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Geology of the Southern Pilot Range, Elko County, Nevada and Box Elder and Tooele Counties, Utah

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This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of The University of New Mexico in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN GEOLOGY

GEOLOGY OF THE SOUTHERN PILOT RANGE,
ELKO COUNTY, NEVADA, AND BOX ELDER
AND TOOELE COUNTIES, UTAH
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GEOLOGY OF THE SOUTHERN PILOT RANGE, ELKO COUNTY, NEVADA, AND BOX ELDER AND TOOELE COUNTIES, UTAH

BY
JOHN MICHAEL O'NEILL
B.S., The University of New Mexico, 1967

THESIS

Submitted in Partial Fulfillment of the
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ABSTRACT OF THESIS

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GEOLOGY OF THE SOUTHERN PILOT RANGE, ELKO COUNTY, NEVADA, AND BOX ELDER AND TOOELE COUNTIES, UTAH

John Michael O'Neill
Department of Geology
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The southern Pilot Range is a slightly sinuous, north-trending mountain range located in the northeastern part of the Great Basin.

Approximately 18,500 feet of miogeosynclinal sedimentary rocks representing every system from late Precambrian to Permian (?) are exposed in the southern Pilot Range. Because of intense faulting, many of the stratigraphic relationships between the formations are impossible to determine. Mesozoic and Tertiary strata are absent; however, Pleistocene Lake Bonneville deposits are widespread, although thinly distributed. Small igneous stocks, dikes, and sills are common only in the southern two-thirds of the map area. Stocks are principally granodioritic. In several cases the intrusions of the stocks are structurally controlled, occurring primarily along a decollement thrust. Dikes and sills range from

rhyolite to diorite; in places extremely silicic or mafic assemblages are present. A large pluton five miles north of the map area has been dated as Oligocene (Coats _et_ _al_., 1967) and may indicate the age of the stocks.

Three periods of deformation are recorded in the southern Pilot Range. Mid-Mesozoic deformation is represented by thrusts, decollement thrusts, and related folding and tectonic thickening, thinning, and elimination of units, accompanied by regional metamorphism of late Precambrian and lower Cambrian strata. Early (?) Cenozoic deformation created a mosaic of high-angle faults within the range, truncating earlier structures. Later Cenozoic (Basin-Range) range-marginal faulting has blocked out the range and elevated it to its present height.

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INTRODUCTION

Location and Accessibility

The Pilot Range is slightly sinuous and trends north along the Utah-Nevada state line from 15 miles north of Wendover, Utah-Nevada to Lucin, 40 miles to the north. The range lies within the area bounded by 40°52' and 41°20' north latitude and 113°51' and 114°7' west longitude, occupying parts of southwestern Box Elder and northwestern Tooele Counties, Utah, and eastern Elko County, Nevada (Fig. 1 and 6).

That part of the range that was mapped is 18 miles in length, extending from the southern tip to approximately 41°5' north latitude. The maximum width of the range is about five miles in the south-central part. Near the southern end the range thins to one-half mile.

Wendover, Utah-Nevada is located on U. S. Highway 40, 125 miles west of Salt Lake City, Utah. The Pilot Range is accessible from this main highway by improved and unimproved dirt and gravel roads. Stockmen using the range and the surrounding area as a winter range for

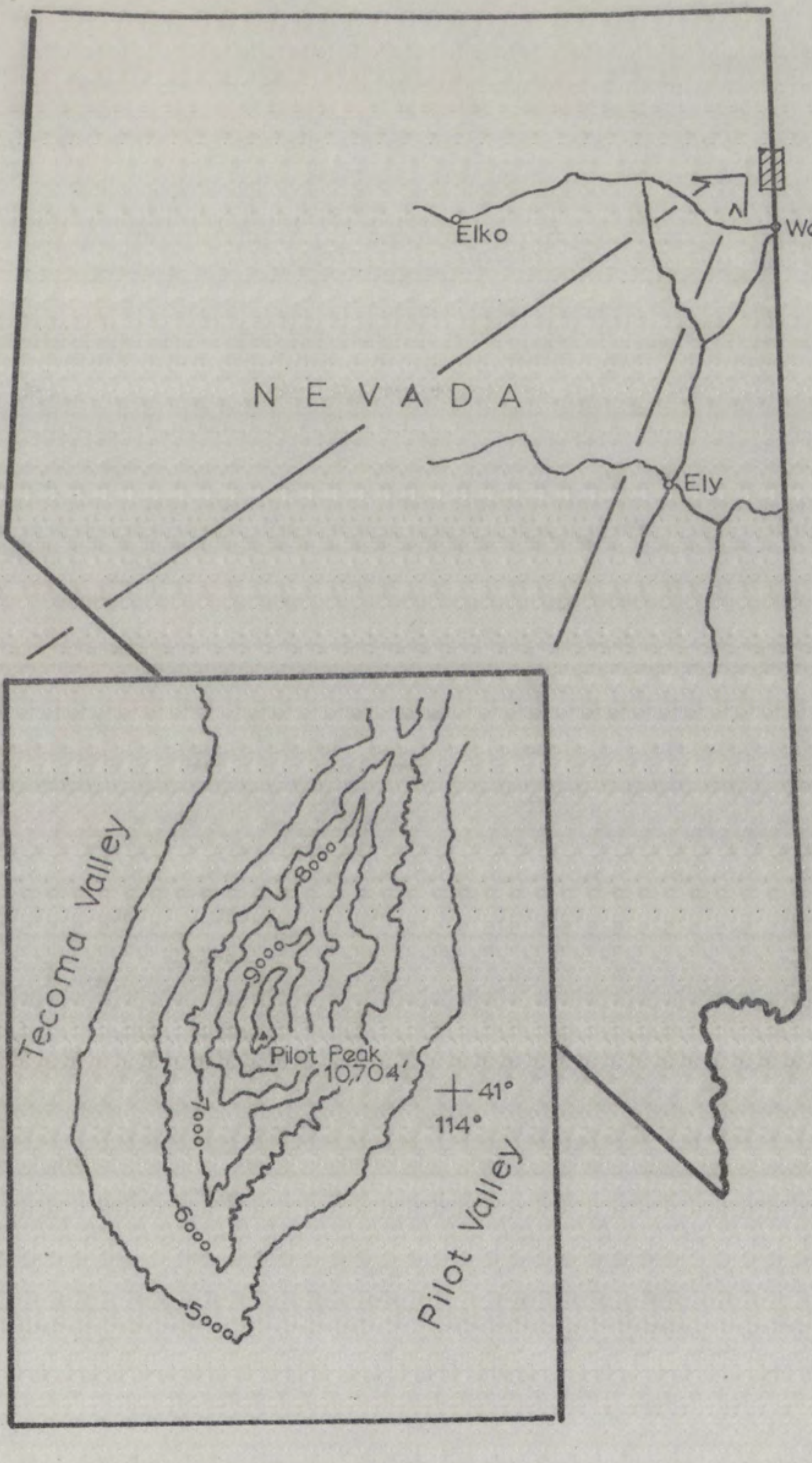

Figure I. Index Map

sheep and cattle have constructed a few poor roads to the base of the range.

Physiography

The Pilot Range, rising abruptly above the surrounding lowlands, is situated in the northeastern part of the Great Basin, Basin-Range physiographic province. Elevations at the base of the range vary from 4220 feet on the east in the Great Salt Lake Desert to 4500 feet in the Tecoma Valley to the west. The average elevation is approximately 8,500 feet, although along the crest of Pilot Peak, for a distance of two miles, the elevation exceeds 10,000 feet. The range is covered with vegetation except for the southernmost part, which is barren and extremely dissected by intermittent streams; numerous perennial streams and springs drain the higher parts of the range.

Strand lines from Pleistocene Lake Bonneville completely surround the range, but are subdued by post-Bonneville erosion and growth of grass and sagebrush. Alkali and salt flats are common east and south of the range and some may hold water during the summer.

Field Methods

Field work was carried out from June through September 1967. Mapping was done with the aid of aerial photographs flown for the USGS in 1953 at a scale of 1:60,000. Geologic data were transferred to a topographic base map, scale 1:31,250, modified from Army Map Service topographic maps. Stratigraphic sections were measured with a Jacob staff.

Previous Work

Pilot Peak, named by John Fremont of the Fremont Expedition in 1845, served as a guide to his and following expeditions crossing the Great Salt Lake Desert.

The reconnaissance of the Great Salt Lake area was made in 1849 by the Stansbury Expedition. In his hasty traverse, Stansbury (1853) noted the numerous dikes and metamorphic rocks in the Pilot Range and the composition of the surrounding alluvial deposits.

Hague (1877) made a geologic reconnaissance of the Pilot Range (then called the Ombe Range). Working mostly in the Lucin mining district, Hague investigated the southern part of the range, noting folding and the great thicknesses of quartzites which he correlated with the

Weber Quartzite; apparently the quartzite noted by Hague is Precambrian. He also attempted a correlation between the quartzites of Pilot Peak with those Cambrian quartzites of Bonneville Peak, Aqui Mountains.

Butler _et_ _al_. (1920) also briefly investigated the range, although concerned primarily with the economic geology of the Lucin area. In his report he suggests strong faulting along the eastern base of the range.

Eardley _et_ _al_. (1957) in a report "Hydrology of Lake Bonneville" counted lake terraces on the eastern slopes of the range between the Bonneville lake level and the valley floor.

D. M. Blue (1960) mapped the Lucin district, making a study of the ore deposits and reserves of the area as part of a University of Utah master's thesis. Blue also published an abstract (1963) giving the generalized stratigraphy of the range.

Woodward (1967) made a detailed study of the late Precambrian metasedimentary rocks of the range, correlating the units with the late Precambrian McCoy Creek Group (Misch and Hazzard, 1962).

Acknowledgments

The author takes this opportunity to thank Dr. Lee Woodward of the Department of Geology, University of New Mexico, who suggested the geology of the southern Pilot Range as a thesis problem, and who, as advisor, gave continuted guidance, and made suggestions and offered constructive criticism throughout the preparation of this report.

I also wish to thank Professors J. P. Fitzsimmons and A. Kudo for help in thin-section identification in addition to the constructive criticism offered.

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STRATIGRAPHY

General Statement

Approximately 18,500 feet of late Precambrian to Pennsylvanian-Permian miogeosynclinal sedimentary rocks are exposed in the southern Pilot Range. The central and northern parts of the map area are composed mostly of Precambrian quartzites and argillites and Cambrian Prospect Mountain Quartzite (restricted). In the southern part of the range and along the eastern flank of Pilot Peak, limestone, dolomite, shale, and quartzite represent every system of the Paleozoic. Because of intense faulting, stratigraphic relationships between the formations are difficult to determine. Sedimentary formational contacts commonly are not exposed; rather, formations are usually juxtaposed by faulting.

No Mesozoic or Tertiary strata are exposed in the map area.

The Quaternary System is represented by fluvial and Lake Bonneville lacustrine deposits along the flanks of the range and in surface exposures in the flats of the valley floor. Large talus slopes are common in the higher parts of the range.

Terminology for stratigraphic thicknesses follow that used by McKee and Weir (1953).

Precambrian System

The Precambrian System in the southern Pilot Range, represented by the McCoy Creek Group, contains seven identifiable formations which aggregate 4775 (+) feet in thickness.

The type locality of the McCoy Creek Group, named by Misch and Hazzard (1962) from rocks of the central Schell Creek Range, White Pine County, Nevada, includes nearly 9,000 feet of phyllites, argillites, slates, quartzites, and conglomerates concordant below the Lower Cambrian Prospect Mountain Quartzite (restricted). Eight units and several subunits were identified and referred to as units A through H. Misch (1960) and Misch and Hazzard (1962) ascribe a Mesozoic age of regional metamorphism for the McCoy Creek Group of the southern Snake and Schell Creek Ranges. Locally, the metamorphism extends as high as the Lower and Middle Cambrian Pioche Shale (Misch and Hazzard, 1962).

Woodward (1967) has made a detailed correlation of the five uppermost metasedimentary units of the Pilot Range with the Precambrian of the norther Deep Creek Range (Woodward, 1965), the central northern Egan Range (Woodward, 1963), the northern Egan Range (Fritz, 1960), and the southern Snake and Schell Creek Ranges (Misch and Hazzard, 1962) (Fig. 2). Character and thickness of these sedimentary units are taken largely from his work.

In addition to the units described by Woodward (1967) there are metasedimentary strata exposed in faulted-bounded blocks that are tentatively assigned to Units A and B.

The Precambrian units are conformable with each other; however, the concordant contact with the overlying Cambrian Prospect Mountain Quartzite (restricted) appears to be disconformable (Woodward, 1967).

Unit A (?)

Exposures of Unit A (?), 690 (+) feet thick, along the eastern flank of the Pilot Range, are divided into three members.

