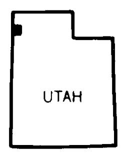
GEOLOGIC MAP OF THE LUCIN QUADRANGLE, BOX ELDER COUNTY UTAH

By David M. Miller
U.S. Geological Survey



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INTRODUCTION

The Lucin quadrangle is located in northwestern Utah about 3 km (1.8 mi) east of the Nevada-Utah border and about 65 km (40 mi) south of the Idaho-Utah border. Part of the northern end of the Pilot Range and nearby hills to the east are exposed within this quadrangle. The Pilot Range is a north-trending, fault-bounded mountain range, typical of the ranges in the northern Basin and Range Province (Cook and others, 1964). In this range, sedimentary rocks typical of the Cordilleran miogeocline were deposited during Late Proterozoic and Paleozoic time. The area was the site of igneous intrusion, metamorphism, folding, and low-angle faulting during Mesozoic time. Cenozoic high- and low-angle faulting, igneous activity, and local metamorphism modified the Mesozoic structures, commonly making their recognition difficult.

Stratigraphic and structural studies were undertaken in the Pilot Range as part of a project to investigate the Mesozoic and Tertiary tectonics of northwestern Utah. This work and previous geologic mapping by Blue (1960) in the northern Pilot Range and by Doelling (1980) east of the range have revealed that complicated Mesozoic and Tertiary faults control the present distribution of sedimentary, metamorphic, and igneous rocks. Radiometric dating of low-grade metamorphic rocks and of plutons in the Pilot Range allowed partial resolution of the Mesozoic and Cenozoic structural and thermal history (Hoggatt and Miller, 1981).

The Lucin quadrangle is one of a series of maps that describe stratigraphic and structural relations in the Pilot Range (fig. 1). Mapping these quadrangles has revealed a chronology of Mesozoic metamorphism, low-angle faulting and folding, and Tertiary low- and high-angle faulting (Miller and Schneyer, 1983).

Bald Eagle Mountain, at 2447 m (8028 ft) the highest point in the northern end of the Pilot Range, lies one km (0.6 mi) west of the Lucin quadrangle. To the east, the lowlands, ranging from 1890 to 1330 m (6200 to 4360 ft), are underlain in part by a pediment consisting of Tertiary granite and strata. Surficial deposits of Pleistocene Lake Bonneville occur at the lowest elevations. Abrupt boundaries between the mountains and lowlands in the Lucin quadrangle are typical of Basin and Range physiography.

STRATIGRAPHY

Proterozoic and Paleozoic strata in the Pilot Range belong to the Cordilleran miogeocline. Cenozoic deposits include thick Tertiary lacustrine deposits and felsic volcanic rocks, and varied Quaternary deposits. Detailed descriptions and discussions of problematical aspects for some of these stratigraphic units are given in this section; additional data are given by Miller and Lush (1981), Miller and others (1982), and the companion report on the Tecoma quadrangle (Miller and Schneyer, 1985).

GARDEN CITY FORMATION (ORDOVICIAN)

Thinly interbedded and laminated blue-gray limestone, gray and brown silty limestone, and brown calcareous limestone.

This thick formation underlies most of Gartney Mountain and pediments south of the mountain. It is complexly folded, making stratigraphic subdivision difficult. In general, the lower part of the formation is composed of silty limestone and siltstone showing abundant trace fossils and crinoid fragments, and having diagnostic edgewide conglomerate and thin beds of pisoliths and rounded chert and quartz sand grains. The upper part is bluish-gray, thick-bedded limestone that underlies the high parts of Gartney Mountain. Local zones of black to dark brown dolomite and jasperoid occur at Lion Mountain.

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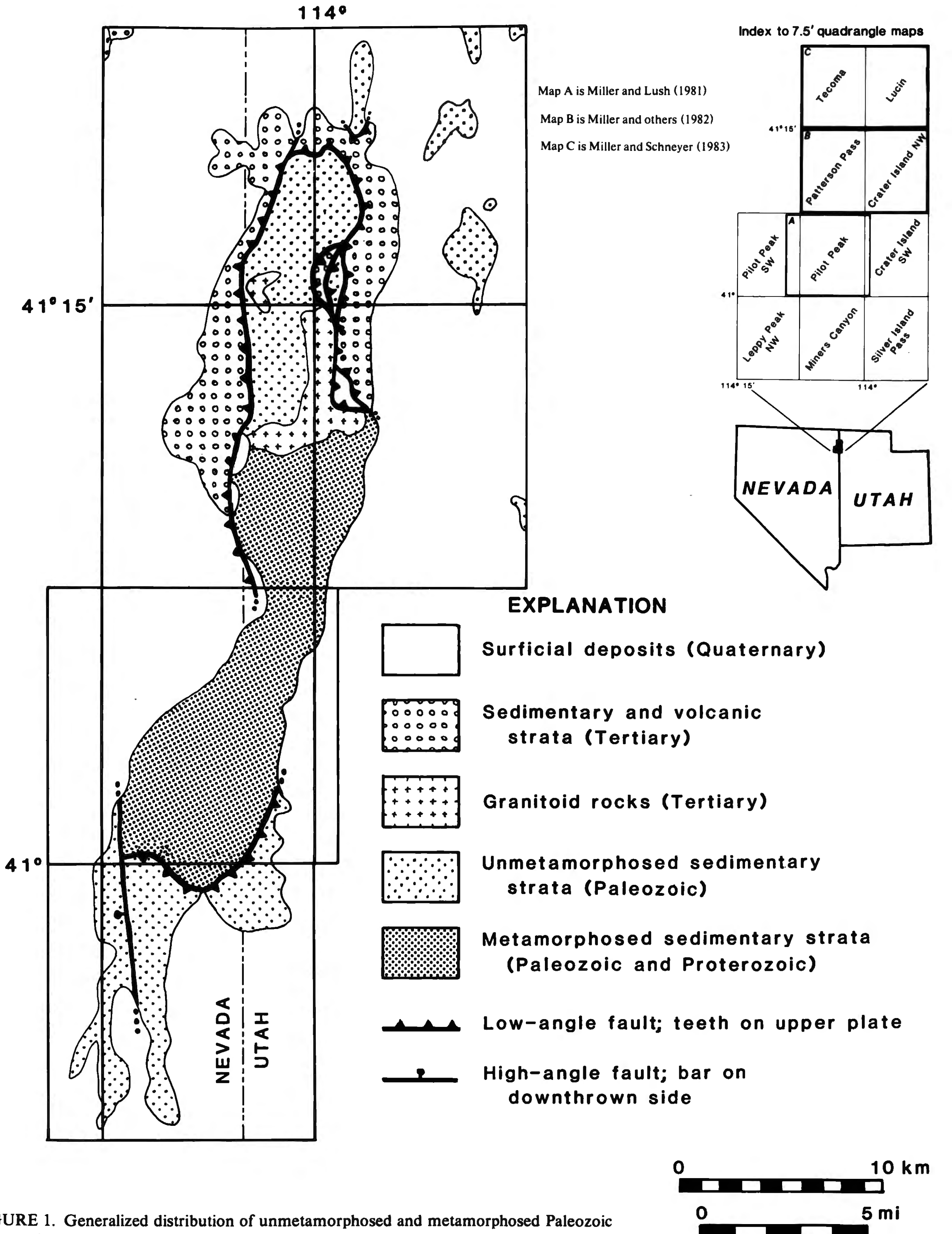

FIGURE 1. Generalized distribution of unmetamorphosed and metamorphosed Paleozoic strata in the Pilot Range.

