UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Preliminary geologic map of Tecoma and Lucin quadrangles, Box Elder County, Utah, and Elko County, Nevada

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Open-File Report
83-725

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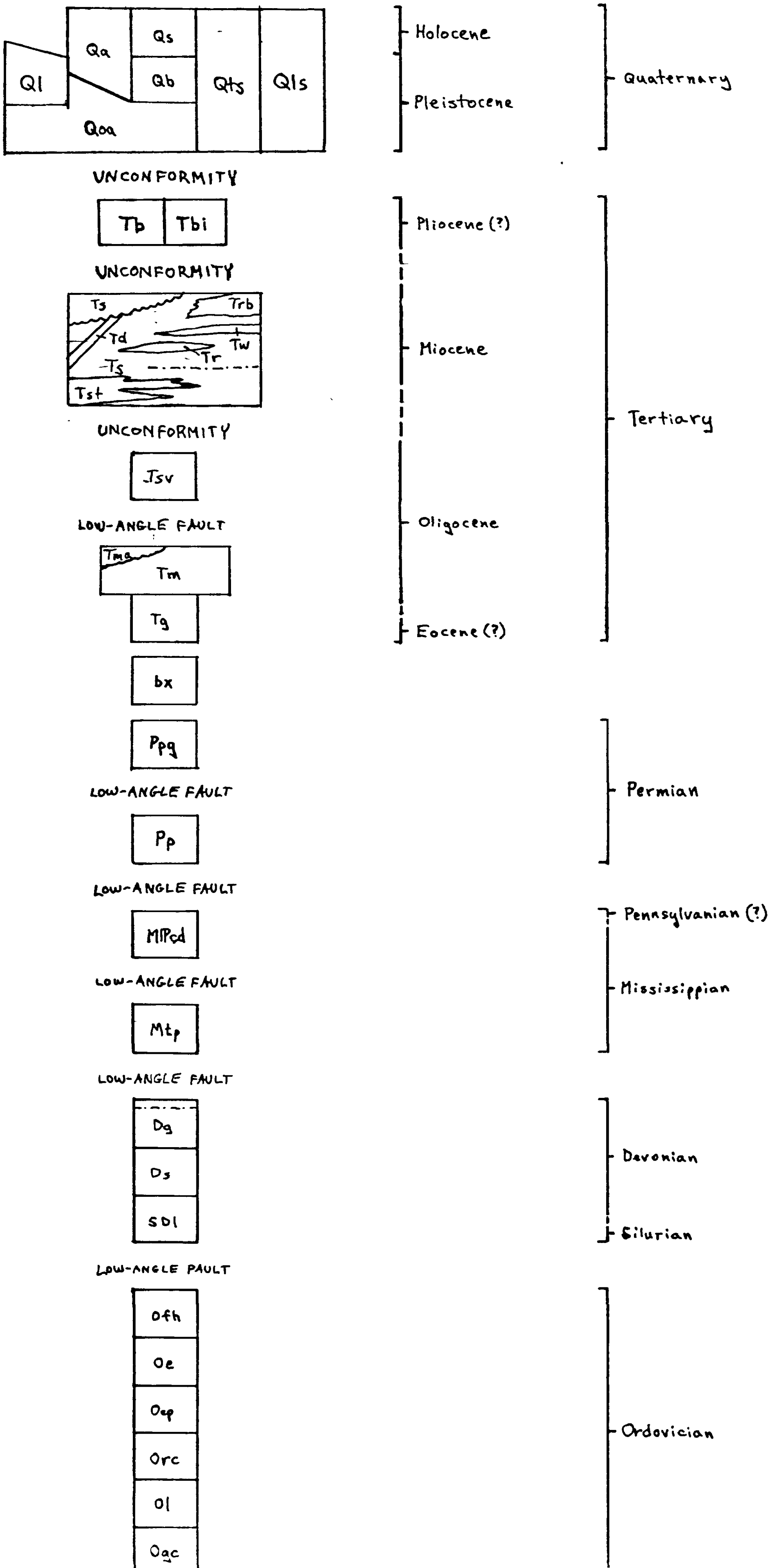
CORRELATION OF MAP UNITS



CONTACTS--Dotted where covered

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

Normal fault; bar and ball on downthrown side

Strike-slip fault; arrows show sense of separation

LOW-ANGLE FAULTS--Dashed where location inferred, dotted where covered. Barbs on upper plate.

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

Bedding plane and listric normal faults cutting Oligocene and (or) younger rocks

GRAVITY SLIDE BLOCK--Tertiary or Quaternary age; dashed where location inferred, dotted where covered

ORIENTATION OF BEDDING

37 Inclined

12 Overturned

Vertical

ORIENTATION OF FOLIATION

42 Inclined

11 7 ORIENTATION OF SMALL FOLDS IN BEDDING

21 7 ORIENTATION OF LINEATION IN FOLIATION

TRACE OF AXIAL SURFACE OF SYNCLINE

a 42 ORIENTATION OF APLITE DIKES

MAP UNIT IDENTIFIED BY FLOAT ONLY

DESCRIPTION OF MAP UNITS

Qa ALLUVIUM (Quaternary)--Unconsolidated stream and fan deposits of cobble, gravel, sand, and silt; slopewash included locally

Qs WINDBLOWN SAND (Quaternary)--Unconsolidated tan and light-brown fine sand and silt forming complexes of small dunes less than 4 m in height. Commonly contains detrital calcite and gypsum. Most dunes stabilized by vegetation

Qts TALUS AND SLOPEWASH (Quaternary)--Unconsolidated rubbly talus deposits and cobble, gravel, and sand slope-wash deposits