The lower member consists of 500 (+) feet of cliff-forming, medium-grained, light tan to medium gray quart-

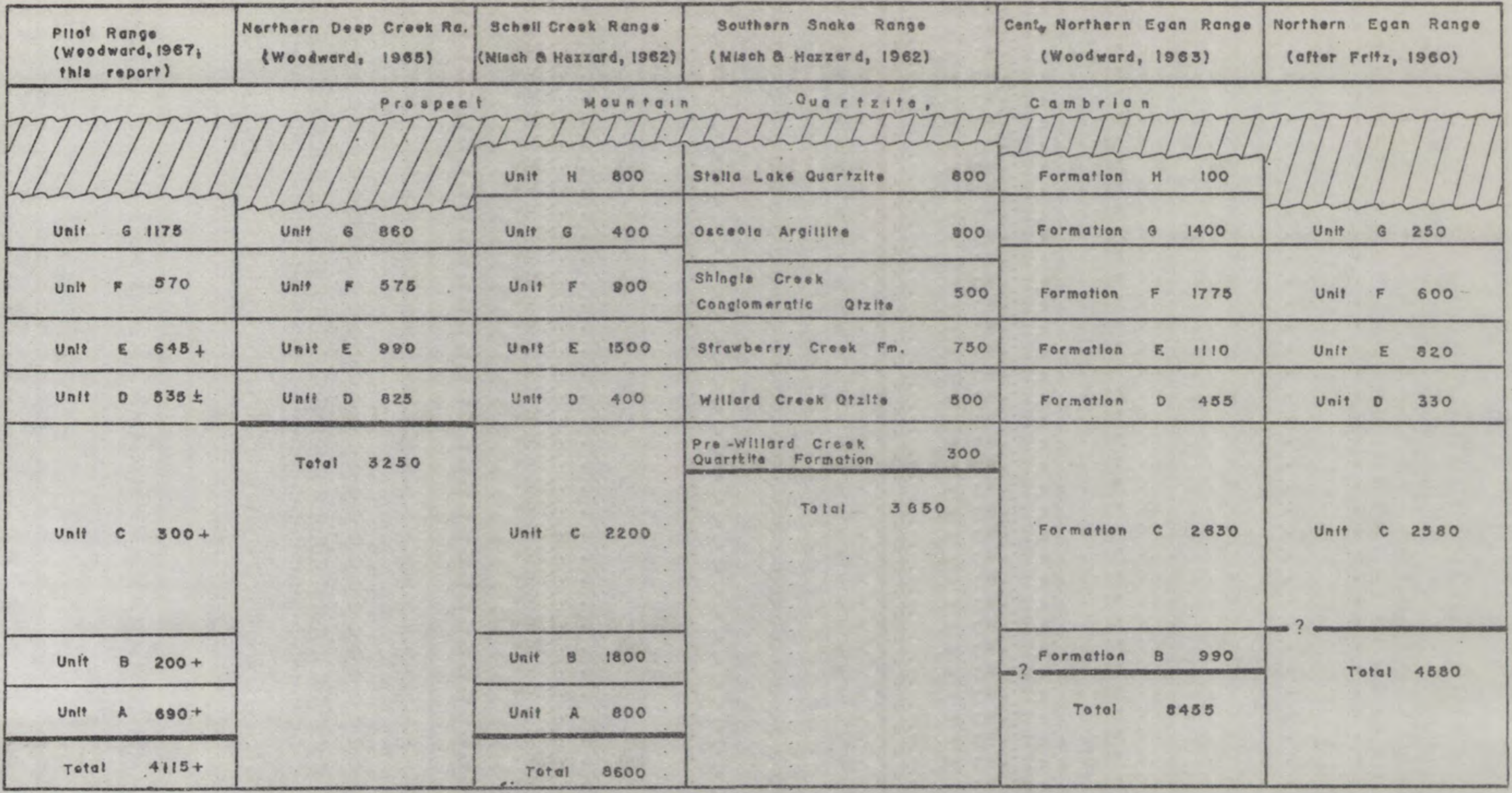


Figure 2. Proposed correlation of late Precambrian of Pilot, northern Deep Creek, Schell Creek, Southern Snake, and Egan Ranges. Letter symbols of strata described by Fritz (1960) in northern Egan Range are adjusted to those established by Misch and Hazzard (1962) in Schell Creek Range. Thicknesses are in feet. (Modified from Woodward, 1967)

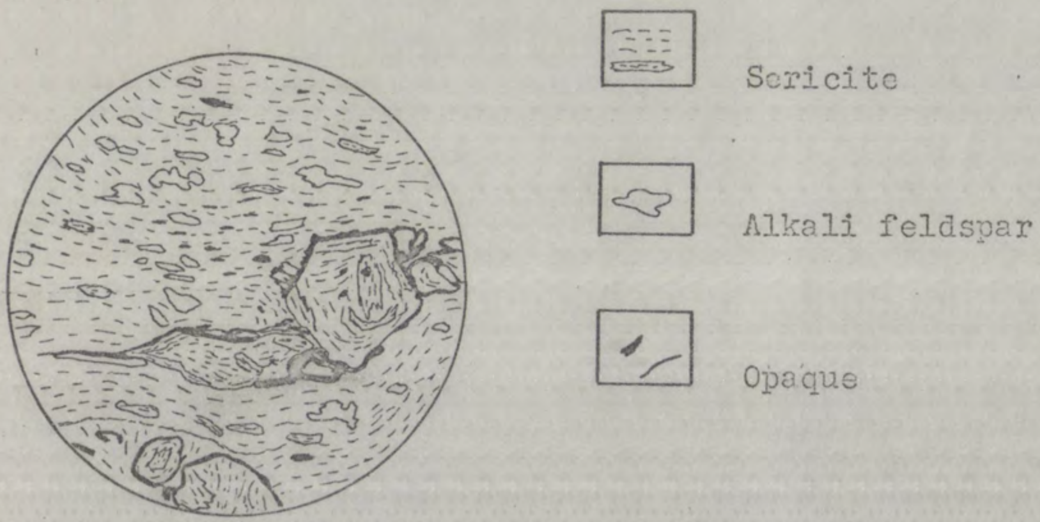
zite which weathers orange-tan, brown, and red-brown. Lenses of platy, light gray, fine-grained quartzite and micaceous quartzite are present throughout the section. In thin section these lenses show elongate, fine-grained, sutured quartz clasts with minor interstitial sericite.

The middle member, wedging out southward, consists of amphibolitic metamorphosed sills and black to green argillite and phyllite. The metamorphosed sills consist of well-formed tremolite crystals (65%) surrounded by alkali feldspar (25%) and minor amounts of sericite, epidote, and quartz.

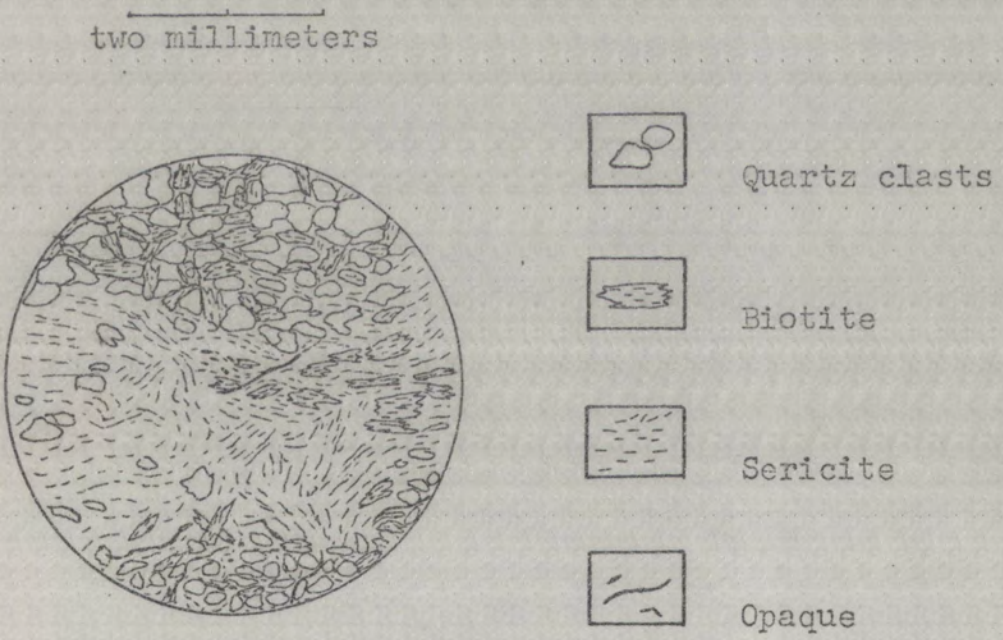
In thin section the phyllite is highly deformed. Shearing and recrystallization occurred simultaneously except in the final stage of deformation when individual 'lenses' and 'balls' of contorted sericite were rotated and sheared without accompanying recrystallization (Fig. 3a,b).

Composition of the phyllite varies, although the main constituents are sericite, alkali feldspar, and quartz clasts.

The upper member, 190 (+) feet thick, consists of thin- to very thin-bedded, slope-forming, light and dark gray laminated, fine-crystalline marble. In thin section



a. Deformed phyllite showing rotated and sheared lenses and balls of sericite.



b. Deformed phyllite showing contorted sericite.

Figure 3. Microtextures of the phyllite of Unit A (?)

the marble consists mostly of calcite, clay size quartz clasts, and minor sericite. Bedding (s_1) and schistosity (s_2) are parallel. Slices of coarser-grained calcite surrounded by a very fine-grained calcite matrix are elongate in the schistosity (Plate 1).

The base of Unit A (?) is not exposed. The upper marble member is in fault contact with Unit F.

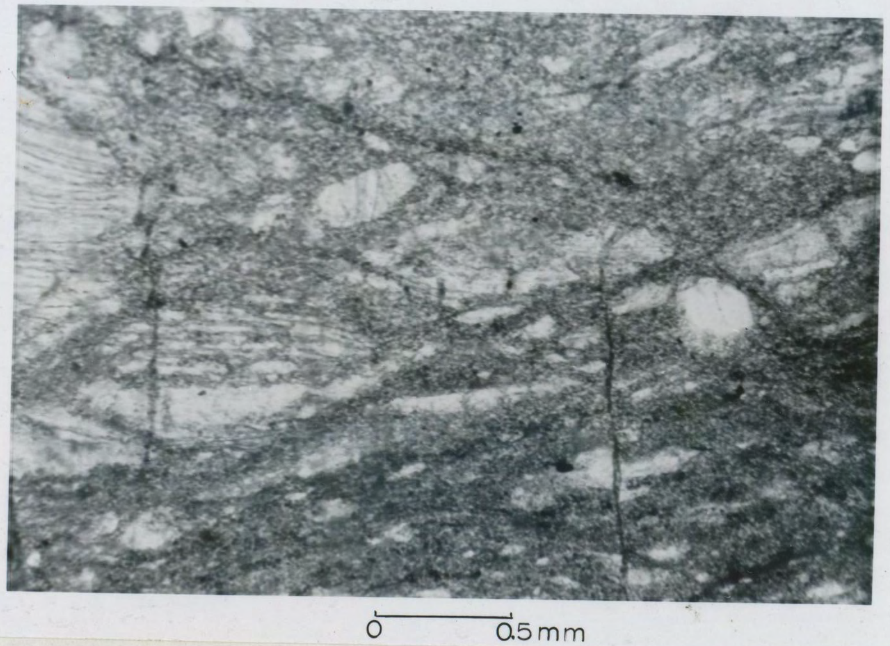
Unit B (?)

Exposed in a fault-bounded block immediately north of Anderson Canyon, Unit B (?) is represented by a marble-phyllite-marble sequence. The marbles, thin- to very thin-bedded, light and medium gray laminated, and medium-crystalline, are separated by approximately 40 feet of dark brown and green phyllite and micaceous schist. The unit aggregates approximately 200 feet. Neither the base nor the upper contact of the unit is exposed.

Unit C

Unit C, exposed along the western base of the range from Shell Canyon northward, forms gentle, float-covered slopes. The unit contains platy, greenish and gray, spotted phyllites with minor dark greenish gray, fine-grained quartzite intercalations. Original bedding (s_1)

Plate 1 Photomicrograph of upper marble member, Unit A (?). Note large slices of coarse-crystalline marble in the fine-grained matrix of calcite.



and schistosity (s_2) coincide. The spotted appearance is due to porphyroblasts of opaque minerals.

The maximum exposed thickness of the unit is approximately 300 (+) feet. The base of the unit is not exposed and the upper contact is covered by quartzite talus from the overlying unit. The quartzites of Unit D lie conformably but with marked lithologic contrast upon the slope-forming phyllites of Unit C.

Unit D

Unit D is well exposed north and south of Debs Canyon. The unit aggregates 535 feet in thickness and can be divided into two members. The lower 410 feet consists of massive, cliff-forming, medium-grained to gritty quartzite and becomes coarser-grained upward, with shades of gray, white, green, and pink. This member weathers light to dark gray and orange-brown and is commonly cross-bedded.

The upper part of the unit contains two 25-foot zones of bench-forming green slate and phyllite separated by 60 feet of thick-bedded, cliff-forming greenish grit, containing clear to whitish subrounded quartz granules set in a medium- to fine-grained matrix. The upper 15 feet consists of a similar greenish grit.

Well-aligned sericite and chlorite in the slates define a schistosity (s_2) that is parallel with bedding (s_1). Locally s_2 has been isoclinally microfolded with shears (s_3) developed along the limbs.

The conformable contact between Unit D and the underlying Unit C is not exposed and is taken at the highest occurrence of phyllite float characteristic of Unit C. The upper contact of Unit D is placed at the top of a 15-foot greenish grit and at the base of a slope-forming, platy, green and blue slate and phyllite of Unit E.

Unit E

Unit E, a slope-former, is exposed from Shell Canyon northward, and aggregates 645 (+) feet in thickness. The lower 150 feet consists predominantly of blue, light to dark green, and blackish slate and phyllite. Minor beds of conglomerate and grit that resemble the uppermost beds of Unit D are present. A high-angle strike fault is present; some strata may have been eliminated along this fault. Above the fault is 495 feet of green and blue-gray slate, argillite, and phyllite. Minor thin interbeds of medium-grained green quartzite occur in the lower part of the sequence. Approximately 260 feet below the top of the unit is a thick-bedded, cliff-forming, 25-foot zone of green and brown conglomerate, grit, and very coarse-grained quartzite. Subrounded white quartz pebbles and granules make up the clasts.

The schistosity in the pelitic rocks is defined by sericite, chlorite, and abundant elongate silt-size quartz grains. In the upper part of the unit the schistosity has been isoclinally microfolded. Dark siliceous seams suggest that bedding (s_1) is parallel to schistosity (s_2).

The gradational contact between Unit D and Unit E has been described. The sharp contact between Unit E and the overlying quartzite of Unit F is placed at the topographic break between the slope-forming phyllite and slate of Unit E and the cliff-forming, coarse-grained, light gray quartzite of Unit F.

Unit F

Unit F, 570 feet thick, is well exposed as bold cliffs from Pilot Spring northward. The unit is composed mostly of resistant, thick- to very thick-bedded, coarse-grained to gritty, medium to light tannish gray quartzite that weathers tan, brown, and reddish brown. A few thin layers of granular quartzite are present. Rounded to subrounded clasts of white quartz and subordinate sodic plagioclase, microcline, and orthoclase increase in size upward to two inches across. Minor sericite, chlorite, and biotite are present.

