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INTERIM GEOLOGIC MAPS AND EXPLANATION PAMPHLET FOR PARTS OF THE STOCKTON AND LOWE PEAK 7 1/2-MINUTE QUADRANGLES, UTAH

By

Edwin W. Tooker[1] and Ralph J. Roberts[2]

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This report is preliminary and has not been reviewed for conformity with Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey

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INTRODUCTION

The Stockton and Lowe Peak quadrangles lie in the central part of the Oquirrh Mountains, and include the Stockton (Rush Valley) and Ophir-Dry Canyon mining districts. Mining began in the Stockton district as early as 1864, and in the Ophir district, beginning in 1870. These districts have been active sporadically in recent years; the mines at Stockton were closed in 1970 and those at Ophir soon after in 1971. The map areas were included in the report of the Stockton and Fairfield quadrangles by Gilluly (1932) and the ore deposits were described.

This preliminary report provides descriptions and interpretations of data shown on the geologic map and contains structural and lithologic information based on the geologic mapping Roberts and Tooker (1961-1967), and more recently by Tooker (1986-1988). Emphasis in this pamphlet is on the stratigraphic and structural feataures of the sedimentary rocks in these quadrangles. Recognition of the regional thrust fault nappes that were developed during the Sevier Orogeny in the late Mesozoic have forced a new appraisal of sedimentary rocks, and more detailed measured sections are now available (Tooker and Roberts, 1970; this report). The igneous rocks were carefully described by Gilluly (1932), and those data are summarized in the descriptions of map units. We are grateful for the assistance of U.S. Geological Survey colleagues, W.J. Moore, Mackenzie Gordon, Jr., R.C. Douglass, and H.M. Duncan for map, geochronologic, and paleontologic data. Although presently incomplete, these maps contain information in areas of interest to two taxpayer requestors for a preliminary open-filing. These maps have not been field checked; they will be updated, and rereleased when the mapping has been completed.

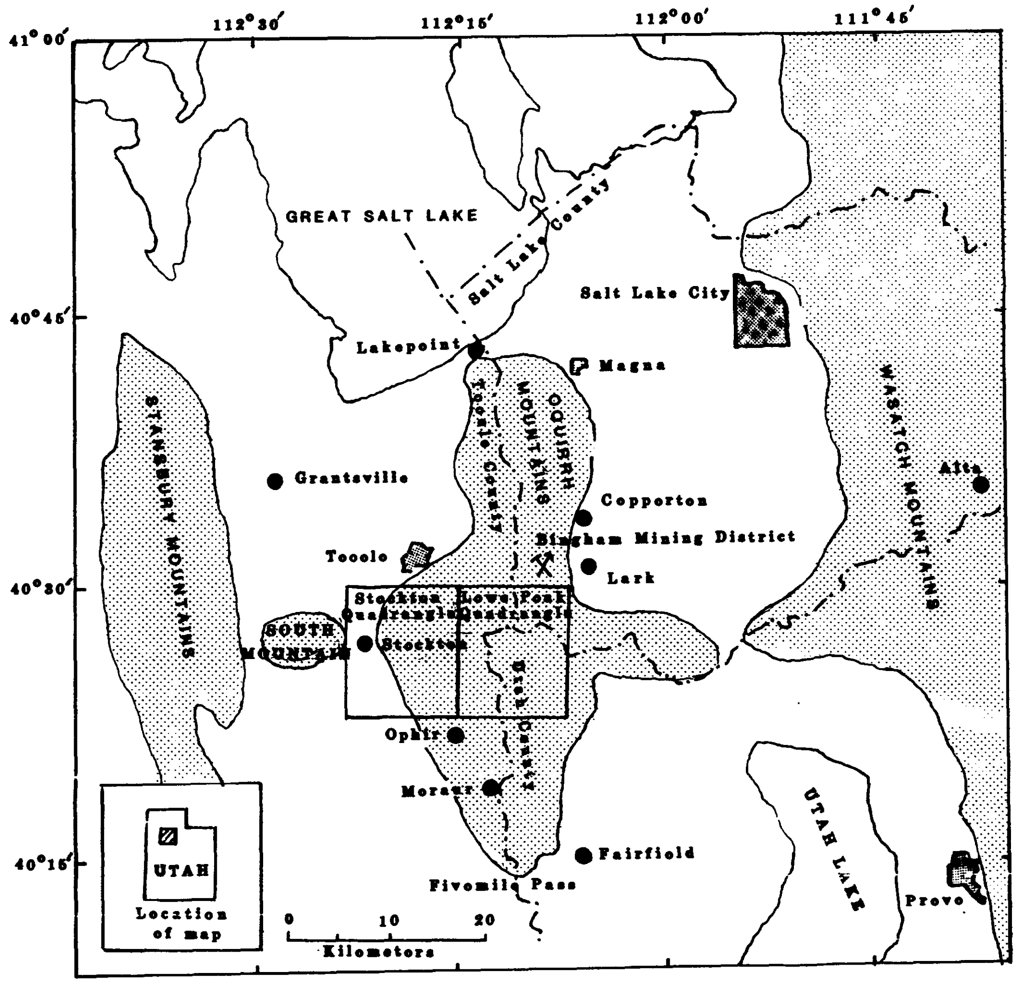
GEOLOGY OF THE STOCKTON AND LOWE PEAK QUADRANGLES

Location: The adjoining Stockton and Lowe Peak 7-1/2 minute quadrangles, Utah, span the central Oquirrh Mountains, about 20 km west-southwest of Salt Lake City, Utah (fig. 1). The quadrangles include parts of Tooele, Salt Lake, and Utah Counties. The Stockton and Ophir mining districts occur in the Stockton quadrangle and are accessible on the west side of the range via Utah highway 36.

Geologic overview: The Oquirrh Mountains are composed of allochthonous folded upper Paleozoic sediments on nappe plates that were emplaced in the foreland of the Sevier thrust belt during the late Mesozoic Sevier Orogeny (Armstrong, 1968). These rocks were subsequently intruded by Tertiary porphyritic igneous rocks, and later segmented and tilted eastward by basin-and-range extensional faults. The upper plates of two of the decollement nappes, the South Mountain and Bingham plates, are stacked together in the Stockton and Lowe Peak quadrangles. They contain comparably aged but somewhat distinctively different clastic and carbonaceous sediments. The structural configurations in the two thrust plates are also diffferent and provided unique sites for two of Utah's base and precious metal mining districts at Stockton and Ophir.