Qls LANDSLIDE DEPOSITS (Quaternary)--Deposits of disaggregated rock and surficial deposits displaced downslope by gravity, forming hummocky terrain

Ql BONNEVILLE LAKE DEPOSITS (Quaternary)--Unconsolidated lacustrine gravel, sand, silt, and soft, white calcareous clay, generally forming thin veneers overlying older alluvium and pediment surfaces. Tufa mounds locally occur at wave benches. Includes small exposures of older and younger rocks

Qb GRAVEL BEACHES AND BARS (Quaternary)--Unconsolidated cobbles, gravel, and sand deposited on beaches and offshore bars at several stands of Lake Bonneville. Clasts well rounded and well size-sorted, commonly with little matrix material. Locally cemented by calcareous silt

Qoa OLDER ALLUVIUM (Quaternary)--Unconsolidated to partly consolidated, poorly sorted boulder-sized to silt-sized alluvial deposits forming raised terraces. Cut by Holocene stream channels and wave benches of the highest stand of Lake Bonneville

Tb BASALT FLOWS (Pliocene?)--Black, aphanitic plagioclase-olivine-pyroxene basalt forming remnants of flows and ponded flows. Locally complexly jointed

Tbi BASALT FEEDER DIKES (Pliocene?)--Resistant feeder dikes of aphanitic plagioclase-olivine-pyroxene basalt intruding Tertiary sediments adjacent to ponded basalt flows. Joints form horizontal columns

Td DIABASE (Miocene or Pliocene)--Dikes and sills of predominantly fine-grained, pyroxene diabase, hornblende-pyroxene diabase and hornblende rich mafic rock. Includes reddish brown, resistant diabase dikes as well as large nonresistant bodies that have weathered to form soft, loose brown soils. Diabase both intrudes, and is cut by, fault zones

SEDIMENTARY AND VOLCANIC ROCKS (Oligocene(?) to Miocene)--Stratified rocks including lake deposits, alluvial deposits, and silicic tuffs and lava flows. Minimum thickness exposed on eastern side of Pilot Range about 3000 m. Divided into:

Ts 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, water-lain vitric tuff. Lake deposits generally siliceous, thin bedded and fine grained, and rich in volcanic glass; coarse-grained alluvial deposits occurring in lower part of section are poorly sorted and bouldery. Siliceous limestone is silty, dark-brown, thin-bedded. Marker units of pebble conglomerate containing clasts of lineated metaquartzite indicated by dot-dashed line. Greater than 350 m thick on the west side and greater than 3000 m thick on the east side of the range

Trb Rhyolite of Rhyolite Butte--Dark-brown weathering, glassy sanidine-quartz-plagioclase-pyroxene rhyolite flow. Thick vitrophyre at base contains abundant spherules. Typically columnar jointed. Overlies Miocene sediments with slight angular unconformity. Flow about 100 m thick with erosional top; basal vitrophyre 5 to 12 m thick

Tr Rhyolitic Flows--Purple, pink, and brown, flow-banded, rhyolitic welded tuff containing phenocrysts of biotite, plagioclase and quartz in glass matrix

Tw Welded Tuff and Vitrophyre--Welded sanidine rhyolitic tuff about 10 m thick and underlying 3 m-thick black vitrophyre, commonly perlitic

Tst Vitric Tuff--White to light-gray, thin, to thick bedded vitric tuff containing no phenocrysts. Graded bedding, cross-stratification, and interbedding of silt and sand suggest subaqueous deposition. Thickness 2-600 m, but generally less than 200 m; where thinner than approximately 20 m, tuff is included in sedimentary rocks unit (Ts)

Tsv VOLCANIC ROCKS (OLIGOCENE)--Interlayered vitrophyre, tuff breccia, and white, altered tuff; flow-banded rhyolite. Tuff contains grains of plagioclase, quartz, and biotite in chalky, siliceous to clayey devitrified ash matrix. Flow-banding and rounded quartz grains occur in rhyolite flows. Minimum thickness about 600 m. Poorly sorted conglomerate interbedded with volcanic rocks contains siliceous Paleozoic clasts and Tertiary volcanic clasts. All rocks probably Oligocene; bulk of unit is 36.9 m.y. old (W. C. Hoggatt-Hillhouse, 1983, written commun.)

Tm MONZOGRANITE OF MCGINTY (Oligocene)--Coarse-grained, white to gray, porphyritic monzogranite to granodiorite. Euhedral zoned phenocrysts of alkali feldspar, as large as 5 cm maximum diameter, set in coarse-grained matrix of subhedral plagioclase and alkali feldspar (5 mm), subhedral quartz (8 mm), and biotite. Accessory hornlende, zircon, sphene, apatite, and xenotime(?). Biotite, generally 6-9%, is partially altered to chlorite.