EUREKA QUARTZITE (ORDOVICIAN)

A white and light gray, vitreous, medium-grained orthoquartzite weathering to orange-brown patina with trace amounts of hematite present as grains and cement. Well-sorted and well-rounded quartz sand grains indented by pressure solution, partly recrystallized in places; grains cemented by syntaxial overgrowths; generally well bedded and cross laminated.

Cliff-forming Eureka Quartzite crops out in an isolated area southwest of Indian Spring and in several prominences in Lion Mountain. In most exposures the quartzite is highly fractured and bedding is not discernible.

ELY SPRINGS DOLOMITE (ORDOVICIAN)

Medium-gray to black, poorly bedded and fractured, massive calcareous dolomite weathering dark- to medium-gray.

The basal dark dolomite, medial white-spotted burrowed dolomite, and upper light-gray dolomite of the Ely Springs Dolomite is exposed in faulted segments at Lion Mountain and at one place about 1 km (1/2 mile) southwest of Indian Spring. At Lion Mountain the upper part of the formation is truncated by a fault approximately parallel with bedding that places rocks probably correlative with the Roberts Mountains Formation, herein assigned to the thick-bedded dolomite unit, above the Ely Springs.

THICK-BEDDED DOLOMITE (DEVONIAN AND SILURIAN)

Grayish-white, light- and medium-gray, poorly bedded to structureless dolomite and calcareous dolomite. Upper part white to light gray and structureless. Middle part mostly medium gray, poorly bedded, and crinoid-bearing, with some light-gray and dark-gray layers. Lower part light gray and containing sparse chert nodules.

A thick section of generally light-colored, nearly structureless dolomite underlies the Simonson Dolomite. Neither the distinctive tripartite division of the Laketown Dolomite, nor the laminations characteristic of the Sevy Dolomite are present in the thick-bedded dolomite unit. Silty, platy limestone within the thick-bedded dolomite unit in the southern Pilot Range and in the nearby Silver Island Mountains (Sheehan, 1979; Sheehan and Pandolfi, 1983) suggests that the thick-bedded dolomite unit might be broadly correlative with the Roberts Mountains Formation and Lone Mountain Dolomite. However, platy limestone does not crop out in the northern Pilot Range, with the exception of a fault(?) slice of platy, silty dolomite about 6 m thick which locally occurs above the Ely Springs Dolomite northeast of Copper Mountain in the Tecoma quadrangle. It is likely that the thick-bedded dolomite unit is partly equivalent to the Laketown and Sevy to the east and partly to the Roberts Mountains and Lone Mountain to the west (Poole and others, 1977); in the Pilot Range there is an intertonguing of these facies.

A disconformity evidently occurs between the thick-bedded dolomite unit and the overlying Simonson, because the upper beds of the thick-bedded dolomite unit are Early Devonian and (or) Late Silurian (Miller and others, 1982). The lower part of the thick-bedded dolomite unit is typically truncated structurally, but it rests concordantly on Ordovician strata at Quartzite Canyon in the Tecoma quadrangle. Silurian strata are not positively identified in the northern Pilot Range, but are presumably present, based on correlation of this unit with Silurian and Devonian strata nearby (Sheehan, 1979).

SIMONSON DOLOMITE (DEVONIAN)

Interlayered dark- to medium-gray and light-gray calcareous dolomite; forms steep slopes with distinctive alternating light and dark bands. Medium to thick bedded; most beds finely laminated, but a few beds are extensively bioturbated. Contains beds of Amphipora *sp.*

The generally dark, finely laminated dolomite assigned to the Simonson Dolomite sharply contrasts with the underlying pale, nearly featureless thick-bedded dolomite and the overlying pale-weathered cliffs of black limestone assigned to the Guilmette Formation. Blue (1960) considered the Simonson to be Middle Devonian in age on the basis of stromatoporoids and brachiopod fragments. In the southern Pilot Range, a Middle Devonian age has been established for the uppermost part of the Simonson on the basis of conodont collections (Miller and others, 1982).There, the lowermost part of the unit is considered latest Early Devonian or earliest Middle Devonian on the basis of conodont identifications (A. G. Harris, 1983, written commun.).

GUILMETTE FORMATION (DEVONIAN)

Dark-gray, blue-gray, and black, cliff-forming limestone; weathering light-gray to white. Well bedded or laminated throughout; fossiliferous and contains abundant algal structures. Sedimentary breccia and soft-sediment slump features common. Lower part commonly contains stringers and beds of dolomite. Quartz sandstone beds and sandy limestone occur near top, as indicated by dot-dash lines. Minor diagenetic gray-brown chert occurs in irregular blebs and stringers. Base of formation drawn at bottom of cliff-forming limestone and dolomite and at top of steep slope-forming Simonson Dolomite.

Massive limestone cliffs typify exposures of the Guilmette Formation in the Lucin quadrangle. Zones of calcareous and quartzose sand at the top of the Guilmette are well developed. Beds of quartz sandstone as much as 8 m (25 ft) thick occur in the upper part of the Guilmette where it crops out along the eastern flank of Bald Eagle Mountain. Outcrops of the Guilmette about 1 km (0.6 mi) west of Lucin Hill contain thick sandstone beds that consist of well-rounded quartz grains in a calcareous matrix. Here, corals and brachiopods collected from a limestone bed 30 m (100 ft) below the sandstone beds are early Late Devonian in age (table 1, sample 6). The lower part of the Guilmette is dolomitized at Lion Mountain; as a result, the location of the basal contact with underlying dolomite units is imprecise.

TRIPON PASS LIMESTONE (MISSISSIPPIAN)

Dark-gray to black, regularly bedded, silty limestone and subordinate interbeds of calcareous siltstone. Weathers light-gray with a pinkish hue.

The Tripon Pass Limestone typically forms rounded, grassy slopes that are covered by light-gray, fissile to platy, cleaved limestone fragments. Less common are cliffy exposures of medium- to thin-bedded limestone. Worm burrows, crinoids, and rare bryozoan fragments are present locally, but the unit is generally remarkably unfossiliferous. Rusty-colored, sand-bearing laminae occur locally, and brown chert nodules occur locally near the top of the unit. The unit was designated the "shaly limestone member" of the Guilmette Formation by Blue (1960) in the absence of paleontologic data. Conodonts collected from the Tripon Pass Limestone in the Patterson Pass quadrangle (Miller and others, 1982) are Early Mississippian (Kinderhookian). Reworked Ordovician conodonts in one sample open the possibility that the Mississippian conodonts may also have been redeposited.

The Tripon Pass tectonically rests on the Guilmette Formation or intervening siliceous breccia. It is rarely more than 10 m (30 ft) thick in the Tecoma quadrangle, in contrast with sections greater than 400 m (1300 ft) thick just 3 km (2 mi) to the south.

The Tripon Pass Limestone in the Pilot Range is similar to the Tripon Pass Limestone exposed 40 km (25 mi) to the west in the Pequop Mountains (Poole and Sandberg, 1977) but differs from the temporally equivalent Joana Limestone exposed in the nearby Silver Island Mountains. There, the Joana Limestone is a dark, cliff-forming, bioclastic limestone containing only minor silt, and it is much thinner than the Tripon Pass Limestone (Schaeffer,1960; Poole and Sandberg, 1977).

CHAINMAN SHALE AND DIAMOND PEAK FORMATION, UNDIVIDED (MISSISSIPPIAN)

Dark-gray, dark-brown, and black siliceous sandstone and brown-weathering conglomerate, both containing quartzite, quartz, black and green chert, feldspar clasts, dark-gray shale, and tan to gray siltstone. Medium to thick bedded; conglomerate beds are 0.5 to 2 m (1.5 to 7 ft) thick and form cliffs and resistant ledges. Shale and sandstone form brown slopes.