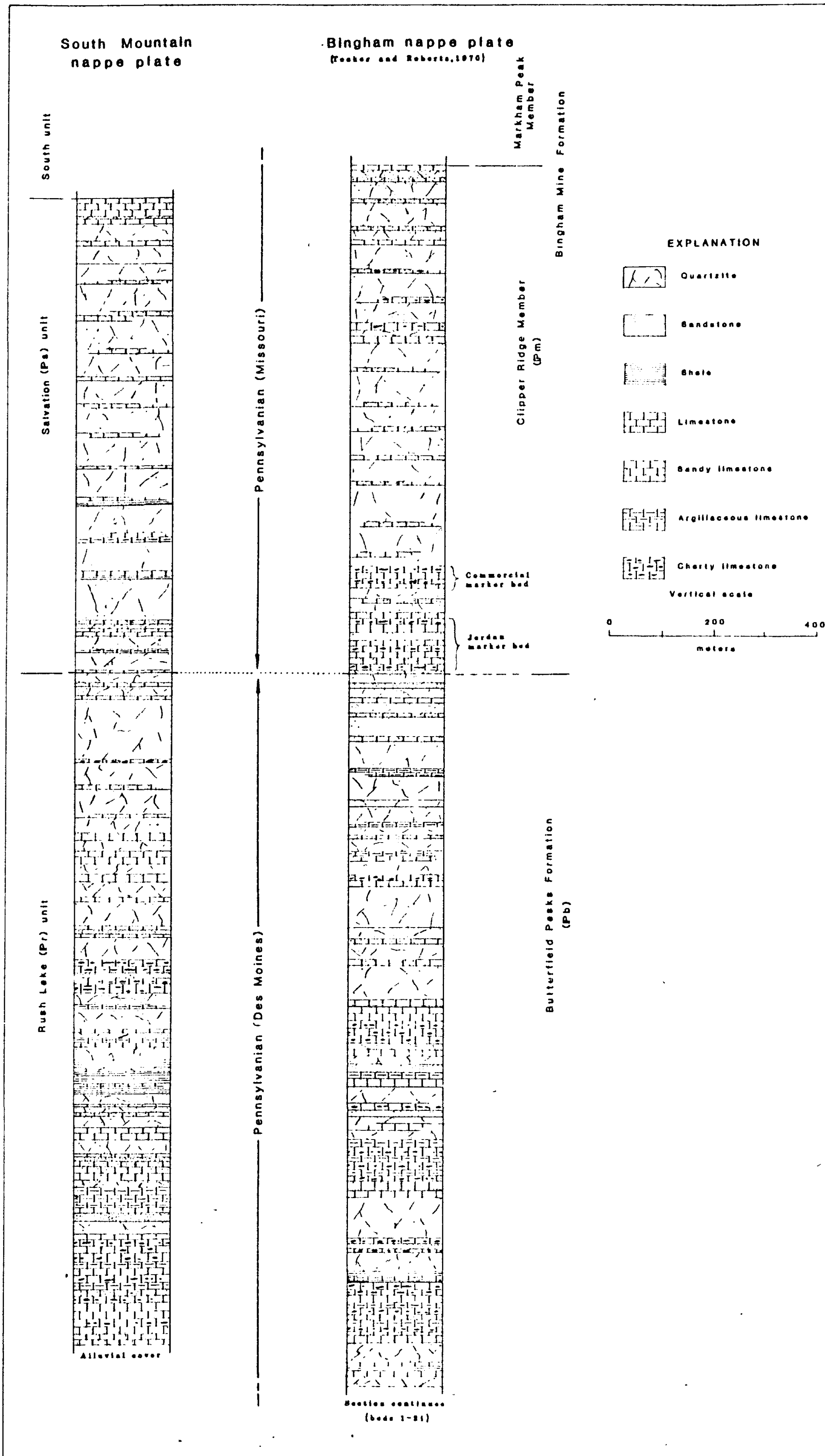
Stratigraphy: The allochthonous Bingham and Stockton nappe plates differ in thickness, and, where comparable in age, are of generally similar composition, although there are some important lithologic differences. The Bingham plate consist of early to late Paleozoic sediments. Only the late Paleozoic part of the section is exposed on South Mountain. Corresponding parts of the stratigraphic section in the two quadrangles are diagrammed in fig. 2. The stratigraphic section on the Bingham plate is 3,800 m thick; the lower 1,465 m are not shown in fig. 2. The exposures measured on the South Mountain plate aggregate 2,184 m; however, the total thickness of the Rush Lake unit in not known. The Bingham plate data in this figure are by Tooker and Roberts (1970),

Figure 1.--Index map showing the location of the Stockton and Lowe Peaks quadrangles, Utah.



112°30′
112°15′
112°00′
111°45′
41°00′
40°45′
40°30′
40°15′
GREAT SALT LAKE
Salt Lake County
Salt Lake City
Lakepoint
Magna
OQUIRRH MOUNTAINS
Tooele County
STANSBURY MOUNTAINS
WASATCH MOUNTAINS
Grantsville
Alta
Copperton
Bingham Mining District
Tooele
Lark
Stockton Quadrangle
Lowe Peak Quadrangle
SOUTH MOUNTAIN
Stockton
Ophir
Mercur
Fairfield
Fivemile Pass
UTAH LAKE
Provo
UTAH
Location of map
0
10
20
Kilometers

Figure 2.--Columnar section comparing stratigraphy in the Bingham and South Mountain nappe plate.


South Mountain nappe plate
Bingham nappe plate
South unit
Salvation (Ps) unit
Rush Lake (Pr) unit
Alluvial cover
Pennsylvanian (Missouri)
Pennsylvanian (Des Moines)
Markham Peak Member
Bingham Mine Formation
Clipper Ridge Member (Pm)
Commercial marker bed
Jordan marker bed
Butterfield Peaks Formation (Pb)
Section continues
EXPLANATION
Quartzite
Sandstone
Shale
Limestone
Sandy limestone
Argillaceous limestone
Cherty limestone
Vertical scale
0
200
400
meters

but the section has also been described by James and others (1961), and Swensen (1975). Gilluly (1932) is the primary source of stratigraphic data for the pre-Pennsylvanian sediments. The general stratigraphy of the Stockton plate was described by James and others (1961); the measured sections of the Rush Lake and Salvation units by Roberts and Tooker (unpublished notes, 1961) are in part included in the map unit descriptions in this report.

Oquirrh Group rocks of middle and upper Pennsylvanian age, which comprise the youngest consolidated sedimentary rocks of the Bingham plate in the Lowe Peak and Stockton quadrangles, may be compared with South Mountain plate rocks of comparable age on South Mountain and in the Stockton mining district. The Bingham plate rocks include the upper part of the Butterfield Peaks Formation and Clipper Ridge Member of the Bingham Mine Formation. Comparable strata on the South Mountain plate include the Rush Lake and Salvation units. The uppermost part of the section on South Mountain, the South unit (not described in this report), contains rocks correlative with the Markham Peak Member of the Bingham Mine Formation; however, rocks of this age or composition do not crop out in the Stockton plate in the Stockton quadrangle.

The Clipper Ridge Member of the Bingham Mine Formation is 910 m thick in the Bingham plate and consists mostly of orthoquartzite, calcareous quartzite, and calcareous and quartzose sandstone interbedded at the base with two limestone marker beds, the Jordan and Commercial, which are more than 30 m thick and numerous thinner (3-21 m) thick limestones in the upper part (Roberts and Tooker, 1970). The quartzite commonly is medium to thick bedded and fine to medium grained and ranges from 46-91 m in thickness. Some beds are finely banded and locally crossbedded. Megafossils, mostly syringoporid corals, are sparse and poorly preserved except in arenaceous limestone or calcareous sandstone, which contain fusulinids. *Triticites* is the most common, and the forms are believed to be of Missouri age.