Tma Altered Rocks--Altered igneous and sedimentary rock in intrusive contact region

Tg GRANODIORITE DIKES (Eocene?)--Highly altered brown felsic dikes

bx SILICIFIED BRECCIA--Dense, resistant, dark-brown, brecciated jasperoid, silicified sandstone, altered carbonate rock, and siliceous vein rock and vug fillings. Some protolith material Paleozoic; age of silicification and brecciation unknown. Breccia probably of tectonic and hydrothermal origin; possibly also includes some primary cherty rocks

Ppg GRANDEUR FORMATION(?) OF THE PARK CITY GROUP (Lower Permian)--Siliceous, light- and medium-gray, thin- to medium-bedded dolomite and quartz sandstone. Quartz sandstone fine-grained, cemented by calcite, and commonly silicified; brown where weathered. Dolomite sandy, well-bedded, and rarely fossiliferous. Approximate thickness estimated from cross sections 490 m; top of unit not exposed. Conatact with underlying Pequop Formation at base of lowest silicified bed

Pp PEQUOP FORMATION (Lower Permian)--Dominantly laminated to thin-bedded, platy, charcoal-gray, silty limestone; interbedded with laminae and thin beds of tan to brown siltstone. Some limestone beds bioclastic, grainstone containing crinoid fragments, spirifer brachiopods, and large recrystallized fusilinids. Thickness estimated from cross sections 730 m, but true thickness of unit is uncertain because of folding and faulting. Typically forms tan-weathered slopes

MIPcd CHAINMAN-DIAMOND PEAK FORMATIONS, UNDIVIDED (Pennyslvanian(?) and Mississippian)--Dark-gray, dark-brown, and black siliceous sandstone and brown-weathering conglomerate, both containing quartzite, quartz, black and green chert, and feldspar clasts; and dark-gray shale and tan to gray siltstone. Medium to thick bedded; conglomerate beds are 0.5 to 2 m thick and form cliffs and resistant ledges. Shale and sandstone form brown slopes. About 185 m thick

Mtp TRIPON PASS LIMESTONE (Lower Mississippian)--Dark-gray to black, regularly bedded, silty limestone with subordinate interbeds of calcareous siltstone. Weathers light-gray with a pinkish hue

Dg GUILMETTE FORMATION (Upper and Middle Devonian)--Dark-gray, blue-gray, and black, cliff-forming limestone; light-gray to white weathering. Well-bedded or laminated throughout; fossiliferous. Sedimentary breccia and soft-sediment slump features common. Lower part contains common 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. Active dissolution-reprecipitation present in Crystal Cave in the Tecoma quadrangle (Doelling, 1980). Base of formation drawn at bottom of cliff-forming limestone and dolomite and top of steep slope-forming dolomite of Simonson Dolomite

Ds SIMONSON DOLOMITE (Middle and Lower(?) 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. Maximum thickness 320 m

SDl LONE MOUNTAIN DOLOMITE (Lower 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 contains sparse chert nodules. Greater than 425 m thick

Ofh FISH HAVEN DOLOMITE (Ordovician)--Dark- to medium-gray weathered, medium-gray to black, poorly bedded, fractured massive calcareous dolomite

Oe EUREKA QUARTZITE (Ordovician)--White and light-gray, vitreous, medium-grained orthoquartzite. Weathers to orange-brown patinae. Trace amounts of hematite grains and cement present. Well-size-sorted and well-rounded quartz sand grains indented by pressure solution, and in places partly recrystallized; cemented by syntaxial overgrowths of quartz grains. Generally well-bedded and cross-laminated. About 80 m thick at Quartzite Canyon

Ocp CRYSTAL PEAK DOLOMITE (Ordovician)--Medium-gray, thin-bedded to laminated limestone with silty partings. Contains uncommon interbeds of dark-gray dolomite near top. About 95 m thick

Orc FORMATION OF RAVENS CAVE (Ordovician)--Dark-gray, black, and dark-brown sandy dolomite and dolomitic quartzite. About 15 m thick

Ol LEHMAN FORMATION (Ordovician)--Gray, thin-bedded, fossiliferous silty limestone with tan to orange siltstone partings

Ogc GARDEN CITY FORMATION (Ordovician)--Thinly interbedded and laminated blue-gray limestone, gray and brown silty limestone, and brown calcareous siltstone. Greater than 325 m thick at Gartney Mountain

INTRODUCTION

The Tecoma and Lucin quadrangles are located on the northern Nevada-Utah border about 80 km south of Idaho. Within these quadrangles, the Pilot Range and nearby mountains are north trending fault-bounded mountains, typical of the northern Basin-Range province (Fig. 1). Previous geologic mapping by Blue (1960) in the northern Pilot Range outlined the general geologic setting. Sedimentary rocks typical of the Cordilleran miogeocline were deposited in the northern Nevada-Utah region during the late Proterozoic and the Paleozoic. The area was the site of igneous intrusion, metamorphism, folding, and low-angle faulting during the Mesozoic. Cenozoic high- and low-angle faulting, igneous activity, and local metamorphism modified the Mesozoic structures, commonly making their recognition difficult (Armstrong, 1972).

As part of a project to investigate the Mesozoic and Tertiary tectonics of northwestern Utah, stratigraphic and structural studies were undertaken in the Pilot Range area. This report represents a part of these studies. This work has revealed complicated Tertiary and Mesozoic faulting that controls the present distribution of sedimentary, metamorphic, and igneous rocks. Recently obtained radiometric dates for low-grade metamorphism and the intrusion of several plutons in the Pilot Range allow partial resolution of the Mesozoic and Cenozoic structural and thermal history (Hoggatt and Miller, 1981). Similar stratigraphy and post-Paleozoic deformational and metamorphic relations have been mapped and described directly south of the Tecoma and Lucin quadrangles, in the Patterson Pass and Crater Island NW quadrangles (Fig. 2), where a chronology of Mesozoic metamorphism, low-angle faulting and folding, and Tertiary low- and high-angle faulting has been determined (Miller and others, 1982).

