 1 E. They identified conodont and fusulinid assemblages, and discussed depositional environments.

PERMIAN

Pk — **Kirkman Formation** (Lower Permian [lower Leonardian to middle Wolfcampian]) – Interbedded limestone and calcareous sandstone, minor shale. Some limestone units include distinctive dark-gray, laminated to thinly bedded, finely crystalline limestone that weathers to medium gray, light gray, and grayish yellow; laminations are commonly gray and yellow on millimeter scale and larger; calcite stringers also present. Other limestone units are medium gray with thin to medium bedding, and locally have black chert in irregular bands up to 1 foot (0.3 m) thick, calcite stringers, and fossils, including fusulinids, and crinoid and brachiopod fragments. Calcareous sandstone is medium gray and very pale orange, weathers to light brown or orange brown with light-red patches, and contains fine sand with calcareous cement. Formation also contains minor dark-gray shale that weathers pale red. Bedding is very thin to thick; locally well indurated forming fractured ledges. Formation forms ledges and slopes in block north of West Mountain fault and near Quarry Hills thrust fault. Lower contact mapped at change from primarily calcareous sandstone (Freeman Peak and Curry Peak) to interbedded limestone and calcareous sandstone (Kirkman). Fusulinids indicate early Leonardian and middle Wolfcampian ages (table 2); apparent discrepancy in age and stratigraphic position of sample W-20 suggests unresolved structural complications; regionally, the age of the Kirkman is not well constrained, and is reported as Wolfcampian (Welsh and James, 1961; Hintze, 1962), although Dunbar and others (1960) indicated an early Leonardian age at type locality. Upper part of unit truncated by West Mountain fault; exposed thickness of approximately 1000 feet (300 m) measured by H.J. Bissell (Swanson, 1952; White, 1953); regional thickness up to 1600 feet (490 m) at type section east of Springville, Utah (Baker and Williams, 1940; Hintze, 1962).

Pfc — **Freeman Peak and Curry Peak Formations, undivided** (Lower Permian [middle and lower Wolfcampian]) – Combined where separation of formations is unclear due to similar lithologies and lack of paleontologic data; mapped on north side of West Mountain fault. Exposed thickness estimated at 2000 feet (600 m); probable correlative, Granger Mountain Member of the Oquirrh Formation, is 8200 to 10,255 feet (2500 to 3126 m) thick in the Wasatch Mountains (Constenius and others, 2006).

Pfp — **Freeman Peak Formation** (Lower Permian [middle to lower? Wolfcampian]) – Calcareous sandstone, lesser pale-orange quartzite, and minor medium-gray limestone that is very thin to thick bedded. Medium-gray to very pale-orange calcareous sandstone weathers to light brown and yellowish gray with light-red patches, contains fine sand, and is fractured where better indurated. Exposed with Kirkman Formation near Quarry Hills thrust fault, and also exposed with underlying Curry Peak Formation? (see map unit Pfc) and overlying Kirkman Formation in block north of West Mountain fault; formation forms ledges and slopes; contact with underlying Curry Peak Formation not mapped (see Pfc); age based on fusulinids (table 2); 100 feet (30 m) exposed near Quarry Hills thrust, total exposed thickness uncertain (see Pfc); formation thickness of 2000 to 2450 feet (600-750 m) reported in the Oquirrh Mountains (Welsh and James, 1961; Swenson, 1975).

Pcp — **Curry Peak Formation** (Lower Permian [middle? to lower Wolfcampian]) – Calcareous sandstone with lesser limestone and minor sandy shale that is very thin to thick bedded. Medium-gray to very pale orange calcareous sandstone weathers to moderate yellowish brown, brown, and yellowish gray with light-red patches, contains fine sand and is locally cross-bedded, where more indurated forms fractured ledges and weathers to darker orange brown. Dark- to medium-gray limestone interbeds are generally 3 feet (1 m) or less thick, and locally have fusulinids, brachiopods and other fossil fragments, calcite stringers, and sandy intervals. Also includes minor, chippy, dark-gray sandy shale. Forms ledges and slopes on lower east flank and southwest side of West Mountain north of West Mountain fault; queried where uncertain designation. Contact with underlying Bingham Mine Formation located with the aid of fossils; conodonts and fusulinids in these beds at West Mountain include several species ranging from middle? to early Wolfcampian (table 2). Base of formation is locally exposed on east flank of range above West Mountain thrust fault and southwest of West Mtn 2 triangulation station (Hill 6904); maximum exposed thickness of 1500 feet (500 m); formation thickness of 2450 to 2800 feet (750-850 m) in the Oquirrh Mountains (Welsh and James, 1961; Swenson, 1975).