The Butterfield Peaks Formation exposed in the Stockton and Lowe Peak quadrangles is 2,765 m thick and composed predominantly of interbedded calcareous sandstone and arenaceous cherty argillaceous, and fine grained dense limestones (Tooker and Roberts, 1970). Calcareous quartzite is brown gray, fine to medium grained, medium to massive bedded and locally may contain argillaceous limestone laminations. Locally the quartzite is crossbedded and ripple-marked on bedding surfaces. It weathers tan to light brown to red-brown. Silica-cemented orthoquartzite beds stand in prominent relief and have a hard vitreous weathered surface; carbonate-cemented calcareous quartzite beds weather to a soft outer surface rind. Limestones typically are medium dark gray, finely crystalline to medium sandy, and thin to medium bedded; they weather light gray. Thin black chert nodules and lenses locally band the limestones. Thin coarse arenaceous limestones, commonly bioclastic and crossbedded, are interlaminated by shales and argillaceous limestone beds. Limestones in the lower part of the formation are very fossiliferous, and contain brachiopods, bryozoans, corals, and fusulinids of Des Moines (Middle Pennsylvanian) age.

The Salvation unit in the South Mountain plate, which is named for the Salvation-Hercules mine in Ben Harrison Gulch, is composed mainly of interbedded calcareous quartzite, othoquartzite, calcareous sandstone, and lesser amounts of arenaceous, argillaceous, fossiliferous, and dense crystalline limestones 832 m thick. The quartzites are generally light and gray, medium bedded with interbedded calcareous sandstone and (or) limestone lenses, locally crossbedded and weather buff. Limestones are medium to dark gray, medium bedded, fine grained to sandy, and weather medium light gray. Locally the limestones contain brachiopods, *Syringopora* corals and fusulinids. The age suggested in the upper limestone bed is Late Pennsylvanian, probably of late Missouri or earliest Virgil equivalent, and of Missouri equivalent in the lowest part. There are no thick predominantly limestone beds in the lower part comparable to the Jordan and Commercial marker beds in the Bingham plate.

The part of the Rush Lake unit exposed in the South Mountain plate contains nearly 1,352 m of interbedded limestone, quartzite, and occasional shale beds. Limestone is generally medium grained, medium bedded, with local shale partings, is often sandy, silty, bioclastic, and crossbedded, argillaceous and cherty. Quartzite contains thin limestone partings, is buff-tan, coarse sandy, medium bedded, locally crossbedded, weathers to pitted surface where the bed has calcareous cement, local interbedded ferruginous layers with worm trails. Megafossils in carbonate beds include *Syringopora* and cup corals, brachiopods, and fusulinids. The suggested age is Middle Pennsylvanian, late Des Moines equivalent.

Structure: The Oquirrh Mountains are composed of allochthonous folded upper Paleozoic sedimentary strata (fig. 2), Tertiary intrusive rocks, and flanking Quaternary unconsolidated sediments. The sedimentary rock sequences are on the upper plates of two main regional thrust faults (Tooker, 1983), produced during the late Mesozoic Sevier orogeny (Armstrong, 1970). Two miogeoclinal rock sequences were deposited west of this area in adjoining parts of the craton shelf during the late Paleozoic, and derived sediments from different parts of the craton on the east and from the Antler highland to the west (Roberts, 1964). As a result of thrust faults, adjoining sedimentary rock assemblages of nappe plates are of comparable ages but of nonuniform lithologic facies. Lobes of the Sevier decollement thrust nappes moved generally eastward unknown distances toward a foreland in the Salt Lake recess during late Mesozoic time (Tooker, 1983). Two of the lobes are represented in these quadrangles, and contain the Bingham and South Mountain sequences on the upper plates of the Midas and Stockton thrust systems. Not only are the stratigraphic sequences distinctive, but the fold structures in the plates also differ.

Most of the two quadrangles are covered by rocks of the Bingham (upper) plate of the Midas thrust system. The Midas thrust system is the oldest in these quadrangles, and is not exposed therein; however, an upper strand of the fault is exposed in the Bingham Canyon quadrangle (Tooker and Roberts, in press) which adjoins the Lowe Peak quadrangle to the north. Several imbricate thrusts of small magnitude occur in the upper (Bingham) plate of the Midas thrust system, particularly where the folds become tight and are locally overturned (to the northeast). The trends of the major large amplitude folds, the Ophir anticline, Pole Canyon syncline, and Long Ridge anticline, are northwest. They plunge and rise gently along the trend, and dip beneath the Quaternary range front sedimentary cover and the overlying Stockton thrust at the north-west corner. The plate is cut by prominent northeast-trending steep-dipping normal faults, generally having small displacement, and less abundant northwest-trending normal faults. South of Soldier Canyon, the range front is developed along northwest and northeast steep dipping normal faults.

The South Mountain thrust plate is the site of the Stockton mining district. The thrust plate is bounded on the east by the Soldier Creek tear fault, which trends northeast from the mouth of Soldier Canyon, crossing the ridge at the headwaters of Right Hand Stump Fork (of Settlement Canyon). The Stockton thrust fault then trends generally northwestward toward the mouth of Silcox Canyon in at least two imbricate plates. The folds in the South Mountain plate are close-spaced, of low amplitude, and trend in an arc from west-northwest to west to west-southwest. They are truncated by range front faults and the large alluvial fans composed of Harkers fanglomerate. The folds are locally overturned to the north near the distal edge of the thrust plate. The range front is formed along a north-northwest set of steep dipping normal faults which seem to flex to the north-northwest near the town of Stockton, and are covered to the south by thick Harker fanglomerates deposits.

DESCRIPTION OF MAP UNITS IN THE STOCKTON AND LOWE PEAK QUADRANGLES, UTAH

Brief lithologic or petrologic descriptions of the units shown on the maps of the Stockton and Lowe Peak quadrangles, include unconsolidated and consolidated sedimentary and intrusive igneous rock units. References to more detailed descriptions are given for the individual unit described below.

Qod **Mine waste dump materials (Holocene)**

Qac **Alluvium and colluvium (Holocene)**--Undifferentiated, unconsolidated alluvial fan and stream gravel, sand, silt, talus, gravel, and boulder deposits within and bordering the mountain range and its flanking sediments. Thickness of fan deposits is variable and estimated to range from less than 0.3 m at distal edges to more than 10 m locally in the upper parts. Stream-fill deposits are estimated to be less than 1.5 m thick, except, possibly, in the large canyon such as Middle, Pine, Barneys, and Bingham Canyons. Generally irregular small talus deposits, of variable thickness flank the alluvial deposits in many parts of streams courses

Q1 **Landslide debris (Holocene)**--Generally irregular unconformable slide blocks in Soldier and West Canyons composed of detached and rotated Great Blue Limestone and Manning Canyon Shale in strucutrally over-steepened, deeply eroded thrust fault terranes

Qa **Alluvium (Pleistocene)**--Pre- and post-Lake Bonneville, post-Harkers Alluvium, fine-grained alluvial deposits consisting of poorly sorted thin gravel, sand, and silt layers and lenses in an extensive series of coalescing fans issuing from most of the canyons emptying into Rush Valley. Thickness of these fans is unknown, but is estimated to be tens of meters thick at the range front, thinning toward the distal margins of the fans, where locally, they merge with shoreline deposits. The fans generally lie disconformably on Harkers Alluvium