The main physiographic elements of the Tecoma and Lucin quadrangles are the northern end of the Pilot Range, at its highest 2447 m (8028 ft) on Bald Eagle Peak, and the surrounding lowlands ranging from 1890 to 1330 m (6200 to 4360 ft). The lowlands are, in part, pediment exposures of Tertiary granite and strata and, generally in the lower reaches, surficial deposits of Lake Bonneville. Abrupt boundaries between the mountains and lowlands in these quadrangles are typical of basin and range physiography. Isolated hills, including Lion Mountain, Lucin Hill, Gartney Mountain, and other unnamed hills in the northeastern and northwestern corners of the map occur in the lowlands area.

STRATIGRAPHY

Precambrian and Paleozoic strata in the Pilot Range belong to the Cordilleran miogeocline. Cenozoic deposits include thick basin fill of Tertiary age and varied Quaternary deposits. Detailed descriptions, discussions of problematical aspects, and interrelations of these units are given in Miller and Lush (1981) and Miller and others (1982); additional data specific to facies of these units in the Tecoma and Lucin quadrangles are given in this section.

Bonneville Lake deposits--Beaches cut at the high stand of Lake Bonneville presently are at about 1585 m elevation on the west and east sides of the northern Pilot Range. Higher terraces in the Lucin quadrangle near Coal Bank Spring may represent beaches from an older, higher stand of the lake at about 1615 m elevation.

Sedimentary and volcanic rocks--These heterogeneous rocks are probably entirely Miocene, but may include some Oligocene strata. Welded tuff (Tw) near Rhyolite Butte is 11.5 m.y. (K-Ar on sanidine). The rhyolite of Rhyolite Butte (Trb), locally overlying a thick section of sedimentary and volcanic rocks (Ts),

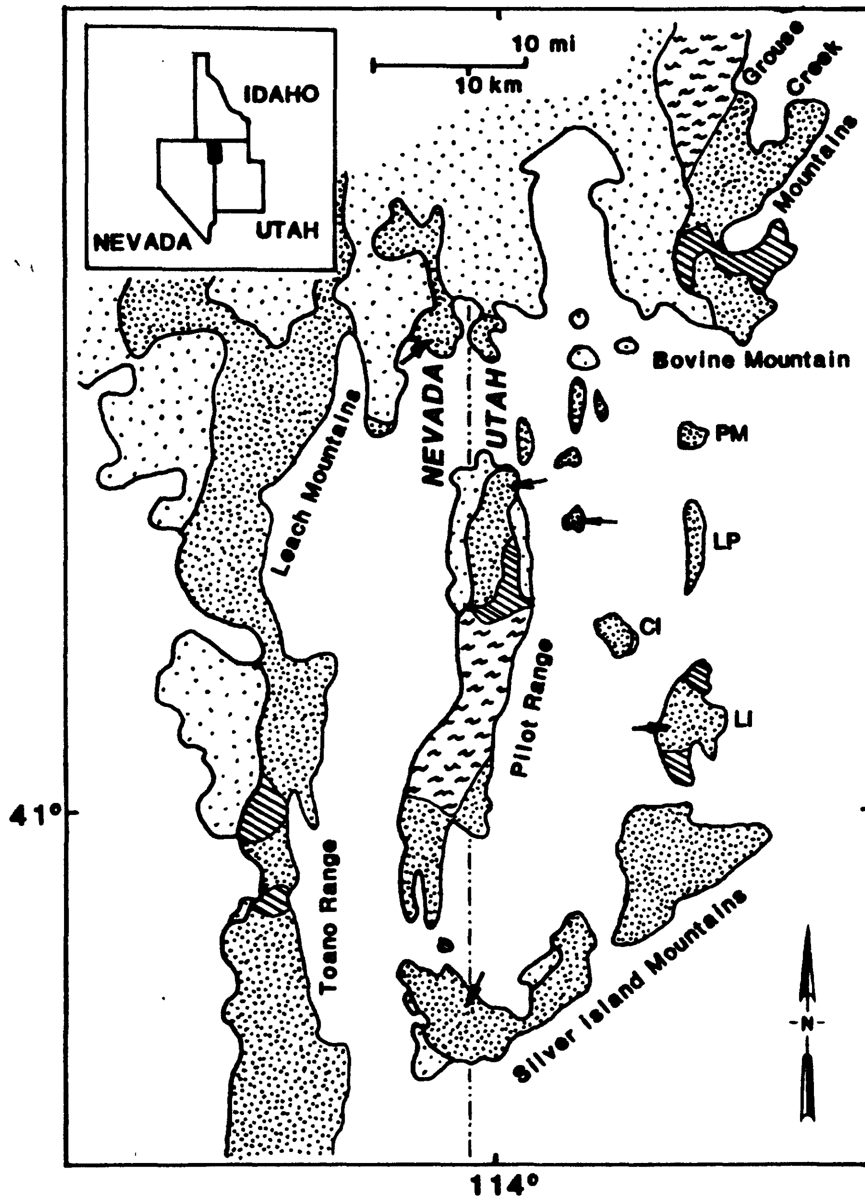


Figure 1. Location map showing Pilot Range and adjacent mountain ranges. Light stipple = Tertiary rocks; heavy stipple = Paleozoic and Precambrian strata; ruled pattern = granitic rocks; wavy lined pattern = metamorphic rocks. Arrows point to ranges where silicified rock and/or low-angle faults occur at the top of the Devonian Guilmette Formation. LI = Lemay Island; CI - Crater Island, LP - Little Pigeon Mountains, PM - Pigeon Mountain.