Unconformity?

PENNSYLVANIAN

IPo — **Oquirrh Group, undivided** – shown on cross section only.

Oquirrh Group – divided into the following units:

IPobm — **Bingham Mine Formation** (Upper Pennsylvanian [Virgilian to Missourian]) – Calcareous sandstone with minor limestone, quartz sandstone, and shale and including a limestone marker unit (IPoml). Calcareous sandstone is medium gray to light brown weathering to light brown, light gray, grayish orange with light-red patches, and very thin to thick bedded, with fine sand in calcareous matrix. Limestone interbeds are medium gray, quartz sandstone is white and weathers to light brown, and sandy shale is dark gray to light brown. Basal part of formation (~300 feet [100 m]) also includes dark-gray limestone weathering to medium gray, friable light- to moderate-red sandstone, and few thin orthoquartzite beds. Formation forms ledges and ledgey slopes and crops out on eastern upper flank and southwestern upper flank of West Mountain. Age based on early Virgilian fusulinids (table 2) obtained from uppermost part of limestone marker unit (map unit IPoml); Nolan (1950) assigned a Missourian age to lower part of the formation. Contact with underlying Butterfield Peaks Formation mapped at change from calcareous sandstone (Bingham Mine) to relatively thick quartzite interval (Butterfield Peaks), but no fossil ages were obtained there; Jordan and Commercial limestone units marking the base of the formation in the Oquirrh Mountains (Welsh and James, 1961) do not appear to be present on West Mountain. Formation thickness of approximately 4000 feet (1200 m) estimated from cross section A-A'; thicknesses of 5300 feet (1600 m), 6500 feet (2000 m), and 7311 feet (2229 m) reported by Swenson (1975), Welsh and James (1961), and Tooker and Roberts (1970), respectively, in the Oquirrh Mountains; the correlative Wallsburg Ridge Member of the Oquirrh Formation is from 3700 to 7900 feet (1100-2400 m) thick (Baker, 1976; Constenius and others, 2006).

IPoml — **Limestone marker unit of Bingham Mine Formation** (lower Virgilian) – Medium-light-gray to medium-gray limestone locally grading to medium-gray and light-brown calcareous sandstone; thinly to indistinctly bedded; limestone is finely crystalline with calcite stringers, sandy laminae, irregular black chert lenses to 1 inch (3 cm) thick, and fossil fragments (brachiopod, fusulinid); ledge- to cliff-forming; age based on early Virgilian fusulinids (table 2) from near top of unit; exposed thickness up to 100 feet (30 m).