Qt **Talus deposits (Pleistocene)**--Pre-Lake Bonneville deposits, post-Harkers Alluvium talus slope deposits occur along the walls of the larger canyons in quartzite-dominant rock terranes, such as in Middle Canyon. The poorly sorted angular to subrounded fragments range up to 0.3 m in diameter; the deposits may be several meters thick at its base

Qlb **Lake Bonneville deposits (Pleistocene)**--Undifferentiated and unconsolidated thin layers of silt, sand, and gravel in shoreline and pluvial lake bottom deposits (Eardley and others, 1957). A prominent sand and gravel bar and spit deposit occurs north of Stockton, connecting the Oquirrh and South Mountains; its beveled top is at the 1,585 m (5,200') Bonneville level still-stand of Lake Bonneville. Elsewhere along the range front northeast of Stockton, the deposits are marked by wave-cut terrances of sand and gravel (derived primarilly from erosion of Harkers Alluvium) at or near the 5,200' elevation. Southeast of Stockton and the mouth of Soldier Canyon, the deposits overlap the large alluvium fans that mantle a prominant pediment along the west margin of Rush Valley. The maximum thickness of Lake Bonneville deposits is unknown because they are difficult to distinguish from Harkers Alluvium (Qh) in drilled well records, but the Lake Bonneville unit may be as much as a few tens of meters thick locally against normal range front faults. The deposits thin to a few meters outward from the range. Away from the edge of the range, sand and gravel bar deposits, as much as 10 m thick parallel the Bonneville shorelines and are local sources of construction materials in Tooele Valley (Tooker, 1980). The very prominant Stockton bar and spit deposits are at least 91 m thick locally. The Lake Bonnevile deposits unconformably overlie the Harkers Alluvium, older alluvium, and locally are overlain unconfomatably by Holocene alluvial and colluvial depoists

Qh **Harkers Alluvium (Pleistocene)**--Undifferentiated, partly disected, unconsolidated, thick coarse franglomerate deposits along the western range front in Tooele and Rush Valleys, as well as locally up the large canyons (Silcox, Settlement, Soldier). The fanglomerates project basinward as fill deposits of undetermined thickness. These deposits are notched by the Lake Bonneville (Bonneville level at 5,210 ft) shoreline, and locally are overlain by Pleistocene pre-Lake Bonneville alluvial fan (Qa) deposits. The unit confomably overlies upper Paleozoic sedimentary rock sequences. The poorly sorted angular to rounded boulders, coarse to fine gravel, sand, silt, and mud are assigned to the Harker Alluvium (Slentz, 1955; Tooker and Roberts, 1971). Unit total thickness is unknown, but where erosion has cut through the conglomentrate at the mouth of Soldier Canyon and along the range front at the mouth of Silcox Canyon at least 61 m are exposed; this is believed to a minimal value. The age of the unit is considered Pleistocene (probably early Pleisotcene); no fossils have been found

Tv **Latite flows and breccias, undivided (Oligocene)**--Extensive biotite-hornblende and augite-biotite latite flows, locally with phenocrysts 1-4 mm in length in a fine-grained groundmass (Swenson, 1975) occur along the eastern margin of the Lowe Peak quadrangle. Flow banding is evident in many specimun. The age is about 38.8 my. The breccia contains angular to subrounded fragments of the flows, commonly less than .3 m in diameter. The fragments compose 10-75 percent and are set on a matrix of crystal lithic buff. Beds of water-laid tuff, tuffaceous sandstone, and conglomerate are interbedded in braccias. The breccias are generally considered to be younger then the flows

Teh **Eagle Hill Rhyolite (Oligocene)**--Porphyry dikes, sills, and stock-like bodies occur in the Ophir mining district (Gilluly, 1932). A vertical dike, 3 to 9 m thick cuts, across the early Paleozoic sediments on the north wall of Ophir Canyon. It seems to coalesce upward with an irregular sill-like mass of brecciated rhyolite and limestone. Several other sill-like bodies of rhyolite occur in the Dry Canyon area, and a large mass on the slope of Bald Mountain forms an irregular stock. The common variety of rhyolite is light gray to buff, dense groundmass with numerous (5-10 percent) pheno-crysts of quartz, up to 5 mm in diameter, feldspar, generally less than 1 mm long, and biotite, up to 21 cm in length. Flow structure is visible in some thin sections. The age of this unit is based on K/Ar age of 31.6^{+}-0.9 m.y. (Moore, 1973) from exposures at Mercur

Tqlp **Quartz latite porphyry (Oligocene)**--Numerous dike- and sill-like bodies of variable size are represented by the 1.5-30 m thick steep dipping dike on the north side of Middle Canyon in the Lowe Peak quadrangle. This unit is one of several that trend southwest from the Bingham district toward the Stockton district and intrude the Butterfield Peaks Formation and Clipper Ridge Member of the Bingham Mine Formation. The medium gray porphyry is composed of orthoclase (50 percent), plagioclase (30 percent), biotite (10 percent), and hornblende (5 percent) phenocrysts. Carlsbad twinned orthoclase phenocrysts may exceed 1 cm in length; the other minerals generally are about 1 mm long. Biotite is euhedral. Groundmass quartz (5 percent) occurs as broken phenocrysts about 1 mm in diameter. Minor groundmass plagioclase, augite, apatite, and magnetite are also present (Gilluly, 1932). The age of this unit is based on the K/Ar age of 37.1 ± 1.1 m.y. (Moore, 1973)

Tqm **Quartz monzonite (Oligocene)**--The large to medium-large gray intrusion east of the Soldiers Creek fault in the Stockton quadrangle, the Soldier Canyon stock, was classed by Gilluly (1932) as "approaching quartz monzonite in composition". The elongated stock is generally subparallel with the Butterfield Peaks Formation it intrudes. A number of dioritic and monzonitic plugs and sills that occur peripheral to the stock are described by Gilluly (1932). The central part of the body is granitic in texture; locally along the border the unit is coarse-grained and more feldspathic. Euhedral plagioclase (0.1-2 mm), and subhedral orthoclase, and microcline are also present. Microcline composes about 65 percent of the rock; anhedral quartz make up 15 percent the remainder includes green pyroxene, diopside, biotite, pyrite, and accessory magnetite and apitite. In the coarse phase microcline is more abundant than plagioclase and pyroxene is more alteredd to hornblende; no biotite is present. The K/Ar age of this unit has not been determined, but is inferred to be Oligocene because of its close compositional and location relative to the nearby quartz monzonite porphyries in the Stockton area

Tqmp **Quartz monzonite porphyry (Oligocene)**--The most common intrusive rocks of the Stockton mining district occur in several textural types (Gilluly, 1932). The rock generally is medium-gray porphyry containing abundant (50 percent) phenocrysts of pink orthoclase, less conspicuous quartz, plagioclase, biotite, and hornblende. The groundmass is microgranitic. Epidote is present in mineralized areas, replacing mafic mineral and feldspars. The 61 m thick sill at the mouth of Silcox Canyon, and the "Raddatz" porphyry which crops out on the north side of the draw south of the Honerine mine shaft and north of the Calumet mine, represent phases containing coarse grained orthoclase phenocrysts. Fine grained monzonite porphyry dikes and plugs crop out near the Calumet mine. Numerous small dike, sill, and plug-like bodies of fine grained monzonite-related rocks occur elsewhere in the Stockton district. The dikes commonly parallel north-northeast-trending faults. The age of these rocks is represented by K/Ar age of 38.0 ± 1.1 m.y. for the sill at the mouth of Silcox Canyon (Moore, 1971)