Quartzite, with subordinate gray shale and siltstone, and heterolithic conglomerate crop out as a slope-forming, dark-weathering unit. Sandstone clasts are dominantly three types: (1) well-rounded undeformed quartz, (2) subrounded to subangular dark chert or siliceous siltstone, and (3) subangular to angular quartz with undulatory extinction. Rare plagioclase also occurs. The sandstone matrix is composed of fine sand- to silt-sized quartz and clay. Medium-gray shale, as much as 20 m (65 ft) thick, contains bryozoan and brachiopod fragments. Conglomerate is silicified and resistant, containing clasts of chert, sandstone, calcareous sandstone, and jasperoid. Clast diameters are generally 3 to 6 cm (1 to 3 in) and the maximum diameter is 20 cm (8 in).

The undivided Chainman Shale and Diamond Peak unit is cut by a low-angle fault at its structural base where it is juxtaposed with the Mississippian Tripon Pass Limestone, silicified breccia, and Guilmette Formation. This contact is interpreted as a low-angle fault, rather than an unconformity, because (1) beds of the Tripon Pass Limestone below the contact are tightly folded and discordant with it, and (2) much or all of the undivided Chainman and Diamond Peak is truncated along much of its strike length, and yet no anomalous facies indicative of 150 to 200 m (500 to 650 ft) of relief on an unconformity are present in the unit.

Blue (1960) described fauna from shale in the northern Pilot Range that were identified as Late Mississippian in age. Poole and Sandberg (1977) described locations west of the Pilot Range for which an Early Pennsylvanian age for the upper part of the Diamond Peak has been established, but, in the absence of paleontological data, the undivided Chainman Shale and Diamond Peak unit in the Pilot Range is considered to be entirely Mississippian.

PEQUOP(?) FORMATION (PERMIAN)

Predominantly laminated to thin-bedded, platy, charcoal-gray, silty limestone; interbedded with laminae and thin beds of tan to brown siltstone. Lower part commonly siltstone. Some limestone beds are bioclastic grainstone containing crinoid fragments, spirifer brachiopods, and recrystallized fusulinids. Typically forms tan-weathered grassy slopes.

The Pequop(?) Formation in the Lucin quadrangle typically forms gentle slopes covered by dark-gray, platy, silty limestone fragments. The section varies greatly in thickness and in many locations it is bounded by low-angle faults below and above. Brecciation and local bedding discordances within the section indicate the presence of low-angle faults.

The Pequop(?) Formation has been divided into three informal members: a lower calcareous siltstone to silty limestone member; a middle black, platy, silty limestone member with debris flow beds of fossil "hash"; and an upper, coarsely bioclastic limestone member. The lower member is at most 15 m (49.2 ft) thick and is gradational into overlying platy, dark-gray to black, silty limestone of the middle member. The middle member is characterized by thin bedding, decreasing silt upward, and irregularly spaced resistant debris flow beds bearing abundant shell fragments. The upper member consists of coarse bioclastic limestone in thick beds with lesser silty limestone interbeds. The upper member is as much as 100 m (320 ft) thick but typically is truncated at its top.

The lower member of the Pequop(?) Formation is of uncertain age. It is lithologically similar to the Wolfcampian and lower Leonardian Buckskin Mountain(?) Formation that occurs beneath the Pequop(?) Formation in the Leach Mountains (Martindale, 1981) and to the Third Fork Formation in the Cassia Mountains (Mytton and others, 1983). Because the lower member is thin and is exposed only sporadically in the northern Pilot Range, it has not been mapped as a separate unit. If the above lithologic correlations are correct, the member is Wolfcampian and Leonardian; the upper part of this member, present in the Pilot Range, may be entirely Leonardian.

Fossils collected from the middle and upper members in the Pilot Range yield Early Permian ages (table 1, samples 3, 4, 5). The middle and upper units are correlated on the basis of lithology and age with the Pequop(?) Formation in the Leach Mountains (Martindale, 1981). They also probably correlate with the Badger Gulch and Trapper Creek Formations (Mytton and others, 1983).

CHERT AND DOLOMITE (PERMIAN)

Siliceous, light and medium gray, thin- to medium-bedded dolomite and quartz sandstone. Quartz sandstone is fine-grained, cemented by calcite or dolomite, and commonly silicified; brown where weathered. Dolomite is sandy, well-bedded, and rarely fossiliferous. Contact with the Underlying Pequop (?) formation mapped as a fault at base of lowest silicified bed.

Highly silicified dolomite and sandstone that are typically thick- to thin-bedded and have a cherty appearance are found at the top of the Paleozoic stratigraphic section. Rare fossils include crinoid fragments, silicified brachiopods(?), and possible silicified fusulinids. Locally, cryptalgal laminae and worm burrows are identifiable in the dolomite, and the sandstone is cross-laminated. The unit is highly fractured and gently folded but appears to overlie the Lower Permian Pequop(?) Formation conformably in a few places because the units are gradational. In many other places there is a distinct lithologic break between the units, and brecciated and truncated beds suggest a low-angle fault.

The chert and dolomite unit correlates with the lithologically similar, but thicker, Grandeur(?) Formation of the Park City Group in the Leach Mountains (Fedewa, 1980; Martindale, 1981). However, this unit cannot be precisely correlated with the type Grandeur Formation, and therefore the chert and dolomite unit in the Pilot Range is left unnamed at present. Other possible equivalent rock units in the area are the Kaibab Limestone of the Park City Group (Wardlaw and others, 1979), and part of the Trapper Creek Formation (Mytton and others, 1983).

Conodonts collected near the faulted base of the unit indicate an early Leonardian age in one case (B.R. Wardlaw, 1982, written comm.) and late Leonardian in another (table 1, sample 2). This difference in ages raises three possibilities: 1) a low-angle fault forms the structural base of the unit and cuts obliquely across beds, thus placing different parts of the section on underlying units; 2) the chert and dolomite unit as mapped herein represents a zone of secondary silicification and dolomitization that transgresses primary lithostratigraphic boundaries; or 3) the base of the unit is sharply time-transgressive. The possibility that the depositional base of the unit is sharply time-transgressive is unlikely because over much of Utah, Nevada, and Idaho the age of the basal units is about uniform. Mytton and others (1983) noted that in the Cassia Mountains of southern Idaho the Grandeur Tongue of the Park City Formation is late Leonardian, and underlying silicified limestone of the Trapper Creek Formation is early Leonardian. The Trapper Creek Formation may be equivalent to part of the chert and dolomite unit in the Pilot Range area. However, at Lemay Island, about 15 km (9 mi) southeast of the Tecoma quadrangle, silicification and dolomitization of the Pequop(?) Formation locally make the Pequop(?) difficult to distinguish from the chert and dolomite unit. Silicification of the upper part of the Pequop(?) Formation also occurs in the northwestern part of the Leppy Range in the southwestern Silver Island Mountains (J.D. Schneyer, 1983, unpubl. mapping). The discordant age data for the base of the chert and dolomite unit are therefore interpreted to indicate that the formation as mapped herein may transgress primary lithostratigraphic boundaries and may thus include parts of other formations. This boundary also has been modified by bedding-plane faulting in most places.