The sharp upper contact of Unit F is marked by the lowest slope-forming green and gray slate and argillite of Unit G.

Unit G

Exposures of Unit G between Pilot Canyon and Debs Canyon consist of approximately 1175 feet of slope-forming slate, argillite, metasiltstone, and subordinate marble and quartzite.

Green and gray slate and metasiltstone make up the lower 800 feet of the unit. Some of the slate shows maroon flecks of unknown origin. Quartz-rich silty layers commonly alternate with slate layers. Thin interbeds of very fine-grained gray quartzite occur sparingly in the upper part of this sequence.

The upper and lower parts of the unit are separated by a 75-foot unit of black and white marble. The white bands of the marble are pure calcite; the black bands contain chlorite, sericite, quartz silt, and opaque minerals in addition to calcite. This marble appears to lens out in the vicinity of Pilot Canyon.

The upper 300 feet of the unit consists of green and gray metasiltstone and argillite which weather green, gray, and reddish brown. The unit commonly contains green and dark gray quartz-rich laminations.

Crystallization schistosity (s_2) and microfolds of mica indicate that Unit G was synkinematically metamorphosed. Randomly oriented and non-deformed porphyroblasts of chlorite, biotite, and epidote that transect the schistosity show that the rocks were subsequently thermally metamorphosed under static conditions.

The disconformable upper contact of Unit G with the overlying Cambrian Prospect Mountain Quartzite (restricted) is placed at the highest occurrence of slate and argillite. The distinctive white quartzites of Unit H of the type McCoy Creek Group are absent from the Pilot Range.

Cambrian System

The Cambrian System in the southern Pilot Range is represented by 11 formations which aggregate approximately 6635 feet in thickness.

Terminology of the Cambrian System follows that used by Schaeffer (1960) in the Silver Island Range, as emended by Robison and Palmer (1968), and Wheeler (1948) in the House Range as emended by Robison (1960).

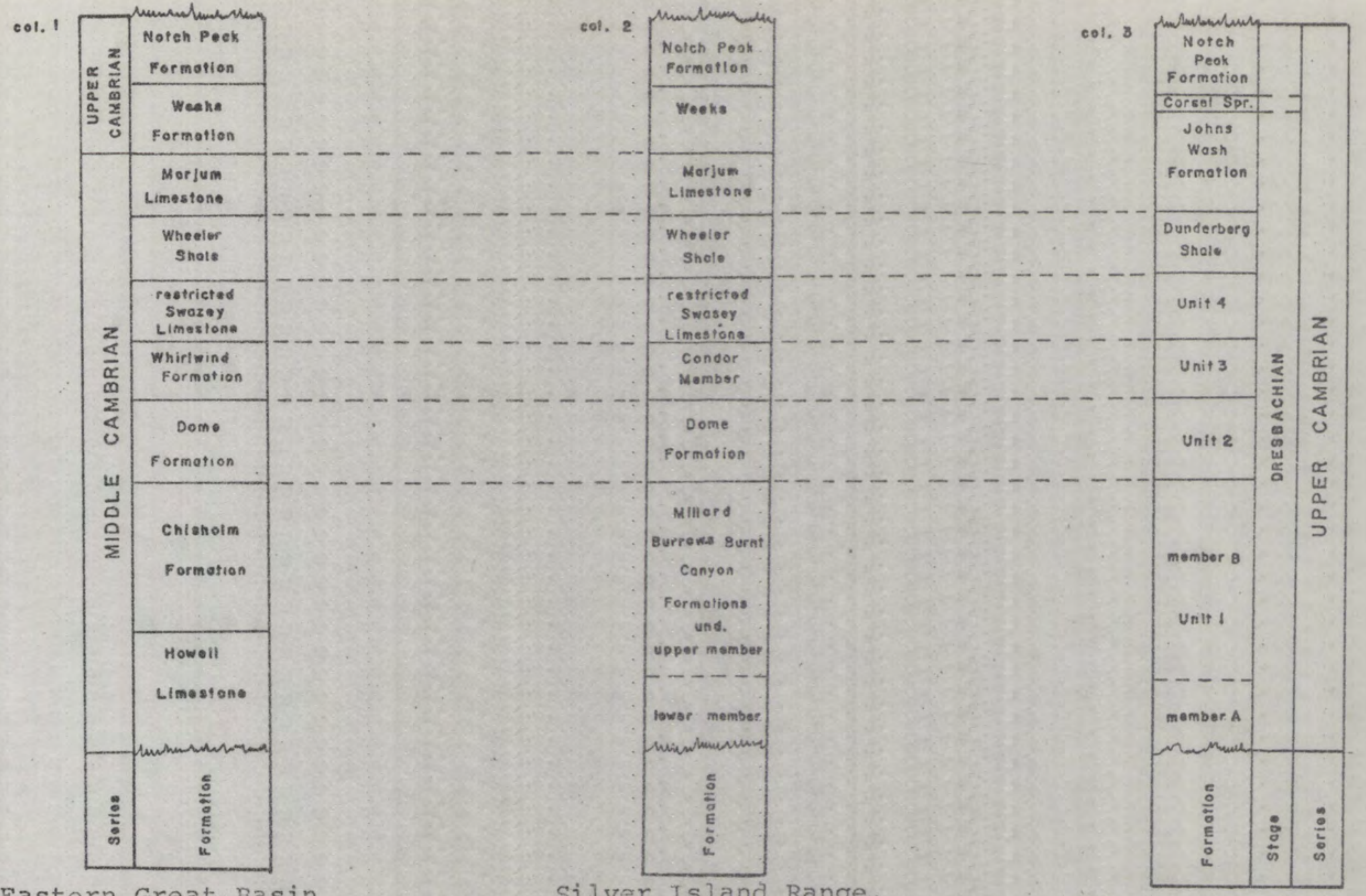
The most widely used stratigraphic units in the Cambrian section in northeastern Nevada and western Utah are, from base to top, the Prospect Mountain Quartzite (restricted), Pioche Shale, Busby Quartzite, Howell Limestone, Chisholm Formation, Dome Formation, Whirlwind Formation, Swasey Limestone (restricted), Wheeler Shale, Marjum Limestone, Weeks Formation, Orr Formation, and the Notch Peak Formation. These formations, except for the Orr Formation which wedges out northward from the House Range (Bentley, 1958), were mapped in the Silver Island Range, 15 miles southeast of the Pilot Range; however, Robison and Palmer (1958) found that the unusually thick Middle Cambrian section (Busby Quartzite through Marjum Limestone) in the Silver Island Range is actually Upper Cambrian (except for the Busby Quartzite and the lower member of the Howell and Chisholm Formations undifferentiated). An alternative correlation and terminology was proposed for the section (Fig. 4).

In the southern Pilot Range, terminology for the standard Cambrian section of Howell Limestone through Weeks Formation (Fig. 4, col. 1) will be as follows: Units 1A, 1B, 2, 3, and 4, Dunderberg Shale, Johns Wash Formation and the Corset Spring Formation (Fig. 4, col. 3). The Busby Quartzite is not exposed in the range and has probably been tectonically eliminated. The Corset Spring Formation is probably present, but covered by Quaternary fill.

Prospect Mountain Quartzite (restricted)

The Prospect Mountain Quartzite was named by Hague (1883) for 1500 feet of well-bedded quartzites and minor amounts of conglomerate and arenaceous and micaceous slates at Prospect Peak near Eureka, Nevada. It originally included 200 (+) feet of beds now assigned to the Pioche Shale (Nolan et al., 1956). Misch and Hazzard (1962) restricted the term Prospect Mountain Quartzite to those beds consisting principally of quartzite and overlying the slates and quartzites of the late Precambrian McCoy Creek Group.

The Prospect Mountain Quartzite (restricted) occurs



Eastern Great Basin
(Wheeler, 1948; Robison, 1960)

Silver Island Range,
Utah,
(Schaeffer, 1960)

Silver Island Range, Utah
Pilot Range, Utah-Nevada
(Robison, & Palmer, 1968)

Figure 4. Middle and Upper Cambrian Stratigraphic Nomenclature, Eastern Great Basin, Utah-Nevada

at the highest points in the Pilot Range and forms the main mass of Pilot Peak. The unit, approximately 3000 feet thick, consists principally of thin- to thick-bedded, medium- to coarse-grained quartzite which is light gray, white, light green, and pinkish on fresh fracture and weathers tan to dull red-brown. Ferruginous staining increases upward. Cross-bedding is common. Lenses of coarse-grained quartzites and micaceous quartzites occur in the section, although they are not common. The unit forms large cliffs and pronounced dip slopes.

The Prospect Mountain Quartzite (restricted) lies disconformably and with marked lithologic contrast on the late Precambian Unit G (Woodward, 1967). The contact is placed at the top of the green and gray argillite of Unit G and at the base of the quartzite. The upper contact of the quartzite is marked by the weakly resistant black and purple phyllite of the overlying Pioche Shale.

The Prospect Mountain Quartzite (restricted) of the Pilot Range is correlated with its type section on the basis of lithology and stratigraphic position.

Pioche Shale

The Pioche Shale was first described by Walcott

(1980b) from exposures in the Pioche district, Nevada. The section was redefined by Deiss (1938) as a "...lower 255 feet principally slope-covered drab gray, fine-grained, argillaceous and blue gray, medium-grained, fossiliferous limestone irregularly banded drab tan. The upper 194 feet is a dull tan brown, micaceous and arenaceous, chunky shale, thin bedded micaceous sandstone...."

The exposures of Pioche Shale in the southern Pilot Range occur as float-covered slopes directly south of South Spring Canyon. The unit consists of 150 (+) feet of black to purple platy phyllites. Interbedded platy, brown-weathering metasiltstones are locally abundant. Small hematite pseudomorphs after pyrite are common. In thin section the shale shows low grade synkinematic metamorphism. Folded bands of sericite and clay size quartz clasts are elongate in the schistosity (s_2). Microshears (s_3) are present. Later static metamorphism by the intrusion of a small igneous stock resulted in the growth of muscovite across pre-existing schistosity.

The conformable lower contact of the shale is marked by the pronounced dip slope of the underlying Prospect Mountain Quartzite (restricted). The upper contact of the Pioche Shale is not exposed, as the unit is in fault contact with Lower Ordovician strata.

The Pioche Shale is correlated with the type Pioche on the basis of lithology and stratigraphic position.

Unit 1

Unit 1 (equivalent to strata previously called the Howell and Chisholm Formations undifferentiated in the Silver Island Range) is exposed immediately south of Miners Canyon. This slope-forming unit is divisible into two parts:

The lower 385 (+) feet consists of fine-crystalline, medium gray, cliff-forming limestone that is locally mottled orange, and medium-bedded, fine- to medium-crystalline, argillaceous, white to light gray, calcareous dolomite.

The upper member consists of alternating beds of orange and gray, thin-bedded, argillaceous, fine- to medium-crystalline limestone that is commonly extremely mottled.

The unit is in fault contact with Cambrian and Lower Ordovician strata. The upper contact is placed at the top of the highest platy, argillaceous, orange-mottled limestone and at the base of a slope-forming, tan dolomite.

The unit is correlated with the lowest Upper Cambrian formation (Robison and Palmer, 1968) in the Silver Island Range based on lithology.

Unit 2

Unit 2 is exposed one-half mile south of Miners Canyon. This slope-forming unit aggregates approximately 225 feet in thickness. Medium-crystalline, thin-bedded, dark gray calcareous dolomite which weathers medium gray occurs in the lower part. Light gray and black chert nodules and stringers weathering black to orange-brown are common. 'Zebra banding' and medium-crystalline black and white specked dolomite are locally present. The rocks are locally mottled.

The upper part of the formation consists of approximately 75 feet of light gray to white, fine- to coarse-crystalline dolomite and calcareous dolomite.

The lower contact is tentatively placed at the top of a medium to dark gray, fine-crystalline limestone of Unit 1 (?) and at the base of a cherty, thin-bedded calcareous dolomite.

The unit is correlated with the corresponding Unit 2 in the Silver Island Range (Robison and Palmer,

1968) based on lithology and stratigraphic sequence.

Unit 3

In the Pilot Range, Unit 3 is exposed in Morrison Canyon. The formation, 300 (+) feet thick, consists of slope-forming, thin- to thick-bedded, fine- to medium-crystalline, argillaceous, dark gray to tan-gray limestone which weathers yellowish tan to dull tan-gray. The lower 50 feet consists of interbedded calcareous siltstone and fine- to medium-grained sandstone which weathers orange-brown to light tan.

The base of Unit 3 is not exposed. The upper contact is gradational and is placed at the top of a float-covered zone of limestone and at the base of the silty limestone of Unit 4.

The unit is correlated with the corresponding Unit 3 in the Silver Island Range (Robison and Palmer, 1968) based on lithology and stratigraphic sequence.

Unit 4

Unit 4, exposed in Morrison Canyon, aggregates 230 feet in thickness. It is composed of light to dark gray, argillaceous limestone which weathers medium to dark gray. The unit is thick- to very thin-bedded. Dark brown, calcareous silt lenses, one-half to three inches thick are characteristic of the unit. The unit forms cliffs and steep slopes.

The lower contact of Unit 4 is gradational and is placed at the base of the lowest silty limestone. The upper contact is placed at the top of a 17-foot light gray-weathering limestone and at the base of the platy, brown-weathering argillite of the Dunderberg Shale.

The unit is correlated with Unit 4 of the Silver Island Range (Robison and Palmer, 1968) based on lithology and stratigraphic position.

Dunderberg Shale

The Dunderberg Shale was named by Walcott (1908a) for exposures of shale lying above the Hamburg Limestone near the Hamburg and Dunderberg mines in the Eureka district, Nevada.