Oquirrh Group (Pennsylvanian)--Originally named the Oquirrh Formation but not subdivided into members by Gilluly (1932), these rocks on the upper plate of the Midas thrust fault system were raised to the Oquirrh Group by Welsh and James (1961), and its three formations described by Tooker and Roberts (1970). The type localities of a the formation are in the Lowe Peak and Bingham Canyon quadrangles. The Midas thrust is not exposed in the Stockton or Lowe Peak quadrangles but one of its upper strands crops out in the Bingham Canyon quadrangle, north of Lowe Peak (Tooker and Roberts, in press). The Bingham and South Mountain nappes are both composed of Oquirrh Group rocks in the Stockton quadrangle. The Stockton thrust, which underlie the South Mountain plates, crops out north and east of Stockton; the thrust is not exposed on South Mountain

Bingham nappe plate strata (Pennsylvanian)--The Clipper Ridge Members of the Bingham Mine Formation, Butterfield Peaks Formation, and West Canyon Limestone are exposed in these quadrangles; the Clipper Ridge Member and West Canyon Limestone are exposed only in the northeastern part of the Lowe Peak quadrangle, and include the type localities

Bingham Mine Formation (Upper Pennsylvanian)--Named by Welsh and James (1961, p. 8-9) for quartzite, sandstone, and limestone sedimentary rocks in the Bingham mining district. Tooker and Roberts, (1970, p. A-33) subdivided the section into the lower Clipper Ridge Member, 910 m thick, and the overlying Markham Peak Member, 1,319 m thick. Only the lower part of the lower member is present here. The Bingham Mine Formation is conformable with the underlying Butterfield Peaks Formation.

IPbc **Clipper Ridge Member**-- A series of prominent orthoquartzite, calcareous quartzite, and calcareous and quartzose sandstone interbedded with a few thick cherty, arenaceous, argillaceous, and fossiliferous limestone beds. The thickest bed at the base is 100 m (Jordan Limestone marker bed in the Bingham mining district). Limestones become thinner 3-21 m) in the upper part (Tooker and Roberts, 1970). The member is about 910 m thick; only the lower part is exposed north of Middle Canyon in the Lowe Peak quadrangle. The member is conformable with the Butterfield Peaks Formation. Gordon and Duncan (1970) report a probable Missouri age, based mainly on the presence of the fusulinid *Triticites*

IPb **Butterfield Peaks Formation (Middle Pennsylvanian)**--Cyclically interlayered, thin- to medium-bedded, locally cross-bedded calcareous quartzite; tan to grayish-brown orthoquartzite and calcareous sandstone; medium-gray limestone and fossiliferous limestone; and olive-gray, brown-gray, and dark-gray arenaceous cherty, and argillaceous limestone. Limestones predominate over quartzites (Tooker and Roberts, 1970). The formation is 2,765 m thick, and is exposed, in part, in the northeastern part of the Stockton quadrangle, and more extensively in the Lowe Peak quadrangle; the type section is in the Lowe Peak quadrangle, measured from the head of West Canyon, northwest across the ridge into Middle Canyon (Tooker and Roberts, 1970). The Butterfield Peaks section conformably overlies the West Canyon Limestone. The formation contains an abundant brachiopod, bryozoan, coral, and fusulinid fauna. The age of the rocks is Des Moinsean (Middle Pennsylvanian) (Gordon and Duncan, 1970)

IPw **West Canyon Limestone (Lower Pennsylvanian)**--The formation is 438 m thick in the type section in the Lowe Peak quadrangle (Nygreen, 1958) and about 321 m thick at Lewiston Peak in the Mercur quadrangle (Tooker and Roberts, 1970). The rocks are principally cyclical clastic, arenaceous limestones, composed of quartz and calcite grains and fossil fragments, and interbedded thin chert, argillaceous, and dense crystalline limestone beds. Thin calcareous quartzite and calcareous sandstone generally banded or cross bedded separate thicker limestone beds. Calcareous quartzite beds thicken toward the upper conformable contact with the Butterfield Peaks Formation. The lower contact with Manning Canyon Shale is conformable in Ophir Canyon. Fossils are locally abundant, brachiopods typical of the *Rugoclostus* zones are most abundant, bryozoan fairly common corals rare, and trilobite fragment Nygreen (1958) reported finding the fusulind *Millerella* in the upper part of the formation. A Morrowan age is suggested

IPMm **Manning Canyon Shale (Lower Pennsylvanian and Upper Mississippian)**--Gilluly (1932) provided no type locality for the Manning Canyon Shale because of poor exposures in the southern Oquirrh Mountains; he noted that the most complete stratigraphic section is exposed in Soldier Canyon (in SE-1/4, NE-1/4, sec. 33, T. 4 S., R. 4 W. in the Stockton 15-minute quadrangle, Utah). This is designated as the principal reference locality for the formation. Here the unit consists of 350 m of interbedded calcareous shale and fossiliferous, argillaceous, and thin-bedded crystalline limestone, and a prominent 1.2 m ledge-forming brown weathering quartzite capping the lower one third. The section is comformably gradational from the limestone and lesser shale units of the underlying Great Blue Limestone into predominately dark-gray carbonaceous shales and thin-bedded gray limestone. Contact with the overlying Oquirrh Group is conformable and represnts a transition from shale into clastic limestone of the West Canyon Limestone. The Mississippian-Pennsylvanian boundary occurs in the upper part of the formation. Carbonate beds are abundantly fossiliferous, consisting of bryozoans (including *Archimedes*), brachiopods (including productid and spirifierid types), and corals (including *Amplexizaphrentis*) (Gordon and Duncan, 1970)

Great Blue Limestone (Upper Mississippian)--Neither Spurr (1895), who named the formation for rocks in the Oquirrh Mountains, nor Gilluly (1932), who subdivided the unit into member there, indicated a type locality for the 764 m thick Great Blue Limestone. In this three-part subdivision, Gilluly specified a type locality only for the middle unit, the Long Trail Shale Member, at the head of Long Trail Gulch (center sec. 25, T. 5 S., R. 4 W., Mercur 7-1/2 minute quadrangle Utah). Morris and Lovering (1961) redefined the formation in the East Tintic Mountains as the Great Blue Limestone, consisting of four members. There, a prominent shale and shale-rich carbonate sedimentary facies comprises the upper two members; these contrast sharply with strata of comparable age in the single upper member in the Oquirrh Mountains. There is, however, a close resemblance between the lower two members at Tintic and the lower member in the Oquirrh Mountains. The Long Trail Shale member is not recognized at Tintic. Because of the differences, Tooker and Gordon (1978) subsequently designated the Silveropolis Hill-Long Trail Gulch area in the Mercur quadrangle as the type section for the unit in the Oquirrh Mountains and retained the original name of the formation, Great Blue Limestone