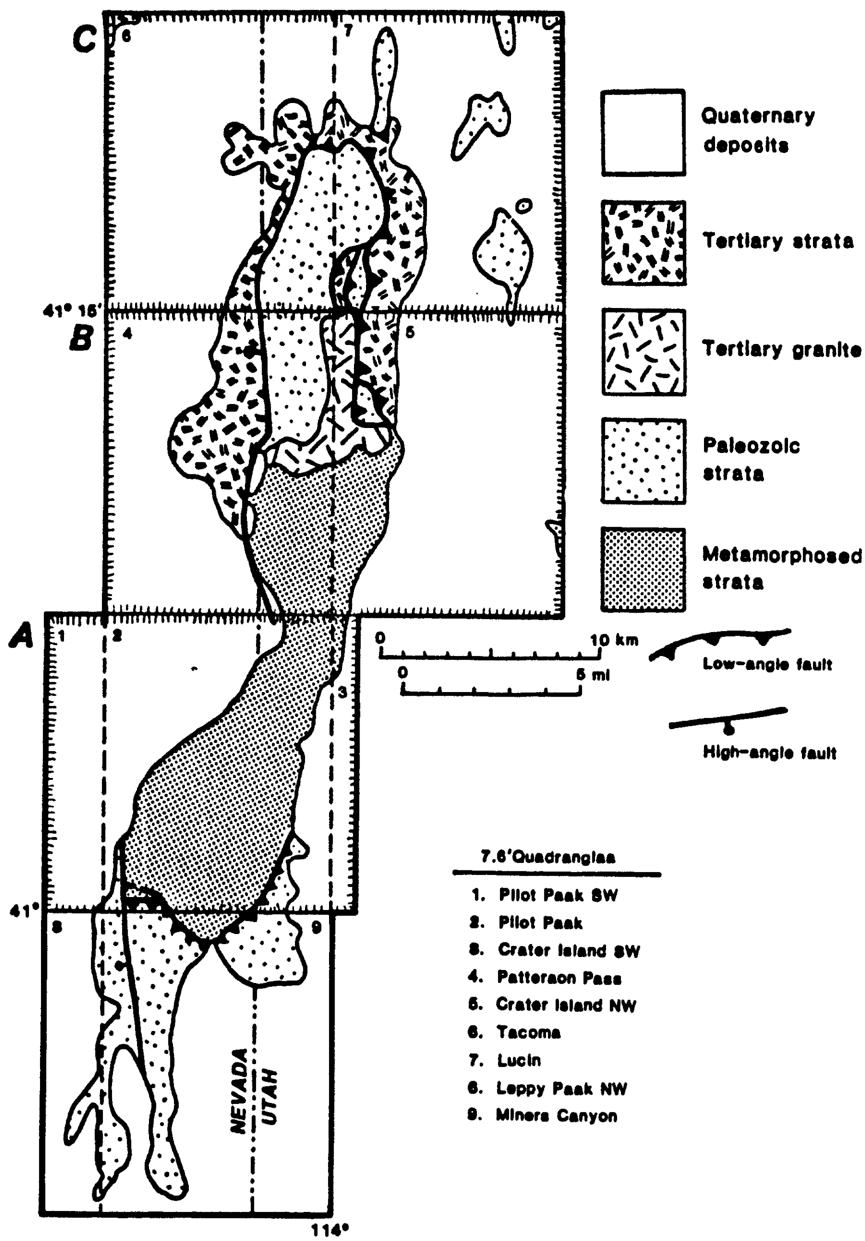


Figure 2. Generalized distribution of Paleozoic unmetamorphosed and metamorphosed strata (above and below the Pilot Peak decollement, respectively) in the Pilot Range. Map A is Miller and Lush (1981); map B Miller and others (1982); map C this report. Remainder of map generalized after D. M. Miller and J. D. Schneyer (unpubl. data, 1981).

is 8.8 ± 0.3 m.y. old (Miller and Hoggatt-Hillhouse, 1983) to 8.4 ± 0.2 m.y. old (Armstrong, 1970); both determinations were K-Ar dates on sanidine. However, parts of the section may be younger than the rhyolite of Rhyolite Butte because clasts of diabase (Td), that apparently cuts the rhyolite, are incorporated into conglomerate zones interbedded with tuffaceous siltstone about one kilometer south of Black Butte. Additionally, sedimentary rocks appear to overlie the rhyolite at the outcropping one km east of Rhyolite Butte; poor exposure there does not preclude faulted contacts, however.

The unit of sedimentary rocks (Ts) consists of waterlain tuffaceous sandstone and siltstone. These rocks are predominantly thin-bedded, well-sorted, siltstone and sandstone with minor dark-green to black shale and green or brown silty limestone. Virtually all 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.

Five paleocurrent measurements that were obtained from cross-bedding in channel conglomerate and sandstone and from conglomerate intertonguing with siltstone all indicate south- to southeast-directed currents. These paleocurrent directions are generally consistent with clast composition: lineated, flaggy quartzite and rare white marble present in the clast assemblage are seen in nearest outcrop in the Grouse Creek Mountains (Fig. 1).

Depositional environments may have ranged from distal fan to lacustrine, with a majority of the rocks (siltstone and limestone) exposed in the pediment on the east side of the Pilot Range being of lacustrine origin. Heterogeneous, poorly sorted clonglomerate locally occurring near the base of the section was presumably deposited close to its source, and possibly in an alluvial fan setting. Most overlying rocks are fine grained, thin-bedded to laminated and have few sedimentary structures, suggesting shallow water deposition.