IPobp — **Butterfield Peaks Formation** (Middle to Lower Pennsylvanian [Desmoinesian-Morrowan]) – Repetitively interbedded calcareous sandstone, quartzite, and limestone that is very thin to thick bedded, with relative limestone abundance decreasing upsection and quartzite interval at top. Calcareous sandstone is medium-gray to light-brown weathering to very pale orange and light gray, with fine to medium quartz sand grains in calcareous matrix. Quartzite is very pale orange to grayish orange and white, commonly cross-bedded and fractured. Limestone is dark gray to medium gray, locally with irregular lenses and spheres of black chert that weathers to grayish orange, and locally fossiliferous with brachiopods, bryozoans, crinoids, and fusulinids, and with calcite in stringers and small masses. Nolan (1950) reported 620 foot- (190 m) interval of quartzite at top of formation. Forms ledges and slopes along the west flank and crest of West Mountain. Nolan (1950) reported fusulinids including *Fusulina* (Desmoinesian) and *Fusulinella* (Desmoinesian-Atokan) from about the lower 3500 feet (1100 m) of section exposed on the west flank of West Mountain, whereas Desmoinesian conodonts obtained from a similar interval include *Idiognathodus* sp. and *Neognathodus* sp. (table 2); *Chaetetes* coral bed was not observed near the west base of the range as reported by White (1953); lower portion of unit (Atokan?-Morrowan) and base not exposed. Exposed thickness of approximately 7300 feet (2200 m) (Nolan, 1950; White, 1953); Biek (2004) and Biek and others (2006) reported an incomplete thickness of up to 4500 feet (1370 m) in the Lake Mountains, while Tooker and Roberts (1970) stated the formation is 9070 feet (2770 m) thick in the Oquirrh Mountains; the correlative Bear Canyon Member of the Oquirrh Formation to the east is about 3250 to 8350 feet (990-2550 m) thick (Baker, 1976; Constenius and others, 2006).

IPobl — **Limestone marker unit of Butterfield Peaks Formation** (Desmoinesian) – Medium-dark-gray limestone; fine grained, thin to medium bedded, generally with characteristic spherical black chert, 1 inch (3 cm) or less in diameter in selected beds, but locally absent to north; chert also occurs as irregular masses and nodules that weather to orange brown; forms ledges and saddles; samples W-5 and W-6 yielded *Idiognathodus* sp. conodonts (Desmoinesian) (table 2); appears to be uppermost limestone unit with spherical black chert inWest Mountain; limestone units with spherical chert have been mapped in the Lake Mountains (Biek, 2004; Biek and others, 2006); ranges from about 40 to 100 feet (12-30 m) thick.

IPowc — West Canyon Limestone (Lower Pennsylvanian [Morrowan]) – Not exposed; basal formation of the Oquirrh Group present in the Lake Mountains and Oquirrh Mountains; probably correlative with Bridal Veil Limestone Member of the Oquirrh Formation in the Wasatch Range.

PENNSYLVANIAN?-MISSISSIPPIAN

IPMmc — Manning Canyon Shale (Lower Pennsylvanian? to Upper Mississippian) – Not exposed; possibly faulted out along Quarry Hills thrust fault (White Lake Hills thrust of Schindler, 1952; White, 1953); regionally forms an important decollement zone for Sevier belt thrust plates.

West Mountain fault – formerly West Mountain thrust (Swanson, 1952; White, 1953) and Inez tear fault of H.T. Morris (see Morris and Shepard, 1964; Morris, 1983; Morris, 1987)

Unit descriptions for Mississippian, Devonian, and Cambrian rocks modified from Elison (1952), Schindler (1952), Swanson (1952), White (1953), and John Welsh (unpublished data, 1978). Also refer to the measured section by Welsh on plate 3. The lower hills between the West Mountain fault and State Route 141 and including Keigley Quarry, were referred to as the White Lake and Keigley Quarry Hills by the BYU students, but are not named on the present topographic base map; herein these hills are informally referred to as the "Quarry Hills." Goshen Hill is located south of State Route 141. Geology under disturbed land at Keigley Quarry is located approximately from Elison (1952), White (1953), and unpublished Geneva Steel map data. The Quarry thrust fault was formerly called the Keigley Quarry Hills thrust by Schindler (1952), Elison (1952) and White (1953).

MISSISSIPPIAN

Mgb — **Great Blue Formation** (Upper Mississippian) – Dark-gray limestone weathers to medium bluish gray and medium gray with some slope-forming sandstone and possibly shale in lower part; limestone is fine to medium crystalline, thin to very thick bedded, locally cherty and with calcite stringers, and locally fossiliferous with brachipods and bryozoans. Formation crops out on the east side of Quarry Hills forming ledges and some small cliffs; contact with Humbug Formation based on change from sandstone and limestone to primarily limestone of Great Blue; age from Gordon and others (2000). Top not exposed in quadrangle, but exposed thickness is approximately 1200 feet (400 m) (Elison, 1952; Schindler, 1952; Swanson, 1952; White, 1953). Gordon and others (2000) discussed a three-member separation of the Great Blue Limestone in the Oquirrh Mountains, which Biek (2004) and Biek and others (2006) mapped in the Lake Mountains. Morris and Lovering (1961) separated the Great Blue Formation into four members in the East Tintic Mountains. No member separation could be mapped in the West Mountain quadrangle. Regionally the formation is about 2500 to 2800 feet (760-850 m) thick (Morris and Lovering, 1961; Gordon and others, 2000; Constenius and others, 2006).