The Dunderberg Shale in the Pilot Range is exposed immediately south of Morrison Canyon. It consists of platy, interbedded brown siltstones and limestones and thin-bedded argillaceous limestones weathering orange-brown, greenish tan, and black. The unit, intruded by an igneous stock, has been thermally metamorphosed, reaching the hornblende-hornfels facies near the intrusive contact and grading outward to the albite epidote-hornfels facies. In thin section the hornblende-hornfels facies consists of porphyroblasts of oligoclase with rims of albite (25%) and hornblende (15%) in a matrix of alkali feldspars, hornblende, and minor quartz. In the low grade albite epidote-hornfels facies porphyroblasts of hornblende and minor epidote are present in a matrix of calcite (55-75%), minor quartz, and interstitial alkali feldspar and occasionally clinozoisite.

The unite is internally deformed and a meaningful thickness cannot be obtained.

The base of the unit is placed at the top of a 17-foot light gray limestone of Unit 4 and at the lowest platy argillites of the Dunderberg Shale. The formation is in fault contact with the Prospect Mountain Quartzite (restricted); the upper contact is not exposed.

The formation is correlated with the type section on the basis of lithology and stratigraphic position.

Johns Wash Formation

The Johns Wash Formation was named by Drewes and Palmer (1957) from exposures at the head of Johns Wash, southern Snake Range, Nevada. The name was applied to a "...250-foot unit of coarsely crystalline and clastic, light to dark gray limestone that commonly makes a cliff..."

In the southern Pilot Range the Johns Wash Formation is exposed along the eastern flank of Pilot Peak. The formation is in fault contact with the Prospect Mountain Quartzite (restricted). The formation is divided into two members. The lower member is 250 (+) feet thick and consists of slope-forming, micaceous, calcareous, green and brown siltstone and slate. The unit is very platy and weathers green to light orange-brown. Black, red, and brown phyllites having a mimetic schistosity are associated with the numerous dikes and sills intruded into the unit. The conformable upper contact is placed at the top of a platy, brown-weathering argillite and at the base of the white, coarsely-crystalline calcareous dolomite of the upper member.

The upper member, exposed as low ridges north of Miners Canyon along the base of Pilot Peak, consists of a basal thin-bedded, light gray, white, and bluish white, medium- to coarse-crystalline calcareous dolomite. Argillaceous partings increase upward and give the unit a dull orange-brown cast. Dark bands of anastomosing seams of argillaceous material are locally present. Platy, extremely argillaceous white limestone which weathers orange-brown, and dark brown, calcareous siltstone caps the unit. A high-angle strike fault has eliminated some strata and in juxtaposition is thin- to thick-bedded, medium-crystalline, argillaceous, dark gray and black calcareous dolomite of the uppermost (?) Johns Wash Formation. This part is poorly exposed.

Exposures of the upper member are structurally complex. Numerous recumbent isoclinal folds are present throughout and there appears to be a three-fold repetition of lithology suggesting large-scale overfolding. Normal (?) faults subparallel to bedding also cut the unit. The exposures of the upper member aggregate approximately 1000 (+) feet; a meaningful stratigraphic thickness could not be measured. Similar dolomite and limestone in the Silver Island Range aggregate 309 feet in thickness (Schaeffer, 1960).

The Johns Wash Formation is correlated with the same formation in the Silver Island Range and with its type section on the basis of lithology.

Notch Peak Formation

The Notch Peak Formation was named by Walcott (1908b) for exposures on Notch Peak, House Range, Utah, where a gray, arenaceous limestone, 1890 feet thick lies above the Orr Formation.

In the Pilot Range, the Notch Peak Formation is exposed in a fault-bounded block one mile north of Miners Canyon. The unit, aggregating 250 (+) feet in thickness, consists of a light gray to white, thin- to thick-bedded, fine- to medium-crystalline limestone. The unit becomes increasingly argillaceous upward. The upper 75 feet of the unit weathers red-brown; a fine-grained calcareous siltstone caps the unit.

The Notch Peak Formation of the Silver Island Range is correlated with the type section based on lithology, stratigraphic position, and faunal evidence (Schaeffer, 1960; Bentley, 1958). The unit in the Pilot Range, lithologically similar to the lowermost part of the Notch Peak of the Silver Island Range, is tentatively correlated with the type Notch Peak.

Ordovician System

The Ordovician System in the southern Pilot Range is represented by approximately 4576 feet of argillaceous limestone, shale, quartzite, and calcareous dolomite. Stratigraphic terminology follows that used in western Utah and eastern and central Nevada.

Pogonip Group

The Pogonip was originally defined by Clarence King (1878) for all Cambrian and Ordovician strata between the Prospect Mountain Quartzite and the Eureka Quartzite. The type section was on Pogonip Ridge, in the White Pine mining district, 30 miles southeast of Eureka, Nevada. Hague (1883) adopted the name for those beds lying between the Cambrian Dunderberg Shale and the Eureka Quartzite.

Sharp (1942) and others working in Nevada, Utah, and California restricted the Pogonip to the Ordovician System. (See Sharp, 1942, p. 657, for a complete résumé of the term.)

Hintze (1951) elevated the Pogonip to group status and described six formations near Ibex, Utah. They are, from base to top, the House, Fillmore, and Wah Wah Limestones (Canadian), and the Juab Limestone, Kanosh Shale, and Lehman Limestone (Chazyan).

Nolan _et al_. (1956) have divided the Pogonip into three lithologic units in central Nevada.

Hintze (1959) suggested that Pogonip terminology be used for the northern Utah Basin (i.e., north of the Tooele Arch). Webb (1956) placed the nose of the west-trending Tooele Arch near Wendover, Utah, along the westernmost edge of the Utah Basin. Schaeffer (1960) has recognized the Garden City Formation in the Silver Island Range, but he includes it as part of the Pogonip Group.

In this report the Pogonip Group contains five mappable units that are in ascending order: the Garden City Formation, Kanosh Shale, Lehman Limestone, Swan Peak Quartzite, and the Crystal Peak Formation.

Garden City Formation

The Garden City Formation was named by Richardson (1913) for exposures along Garden City Canyon, west of Bear Lake, Utah. It consists of approximately 1000 feet of thick- to thin-bedded gray limestone in the type area.

The Garden City Formation is exposed one-half mile south of Miners Canyon in the southern Pilot Range and can be divided into two members.

The basal member is divided into two parts. The lower part consists of 605 (+) feet of slope-forming, shaly, argillaceous, orange- and yellow-mottled, medium gray limestone which weathers light medium gray to brown-gray. Lenses of intraformational conglomerate are present. At 185 feet below the top there is a 50-foot, thin-bedded, yellowish white, fine- to medium-crystalline limestone that is locally very cherty. The upper part of the basal member, 465 feet thick, consists of medium gray limestone that is mottled orange-yellow; argillaceous partings up to 2 mm. thick occur locally. No chert is present. The member, thin- to very thick-bedded, forms alternating cliffs and slopes.

The upper cherty member is 1370 (+) feet thick and consists of flaggy, slope-forming, orange- and yellow-mottled, medium to light gray limestone which weathers dull yellow-tan to medium gray, and contains chert stringers and nodules throughout. Dolomite and calcareous dolomite, 235 feet thick, are present 115 feet above the base of the unit. The dolomite is dark to medium gray and becomes increasingly calcareous upward. A high-angle strike fault has eliminated part of the upper member.

The base of the Garden City Formation is not exposed. The upper contact is placed at the lowest occurrence of the orange-brown argillaceous shales and mudstones of the overlying Kanosh Shale.

The Garden City Formation is correlated with its type section on the basis of lithology and stratigraphic position. It is correlated with the lower (Canadian) Pogonip Group of the Ibex Basin on stratigraphic position.

Kanosh Shale

The Kanosh Shale was named by Hintze (1951) for exposures near the village of Kanosh in central Utah. There, it is yellowish brown, olive, gray, and pink fissile shale with intercalated thin-bedded limestone; siltstone and fine-grained sandstone occur in the upper part of the unit.

In the Pilot Range the Kanosh Shale is exposed one mile south of South Spring Canyon. It consists of 215 feet of platy mudstones and argillaceous shales weathering dark red-brown and dark green. Interbedded dark yellow-green and yellow-orange mudstones and dark gray, platy, fine- to medium-crystalline argillaceous limestones containing silt lenses one to two inches thick occur in the upper 120 feet.

The upper contact of the Kanosh Shale is placed at the highest occurrence of yellow-brown mudstone and shale.

The Kanosh Shale is correlated with the lower part of the type section of the Swan Peak Quartzite (Webb, 1959) on the basis of lithology, and with the type Kanosh Shale on the basis of lithology, faunal evidence, and stratigraphic position.

Lehman Formation

The Lehman Formation was named for exposures in the Snake Range near the Lehman Caves, Nevada (Hintze, 1951). At the type section it consists of fossiliferous, thin- to thick-bedded, blue-gray calcilutite and a few alternating beds of sandstone and quartzite.

The Lehman Formation, exposed one mile south of South Spring Canyon, consists of 840 (+) feet of flaggy, argillaceous, orange- and maroon-mottled, medium-crystalline, dark gray limestone. A high-angle dip-slip fault eliminates part of the unit.

The base of the Lehman Formation is placed at the highest occurrence of the mudstones of the Kanosh Shale. The upper contact is placed at the base of the cliff-forming Swan Peak Quartzite.

The Lehman Formation is correlated with its type section on the basis of lithology and stratigraphic position.

Swan Peak Quartzite

The Swan Peak Quartzite was defined by Richardson (1913) for strata lying between the Garden City Formation and the Upper Ordovician dolomites near Bear Lake, Utah. There, the unit consists of a lower, intercalated sandstone and shale member similar in lithology to the Kanosh Shale (Hintze, 1951; Webb, 1956) and an upper quartzite member. Webb defines the Watson Ranch tongue of the Swan Peak (?) Quartzite at Smooth Canyon, Ibex, as that quartzite lying between the Lehman Formation and the Crystal Peak Formation.

Exposures of the Swan Peak tongue in the Pilot Range are closely associated with those of the Lehman Formation. The unit is 46 feet thick and consists of cliff-forming, thin-bedded, very fine-grained, white to light gray quartzite that weathers dark gray to dark rusty brown. The unit thins to the south and one-half mile north of Dead Mans Canyon the quartzite is 15 feet thick and is overlain by 35 feet of interbedded shaly calcarenite and one- to two-foot dark gray quartzite beds.

The upper contact of the unit is placed at the top of the quartzite (or calcarenite) and at the base of the slope-forming, shaly limestone of the Crystal Peak

Formation.

The tongue of Swan Peak Quartzite is correlated with the upper part of the type section and with the Watson Ranch tongue (Webb, 1956) on the basis of lithology and stratigraphic position.

Crystal Peak Formation

The Crystal Peak Dolomite was named by Webb (1956) from exposures north of Crystal Peak, Confusion Range, Utah. The unit lies between the Watson Ranch tongue of the Swan Peak (?) Quartzite and the Eureka Quartzite, where it aggregates 89 feet of dolomite and intercalated silty limestone.

In the southern Pilot Range the unit consists of argillaceous limestone; therefore, it is referred to as the Crystal Peak Formation. The Crystal Peak Formation is exposed one mile south of South Spring Canyon. It consists of 320 feet of platy, argillaceous, red- and orange-mottled, dark gray to black limestone which weathers medium to light gray. No dolomite was noted in the section.

The overlying Eureka Quartzite lies concordantly and with marked lithologic contrast on the slope-forming limestones of the Crystal Peak Formation.

The unit is correlated with the type section on the basis of stratigraphic position and faunal evidence.

Eureka Quartzite

The Eureka Quartzite was named by Hague (1883) from exposures of resistant white quartzite in the vicinity of Eureka, Nevada. Kirk (1933) proposed a new type section for the quartzite along the base of Lone Mountain, 19 miles northwest of Eureka, Nevada. He divided the formation into three parts. Webb (1958) restricted the Eureka Quartzite to the upper 181 feet of Kirk's reference section and divided it into four members which can be traced with some confidence across central Nevada. Two additional members occur east of Eureka (Webb, 1958).

Hintze (1960, from Webb, 1958) noted that there appears to be "...an important unconformity within the Eureka Quartzite, at the top of a 45-foot, shaly quartzite member...and that this lower member of the Eureka is related to the regressive tongue of the Swan Peak Quartzite."

The Eureka Quartzite is well-exposed in the southern part of the map area. The formation can be divided into four members.

The lower 20 feet is cliff-forming, medium to light gray, medium- to fine-grained quartzite that weathers tan to dark rusty brown.

The overlying 110 feet consists of fine- to medium-grained, thin-bedded quartzite forming bench and bluff topography. The unit weathers dark brown to tan.

The overlying member, 105 feet thick, grades upward from dark gray, medium-grained, thin-bedded quartzite to very thin-bedded, light gray quartzite. To the south the member becomes white, cliff-forming, medium-grained clean quartzite that weathers light tan to dark brown.

The paraconformable (?) contact between the Eureka Quartzite and the overlying Fish Haven Dolomite (Schaeffer, 1960) is placed at the top of the highest quartzite bed and at the base of the first black dolomite.

The Eureka Quartzite is correlated with its type section on the basis of lithology and stratigraphic position.

Fish Haven Dolomite

The Fish Haven Dolomite was named by Richardson

(1913) for exposures along Fish Haven Creek in the Bear River Range, Utah. It is a fine-textured, medium-bedded, dark gray to blue-black, locally cherty dolomite and is approximately 500 feet thick.

The Fish Haven Dolomite is well exposed one-half mile north of Dead Mans Canyon in the southern Pilot Range. It is divided into three parts.

The basal black dolomite, 195 (+) thick, consists of cliff-forming, thin-bedded, black and medium gray, fine- to medium-crystalline calcareous dolomite, containing chert stringers and nodules throughout. Silt content increases upward; silt concretions up to three inches in diameter are present locally. Some strata have been eliminated by a high-angle strike fault in the measured section.

The middle part, 135 feet thick, consists of slope-forming, medium gray to gray-brown, argillaceous, thin-bedded, calcareous dolomite.

The upper member, eliminated in part by faulting in the measured section, consists of 120 feet of platy, dolomitic limestone. The unit is medium gray to dark grey and black, fine- to medium-crystalline, and locally cherty. Argillaceous partings up to one-eighth inch thick and weathering red to orange-brown increase in abundance upward.