OLDER TUFF (OLIGOCENE)

Interlayered vitrophyre, tuff breccia, and white altered tuff; green flow-banded rhyolite. Tuff contains grains of sanidine, plagioclase, quartz, and biotite in chalky, siliceous to clayey matrix of altered ash. Flow-banding and rounded quartz grains occur in rhyolite flows. Minimum thickness about 600 m (1,965 ft). Poorly sorted conglomerate interbedded with volcanic rocks contains clasts of siliceous Paleozoic rocks and Tertiary volcanic rocks. About 37 m.y. old.

This unit consists of predominantly felsic volcanic rocks occurring in the southwestern part of the quadrangle and is presumably entirely Oligocene in age. Included in the older tuff unit are white to pale green tuff, rhyolitic lava flows, tuff breccia, and vitrophyre. Igneous textures and minerals in these rocks are well preserved. There are few signs of redeposition in the tuffaceous rocks, in strong contrast with the younger tuffaceous rocks of the sedimentary rocks unit (Ts). Biotite from crystal-rich tuff making up most of the sequence southwest of Indian Spring gave a K-Ar date of 36.9 ± 1.1 m.y. (W.C. Hillhouse, written comm, 1983).

SEDIMENTARY ROCKS, WELDED TUFF, AND VITRIC TUFF (MIOCENE)

Sedimentary rocks

Lithified, but generally non-resistant green and brown fanglomerate; lake deposits including conglomerate, sandstone, siltstone, and limestone; and uncommon thin interbeds of altered white, waterlain vitric tuff. Lake deposits generally siliceous, thin bedded, fine grained, and rich in volcanic glass; coarse-grained alluvial deposits occurring in lower part of section are poorly sorted and bouldery. Silicious limestone is silty, dark brown, and thin bedded. Marker units of pebble conglomerate *containing clasts of lineated metaquartzite indicated by dot-dashed line. Greater than 3,000 m (9,900 ft) thick.*

Welded tuff

Welded sanidine rhyolitic tuff 10 to 20 m (30 to 60 ft) thick and underlying 3 m-thick black vitrophyre, commonly perlitic. About 12 m.y. old.

Vitric tuff

White to light-gray, thin- to thick-bedded (5 mm to 50 cm) vitric tuff containing no phenocrysts. Graded bedding, cross-stratification, and interbeds of silt and sand suggest subaqueous deposition. Thickness as much as 600 m (2,000 ft), but generally less than 200 m (650 ft); where thinner than approximately 20 m (65 ft), tuff is included in sedimentary rocks unit (Ts).

The section of heterogeneous sedimentary and volcanic rocks occurring adjacent to the northern Pilot Range is probably entirely Miocene but may include some Oligocene strata. Welded tuff (Twt) in the western part of the quadrangle is dated at 12.0 ± 0.7 m.y. (K-Ar age of sanidine, W.C. Hillhouse, 1984, written comm.). Other parts of the section are not directly dated in the Lucin quadrangle but, in the adjacent Tecoma quadrangle, rhyolite that is dated at 8.8 ± 0.3 m.y. old (W.C. Hillhouse, 1984, written commun.) and 8.6 ± 0.2 m.y. old (Armstrong, 1970) overlies much of the section.

The sedimentary rocks unit (Ts) consists of waterlain tuffaceous sandstone and siltstone. These rocks are predominantly thin-bedded, finely cross-laminated, well-sorted siltstone and sandstone with minor dark-green to black shale and green or brown silty limestone. Virtually all of the rocks contain fragments of volcanic glass. The sandstone and siltstone contain as much as 90 percent glass; these rocks are typically yellow to brown, platy, and hard. Rocks with no noticeable constituents other than volcanic glass are mapped as vitric tuff (Tvt); these rocks are typically porous and lightweight.

Five paleocurrent measurements, obtained from cross-bedding in conglomerate intertonguing with lacustrine siltstone, indicate deposition by south- to southeast-directed currents. These paleocurrent directions are generally consistent with clast composition of the conglomerate: lineated, flaggy quartzite and rare white marble present in the clast assemblage crop out in the Grouse Creek Mountains some 30 km (19 mi) to the northeast.

Depositional environments for the sedimentary rocks unit probably ranged from distal fan to lacustrine, with most of the siltstone and limestone exposed in the pediment on the east side of the Pilot Range being of lacustrine origin. Most rocks of the unit are fine grained, thin bedded to laminated, and have few high-energy sedimentary structures, suggesting deposition under quiet, perhaps shallow lacustrine, conditions.

LACUSTRINE GRAVEL (PLEISTOCENE)

Unconsolidated cobble, gravel, and sand that form shoreline deposits of Lake Bonneville. Clasts well rounded and well sorted, commonly with little matrix. Locally cemented by calcareous silt.

Beaches formed at the high stand (Bonneville level) of Lake Bonneville occur at 1,588 m (5,215 ft) elevation on the east side of the northern Pilot Range. Higher terraces near Coal Bank Spring may represent beaches from an older, higher stand of the lake at 1,615 m (5,300 ft) elevation. Beaches formed at the Provo level are at 1,470 m (4,820 ft) elevation. Spits and bars of lacustrine gravel at levels above and below the Provo level are prominent west and south of Lion Mountain.

UNDIFFERENTIATED LACUSTRINE AND ALLUVIAL DEPOSITS (HOLOCENE AND PLEISTOCENE)

Reworked alluvium and thin lacustrine deposits characterize this unit over most of its extent. In many areas the unit shows many small wave-cut benches cut into alluvial fans; these are particularly prominent in aerial photographs. Near the town of Lucin, and well-exposed in a gravel pit just north of the town, a series of non-alluvial deposits underlie the unit, but they cannot consistently be mapped as a separate unit. This section near Lucin is, from bottom to top: 1) pre-Lake Bonneville alluvial gravels, 2) yellowish-brown clay and silt representing deltaic or underflow fan deposits, 3) brownish-white marl representing deep-water deposits, 4) brown, poorly sorted sand representing regressive lake deposits, and 5) thin, reworked lacustrine and alluvial materials.

PLUTONIC ROCKS

Monzogranite of McGinty

Coarse-grained, white to gray, porphyritic monzogranite to granodiorite. Euhedral zoned phenocrysts of alkali feldspar, as large as 5 cm in maximum diameter, set in coarse-grained matrix of subhedral plagioclase and alkali feldspar (5 mm), subhedral quartz (8 mm), and biotite. Accessory hornblende, zircon, sphene, apatite, and xenotime(?). Biotite, generally 6 to 9 percent, is partially altered to chlorite. About 37 m.y. old.

A pluton ranging from monzogranite to granodiorite crops out extensively in the Lucin quadrangle. Here, and in adjacent quadrangles, the roof of the pluton dips gently on average, but locally it is irregular and has several tens of meters of relief. The pluton lacks foliation.

The monzogranite of McGinty was named for McGinty Ridge in the Crater Island NW quadrangle by Miller and Schneyer (1983); the name "monzogranite of Patterson Pass" used in the report on the Patterson Pass quadrangle (Miller and others, 1982) for the same pluton was changed by Miller and Schneyer to avoid conflicts with earlier usage of that name. The pluton was assigned a 32 ± 1.6 m.y. age (biotite K-Ar) by Coats and others (1965; recalculated with new constants) and a 36.6 ± 0.5 m.y. age (biotite K-Ar) by Hoggatt and Miller (1981).

STRUCTURAL GEOLOGY

Folds and faults in the pre-Quaternary rocks of the Lucin quadrangle are continuous with those described by Miller and others (1982), Miller and Schneyer (1983), and Miller and Schneyer (1985) in the adjacent Patterson Pass, Crater Island NW, and Tecoma quadrangles. These structures are divided into a pre-Oligocene group and an Oligocene and younger group.