<u>Volcanic rocks</u>--This group of predominantly volcanic rocks is probably entirely Oligocene. Biotite tuff making up most of the sequence is 36.9 m.y. old (W. C. Hoggatt-Hillhouse, written comm., 1983); similar tuffaceous rocks in the Patterson Pass quadrangle are 31.7 and 37.0 m.y. old, based on K-Ar ages on biotite (Miller and Hoggatt-Hillhouse, 1983; W. C. Hoggatt-Hillhouse, written comm., 1983). Included in the volcanic rocks unit are rhyolitic lava flows, tuff, tuff breccia, and vitrophyre. All of these rocks generally are white to pale green. Igneous textures and minerals are well preserved. Few signs of redeposition are apparent in the tuffaceous units.

<u>Monzogranite of McGinty</u>--Plutonic rocks ranging from monzogranite to granodiorite outcrop extensively in the Lucin quadrangle, where the body appears to have a flat roof. A similar geometry for the body is supported by studies in adjacent quadrangles (Miller and others, 1982). The outcrops of this body near Six-Shooter Canyon in the Tecoma quadrangle appear to have steeper walls.

The monzogranite of McGinty is named for McGinty Ridge in the Crater Island NW quadrangle (Fig. 2); the name "monzogranite of Patterson Pass" used in the report on the Patterson Pass quadrangle (Miller and others, 1982) is herein changed to avoid conflicts with former usage of that name.

<u>Grandeur Formation</u> -- This unit consists of dolomite and sandstone that are highly silicified, typically having a massive to bedded cherty appearance. Fossils are rare; those observed include crinoid fragments, rare silicified brachiopods(?), and possible silicified fusilinids. Conodonts from near the faulted base of the unit indicate an early Leonardian (early Permian) age in one case and

late Leonardian in another (B. R. Wardlaw, 1982, written comm.), raising two possibilities: 1) low-angle faults that form the structural base of the unit may cut obliquely across beds and thus may place different parts of the section on underlying units, or 2) the Grandeur as mapped herein may represent a zone of secondary silicification that transgresses primary lithostratigraphic boundaries. The possibility that the depositional base of the Grandeur is sharply time-transgressive is ruled out by regional relations. Mytton and others (1983) note that in the Cassia Mountains of southern Idaho the Grandeur is late Leonardian and underlying silicified limestone is early Leonardian. This underlying unit, the Trapper Creek Formation, may be indistinguishable from the Grandeur in the Pilot Range area. However, at Lemay Island, about 8 km southeast of the Lucin quadrangle (Fig. 1), silicification and dolomitization of the Pequop Formation locally renders it indistinguishable from the Grandeur; a sequence of silicified rocks about 500 m thick containing typical Grandeur lithologies is traceable along strike into typical Pequop lithologies of early Leonardian age (D. M. Miller and L. L. Berg, 1983, unpublished mapping). Siliciification of the upper part of the Pequop also appears to occur at Crater Island, 10 km southeast of the Lucin quadrangle (J. D. Schneyer and T. E. Jordan, unpubl. mapping, 1983), and in the northwestern part of the Leppy Range, southwestern Silver Island Mountains (Fig. 1) (J. D. Schneyer, unpubl. mapping, 1983). Therefore, we interpret the discordant age data for the base of the Grandeur to indicate that the formation as we map it may transgress primary lithostratigraphic boundaries, and may thus include parts of other formations that are more readily distinguishable from the Grandeur in some neighboring regions.

Pequop Formation -- Silty and sandy platy limestone in the Pilot Range is similar to the type Pequop Formation in the Pequop Mountains, some 60 km to the west. Fossils collected from the unit in the Pilot Range yield Early Permian ages consistent with assignment to the Pequop (R. C. Douglass, written comm., 1981, 1982; O. L. Karklins, written comm., 1981).

Guilmette Formation --Irregular zones of calcareous and quartzose sand at the top of the Guilmette mapped by Miller and others (1982) are better developed northward in the Tecoma and Lucin quadrangles. Beds of quartz sandstone as much as 8 m 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 west of Lucin Hill expose thick beds of sandstone that contain well-rounded quartz grains in a calcareous matrix. Here, corals and brachiopods collected from a limestone bed 30 m below the sandstone are early Late Devonian (J. T. Dutro, Jr., 1982, written comm.; W. A. Oliver, Jr., 1982, written comm.).

Crystal Peak Dolomite -- The Crystal Peak Dolomite, exposed in Quartzite Canyon and on Lion Mountain, is silty, thin-bedded limestone with uncommon beds of dolomite near the top. As noted by O'Neill (1968) in the southern Pilot Range, the Crystal Peak in the Pilot Range area differs lithologically from the type Crystal Peak, which is dolomite, but occupies the same stratigraphic interval. O'Neill's usage is followed herein.

Formation of Ravens Cave -- The formation of Ravens Cave is a brown to gray, thin unit of sandy dolomite and limestone occurring in a lower thrust plate at Lion Mountain. The unit is bounded above by silty, thin-bedded limestone of the Crystal Peak Dolomite and below by similar limestone of the Lehman Formation. Mapping by D. M. Miller and J. D. Schneyer (unpub. mapping, 1981) in the Miners Canyon quadrangle (Fig. 2) indicates that the Ravens Cave occupies the stratigraphic position of the Swan Peak Quartzite.

STRUCTURE

Structures in the rocks in the Tecoma and Lucin quadrangles are continuous with those described by Miller and others (1982) in the adjacent Patterson Pass and Crater Island NW quadrangles; details of most structures are not repeated herein. Moderate- and low-angle faults cutting Miocene strata are better developed in the area covered by this report, and will therefore be discussed more thoroughly. Structures are divided into an older group that is post-Middle Jurassic and pre-Oligocene in age and a younger group that is Neogene or younger.