The upper contact of the Fish Haven Dolomite is not exposed in the southern Pilot Range.

The formation is correlated with the type section on the basis of lithology and stratigraphic position.

Silurian System

In the southern Pilot Range the Silurian System is represented by one formation, the Laketown Dolomite.

Laketown Dolomite

Richardson (1913) described this unit from exposures in Laketown Canyon, four miles southeast of Laketown, Utah, as massive, light gray to whitish dolomite containing lenses of calcareous sandstone and having a thickness of approximately 1000 feet.

The exposures of the Laketown Dolomite, two miles north of Dead Mans Canyon, are intensely faulted. Tectonic elimination of much of the unit has occurred. In the Silver Island and northern Pilot Ranges the unit is approximately 1100 feet thick (Schaeffer, 1960; Blue, 1960). Approximately 550 to 600 feet of the dolomite is exposed in the southern Pilot Range and is divided into two parts.

The lower (?) part, aggregating 390 (+) feet in thickness, consists of three members. The lower member, 250 (+) feet thick, consists of thin- to thick-bedded, medium-crystalline, medium gray to black, cliff-forming dolomite and calcareous dolomite. The middle member, 40 feet thick, consists of slope-forming, thin-bedded, medium gray calcareous dolomite and is overlain by 100 (+) feet of dolomite similar to the lower member.

The upper (?) part of the formation, approximately 150 feet thick, is light gray to white, coarse- to medium-crystalline, locally argillaceous dolomite.

Due to faulting, neither the base nor the upper contact is exposed.

The formation is correlated with the type section on the basis of lithology.

Devonian System

The Devonian System in the southern Pilot Range is represented by the Simonson Dolomite and the Guilmette Formation. The absence of the Sevy Dolomite in the northern Pilot Range (Blue, 1960) and in the Silver Island Range (Schaeffer, 1960) may be due to the erosional unconformity at the base of the Simonson Dolomite.

Simonson Dolomite

The Simonson Dolomite, defined by Nolan (1935) and named from exposures in Simonson Canyon, Deep Creek Range, Utah, consists of dark to medium gray, medium-crystalline, thin- to thick-bedded dolomite. The most striking feature is the general presence of fine irregular laminations (Nolan, 1835).

Osmond (1954) stated: "The Simonson Dolomite is readily subdivisible into four members. The lowest member is a massive, cliff-forming unit of tan, coarse-crystalline dolomite. Above this is a distinctive sequence of alternating light gray and dark brown dolomite beds. Lower and upper alternating members are separated by a massive, brown, cliff-forming dolomite member."

In the southern Pilot Range the Simonson Dolomite outcrops as low ridges north and south of Dead Mans Canyon.

The formation, incomplete due to faulting, aggregates 365 feet and is divided into two members.

The basal member, exposed in a fault wedge, is 75 feet thick and consists of medium-crystalline, alternating bands of light and dark gray dolomite; the bands average two feet in thickness.

The upper member, 290 feet thick, consists of interbedded medium gray, fine- to medium-crystalline, finely-laminated calcareous dolomite with local bright red argillaceous partings and zones of fossil hash, and medium to light gray, medium-crystalline, locally laminated dolomite. Irregular bedding planes are common. The member forms bench and bluff topography.

The base and the upper contact of the Simonson Dolomite are not exposed in the southern Pilot Range due to faulting.

The formation is correlated with the type section on the basis of lithology and distinguishing banding and laminations.

Guilmette Formation

The Guilmette Formation was named by Nolan (1935) after Guilmette Gulch, Deep Creek Range, Utah. He described the unit as follows:

> The Guilmette Formation is composed chiefly of dolomite but also contains some thick limestone beds and several lenticular sandstones...The most abundant variety is a fine-grained dolomite, dark to

> medium gray on fresh fracture and weathering to lighter shades of gray...Less abundant but far more striking in character is the dark dolomite filled with fragments of tubular corals.
>
> The limestones...are massively bedded, dense rocks that are light brownish gray on fresh fracture but weather to shades of bluish gray...The sandstone beds form a comparatively small portion of the formation.

Blue (1960) divided the Guilmette of the northern Pilot Range into three members: the lower 'blue black limestone member,' the middle 'massive quartzite member,' and the upper 'shaly limestone member.' There the formation is 2160 feet thick.

The Guilmette Formation in the southern Pilot Range, exposed south of Dead Mans Canyon, is incomplete due to faulting and erosion. Exposures of the 'lower member' (Blue, 1960; Schaeffer, 1960), aggregating 570 feet in thickness, consist of slope-forming, alternating medium gray to black, fine- to medium-crystalline limestone. Bedding is predominantly massive although some platy intervals are present near the base and top of the exposures.

Neither the base nor the upper contact of the formation is exposed in the southern Pilot Range.

The formation is correlated with the type section on the basis of lithology and faunal evidence.

Devonian-Mississippian (?) and Mississippian Systems

The Upper Devonian and Mississippian (?) Pilot Shale and the Lower Mississippian Joana Limestone aggregate 690 feet in the Silver Island Range (Schaeffer, 1960). The formations are not exposed in the southern Pilot Range and are apparently missing because of erosion and/or nondeposition in the northern Pilot Range (Blue, 1960).

Mississippian-Pennsylvanian Systems

Hague (1892) defined the White Pine Shale from exposures in the White Pine Mountains, Nevada. Lawson (1906) correlated a shale-limestone-shale sequence lying between the Nevada Limestone (unrestricted) and the Ely Limestone (unrestricted) near Ely, Nevada, with the White Pine Shale. Spencer (1917) proposed that these subdivisions be given formational rank, naming them, from base to top, the Pilot Shale, Joana Limestone, and the Chainman Shale for exposures in the Robinson mining district near Ely.

Easton *et al*. (1953) retained the White Pine Shale as a formation and regarded the subdivisions as members. Schaeffer (1960) follows Nolan *et al*. (1956)

and believes it desirable to reject the usage of Easton <u>et</u> <u>al</u>. (1953).

The Chainman Shale and the overlying Diamond Peak Quartzite are difficult to separate in parts of the Great Basin. Nolan <u>et</u> <u>al</u>. (1956) stated:

> In particular we have not been able in many places to select a satisfactory boundary between Hague's White Pine Shale and his Diamond Peak Quartzite; black shale layers of considerable thickness and comparable in lithologic character to the bulk of the White Pine persist essentially throughout the interval mapped by Hague as Diamond Peak. Quartzite or conglomerate beds, moreover, that in one place might appear to form a satisfactory boundary between the two formations lens out within relatively short distances; a similar bed may then appear several hundred feet higher or lower stratigraphically.

Nolan <u>et</u> <u>al</u>. (1956) proposed the "...use of the Diamond Peak Formation for the coarse clastic upper portion of the Upper Mississippian sequence where it can be satisfactorily separated from the underlying black shales, and to adopt Spencer's name of the Chainman Shale for the lower unit where it can be mapped separately."

Sadlick (1960) suggests the use of the name Diamond Peak facies of the Chainman Formation.

In the southern Pilot Range the Chainman Shale and the Diamond Peak Quartzite are poorly exposed at the southern tip of the range.

Chainman Shale

The Upper Mississippian Chainman Shale was named from exposures at the Chainman Mine, near Lane, Nevada, where it is "essentially a soft, fissile clay shale grading locally into fine-grained sandy shale."

Exposures of the Chainman Shale, 180 feet thick, consist of alternating medium gray, thin-bedded, argillaceous limestone and thin-bedded, tan sandstone.

Neither the base nor the upper contact of the Chainman is exposed in the southern Pilot Range.

The unit is correlated with the type section on the basis of lithology and faunal evidence.

Diamond Peak Quartzite

The Diamond Peak Quartzite was named by Hague (1883) from exposures at Diamond Peak, near Eureka, Nevada, where 3000 feet of "conglomerate firmly cemented together lie next to the argillaceous shales of the White Pine epoch, but quickly give place to a more massive, uniformly vitreous quartzite."

The Diamond Peak Quartzite in the southern Pilot Range aggregates 425 (+) feet of pebble conglomerate and interbedded medium gray, coarse-grained quartzite. The conglomerate is yellow-white to gray, and weathers very dark orange-brown. Quartz pebbles up to one and three-fourths inches long are subangular to subrounded; 80-85 percent are light colored, the remainder being black.

The upper contact of the quartzite is placed at the top of the thick sequence of pebble conglomerate, and at the base of the first bioclastic limestone of the Ely Limestone.

The Diamond Peak Quartzite is correlated with the type section on the basis of lithology and stratigraphic position.

Pennsylvanian System

In the southern Pilot Range the Pennsylvanian System is represented by the Ely Limestone and the lower Oquirrh Formation undifferentiated.

Ely Limestone and lower Oquirrh Formation undifferentiated

The Ely Limestone was defined by Lawson (1906) as the cherty limestone sequence in the Robinson Mining district near Ely, Nevada. Dott (1955) divided the formation in the Elko and Diamond Ranges into two units, the Moleen Formation and the overlying Tomera Formation, and elevated the Ely to group status. In eastern Nevada and western Utah the Ely Limestone retains its formational rank (Steele, 1959; Schaeffer, 1960).

The Oquirrh Formation, named by Gilluly (1932) from exposures in the Oquirrh Range, Utah, consists of 15,000 feet of alternating limestone and sandstone.

Schaeffer (1960) noted: "The geographical position of the Silver Island Mountains (and the Pilot Range) places it in the transition zone between the lithologies of the Ely and the lower portion of the Oquirrh (Steele, 1959b); therefore, the Ely and the lower portion of the Oquirrh Formations are undifferentiated in this area.... This transition...is based upon quartz clastic content; the Oquirrh having the greater percentage (Steele, 1959b)."

The Ely Limestone and the lower Oquirrh Formations undifferentiated are exposed north and south of Dead Mans Canyon in the southern Pilot Range. The unit, 1040 (+) feet, can be divided into two members.

The lower 'limestone member,' 505 feet thick, consists of dark gray and black, locally bioclastic limestone. The lower 127 feet is medium- to coarse-crystalline and very fossiliferous. Three-foot silt beds were noted near the base and top of the member.

The upper 'argillaceous limestone member,' 535 (+)

feet thick, consists of alternating medium gray, fine- to medium-crystalline limestone and yellow-brown to pink weathering argillaceous limestone and calcareous siltstone; silt and chert nodules occur throughout.

The base of the unit is placed at the top of the highest conglomerate bed of the Diamond Peak Quartzite and at the base of the lowest bioclastic limestone. The upper part of the measured section is in fault contact with the Diamond Peak Quartzite.

This undifferentiated unit is correlated with the Ely and lower Oquirrh Formations undifferentiated in the Silver Island Range. According to Schaeffer (1960): "The lower member of the Ely and Oquirrh (lower portions) undifferentiated (and that part exposed in the southern Pilot Range)...is the time equivalent of the Moleen Formation of Dott (1955); of the West Canyon member of the Oquirrh Formation of Nygreen (1958); and of the Hall Canyon and Meadow Canyon (in part, if not entirely) of Bissel (1959)."

Pennsylvanian-Permian Systems

Pennsylvanian-Permian strata in the southern Pilot Range are represented by an incomplete section of the following undifferentiated formations: Strathern (upper portion), Riepetown Sandstone, Ferguson Springs Formation, and Pequop Formation.

The Strathern Formation was named by Dott (1955) for exposures of arenaceous limestone and chert granule and pebble conglomerate in the Elko Range, Nevada.

The Riepetown Sandstone was named by Steele (1960) for exposures near Riepetown, Robinson Mining District, White Pine County, Nevada.

The Ferguson Springs Formation was named by Steele (1960) for "medium-crystalline, bioclastic, silty limestone sequence with thin interbeds of bituminous shale... occurring above the middle Pennsylvanian regional unconformity and stratigraphically below the Pequop Formation."

The Pequop Formation was named by Steele (1959a) for exposures of purplish gray, irregularly-bedded, platy, silty limestone with interbedded fusuline coquinas in the Pequop Range, Elko County, Nevada.

In the Silver Island Range Schaeffer (1960) did not differentiate the preceding Pennsylvanian-Permian formations for the following reasons:

"In the Silver Island Mountains the Strathearn, Oquirrh (upper portion), and Riepetown are relatively thin, variable in thickness due to facies changes, and are cliff-forming. Thus these formations were not mapped separately. The Ferguson Springs and Pequop Formations have a large thickness in the range, but the writer was unable to differentiate these formations except by the use of fusulinids; thus, these formations were not mapped separately."

The Oquirrh (upper portion) is the easterly facies of the Strathearn, Riepetown, and Ferguson Springs Formations exposed in the western Silver Island Range (Schaeffer, 1960).

In the southern Pilot Range the undifferentiated Pennsylvanian-Permian strata are poorly exposed along the eastern base of Pilot Peak, occurring as low hills largely concealed by Quaternary fill. The unit consists of thin- to thick-bedded, somewhat argillaceous, bioclastic, medium-crystalline, dark gray limestone and minor interbeds of dark brown-weathering siltstone. A meaningful thickness of the unit cannot be obtained. Neither the base nor the upper contact of the unit is exposed.

The undifferentiated unit is correlated with these Pennsylvanian-Permian units of the Silver Island Range on the basis of lithology.

Quaternary System

The Quaternary System in the southern Pilot Range is represented by pediment deposits, Lake Bonneville lacustrine deposits, playa lake deposits, alluvial fan deposits, desert pavement, and talus.

Pre-Bonneville pediment deposits are present along the tops of several low hills along the eastern base of Pilot Peak. The deposits consist of boulders, pebbles, and sands and aggregates 10-20 feet in thickness.

Lake Bonneville terraces and associated thin deposits of calcareous tufa, diatomaceous earth, and calcareous silt surround the range.