PRE-OLIGOCENE FAULTS

Paleozoic strata in the Lucin quadrangle are cut by several low- and high-angle pre-Oligocene faults. Low-angle faults are generally bedding-plane faults and have produced both younger-over-older and older-over-younger juxtapositions of strata. Locally, minor folds with non-systematic orientations occur adjacent to low-angle faults. North of Indian Spring, Devonian and Mississippian rock units and their bounding bedding-plane faults are broadly folded into a rough domal shape. East-striking and north-striking high-angle faults in general cut the low-angle faults. These high- and low-angle faults are Eocene or older because they are intruded by the monzogranite of McGinty.

Bedding-plane faults in the north Pilot Range are localized at particular stratigraphic positions (section AA') and define three major structural blocks: a fault at the top of the Ely Springs Dolomite separates the lower and middle blocks, and a fault at the top of the Guilmette Formation separates the middle and upper blocks. Faults within the upper block occur commonly at the top of the Chainman Shale and Diamond Peak Formation (undivided) and the Pequop(?) Formation. Tectonic slices of siliceous breccia and the Tripon Pass Limestone occur in the fault zone at the top of the Guilmette. The faults bounding the Permian units are poorly exposed, but the units vary greatly in thickness, indicating significant structural modification. Stratigraphic intervals near the base and top of the Pequop(?) Formation typically are truncated, and bedding-plane faults are inferred at those locations. Small bedding-plane faults are probably pervasive throughout the Permian units.

Pre-Oligocene high-angle faults in the northern Pilot Range occur in generally east- and north-striking sets, but individual faults may have east, northwest, and north strikes. The east-striking high-angle faults produce moderate stratigraphic separations with the north sides down. In some cases different structural thicknesses of a given subunit are juxtaposed, suggesting that the faults are lateral ramps to bedding-plane faults at depth. North-striking faults have moderate strike separations and drop strata down on the west. The few northwest-striking faults are inconsistent in sense of separation.

The structural and stratigraphic sequences exposed at Lucin Hill (section BB') and Lion Mountain (section AA') are similar to those in the Pilot Range. At Lion Mountain, east-striking high-angle faults are apparently tear faults (lateral ramps) that connect with bedding-plane faults because they juxtapose sections of the Ely Springs Dolomite that drastically differ in structural thickness. Ramp and flat segments of a bedding-plane fault at the base of the Eureka Quartzite are exposed at Lion Mountain (section AA'). Here, the Eureka and overlying strata ramp across a faulted Ordovician section consisting of the Eureka and the structurally overlying Garden City Formation.

OLIGOCENE AND YOUNGER FAULTS

Paleogene and Neogene strata and Paleogene plutons are cut by moderate- and low-angle Oligocene and younger faults that apparently formed during at least two stages of movement: one or two early periods of listric(?) and low-angle faulting, and a later period of moderate-angle faulting that blocked out the present ranges. Although only two stages of faulting can be demonstrated, several episodes of movement on individual faults may have occurred. These Oligocene and younger faults can be distinguished from the pre-Oligocene faults by age, structural style, and spatial distribution. In most cases the faults cut the Oligocene monzogranite of McGinty and the Oligocene and Miocene strata. Many Oligocene and younger faults tend to outline major topographic breaks because they juxtapose units of different resistance and because, in part, they are youthful features responsible for the blocking-out of the ranges. The Oligocene and younger faults are generally north trending and moderately dipping, and may be marked by slices of brecciated Paleozoic limestone. Where they dip at low angles, these faults typically carry tilted Tertiary strata in the hanging wall. The faults generally crop out at the margins of the range.

Oligocene and younger faults in the northern Pilot Range occur in two distinct geographic and structural settings: on the west side of the Pilot Range (Tecoma quadrangle), where the faults dip moderately westward and bedding in the hanging-wall is inclined gently eastward and northeastward (Miller and Schneyer, 1985); and on the east side of the range, where the faults dip gently to moderately eastward and hanging-wall strata are moderately to steeply inclined eastward. The structures in the Lucin quadrangle are entirely within the eastern province. These two structural provinces join at the north end of the range where the strike of faults and of bedding in the hanging-wall strata in the eastern province change from north to northwest to west. In the area just west of the Lucin quadrangle, moderately tilted Tertiary strata on the east are juxtaposed with gently dipping strata on the west along an unexposed north-striking structure.

The eastern structural province is composed of two distinct areas, an inlier of Oligocene strata in part forming a valley within the range southwest of Coal Bank Springs, and the pediment largely consisting of Miocene strata which flank the range. The inlier consists of volcanic flows and minor sedimentary rocks which dip moderately eastward and are seen in outcrop to be slightly to moderately discordant to bedding in the underlying Permian strata. The basal contact of the Tertiary strata in the inlier is interpreted as a bedding-plane fault because coarse clast assemblages in basal tuff breccia beds contain few sedimentary clasts, none of which are derived from the adjacent Permian rocks, and because layering in Tertiary strata is locally discordant with the basal contact. A subparallel low-angle fault higher in the Tertiary section in the inlier (west of Indian Spring) displaces hanging-wall rocks westward relative to footwall rocks. This latter fault and strata of the inlier are cut on the east by a poorly exposed fault which places Paleozoic strata to the east against Tertiary strata to the west. One and one-half kilometers (1 mi) due west of Indian Spring, segments of this fault bounding the eastern margin of the inlier must dip moderately to steeply west, based upon topographic expression. Also at this location the fault forming the eastern margin of the inlier is possibly cut by the bedding-plane fault basal to the Oligocene strata. Two kilometers (1.2 mi) south of Indian Spring the inferred southern extension of this eastern inlier-bounding fault is nearly horizontal (maximum 15 degrees dip to the west). At this location the fault places Oligocene strata over Paleozoic strata and Oligocene granite. The Oligocene strata of the inlier thus appear to occupy a wedge-shaped structural block that is bounded on the east and west by equivalent (and therefore structurally repeated) Paleozoic sections (section BB'), a structural style that is distinct from the parallel bedding-plane faults of the older group of structures. An east-northeast-striking fault 2 kilometers (1.2 mi) southwest of Indian Spring that causes an apparent left-lateral offset of the basal fault of the inlier may be a tear fault because the Oligocene strata of the inlier change radically in structural thickness across the east-northeast fault. It is also possible that the block north of the east-northeast fault was dropped downward.

The relations described above for the fault-bounded Oligocene strata in the inlier suggest two interpretations. In the first interpretation, the inlier represents a klippe with a deep keel, and thus the bedding-parallel fault on its west margin is continuous with the steep fault on its east margin. In this first interpretation, fault-bounded Oligocene strata near the south boundary of the Lucin quadrangle represent fragments of the klippe, here emplaced on granite and subsequently faulted against Miocene strata on the east. In the second interpretation, the inlier represents a fault block of Oligocene strata which was transported on a nearly horizontal bedding-plane fault. The Oligocene strata and the basal bedding-plane fault were juxtaposed with Paleozoic strata on the east by a steeply east-dipping fault, and then all strata were rotated during Miocene or Pliocene faulting.

In the pediment, Miocene strata and minor Oligocene strata occur. These strata are juxtaposed with granite and Paleozoic rocks by faults that strike north and dip moderately eastward; these faults are better exposed southward along their extensions in the Crater Island NW quadrangle. Oligocene strata similar to those of the inlier locally occupy a fault-bounded position near the base of the thick Miocene section in the pediment in the southwest part of the Lucin quadrangle. Faults in the pediment bounding the top of the Oligocene rocks and near the base of the Miocene section dip moderately to the east in the Lucin quadrangle and continue into listric faults in the Crater Island NW quadrangle (Miller and others, 1982) which flatten eastward. The same faults curve northwesterly near the north end of the Pilot Range.