Mgu **Upper limestone member**--Alternating dark-gray, fossiliferous, sandy, and cherty limestone intervals and intervening shale and shaly limestone are 470 m thick. The lower part of the member is composed predominately of light-brownish gray and tan, thin-bedded, banded, silty, and argillaceous limestone. This lithology grades upward into interbedded medium- to dark-gray silty and argillaceous limestone, calcareous shale, and sandy limestone. The member is exposed in West Canyon, the area between Soldier and Ophir Canyon, and the South Fork of Ophir Canyon in the Lowe Peak and Stockton quadrangles. Fossils are sparse. The member is Chesterian in age. The *Caninia* coral zone was recorded from 122 to 295 m above the base of the member. The only coral between the two zones is *Amplexizaphrentis*

South Mountain nappe plate--The South (not described here), Salvation, and Rush Lake units comprise the sequence of rocks in the type locality on South Mountain; only the latter two units occur, in part in the Stockton quadrangle. The sedimentary rocks on South Mountain are roughly equivalent in age with the Markham Peak and Clipper Ridge Members of the Bingham Mine Formation and the upper part of the Butterfield Peak Formation. The lithologies of the units and formations in the South Mountain and Bingham sequences are similar in general, but are not directly comparable, and their structural styles on the upper plates of the Midas and Stockton thrust systems are distinctly different

IPs **Salvation unit**-- Named for exposures generally north of Ben Harrison Gulch in the Stockton mining district, the type locality was measured on South Mountain nearby. The unit consists of 823 m of interbedded calcareous quartztite, orthoquartzite, and sandy, argillaceous, fossiliferous and dense crystallines limestone. Medium-bedded quartzite rocks prodominate over thin-bedded limestone and shale partings. The characteristic lithologies and ages of these rocks are detailed in the measured section that follows. The rocks are age-correlative with the Late Pennsylvanian Clipper Ridge Member of the Oquirrh Group, described by Tooker and Roberts (1970). The Salvation lithology, particularly at the base of the unit, is not fully comparable with that of the Clipper Ridge Member (fig. 2); there are no thick limestone marker beds in the Salvation unit comparable to the Jordan and Commercial

Stratigraphic section of the Salvation unit in the South Mountain nappe composed of the Oquirrh Group measured on South Mountain along the ridge across S-1/2 sec. 22 and N-1/2 sec. 21, T. 4 S., R. 5 W., Stockton 15-min. or South Mountain 7-1/2 min. quadrangles

[Measured by R.J. Roberts and E.W. Tooker, October, 1961]

	Thickness (meters)	Distance above base (meters)
South unit, Oquirrh Group (lowest beds only):		
Limestone and quartzite, interbedded; sandy limestone and calcareous quartzite with local interlaminated ferruginous sandstone; covered slope		
Contact conformable.		
Salvation unit, Oquirrh Group:		
17. Limestone, medium-gray, fine-grained to sandy, medium-bedded; weathers medium light gray; productid brachiopods, fuslinids in sandy limestone. USGS colln. f22623 at 14 m, "Fine sand with *Triticites* sp. The age suggested is Late Pennsylvanian, probably late Missouri or earliest Virgil equivalent." (R.C. Douglass, written commun. 7/20/62). A brachipod was identified as "*Linoproductus* sp. indet." (Mackenzie Gordon, Jr., written commun. 10/14/66). USGS colln. f22624 at 24 m, "Fine sand with *Triticites* sp. It probably is referable to latest Missouri equivalent but an early Virgil age is a possibility." (R.C Douglass, written commun. 7/20/62). Productid brachiopods and bryozoans common in other layers	29	803

	Thickness (meters)	Distance above base (meters)
16. Quartzite and limestone, interbedded; light tan-gray, sandy, calcareous cement, medium-bedded quartzite, and medium-gray, fine grained to sandy, medium-bedded limestone with shale partings; weathers buff (quartzite) and light blue gray (limestone); fossils locally in limestone include bryozoans and fusulinids USGS colln. f22622 at 10 m, "Fine sand with some bryozoan and *Kansanella* sp. The age suggested is Late Pennsylvanian, probably Missouri equivalent." (R.C. Douglass, written commun. 7/20/62).	12	791
15. Quartzite, light-gray, sandy, mostly calcareous cement in lower part, silica cement more common in upper part, medium-bedded, local banding, interbedded silica-cemented quartzite in lower part and sandy limestone throughout, sparse ripple marked surfaces noted locally; weathers red brown to tan; covered slope	69	722
14. Quartzite, light tan-gray, sandy, mostly calcareous cement, interbedded with locally crossbedded, and often fossiliferous, medium dark-gray sandy limestone up to 1 m thick; quartzite weathers buff, limestone medium blue-gray; fossils (identified by R.C. Douglass, written commun., 7/20/62) in sandy limestone layers include fusulinids, brachiopods, crinoids, bryozoans, Syringopora and cup corals USGS colln. 22615 at 5 m, "Fine sand with crinodal debris, bryozoan fragments and fragments of *Kansanella* sp. The age suggested is Late Pennsylvanian, probably Missouri equivalent." USGS colln f22616 at 46 m, " Fine sand with *Triticites* sp., scattered, and bioclastic limestone with *Tetrataxis* sp., texturalid, *Bradyina* sp., *Millerella* sp., and *Fusulinella* sp. or *Pseudofusulinella* sp. This second piece really looks like a piece from the middle Pennsylvanian."		

Unit	Description	Thickness (meters)	Distance above base (meters)
	USGS colln f22617 at 147 m, "Silty fragmented limestone with *Bradyina* sp. and *Kansanella* sp. The age suggested is Late Pennsylvanian, probably Missouri equivalent." USGS colln. f22618 at 126-132 m, "Fine sand with abundant small fusulinids something like the kind Thompson calls *Oketella* but more globular." and brachiopods and corals in the uppermost part; mostly covered slope	203	519
13.	Limestone, medium-gray, fine-grained to sandy, thick bedded; weathers olive brown to light gray; corals, *Derbyia* brachiopods, bryozoans, and fusulinids USGS colln f22614 at 155 m, " Fine sand with textularids and *Triticites* sp. The age suggests Late Pennsylvanian, probably Missouri equivalent." R.C. Douglass, written commun. 7/20/62	4	515
12.	Quartzite, light tan-gray, sandy, mostly calcareous cemented, medium-bedded with interbedded limy sandstone, crossbedded in part, thin platy to shaly limestone partings; weathers reddish brown to buff, medium-soft surface rind; covered slope	116	399
11.	Quartzite, light tan-gray, sandy, mostly silica cemented, massive to medium-bedded with interbedded sandy limestone up to .3 m thick and thin interlayers of calcareous-cemented quartzite, crossbedded locally; weathers tan buff, platy float; partly covered slope	41	358
10.	Limestone, medium-gray, fine-grained, thin-bedded; weathers light gray; mostly covered slope	1	357
9.	Quartzite, medium tan-gray, medium- to coarse-sandy, mostly calcareous cement, medium-bedded to massive, interbedded thin laminae of limestone, limy sandstone, and shale partings, well-jointed, banded locally; weathers tan buff, pitted thin surface rind, alternate hard and softer layers locally weather in relief; fossils in interbedded sandy limestone, cup and *Syringopora* corals, brachiopods, gastropods (*Omphalotrochus*?) crinoid stems, bryozoans USGS colln. 61F76 at 247 m, "*Syringoporoid* coral, *Straprollus* (*Euomphalus*) sp. ident." (Mackenzie Gordon, Jr., written commun. 10/4/66)	271	86
8.	Limestone, medium dark-gray, fine grained to sandy, medium-bedded; weathers light gray with brown sand partings, platy float	3	83