The better developed lake terraces are: Bonneville, 5204 feet; Rush Valley, 5123, 5075, and 4953 feet; Provo, 4834 feet; Stansbury (Utah Valley arm), 4714, and 4484 feet; and Gilbert, 4251 feet (Eardley *et al*., 1957; Schaeffer, 1960). The Bonneville, Provo, and Stansbury terrace levels are best developed and exposed in and around Dead Mans Canyon where they have been cut into bedrock. The levels are well marked by deposits of calcareous tufa as much as one foot thick and locally containing abundant pebbles (Plate 2). The terraces are

Plate 2. Lake Bonneville calcareous tufa at the Provo lake level. The tufa lies unconformably on the Devonian Guilmette Formation.

poorly developed in the alluvial deposits around the rest of the range, but are marked by a zone of white calcareous silt and diatomaceous earth.

Development of beach bars across embayments as in the Silver Island Range (Schaeffer, 1960) is common; the bars consist of silt and pebbles.

In narrow canyons where Bonneville deposits have been better preserved, very fine-grained friable, light gray, pinkish, yellow-tan, and white calcareous silt and diatomaceous earth up to 20 feet thick are present and are commonly overlain by coarse, platy, poorly cemented beach pebbles which everywhere dip away from the range. Eardley _et al_. (1957) suggested that the pebbles overlying the fine-grained silt deposits represent a regression of the lake.

Playa lake deposits have developed only around the southern margin of the range in the Pilot Valley. These deposits, consisting of light-colored, calcareous clay occasionally covered by a thin veneer of coarsely crystalline salt, are underlain by dark brown to black clays belonging to a period of continuous lake deposition by Lake Bonneville (Nolan, 1927). An extensive salt deposit covering 25 square miles is present in Pilot Valley along the western playa margin directly east of the Cove.

Alluvial fans completely surround the Pilot Range. The main growth of the deposits occurred before Lake Bonneville time; however, in the southern part of the map area recent growth of the deposits has covered numerous lake terraces.

Desert pavement has been widely developed along the southern margins of the range.

Talus deposits, occurring throughout the map area, are principally associated with the Prospect Mountain Quartzite (restricted). They are well developed on Pilot Peak, reaching lengths of over one mile and occurring in areas having relief of more than 2500 feet.

Igneous Rocks

Igneous dikes, sills, and stocks are common along the eastern base of Pilot Peak and are randomly distributed south of South Spring and Miners Canyons (Fig. 5). In the remaining area there appear to be no igneous intrusions except for a small stock one-half mile north of Golliers Canyon.

The stocks, irregular in shape, being both concordant and discordant, reach a maximum size of approximately

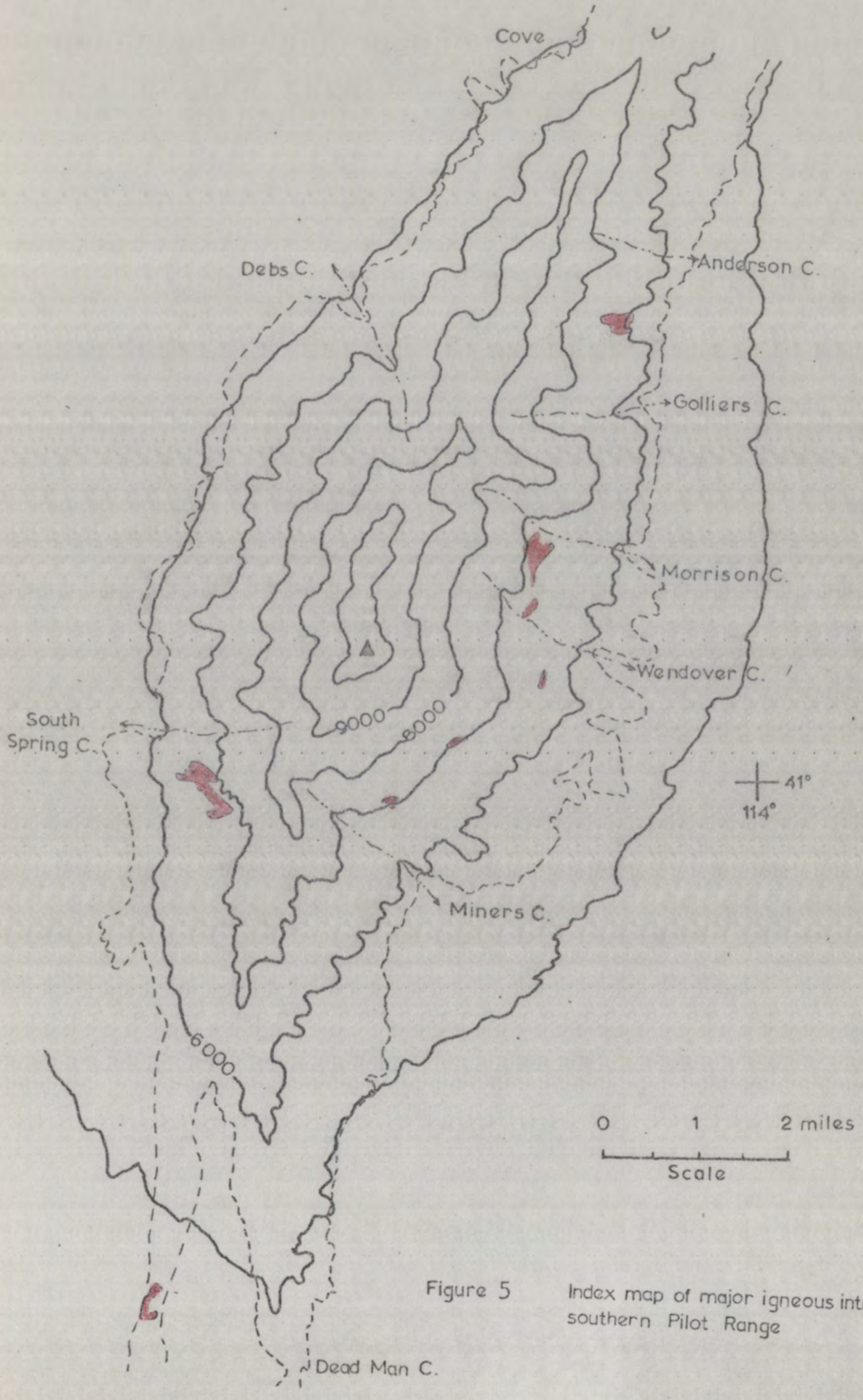


Figure 5 Index map of major igneous intrusions, southern Pilot Range

75 acres, and have thermally metamorphosed surrounding strata up to and including the hornblende-hornfels facies. Dikes and sills are generally one to three feet thick, although several up to 15-20 feet thick were noted. The dikes and sills are discontinuous along strike, generally 100 to 300 feet long, although several can be traced for approximately a quarter mile.

Those intrusions along the eastern base of the peak are in most instances located along pre-intrusive faults; especially noteworthy are the large and numerous intrusions along the décollement. In all other locations there appears to be little structural control of the intrusions.

Only two intrusions are cut by faults; one fault is very minor, and the other is located at the range margin suggesting that the fault may be related to the block-faulting of the range. Coats _et_ _al_. (1967) have dated as Oligocene a larger pluton at Patterson Pass, five miles north of the map area. It seems possible that at least the larger intrusions in the map area are related to the Patterson Pass pluton.

The stocks in the map area are granodioritic (dacitic) in composition with the exception of one small quartz latite intrusion. Textures of the stocks vary from phaneritic to aphanitic porphyritic (the matrix consists of anhedral quartz and feldspar).

The granodiorites and dacites are very similar in compositon, containing, on the average, 40% plagioclase commonly zoned from andesine to oligoclase; 15% alkali feldspar (occasionally indentifiable as microcline); 20% quartz; and 10% hornblende. Alteration of feldspars to sericite and epidote and of hornblende to chlorite and biotite in addition to minor accessories of calcite, apatite, allanite, and opaques comprise the remaining 15%. The granodiorite observed along the eastern base of the peak and the one immediately south of South Spring Canyon differ from the dacites in that the zoned plagioclase has a rim of albite rather than oligoclase.

The quartz latite is estimated to contain 25% andesine and 20% biotite as phenocrysts in a matrix of very fine-grained quartz (30%) and alkali feldspar (20%). Sericitized plagioclase and chloritized biotite are common (5%).

Dikes and sills in the map area range in composition mainly from rhyolitic to dioritic although some are silicic and others are amphibole-rich. Not all sill and dike rocks were examined in thin section; however, those described appear to be representative.

The dikes and sills are aphanitic or aphanitic porphyritic. In many cases the intrusives have been deeply weathered, some becoming quite frangible. In most samples alteration of feldspar to sericite and epidote and of hornblende to chlorite and biotite has occurred. The following rock types are seen in the dikes and sills:

Pegmatite - Pegmatite is not common in the map area; those found are located near Wendover Canyon. They consist of very coarse-grained quartz and feldspar; no mica was noted.

Rhyolite - Rhyolitic dikes and sills are relatively common. They are light colored and uniformly aphanitic. In thin section they consist of very fine-grained alkali feldspar (60%), quartz (20%), and sericite (15%). Minor calcite, chlorite, apatite, and opaques are present.

Quartz latite - These dikes and sills are widespread. They consist of medium-grained phenocrysts of oligoclase and hornblende or biotite constituting as much as 50% of the rock and in an aphanitic matrix (40%) of alkali feldspar and quartz. Minor calcite, epidote, apatite, chlorite, and opaques are present.

Diorite - Diorite dikes, relatively widespread, are generally aphanitic porphyritic, consisting of phenocrysts of hornblende (15%) and labradorite (65%) in a fine-grained matrix of alkali feldspar and epidote. Sericite (10%) after plagioclase and chlorite (2%) after hornblende are common.

Amphibole-rich rocks - Amphibole-rich dikes and sills are not common in the map area and those present appear to be concentrated immediately north of Miners Canyon. Three dikes and a sill, discussed below, were examined in thin section.

One dike contains hornblende as phenocrysts (45%) up to 4 cm long in a matrix of fine-grained, subhedral hornblende (10%), pyroxene (10%), apatite (4%), and interstitial alkali feldspar (15%). Minor sphene and calcite are present. Chlorite (10%) after hornblende is common.

A second dike contains amphibole phenocrysts (70%) that appear to be mostly common hornblende with minor colorless amphibole in optical continuity in some of the crystals. These are found in a matrix of interstitial alkali feldspar (10%) and minor sphene, apatite, calcite, epidote, and opaque.

A sill consisting of euhedral to subhedral phenocrysts of nearly colorless amphibole (70%) in a medium-grained matrix of biotite (15%), microcline (10%), and sphene (5%) occurs near the dikes described above.

Another dike in hand specimen is pale green, phaneritic, with dark brown phenocrysts of pyroxene. In thin section it is estimated to contain euhedral augite phenocrysts (55%) in a matrix of colorless amphibole (20%) locally replacing the pyroxene and anhedral microcline (20%). Minor apatite and allanite are present.

MINERAL DEPOSITS

Mineralization in the southern Pilot Range is limited principally to the Miners Canyon area where an abandoned mine and several prospects are present in the Cambrian formations. Mineralization is associated with a small stock and occurs discontinuously in fractures along the perimeter of the intrusion. Those minerals identified in hand specimen are chrysocolla, malachite, pyrite, and chalcopyrite. The workings are small; little ore appears to have been recovered.

Several prospect pits in the adjacent area have been dug along minor veins of copper mineralization.

A small barite vein is located south of Dead Mans Canyon in ghe Guilmette Formation. The vein is irregular and discontinuous, parallel to bedding, and has a maximum thickness of approximately one foot.

STRUCTURE

Regional Structural Setting and History

The Pilot Range is located in the northeastern part of the Great Basin (Fig. 6). North- to northeast-trending linear mountain ranges composed mainly of thick accumulations of late Precambrian and Paleozoic miogeosynclinal sedimentary rocks are characteristic of the region. These strata were not greatly disturbed until Mesozoic time (Misch, 1960); however, disconformities are present in the Precambrian-Cambrian, Ordovician, Silurian-Devonian, and Devonian-Mississippian Systems. Willden and Kistler (1967) have suggested relatively strong tectonism in the pre-Devonian rocks of the Ruby Range. The effects of this deformation, accompanied by plutonism and regional metamorphism were not noted in the southern Pilot Range. Also, the effects of the late Paleozoic Antler orogeny of central Nevada are recorded in this region only by sedimentary clastic components of the Chainman-Diamond Peak rocks that were derived from this orogenic belt.