Older Faults -- Paleozoic strata are cut by numerous low- and high-angle faults of the older group. Low-angle faults are generally subparallel to bedding, and have produced both younger-over-older and older-over-younger juxtapositions of strata. East-striking and north-striking sets of high-angle faults in general cut the low-angle faults, although south and east of Bald Eagle Mountain low-angle faults at the base of Permian strata apparently ramp over and cut both faults and strata in underlying tilted units. These high- and low-angle faults are Eocene or older on the basis of the intrusive monzogranite of McGinty.

Bedding-plane faults in the north Pilot Range are localized at certain stratigraphic positions (section FF'): a slice of Ordovician strata juxtaposed on either side by the Silurian and Lower Devonian Lone Mountain Dolomite; faults at the top of the Guilmette Formation which bound tectonic slices of silicified breccia, Tripon Pass Limestone, and Chainman-Diamond Peak Formations; and faults bounding the Pequop and Grandeur Formations. The Permian units are poorly exposed, but vary greatly in thickness, indicating significant structural modifications of original thicknesses. Distinctive stratigraphic zones within these units are structurally thinned in several locations. Stratigraphic intervals near the base and top of Pequop Formation are typically truncated, and therefore bedding-plane faults are shown on the map at those stratigraphic positions. Small bedding-plane faults are probably pervasive throughout this unit and the Grandeur.

High-angle faults in the north Pilot Range are not as systematically oriented as in quadrangles to the south. The dominant east- and north-striking sets of the south give way to east- northeast- northwest- and north-striking sets in the Tecoma and Lucin quadrangles. The structural and stratigraphic sequences exposed in Lucin Hill (section CC') and Lion Mountain (section FF') are similar to those in the Pilot Range. At Lion Mountain east-striking high-angle faults are apparently tear faults associated with bedding-plane faults because they juxtapose Ordovician units drastically different in thickness. Also at Lion Mountain ramp and flat segments of a bedding-plane fault at the base of the Eureka are well displayed. The Eureka and overlying strata ramp across a faulted Ordovician section consisting of the Eureka and structurally overlying lower Ordovician strata including the Lehman, Ravens Cave, and Crystal Peak.

Younger (Neogene) faults -- Neogene and Paleogene strata and Paleogene plutons are cut by moderately dipping younger faults that appear to represent at least two stages of movement: early listric(?) faulting and later faulting that block out the present ranges. These younger faults are distinguished from the older by age, structural style, and spatial distribution. The younger faults in most cases cut the Oligocene monzogranite of McGinty (Coats and others, 1965; Hoggatt and Miller, 1981) and Oligocene and Miocene strata. These faults tend to outline major topographic breaks because they juxtapose units of differing resistances and because, in part, they are youthful features responsible for the blocking-out of the ranges. The faults are generally north-trending, moderately to shallowly dipping features that typically contain slices of exotic rock (such as Paleozoic limestone), and they typically cut across tilted Tertiary strata in the hanging wall. The faults generally crop out at the margins of the ranges.

Younger faults occur in two distinct structural settings: the west side of the Pilot Range where the faults dip moderately westward and hanging-wall rocks are inclined gently eastward and northeastward; and the east side of the range where the faults dip gently to moderately eastward and hanging wall strata are steeply inclined eastward. These two structural provinces join at the north end of the range, where the strike of faults in the eastern province change from north to northwest. In this same area moderately tilted (hanging-wall) Tertiary strata on the east are juxtaposed with gently dipping strata on the west along an unexposed north-striking structure east of Rhyolite Butte.

The western structural province contains poorly exposed, generally gently east- and northeast-dipping Miocene strata that are juxtaposed with east-dipping Paleozoic strata along range-front faults that are mostly concealed by alluvium. This fault system is delineated by spring lines and some bedrock exposures in the southern Tecoma quadrangle, and is not traceable northward from about Quartzite Canyon. Masses of siliceous breccia and Grandeur Formation forming spurs along the northwestern side of the Pilot Range are interpreted as gravity-slide blocks on the map, but alternatively may in part represent range-front fault-bounded blocks. Pequop rocks adjacent to these masses are cleaved and contain abundant minor folds trending northwest, suggesting that movement of the overlying Grandeur blocks might have included deeper-seated processes than one might expect for gravity-slide blocks.

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 flanking the range. The inlier consists of sediments and volcanic flows that dip moderately eastward, approximately parallel to bedding in underlying Permian strata. The basal contact of the Tertiary strata is interpreted as a bedding-plane fault because coarse clast assemblages in basal tuff breccia beds contain few sedimentary clasts, none of which are locally derived from the adjacent Permian rocks, and because layering in Tertiary strata is locally discordant with the basal contact. A subparallel fault higher in the Tertiary section places hanging-wall rocks westward relative to footwall rocks. Structures and strata of the inlier are discordantly cut by a poorly exposed fault on the east which places Paleozoic strata against Tertiary. Some segments of this fault (west of Indian Spring) must dip moderately to steeply west, based on topographic expression, and an inferred extension of the fault in the southeast quarter of section 2 (T. 7 N., R. 19 W) is clearly exposed and nearly horizontal (maximum 15° dip west). This fault places the Oligocene strata over Paleozoic strata and Oligocene granite. The Oligocene strata 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 (sections CC' and DD'), a structural style distinct from the parallel bedding-plane faults of the older group of structures. An east-northeast striking fault that causes an apparent left-lateral offset of the basal fault of the inlier section possibly is a tear fault because the section changes radically in thickness across the fault; another possibility is that the block north of this fault is dropped relatively downward.