		Thickness (meters)	Distance above base (meters)
7.	Quartzite, medium dark-gray, sandy, calcareous cement, medium-bedded, banded locally; weathers medium light gray with light-brown bands; mostly covered slope	8	75
6.	Limestone, medium-gray, fine grained to sandy--size increases upward--medium-bedded, sand partings more abundant in upper part; weathers tan to medium light gray, sandy surface, platy float; well-preserved fusulinids, cup corals abundant at base	4	67
5.	Quartzite and limestone, interbedded; (quartzite) calcareous cement (limestone) sandy; covered slope	6	61
4.	Limestone, medium-gray, fine-grained to sandy, medium-bedded; weathers light blue gray, sandy surface; abundant fusulinid, brachiopod, bryozoan, crinoid assemblage USGS colln. f226ll at base, "Coarse bioclastic limestone with fragments of foraminifera including *Bradyina* sp., and *Pseudofusulinella* sp." USGS colln. f22612 at 1 m, "Fine sand with fragments of *Triticites* sp. The age suggested is Late Pennsylvanian, Missouri equivalent." (R.C. Douglass, written commun. 7/20/62)	2	59
3.	Quartzite and limestone, interbedded; light gray tan to olive brown, sandy, calcareous cemented, medium-bedded, locally banded and crossbedded quartzite, and medium-gray platy limestone; weathers yellow brown to reddish brown, thick surface rind (quartzite) and light gray (limestone); mostly covered slope	55	4
2.	Limestone, medium-gray, sandy, medium-bedded; weathers light tan gray; abundant crinoids, cup and *Syringopora* corals and fusulinid fauna USGS colln. f22610 at 2 m, "Fine sand with scattered fragments of *Triticites* sp. The age suggested is Late Pennsylvanian, Missouri equivalent." (R.C. Douglass, written commun. 7/20/62).	3	1
1.	Limestone, medium dark-gray, fine-grained thin-bedded, locally laminated; weathers blue gray, sandy surface; top .3 m brecciated and cemented with white calcite	1	
	Total Salvation unit measured		832

Conformable contact.

Rush Lake unit, Oquirrh Group (upper beds only)

Quartzite, calcareous cement, interbedding limy sandstone

IPrl **Rush Lake unit**--Type locality on South Mountain borders Rush Lake and contains nearly 1,352 m of interbedded limestone, quartzite, and occasional shale of Middle Pennsylvanian age. Only the uppermost portion of the unit is exposed in the Stockton mining district. Limestone predominates and is generally medium-gray, medium-bedded, locally with shale partings, moderately fossiliferous, often sandy, silty, or bioclastic and crossbedded, frequently argillaceous, and contains black chert nodular layers. Infrequent sparse light-gray, thin-bedded and fissile shale layers mostly in limestone units. Quartzite units, which often contain thin limestone parting are buff-tan, coarse sandy, medium-bedded, locally crossbedded, often pitted surfaces, local interbedded punky ferruginous layers with worm trails. The characteristics of the unit lithology in this sequence is detailed in the following measured section. These rocks are are correlative with the upper part of the Butterfield Peaks Formation, but the thick cyclic repetition of limestone, sandstone, and shale of the Butterfield Peaks Foundation, described by Tooker and Roberts (1970), are absent

Stratigraphic section of the Rush Lake unit in the South Mountain sequence, Oquirrh Group, measured on South Mountain along the main ridge across S-1/2 sec. 22 and N-1/2 sec. 21, T. 4 S., R. 5 W., Stockton 7-1/2-minute quadrangle, Utah.

[Measured by R.J. Roberts and E.W. Tooker, October, 1961]

Salvation unit, Oquirrh Group (lowest beds only):

Limestone, medium dark-gray, thin bedded, locally laminated

Contact conformable

Rush Lake unit, Oquirrh Group:

	Thickness (meters)	Distance above base (meters)
37. Quartzite, light gray-tan, sandy, mostly calcareous cement, thin interbedded limy sandstone and sandy limestone partings and layers in upper part; worm trails in thin ferruginous layers and brachiopods, crinoids, and fusulinids, in		

	Thickness (meters)	Distance above base (meters)
limestones; weathers light brown tan to yellow gray, slight local pitting; brachiopod shells and spines, crinoid fragments in limestone, and fusulinids in sandy limestones near top; mostly covered slope	182	1,170
36. Limestone, medium dark-gray, fine-grained, medium-bedded, black chert nodules and lenses; weathers medium gray, chert weathers brown and stands in relief; partly covered slope	1	1,169
35. Quartzite, light gray-tan, sandy, calcareous-cemented, interbedded sandy limestone and limy sandstone layers and partings, in part banded near top; weathers brown with thick surface rind; covered slope	150	1,019
34. Limestone and quartzite, interbedded; sandy limestone and silica and calcareous-cemented fine-grained to sandy quartzite, local ferruginous sandstone and fine-grained sandstone layers; mostly covered slope	133	8861
33. Limestone, medium dark-gray, fine-grained, medium- to thick-bedded; weathers dark blue-gray, rough pitted surface; abundant well-preserved *Syringopora* and cup corals, brachiopods, and fusulinids USGS colln. f22609, "Silty bioclastic limestone with *Tetretaris* sp., *Millerella* sp., textularids, *Bradyina* sp., and *Wedekindellina* sp. The age suggested a Middle Pennsylvanian, late Des Moines equivalent." (R.C. Douglass, written commun., 7/20/62)	2	884
32. Quartzite, medium-gray, sandy, mostly calcareous cement, medium-bedded with interbedded thin silica-cemented quartzite, interbedded thin sandy limestone layers in middle part, banded in upper part, crossbedded locally; weathers reddish tan, platy to blocky float, in part pitted; sandy limestone contains sparse well-preserved fusulinids and *Syringopora* and cup corals at 52+ m; mostly covered slope	111	773
31. Quartzite, tan-gray, sandy, cemented by silica; covered slope	10	763

	Thickness (meters)	Distance above base (meters)
30. Limestone, medium light-gray, fine-grained and silty to sandy, thin-bedded with interbedded thin (up to .3 m) calcareous quartzite layers, black chert nodules locally abundant; weathers yellow gray to tan, platy; covered slope	12	751
29. Limestone, medium dark-gray, fine-grained, thin- to medium-bedded, very thinly laminated in part, sand partings locally, black chert nodules and lenses moderately abundant; weathers medium blue gray, platy; well-preserved brachiopods are sparse, worm trails in yellow weathered limy sandstone at 53 m; covered slope	57	694
28. Quartzite, buff-tan, coarse-sandy, mostly calcareous cement, medium-bedded, banded with minor crossbedding, shaly limestone partings, thin interbedded limestone layers in basal part; weathers reddish tan, thick 5-cm partly ferruginous, porous weathered, rind, pitted surface in more silicified beds; sparse silicified *Syringopora* coral in limestone at base; mostly covered slope	91	603
27. Limestone, medium dark-gray, fine-grained to silty, shaly and thin-bedded; sandy limestone partings; weathers medium light gray; common well-preserved crinoid, bryozoan, and brachiopod assemblage; mostly covered slope	7	596
26. Limestone, medium-gray, fine-grained, dense, medium-bedded to massive, local laminar bands; weathers blue gray, pitted surface; sparse, well-preserved silicified brachiopods, corals, and crinoid fossils; prominent outcrop	12	584
25. Quartzite, light gray-tan, sandy, silica-cemented, banded in part, interbedded ferruginous sandstone layer at 8 m weathers brown to light tan brown; covered slope	25	559