The present structures in the eastern Great Basin

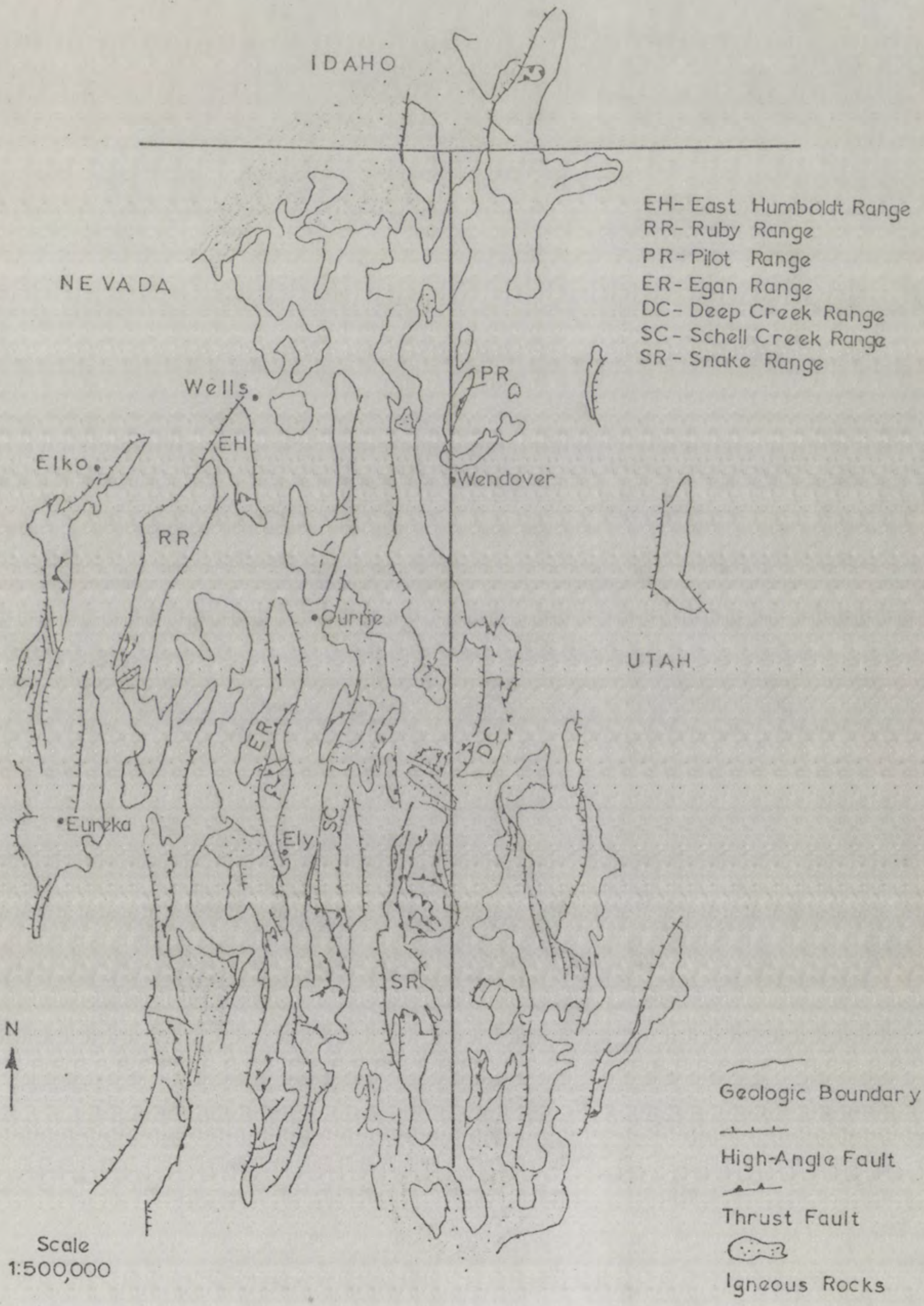


Figure 6 . Tectonic Map of the Eastern Great Basin. (From Tectonic map of the United States, 1961)

are the result of at least three episodes of orogeny, beginning in Mesozoic time and continuing periodically into the Quaternary. Distinctive structural features are related to each deformation.

Overturning, thrust faults, and décollement thrusts that yielded to the east accompanied by synkinematic metamorphism (Misch, 1960) are associated with Mid-Mesozoic orogeny. According to Misch:

> From near the Utah-Nevada line to the Ruby-East Humboldt Range the most distinctive orogenic feature of the present region is the widespread décollement thrusting near the base of the Paleozoic sequence. In a number of ranges such thrusting can be demonstrated to be on a large scale, in terms of areal extent of the exposed movement plane and of the great intensity of attending deformation, such as mylonization and dynamic metamorphism near the top of the substratum, or the production of tectonitic banded marbles in the thrust zone, as highly complex slicing, lensing, imbrication, etc. in these structures at the décollement.

Concomitant with the Mid-Mesozoic faulting is the metamorphism of the late Precambrian and lower Cambrian strata. Misch and Hazzard (1962) have found what appears to be irrefutable evidence for attending synkinematic metamorphism. These are: (1) a gradational change from a garnet zone of metamorphism near the base of the Precambrian section to a chlorite zone at the top of the late Precambrian section in the Snake Range, showing that this metamorphism is of one stage and is post-Precambrian; (2) Metamorphism continues up-section through the Cambrian Prospect Mountain Quartzite (restricted) and into the Cambrian Pioche Shale which shows low-grade metamorphism of the chlorite zone. The lack of undonformities in the Cambrian shows that the age of metamorphism is at least post-Cambrian. (3) The metamorphism must be related to a period of orogeny, as the metamorphism is synkinematic. No major orogeny is recorded until after the early Jurassic and it therefore appears to be related to the Mid-Mesozoic orogeny of the region.

Mesozoic tectonism can be dated precisely in relatively few areas in the region although many areas contain evidence which tends to limit the deformation to the Mesozoic period. Easton (1953) and Nolan _et_ _al_. (1956) found fresh water Lower Cretaceous sedimentary rocks resting unconformably on deformed Paleozoic strata in the Eureka and Illipah districts. In the Currie area rocks as young as Jurassic are involved in the orogeny (Wheeler _et_ _al_., 1949; Nelson, 1956). Though still broadly defined, the orogeny in eastern Nevada has been dated as Mid-Mesozoic.

Mesozoic tectonism was followed by a period of high-angle faulting commonly dated as early Cenozoic; these faults occur within the ranges and their topographic expressions are commonly minor and are related to rock resistance. Blocking out of the mountains along basin-range faults is of later Cenozoic age. Threet (1960) has pointed out objections to the idea of two periods of Cenozoic faulting. However, the evidence appears to support two episodes of high-angle faulting. Gilbert (1875) and Davis (1925, 1930) have discussed criteria for the recognition of block-faulted ranges in the Great Basin. These have been summarized by Nolan (1943).

There are three main lines of evidence that have been advanced to prove the existence of faults bordering the individual ranges in the Great Basin. These are physiographic evidence, stratigraphic evidence, and the presence of the fault plane. The latter two are decisive but commonly not observed. Therefore, the main evidence lies in the physiography of the range. Physiographic criteria are: tilted erosion surfaces, truncation of internal structure, fault or fault-line scarps, triangular facets, alignment of springs, louderbacks, abrupt rise of range, and several others. Nolan (1943) notes that geologic work in the Great Basin "appears to warrant the statement that most if not all of the major ranges in the province are bounded by faults on either one or both sides."

Structure of the Map Area

Three episodes of deformation are seen in the rocks of the Pilot Range (Fig. 7). Mesozoic thrusts and related folds occur principally in the late Precambrian and Cambrian strata in the central and northern parts of the map area. Cenozoic high-angle faults within the range are present throughout the map area, but are most abundant in the southern part of the range. The present physiographic expression of the range is apparently due to block-faulting of later Cenozoic age.

Mesozoic Structure

Mesozoic thrust faults in the southern Pilot Range cut Precambrian through Upper Cambrian strata, thrusting older upon younger, and also younger upon older with tectonic thickening, thinning, and elimination of intervening strata. Associated overturned folds indicate an eastward direction of tectonic transport.

The thrust fault at the head of Debs Canyon (Plate 3; Fig. 7) has moved Precambrian Unit G over

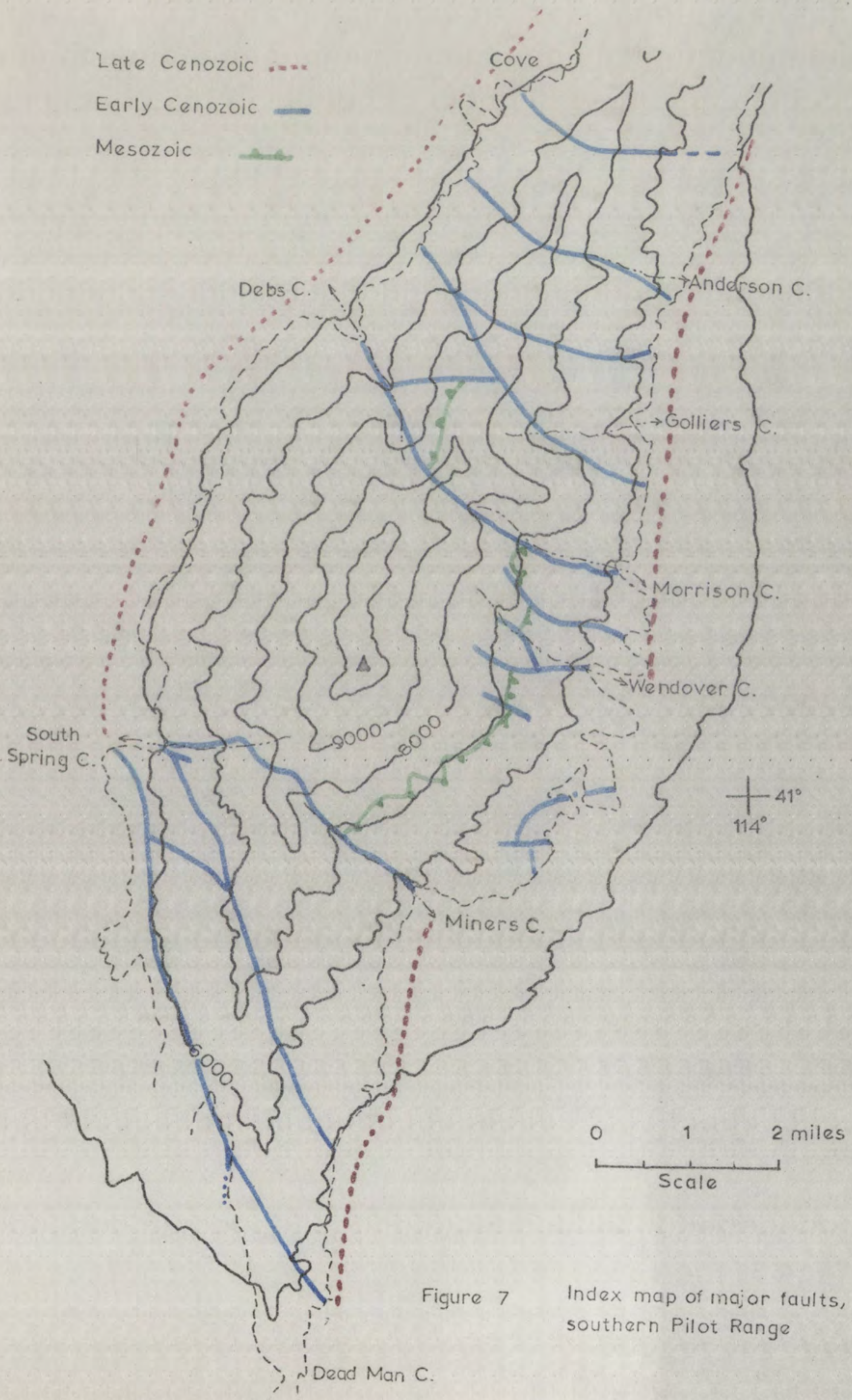
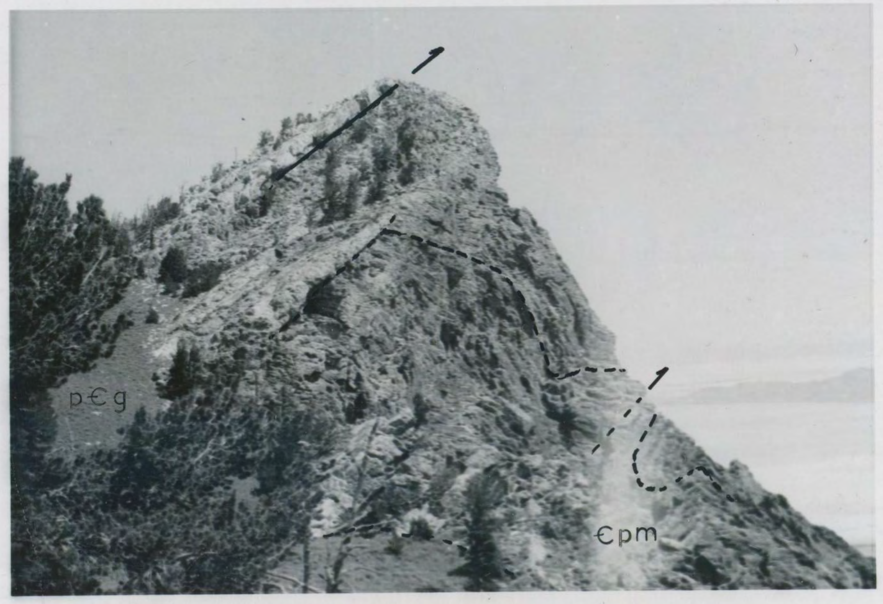


Figure 7 Index map of major faults, southern Pilot Range

Plate 3. Thrust fault at head of Debs Canyon. View is to the north-northeast. Precambrian Unit G, on left, has been thrust eastward over Cambrian Prospect Mountain Quartzite (restricted). Minor folds and thrusts are present in the quartzite. Symbols are same as on geologic map, Pl. 5.



Cambrian Prospect Mountain Quartzite (restricted). The fault is generally concave to the west-northwest and dips northwesterly 30-35 degrees. Stratigraphic separation cannot be determined precisely, although it appears to be on the order of 1000 feet. The thrust is truncated on both ends by high-angle faults. Immediately south of the thrust, contorted and nearly vertical beds in the Prospect Mountain Quartzite (restricted) and a large overturned fold in Unit G, which has repeated approximately 200 feet of strata, suggest that the fault originally extended to the south but is now eroded. Small associated thrusts (shown diagrammatically on the geologic map) and nearly vertical beds are present in the Prospect Mountain Quartzite (restricted) below the fault plane.

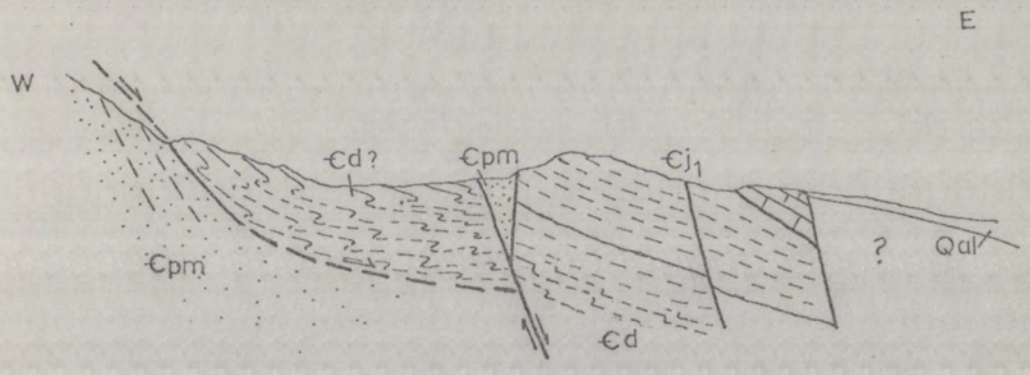
Directly north of Golliers Canyon there is intense internal deformation within Units E and F; locally the beds are overturned. The geometric relationship of these structures to the Debs Canyon thrust cannot be determined because of later displacements by high-angle faults; however, all these structures are probably part of the compressive Mesozoic deformation.