Cook and others (1964) inferred from gravity data that the low-density Tertiary section between the Pilot Range and Lion Mountain is about 750 m (2,500 ft) thick and that more than one fault caused a down-stepping of the higher density basement. One of these inferred faults may be exposed one kilometer (0.6 mi) south of Gartney Mountain, where the Miocene strata are in low-angle fault contact upon the Ordovician Garden City Formation. Repetitions of Paleozoic sections similar to those in the Pilot Range occur at Lion Mountain and Lucin Hill, placing some further constraints on the geometry of faults in the pediment area, but the data are sparse and subject to interpretation.

The timing of Oligocene and younger faults along the east side of the Pilot Range is poorly constrained. The faults bounding the inlier of Oligocene strata may be older than the range-bounding faults because they do not cut rocks younger than Oligocene and because they are apparently cut by faults parallel with the range-bounding faults. The range-front faults cut Miocene rocks and are, in part, contemporaneous with undated diabase that intrudes fault zones but is typically broken in these zones. Latest movement on the range-front faults is unknown. Whether the latest movement on the faults was listric or the youngest faults have broken across the Miocene or Pliocene structures is not known; the latter interpretation is given on the cross sections.

The observation that all of the Oligocene and younger faults place tilted sections of Tertiary strata on older rocks is consistent with current models for Basin and Range extensional tectonics. Regionally tilted strata require low-angle fault(s) at depth and the geometry of faults in the Pilot Range suggests that listric faults may be key elements in the deeper parts of the fault system. Differing amounts of eastward tilt on the east and west sides of the range (Miller and Schneyer, 1983) require either heterogeneous response to faulting, doming of the range during or after faulting, or multiple-stage faulting.

A heterogeneous response to faulting that would cause the observed dichotomy in tilts of Miocene strata, such as might occur across the headwall fault of a detachment province, is difficult to justify based on data in the Lucin quadrangle. However, the data do not specifically preclude such a model. Doming during and (or) after low-angle faulting which caused moderate tilting of Miocene strata is an attractive model because bedding in, and the fault basal to, the Miocene strata wrap around the range on the north. However, bedding inclinations for Paleozoic strata in the Pilot Range are uniformly eastward and thus show no evidence for doming. The doming model, attractive for its simplicity, is not fully supported.

A multiple-stage model for faulting calls for two or more episodes of pre-range-blocking faults which caused early eastward tilting. Such older faults must underlie the range at depth to account for tilting of Paleozoic strata. Tilt directions imply east-to-west movement on low-angle faults. Later faults that blocked out the range may have partly utilized the earlier faults. The latest movement on the faults bordering the range apparently was normal and down toward the basins. The expected later rotation of strata in the basins thus would be westward tilting on the east and eastward tilting on the west. This rotation, added to a previous uniform eastward tilt, should produce decreased tilt on the east, where the youngest normal faults essentially would have partially unrotated strata. Because the reverse relation is observed, with steepest dips on the east, it appears that the latest faults must be approximately planar along their upper few kilometers, as shown in the cross-sections. Therefore, the shallow flat faults on the east side of the Pilot Range are probably older than the deeper ones, and the shallow faults were rotated when faults at depth caused tilting of the Paleozoic strata. That these flat faults were initially at a higher angle and were rotated to gentle dips is suggested by their listric character, with the parts of the faults nearly parallel to bedding (such as in the inlier, section AA') presently tilted and the parts cutting bedding in hanging-wall strata presently flat.

ECONOMIC DEPOSITS

Considerable mining activity took place in the Copper Mountain area of the Lucin District (Blue, 1960; Doelling, 1980), parts of which occur in the southwestern corner of the Lucin quadrangle. Copper, gold, silver and lead were produced in quantity from the Lucin District, and the area is currently being explored. No other major commodities have been produced in significant quantities in the Lucin quadrangle, although small mines and prospects occur in a few places.

Other features with potential economic interest in the Lucin quadrangle are: (1) outcrops of the Eureka Quartzite in Lion Mountain, a potential source for pure silica; (2) jasperoid in the siliceous breccia that structurally overlies the Guilmette Formation, which is similar to mineralized jasperoid occurring 15 km (9 mi) to the north in the Tecoma mining district, and which has recently attracted much attention as a gold play; (3) deposits of well-sorted and rounded gravel along the shores of Pleistocene Lake Bonneville; (4) possible brines in groundwater east of Lion Mountain; (5) magnetite in diabase outcrops, commonly reworked at surface exposures as "black sands" (Doelling, 1980); (6) barite occurring as small replacement and solution fillings in the upper part of the Guilmette Formation; and (7) north-striking siliceous dikes and veins common in the northern Pilot Range which may have served as conduits for mineralizing fluids.

Recently, companies have explored for oil and gas in valleys adjacent to the northern Pilot Range. Extrapolating structures and stratigraphic units mapped in the Pilot Range to bedrock beneath the valley fill is difficult given the structural complexity and the lack of drill-hole and other subsurface data. However, Tertiary structures in the Lucin quadrangle have been extrapolated to depth using the gravity and seismic refraction interpretations of Berg and others (1961) and Cook and others (1964), as shown in sections AA' and BB'. If these extrapolations are correct, the Tertiary strata are unlikely to provide good structural traps because they form a steeply dipping homoclinal block that extends only to about 750 m (2500 ft) depth.

GEOLOGIC HAZARDS

Pleistocene or Holocene faulting 8 km (5 mi) southwest of the Lucin quadrangle in the Pilot Range (Miller and others, 1982) raises the possibility of moderate to large earthquakes in the vicinity of the Pilot Range.

Alluvial fans bordering the Pilot Range and alluvial deposits in canyons within the range were emplaced primarily by debris flow and sheetwash mechanisms. These processes are destructive and potentially could affect land in much of the Lucin quadrangle. For example, during a single autumn storm in 1981, a road fronting the range near Coal Bank Springs was virtually destroyed. Grouse Creek and its tributary Thousand Springs Creek are major intermittent streams in the northern part of the quadrangle. They together drain an immense watershed in Nevada and Utah and therefore potentially could carry large volumes of water, causing flood damage to roads and adjoining property.

Eolian sand deposits in the quadrangle are largely stabilized but, where they are disturbed, the dunes are active and create road maintenance problems. Fine-grained lake deposits provide an unstable substrate for roads; such roads require fill for stability.