Oligocene strata similar to those of the inlier locally occupy a fault-bounded position at the base of the thick Miocene section in the pediment east of the

Pilot Range. This relation is inferred in the Lucin quadrangle because similar geometrical relations occur in the Crater Island NW quadrangle where faulted contacts are evident. Faults bounding the Oligocene rocks and at the base of the Miocene section are moderately east-dipping and continuous with listric faults in the Crater Island NW quadrangle (Miller and others, 1982), where the faults flatten eastward. Near the north end of the Pilot Range strikes in tilted strata of the hanging wall curve to northwesterly, as does the strike of the basal fault.

Cook and others (1964) inferred from gravity data that the Tertiary section between the Pilot Range and Lion Mountain is about 2,500 feet thick and that more than one fault caused a down-stepping of the sub-Tertiary basement. One of these inferred faults may be exposed one kilometer south of Gartney Mountain, where the Miocene strata are in low-angle fault contact upon Ordovician Garden City Formation. Repetitions of Pilot Range-like sections in Lion Mountain and Lucin Hill place some further constraints on the geometry of faults in the pediment area, but the data are sparse and subject to much interpretation. One possible interpretation is given in structure sections FF' and CC'.

All of the normal faults along the east and west sides of the Pilot Range postdate early Oligocene stratified and(or) plutonic rocks. 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 they are cut by faults parallel with the faults bordering the range. The range-front faults cut 8.4-m.y.-old rhyolite and are in part contemporaneous with undated diabase which intrudes fault zones but is typically broken in these zones. Movement on some range-front faults may have been as late as Pleistocene, as established along southward continuations of these fault zones (Miller and Lush, 1981; Miller and others, 1982). Whether the latest movement on the faults was listric or the young faults have broken across the older (Miocene or Pliocene) structures is indeterminate.

All the younger faults apparently place tilted sections of Tertiary strata on older rocks, consistent with current models for "basin-and-range" extensional tectonics. The tilting of sections on a regional scale requires low-angle fault(s) at depth and indicates that listric faults may be key elements in this deeper fault system. Listric faults observed south of the Lucin quadrangle are continuous with faults described herein, suggesting that these faults may be important for models of Tertiary tectonics. Differing amounts of tilt on the east and west sides of the range require either heterogeneous response to faults or multiple-stage models, with pre-range-blocking faults accomplishing early tilting east of the present range. Such older faults must underlie the present range at depth. Tilt directions imply east-to-west movement on low-angle fault segments. Later faults that blocked out the range may have utilized these faults. The latest movement on faults bordering the range apparently was normal and down toward the basins, and the expected pattern of tilted strata would thus be one of decreased tilt on the east, where latest normal faults essentially would unrotated strata partially. 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 are probably older and are the products of east-to-west movement of an extending allochthon. Whether these flat faults were initially higher angle and have been rotated to gentle dips is difficult to demonstrate, but their listric character, with parts of the faults nearly parallel to bedding (such as in the inlie, sections FF' EE') is suggestive of such a history.

It is probable that middle Tertiary listric faults caused tilting of Paleozoic and Tertiary rocks. Present flat faults at the base of Tertiary sections underlying the valleys adjacent to the Pilot Range probably belong to this set; it is likely that these basin-bottom faults are downdropped relative to the Pilot Range along youthful range-bounding faults, requiring that a similar flat fault was once present above the range and that it is now eroded. A deeper flat fault must be present as well to account for rotation of Paleozoic strata in the Pilot Range.

ECONOMIC DEPOSITS

Considerable mining activity took place in the Copper Mountain area of the Lucin District (Blue, 1960; Doelling, 1980), with copper, gold, silver and lead shipped in quantity. No other major commodities have been produced in significant quantities in the Tecoma and Lucin quadrangles, although small mines and prospects occur in a few places.

Other features with potential economic interest are: (1) outcrops of Eureka Quartzite, 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 to the north in the Jackson mining district; (3) deposits of well sorted and rounded gravel along the shores of ancient Lake Bonneville; (4) possible brines in groundwater east of Lucin Hill; (5) magnetite in diabase outcrops (described as "black sands" by Doelling, 1980); and (6) barite occurring as small replacement and solution fillings in the upper part of the Guilmette Formation. Of these possible sources of minerals and industrial materials, the jasperoid in the siliceous breccia has recently attracted much attention as a gold play. North-striking siliceous dikes and veins are common throughout the northern Pilot Range and may have served as conduits for mineralizing fluids.

In addition, many companies recently have been exploring for oil and gas in valleys adjacent to the northern Pilot Range. Extrapolating structures and stratigraphic units mapped in the Pilot Range to depth in the valleys is a virtual impossibility given the likely structural complexities 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 CC' and FF'. If these extapolations are correct, the Tertiary strata are unlikely to provide good structural traps because they form a steeply dipping homoclinal block and the strata only extend to about 700 m depth.

ACKNOWLEDGMENTS

Discussions with Max Crittenden have been most helpful. K-Ar dates by Wendy Hoggatt-Hillhouse have been vital to understanding the age relations. Discussions with Rick Allmendinger, Bob Compton, Anita Harris, Lehi Hintze, Terry Jordan, Mike McCollum, Susan Miller, Barney Poole, and Peter Sheehan about various aspects of our studies have been beneficial. Paleontologists aiding immeasurably by identifying specimens were: Anita Harris, Ray Douglass, J. T. Dutro, Jr., Olgert Karklins, W. A. Oliver, and Bruce Wardlaw. Linda L. Berg helped considerably with drafting. We thank Brett Cox for reviewing an earlier draft of this manuscript.

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