	Thickness (meters)	Distance above base (meters)
24. Shale, light-gray, silty, thin-bedded, interbedded thin banded quartzite and sandy limestone beds; weathers buff to light reddish brown gray, platy covered slope	70	489
23. Quartzite, light tan-gray, sandy, calcareous cement, medium-bedded; weathers tan to light brown; partly covered slope	16	473
22. Limestone, medium-gray, sandy, thin-bedded at base, medium-bedded toward top, sand partings and laminae in lower part, medial 1-meter quartzite layer; weathers light gray, platy float	3	470
21. Quartzite, light gray-brown, sandy, calcareous cement, medium-bedded; weathers tan	7	463
20. Limestone, dark-gray, fine-grained, medium-bedded, dense; weathers light blue gray, pitted surface	1	462
19. Quartzite and sandstone, medium brown-grey, sandy, calcareous and ferruginous cement, medium-bedded; weathers tan and dark brown	9	453
18. Limestone, medium-gray, fine-grained to sandy, medium-bedded, crossbedded locally; weathers light gray, platy float; sparse, well-preserved small cup corals	5	448
17. Quartzite, light gray-tan, sandy, silica-cemented, medium-bedded, a .6 m interbedded sandy limestone with crossbedded sandy partings at top; weathers tan, very thin surface rind, slope and ledge outcrops	14	434
16. Quartzite, light gray-tan, coarse grained sandy, calcareous-cemented, medium-bedded to massive; weathers light brown, thick porous surface rind, blocky float	9	425
15. Limestone, medium-gray, silty, medium-bedded; weathers yellow gray to buff, platy; well-preserved, abundant, crinoid, bryozoan, productid, and spiriferid brachiopod fauna USGS colln. 224387-PC at 23 m, "*Derbyia* aff. *D. crassa* (Meek and Hander), *Neochoneltes* sp., *Grandaurispina* sp., *J urasania* cf. *J. nebrascensis* (Owen), *Cancrinella* cf. *C. broonensis* (Swallow), *Crurithuris* cf. *C. planoconvexa* (Shumard), *Condtathyris perplexa* (McChessney), *Hustedia mormoni* (Marcou), *Composita* ? sp. indet. (fragment), *Beecheria* cf. *B. bovidens* (Morton), *Paralleolodon* ? sp indet., and *Ammonoid* indet. (juvenile). The age of this		

		Thickness (meters)	Distance above base (meters)
	collection of small silicified fossils is Middle Pennsylvanian (Des Moines), although it can also be somewhat younger Pennsylvanian." (Mackenzie Gordon, Jr., written common. 10/14/66)). Mostly covered slope	27	368
14.	Quartzite, light-gray, sandy, silica-cemented, thin- to medium-bedded, banded in part; weathers reddish light gray, hard conchoidal fracture; partly covered slope	30	368
13.	Limestone, medium dark-gray, fine-grained to silty, thin-bedded; weathers light gray tan; common well preserved fenestrate bryozoans and productid and spiriferid brachiopods; mostly covered slope	1	367
12.	Quartzite and limestone, interbedded; thin laminated platy sandy limestone and blocky quartzite, medium bedded; covered slope	9	358
11.	Limestone, dark-gray, fine-grained, medium-bedded; weathers blue gray, smooth surface	1	357
10.	Quartzite, tan-gray, calcareous-cemented quartz grains, medium-bedded; weathers tan to light brown with thin softer weathered surface rind, platy to blocky float; covered slope	3	354
9.	Sandy limestone and quartzite, interbedded; medium gray (limestone) and tan gray (quartzite), sandy, thin- to medium-bedded, black chert nodules with sandy margins locally; mostly covered slope	36	318
8.	Quartzite and shaly limestone, interbedded; well-preserved bryozoans and crinoid stems in limestone; covered slope	13	305
7.	Shaly limestone, medium dark-gray, silty, thin-bedded to platy at top; weathers purple gray and medium gray; brachiopods, bryozoans at base; mostly covered	36	269
6.	Limestone, medium-gray, medium- to fine-grained, medium-bedded; weathers medium light gray, rough pitted surface, fossils rare	3	266

		Thickness (meters)	Distance above base (meters)
5.	Sandstone, reddish-brown and tan, sandy, calcareous cement to part, medium-bedded; weathers light brown tan; mostly covered slope	7	259
4.	Quartzite, brown-tan, sandy mostly silica cemented quartz grains, but is slightly calcareous, medium-bedded with thin interbeds of calcareous sandstone; weathers light brown tan with smooth surface; upper part covered slope	31	228
3.	Limestone, medium-gray and tan, silty and sandy, thin platy and medium-bedded, in part with black chert nodules, in part bioclastic, interbedded with thin (5 cm) quartzite and shale partings; weathers medium light gray brown and yellow brown; fenestrate and stem bryozoans, and brachiopods locally abundant	27	201
2.	Limestone, medium-gray, silty to sandy, thin and platy to medium-bedded,, interbedded shaly and sandy units, crossbedded in part, locally thin interbedded cherty limestone units; weathers medium light gray and yellow brown; bryozoans USGS colln. 61F70A at 169 feet, "Fistuliporoid (?) bryozoan, indet., *Fenestella* sp., *Polypora* sp., *Archimedes* sp. (fragments of fronds), *Penniretepra* sp., rhomboproid bryozoans, crinoid columnals, *Juresania* sp. indet." Fauna is compatible with Des Moines age of section." (Mackenzie Gordon, Jr., written commun. 10/14/66)	30	171
1.	Limestone, medium-gray, fine-grained to sandy, thin-bedded, and distinctly laminated and locally convoluted, to medium-bedded, black chert nodules moderately abundant in medium-bedded rock, shale partings common and sandy bioclastic rock locally abundant, weathers medium light gray, chert nodules to light sandy brown; locally brecciated medium sandy layers; fossiliferous with coral bryozoan, and crinoid stems, and small brachiopods USGS colln f22608 at 3 m, "Bioclastic limestone with *Bradyina*, textularids, and *Fusulina* sp. The age suggested is Middle Pennsylvanian, late Des Moines equivalent." (R.C. Douglass, written commun. 7/20/62)	171	
	Total Rush Lake unit measured	1,352	

Conformable contact (?), lower part of the Rush Lake unit is covered by alluvium.

CORRELATION OF MAP UNITS

The correlation of all rock units mapped thus far in both the Stockton and Lowe Peak quadrangles are shown on the individual maps.

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