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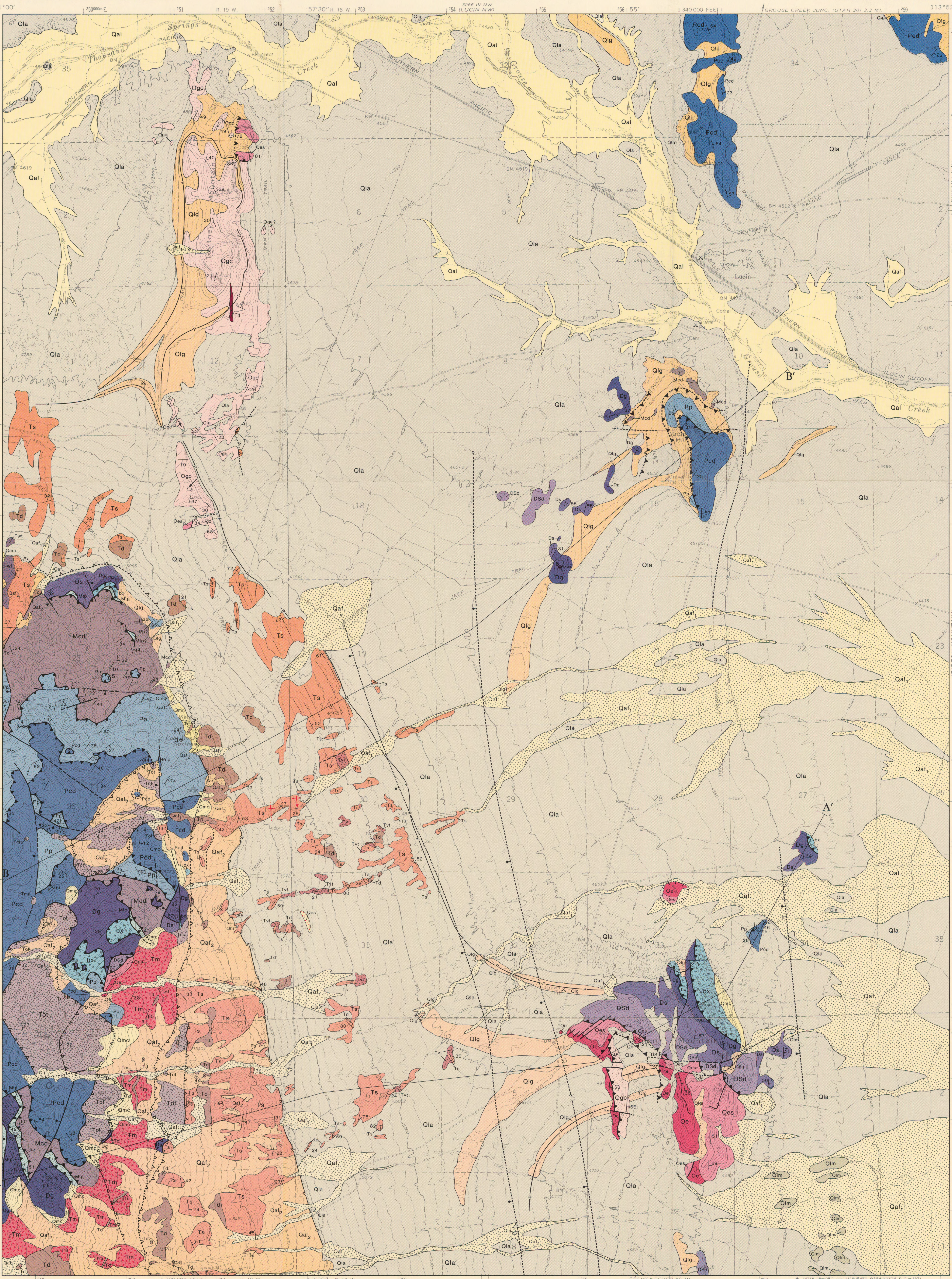

Base map from U.S. Geological Survey
Lucin Quadrangle, Box Elder County, Utah, 1967.

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

Field mapping by D.M. Miller, assisted by J.D. Schneyer, in 1981.

Patricia H. Speranza, Cartographer

UTM GRID AND 1967 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

GEOLOGIC MAP OF THE LUCIN QUADRANGLE, BOX ELDER COUNTY, UTAH

QUADRANGLE LOCATION

by
David M. Miller
U.S. Geological Survey

1985

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CONTACT
Dotted where covered

HIGH-ANGLE FAULTS
Dashed where location inferred; dotted where covered

Normal Fault
Bar and ball on downthrown side; dip indicated

Strike-slip fault
Arrows show relative movement

LOW-ANGLE AND BEDDING-PLANE FAULTS
Dashed where location inferred; dotted where covered; sawteeth on upper plate

Bedding-plane fault
Known or presumed to be pre-Oligocene in age

Bedding-plane or low-angle normal fault
Cutting Oligocene and(or) younger rocks

Gravity slide block
Tertiary or Quaternary age; dashed where location inferred; dotted where covered

STRIKE AND DIP OF BEDDING
Inclined — Vertical — Overturned

STRIKE AND DIP OF IGNEOUS FOLIATION
Inclined — Vertical
Plunge of lineation

STRIKE AND DIP OF APLITE DIKE

TRACE OF AXIAL SURFACE OF FOLD
Arrows show direction of plunge; dotted where covered
Anticline — Syncline

Location of Paleontological sample

Trace of Bonneville shoreline

Trace of Provo shoreline

Prospect — Adit — Quarry — Gravel

FORMATION	SYMBOL	LITHOLOGY	THICKNESS feet (meters)
Chert and dolomite	Pcd		980 (300)
Pequop(?) Formation	Pp		920 (280)
Chainman Shale and Diamond Peak Formation, undivided	Mcd		600 (185)
Tripon Pass Limestone	Mtp		80 (25)
Guilmette Formation	Dg		965 (295)
Simonson Dolomite	Ds		690 (210)
Thick-bedded dolomite	DSd		675 (205)
Ely Springs Dolomite	Oes		420 (130)
Eureka Quartzite	Oe		520 (160)
Garden City Formation	Ogc		1050 (320)