Mh — **Humbug Formation** (Upper Mississippian) – Alternating intervals of light- to blue-gray limestone and very pale orange and light-brown sandstone and quartzite that is thin to medium bedded; limestone is fine to medium grained, crinoidal, with lesser light-gray, finely crystalline, and silty dolomite; sandstone is dolomitic near base, fine to medium grained, with well sorted and rounded quartz grains; mapped in Quarry Hills and Goshen Hill where it forms ledges and slopes; lower contact marked by change from limestone (Deseret) to sandstone and limestone; age from Morris and Lovering (1961); measured thickness of 785 feet (240 m) in quadrangle (Elison, 1952; Schindler, 1952; Swanson, 1952; White, 1953); the Humbug is 700 to 750 feet (210-230 m) thick in the Lake Mountains (Biek, 2004; Biek and others, 2006; Clark and others, 2006), 650 feet (200 m) thick in the East Tintic Mountains (Morris and Lovering, 1961), and 520 feet (160 m) in Rock Canyon of the Wasatch Range (Constenius and others, 2006).

Md — **Deseret Limestone** (Upper to Lower Mississippian) – Light- to dark-gray-blue and dark-gray limestone and fossiliferous limestone with lesser light-gray to medium-gray dolomite. Limestone is micritic to coarse grained, with chert in lower part as nodules, bands, and beds; some black chert bands up to 1 foot (0.3 m) thick; fossiliferous limestone in upper half includes crinoids, and few *Triplophyllites* corals, brachiopods, and *Lithostrotion* corals; limestone thin to medium bedded in lower part with upper part indistinctly bedded. Dolomite is coarse grained, crinoidal, and locally cherty. Thin basal Delle Phosphatic Shale Member is not obvious and may be largely covered. Deseret crops out in Quarry Hills and Goshen Hill primarily as ledges with some slopes; lower contact corresponds to a change from cherty fossiliferous limestone and dolomite (Gardison) to unfossiliferous limestone of the Deseret; age from Morris and Lovering (1961) and Sandberg and Gutschick (1984). Thickness of 765 feet (235 m) measured by John Welsh (unpublished data, 1978); the Deseret is 700 to 1000 feet (210-300 m) thick in the Lake Mountains (Biek, 2004; Biek and others, 2006; Clark and others, 2006), 1000 feet (300 m) in the East Tintic Mountains (Morris and Lovering, 1961), and 575 to 900 feet (175-270 m) thick in the Wasatch Range (Constenius and others, 2006; Solomon and others, 2006). Previously mapped as the Pine Canyon limestone (Elison, 1952; Schindler, 1952; Swanson, 1952; White, 1953).

Mg — **Gardison Limestone** (Lower Mississippian) – Cherty limestone, fossiliferous limestone, and dolomite. Upper part (140 feet [40 m]) is dark-blue-gray to blue-gray cherty limestone, dolomitic at top, fine to medium grained, bioclastic, crinoidal, and containing *Triplophyllites* corals; 10% chert in layers of dark-gray weathering to tan, and 1- to 2-inch (0.4-1 cm) black chert bands; middle part (190 feet [60 m]) is medium- to light-gray dolomite with recrystallized bioclastic and crinoidal clasts, and *Syringopora* corals near top, underlain by light-gray unfossiliferous dolomite that is medium crystalline and medium bedded; lower part (290 feet [90 m]) is blue-gray to dark-gray limestone and gray dolomite, underlain by light- to dark-gray-blue fossiliferous limestone with a fine-grained matrix with varying coarse