Low-angle fault

CORRELATION OF MAP UNITS

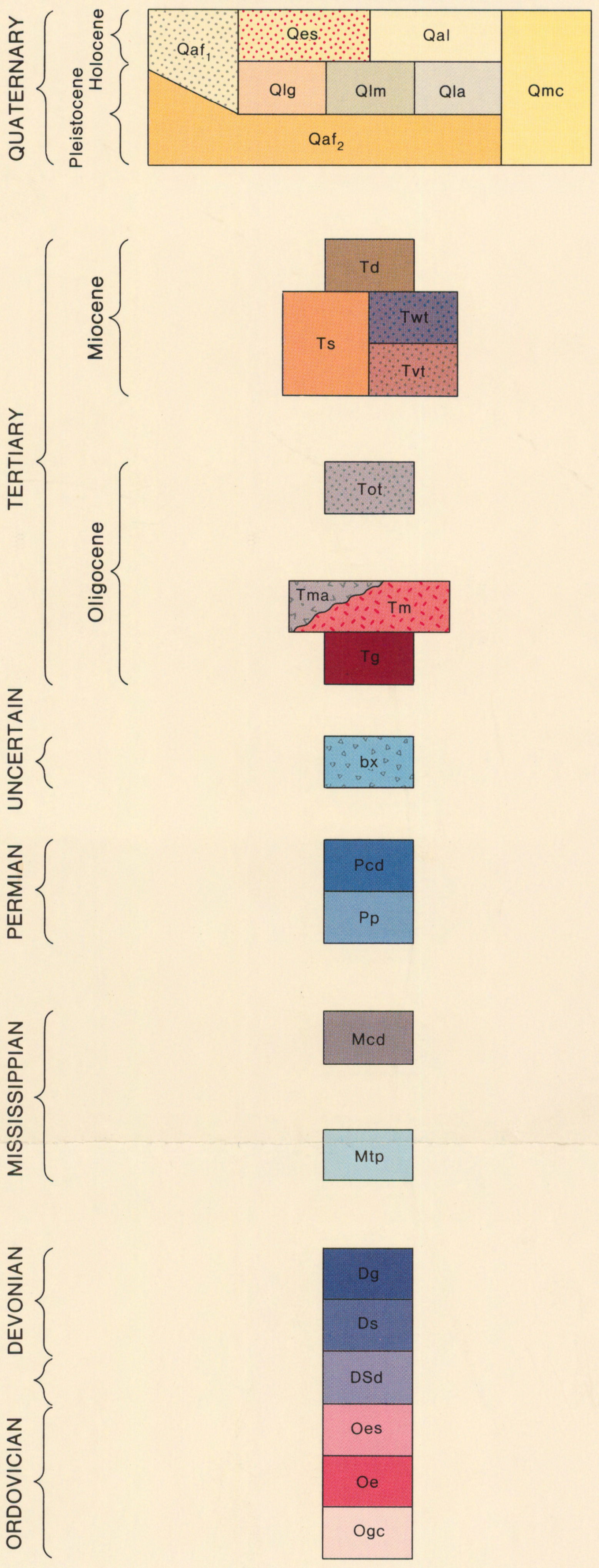

TABLE 1. *Paleontological data for the Lucin quadrangle*

Map location	Field number	USGS collection number	Unit and faunal description	Fossil age	Date of report	Paleontologist	Location: Latitude	Location: Longitude
1	M81PR-127	28192	Chert and dolomite unit. Cystodictyid or a closely similar bifoliate fistuliporid — 2 spec. *Dyscritella?* sp. — 3 spec. Rhabdomesids, indet. — 3 spec. *Rhombotrypella* sp. — 3 spec. *Timanodictya* sp. — 4 spec. The association of the bryozoans *Timanodictya* with *Dyscritella?* and *Rhombotrypella* in this sample indicates Permian age for these strata. *Timanodictya* is known only from rocks of Permian age.	Permian	12/21/81	O.L. Karklins	41°17′05″	113°54′01″
2	M82PR-05	D436-PC	Chert and dolomite unit. *Neostreptognathodus Sulcoplicatus* (late Leonardian) (Youngquist, Hawley, and Miller) 1 Pa, *Stepanovites* sp. 1 Pb, 5 sc. This fauna is common to the upper third of the Grandeur Formation of McKelvey and the lower part of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation CAI=2.0.	late Early Permian	12/30/82	B.R. Wardlaw	41°17′08″	113°53′58″
3	M80PR-14	f14333	Pequop(?) Formation. This sample contains *Schwagerina* sp. and a primitive *Parafusulina?* sp. and suggests latest Wolfcampian to early Leonardian age.	Early Permian	12/18/80	R.C. Douglass	41°18′12″	113°58′36″
4	M81PR-88 to 93	f14485 to f14490	Pequop(?) Formation. These 6 samples from a traverse through the Pequop(?) all have the same fusulinids in them, some largely recrystallized. From the etched slices, it is difficult to assign any of them definitely to the Pequop. All have schwagerinids, but no evidence of *Parafusulina* sp. The schwagerinids present don't rule out Pequop age, however.	Early Permian	8/3/82	R.C. Douglass	41°18′17″	113°59′53″
5	S81PR-10	f14480	Pequop(?) Formation. The fusulinid present is a schwagerinid that is close to Pequop forms but if it is actually Pequop age, it is very early. Not much of the Pequop should be found below it.	Early Permian	8/3/82	R.C. Douglass	41°18′32″	113°59′10″
	S81PR-10	28108-PC	Pequop(?) Formation. *Tabulipora* sp., one specimen. This undescribed species of *Tabulipora* appears to be common in rocks of Late Pennsylvanian and Early Permian ages.	Late Pennsylvanian or Early Permian	10/19/81	O.L. Karklins	41°18′32″	113°59′10″
6	M81PR-114	10341-SD	Guilmette Formation. Brachiopods from this collection confirm a Frasnian age. Most diagnostic is the spiriferoid *Tenticospirifer Utahensis* (Meek) which is represented by one excellent specimen and several fragmentary valves. This species has been reported from late Frasnian rocks in Utah, Montana, Wyoming and Nevada; a very similar species is also present in the Martin Limestone of Arizona and in late Frasnian strata of Iowa.	early Late Devonian	1/20/82	J.T. Dutro, Jr.	41°19′11″	113°55′35″
	M81PR-114	10341-SD	Guilmette Formation. *Amphipora* sp. *Macgeea* sp. *Tabulophyllum* sp. *Macgeea* is known only from rock of Frasnian age in North America although it does occur in upper Middle Devonian rocks in some other areas. *Tabulophyllum* and *Amphipora* are common in the Frasnian but also occur in older rocks.	early Late Devonian	11/24/81	W.A. Oliver, Jr.	41°19′11″	113°55′35″

DESCRIPTION OF MAP UNITS

Qes Eolian sand—*Brown and brownish-gray fine sand and silt.*

Qal Alluvium—*Silt and sand in active streams and washes.*

Qmc Colluvium and talus—*Talus and colluvium of sand and gravel.*

Qaf_1 Younger alluvial fan deposits—*Fan deposits of cobble, gravel, sand, and silt.*

Qla Undifferentiated lacustrine and alluvial deposits—*Soft, white, calcareous clay and lacustrine silt forming thin veneers over older alluvium and pediment surfaces.*

Qlm Lacustrine Marl—*Unconsolidated brownish-white marl.*

Qlg Lacustrine gravel—*Well-rounded and sorted cobble, gravel, and sand that form shoreline deposits of Lake Bonneville.*

Qaf_2 Older alluvial fan deposits—*Poorly sorted boulder- to silt-sized alluvial deposits forming high terraces.*

Td Diabase—*Dikes and sills of diabase and mafic rocks.*

Ts Sedimentary rocks—*Lithified non-resistant lake deposits of conglomerate, sandstone, siltstone, and limestone. Dot-dash indicates marker units of pebble conglomerate containing clasts of lineated metaquartzite.*

Twt Welded tuff—*Welded sanidine rhyolitic tuff and underlying black virtophyre.*

Tvt Vitric tuff—*White to light-gray, thin- to thick-bedded vitric tuff without phenocrysts.*

Tot Older tuff—*Interlayered vitrophyre, tuff breccia, and white, altered tuff.*

Tma Altered igneous and sedimentary rocks.

Tm Monzogranite of McGinty—*Coarsegrained, white to gray, porphyritic monzogranite to granodiorite.*

Tg Granodiorite Dike—*Highly altered, brown-weathered felsic dikes.*

bx Silicified breccia—*Dense, resistant, dark-brown, brecciated jasperoid, silicified sandstone, altered carbonate rocks, and siliceous fracture and vug fillings.*

Pcd Chert and dolomite—*Siliceous, light- and medium-gray, thin- to medium-bedded dolomite and quartz sandstone.*

Pp Pequop(?) Formation—*Mostly laminated to thin-bedded, platy, charcoal-gray, silty limestone that commonly forms tan grassy slopes.*

Mcd Chainman Shale and Diamond Peak Formation, undivided—*Dark-gray to black siliceous, slope-forming sandstone and brown-weathering, ledge-forming conglomerate.*

Mtp Tripon Pass Limestone—*Dark-gray to black, regularly bedded, silty limestone with interbeded calcareous siltstone.*

Dg Guilmette Formation—*Dark-gray to black, well-bedded, cliff-forming limestone; light gray to white-weathering, fossiliferous. Dot-dash line indicates quartz sandstone beds and sandy limestone near top.*

Ds Simonson Dolomite—*Interlayered dark- to light-gray calcareous dolomite forming banded steep slopes.*

DSd Thick-bedded dolomite—*Light- to medium-gray, poorly bedded to structureless dolomite.*

Oes Ely Springs Dolomite—*Dark calcareous, cherty dolomite.*

Oe Eureka Quartzite—*White and light-gray, vitreous, medium-grained orthoquartzite, well bedded.*

Ogc Garden City Formation—*Thin-bedded and laminated blue-gray limestone, gray and brown silty limestone, and brown calcareous siltstone.*