A décollement along the eastern base of Pilot Peak has moved Upper Cambrian Johns Wash Formation over lower

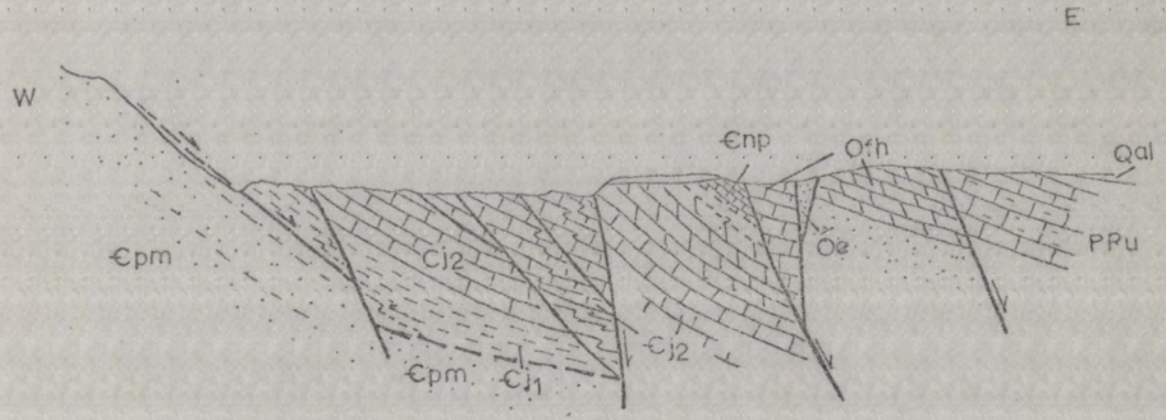
Cambrian Prospect Mountain Quartzite (restricted), eliminating more than 2000 feet of strata. The shear climbs up- and down-section in the Johns Wash Formation south of Wendover Canyon; north of the canyon the shear is in the Dunderberg Shale. The fault plane is subparallel to bedding, dipping 20-25 degrees east. The slip cannot be determined along the fault. The lower plate of quartzite shows little contortion or fracturing; however, the upper plate of shale and carbonate of the Dunderberg Shale and Johns Wash Formation contain numerous recumbent folds overturned to the east with limbs up to 100 feet long, although those with limbs of two to ten feet are most common. Tectonic thickening by two or three times of the Johns Wash Formation seems likely (Fig. 8).

This thrust does not appear to be a local gravity slide due to tilting of the range during later Cenozoic block-faulting. Evidence for this lies in the fact that high-angle faults that are older than the block-faulting of the range (p. 81-82) cut the thrust.

Mesozoic folds in the Pilot Range, other than those directly related to thrusting, are best exposed in the fault-bounded blocks in the northern part of the map area. These folds, in the Precambrian units, trend approximately



one-half mile south of Morrison Canyon



one-half mile north of Miners Canyon

Figure 8. Structure section of the décollement thrust, eastern base, Pilot Peak. View looking north-northeast.

N. 20° E., are upright, symmetrical, and open, with limbs dipping 25-40 degrees.

Smaller flexures are present in the southern part of the map area but their age cannot be determined precisely. Notably, three folds in the Pennsylvanian Ely Formation, two and one-half miles south of South Spring Canyon, are symmetrical, closed, and dip steeply in some instances. The intensity of the folds and their lack of relation to adjacent high-angle faults suggests that these are Mesozoic features.

High-Angle Faults within the Range

Earlier (?) Cenozoic faults cutting known Mesozoic structures are present in the southern Pilot Range, resulting in an internal mosaic of faults that are more closely-spaced in the southern part of the map area. These faults have little or no topographic expression; juxtaposition of strata is the main criterion of recognition. The fault traces are both straight and sinuous, extending several tens of feet to more than six miles. The faults are both normal and reverse and occasionally have undulating fault planes. Stratigraphic separation ranges from several inches to at least 7700 feet. These faults will be discussed as northern, central, and southern faults in the map area.

In the northern part of the map area there are two sets of faults. Those trending north-northeast commonly terminate against those trending west-northwest. The faults trending north-northeast are sub-parallel to the range, high-angle, both normal and reverse, and tend to dip steeply to the southeast. Stratigraphic separation ranges from a few tens of feet to at least 1650 feet and may be much more.

The north-northeast trending fault immediately north of Anderson Canyon, juxtaposing Precambrian Units A (?) and F, is a high-angle reverse fault dipping steeply east-southeast. Stratigraphic separation is at least 1650 feet. The fault, offset by a west-northwest trending fault, appears to diminish in stratigraphic separation on both ends.

Several minor faults crossing Golliers Canyon terminate on either end at the junction with the west-northwest-trending faults. These faults are normal, high-angle, and dip steeply to the southeast. Displacements cannot be determined precisely, but appear to be 200 feet or less.

The northern set of faults trending west-northwest and dipping mostly 45 or more degrees to the northeast create a series of transverse horsts and grabens across the range (Fig. 9). Stratigraphic separation ranges from several feet to approximately 700 feet. Fault zones in most cases are confined to several feet in width, although a notable exception is the northernmost fault in the map area which is marked by a zone of fracture approximately 30 feet wide. In the quartzites, narrow faults with small displacement are commonly silicified, protruding several feet above the ground.

Few high-angle faults are seen in the Prospect Mountain Quartzite (restricted) in the central part of the map area; however, this may be due to the difficulty in determining the presence of faults in the quartzite, to the numerous concealing talus slopes, and also to the competence of the unit. Stratigraphic throw of the faults within the Cambrian Prospect Mountain Quartzite (restricted) is difficult to determine because of the lack of marker beds.

Faults have offset known Mesozoic structures as along the eastern base of Pilot Peak where the décollement is cut in Morrison and Wendover Canyons (Fig. 7).

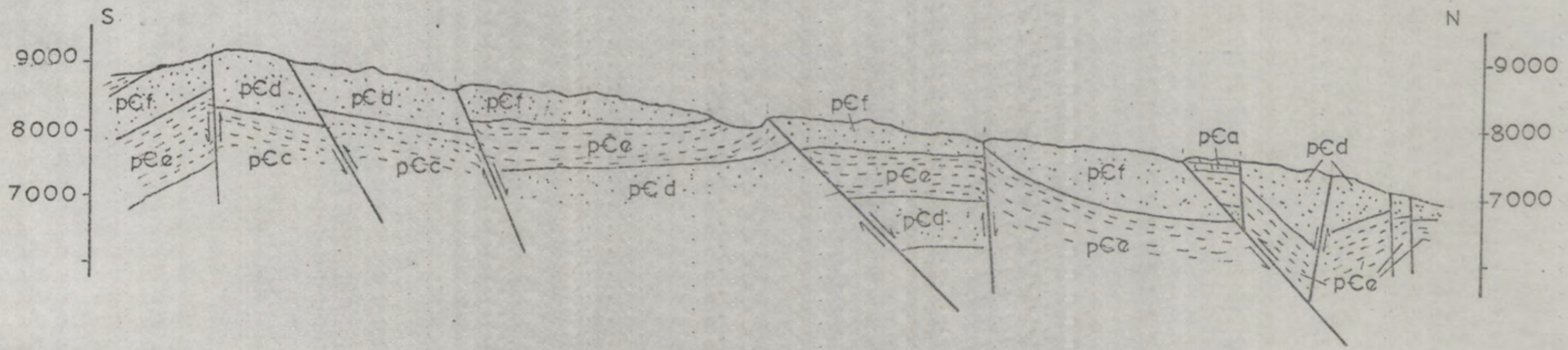


Figure 9 . Structure section of internal transverse faults in the northern part of the map area. View looking west-northwest.

The faults are high-angle and tend to be slightly sinuous. Stratigraphic throw is on the order of several hundred feet.

Faults in the southern part of the map area trend from N. 45° W. to N. 45° E., although there are exceptions. The faults are predominantly high-angle and are both normal and reverse; striae, when visible, indicate dip slip only. Stratigraphic separation ranges from a few inches to as much as 7700 feet. With the larger faults, those having larger separation, the downthrown block is commonly on the southwest; however, the smaller faults show no preference as to which side is downthrown. The smaller faults, trending both northeast and northwest, offset and are terminated against each other. These smaller faults are also offset and terminated against the larger northwest-trending faults.

The South Spring-Miners Canyon fault, trending transversely across the range, juxtaposes Cambrian Prospect Mountain Quartzite (restricted) with younger Cambrian and Ordovician strata. The fault strikes N. 60° W. and dips 50-55° southwest. Stratigraphic separation is about 2500-3000 feet.

A vertical, slightly sinuous fault (Fig. 7, #1) along the western base of the range can be traced from South Spring Canyon for four and a half miles southward where it bifurcates; the east branch cuts obliquely for two miles across the range. Stratigraphic separation increases to the north, from approximately 200 feet to 2600 feet.

A similar fault, northeast of the fault described above (Fig. 7, #2) also trends northwesterly, cutting obliquely across the range. Stratigraphic separation along this high-angle, sinuous fault is 1000 feet (maximum).

A fault located in the foothills along the eastern base of Pilot Peak has a curved trace and may dip steeply to the southeast (Fig. 7, #3). Stratigraphic separation is at least 7700 feet, with undifferentiated Pennsylvanian-Permian strata against Cambrian Notch Peak Formation. Tectonic slices of Ordovician strata are present in the fault. The fault appears to branch toward the south with a wedge of Ordovician rocks between the Notch Peak (?) and Pennsylvanian-Permian formations. Left separation along an east-west fault has offset this large fault.

Smaller faults in the area, both normal and reverse, have separations from several inches to approximately 600 feet. In the majority of cases the fault planes are vertical or nearly so, although some tend to undulate, locally becoming low-angle (Plate 4). These faults commonly terminate at their junctions with other faults.

A large north-northwest-trending Mesozoic (?) and Tertiary strike-slip fault may extend from Oasis (15 miles west of the Pilot Range) westward beyond Wells, Nevada (Thorman, 1968) and can be projected to pass immediately south of the Pilot Range. In the Pequop Range, directly east of Wells, Thorman interprets north-northwest-trending faults as tensional faults resulting from right-slip movement. In the southern part of the Pilot Range, north-northwest-trending normal faults are also present and may be tensional features related to the major right-slip zone suggested by Thorman (1968).

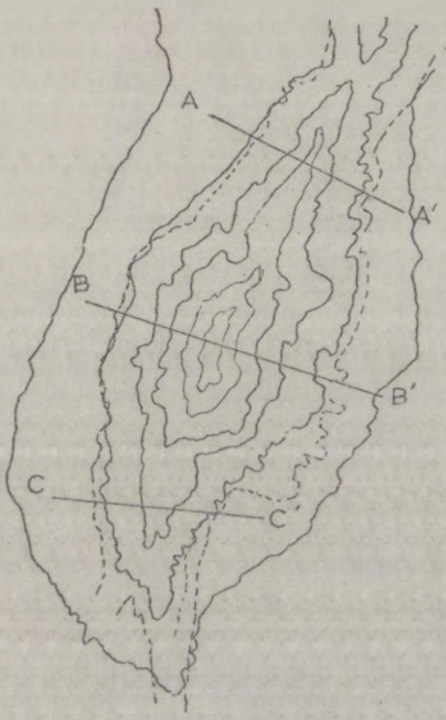
Range Marginal Faults

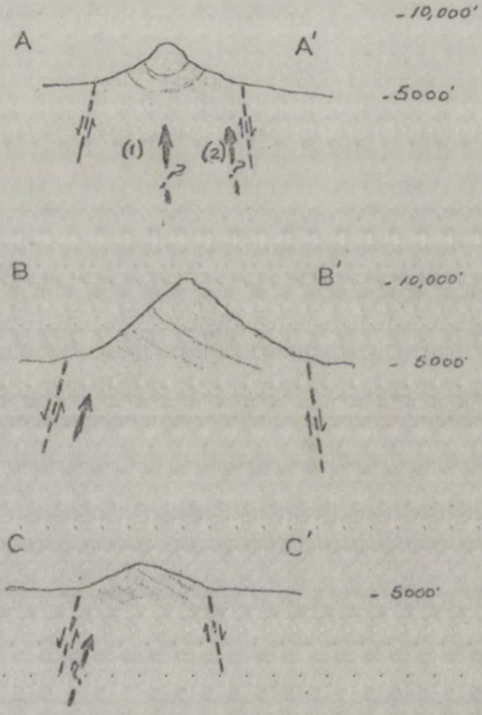
A later Cenozoic block-faulted origin of the range appears likely. Several criteria suggest range marginal faults. These are: (1) a crude alignment of springs along the northwestern base of the range; (2) numerous triangular facets; (3) the relatively anomalous eastward

Plate 4. Early (?) Cenozoic faults within the lower part of the Ordovician Garden City Formation. View is to the north-northwest with Pilot Peak in the background.

dip of the décollement thrust; and (4) the truncation of internal structures. Especially noteworthy with respect to this last criterion are the large internal structures which have little or no topographic expression. If the physiography of the range were related to rock resistance, the lack of pronounced expression of more resistant lithologies and of differential erosion across the internal faults is contradictory.

In the map area the range appears to be a horst with slightly greater uplift on the west; however, differential uplift along the entire range seems probable (Fig. 10).





A-A': Mesozoic folds with vertical axial planes. 1) If fold axes were originally vertical, then uplift along range margins would be equal; 2) If axial planes were originally inclined to the east, then uplift was greater along the eastern margin.

B-B': Strata generally dipping east. PЄc exposed along the western base of range, upper Cpm exposed near eastern margin of range. Uplift was greater on west by approximately 5000 feet.

C-C': No continuous sedimentary horizon is present and area is extremely faulted; however, beds dip predominantly easterly, suggesting greater uplift along the western margin of the range.

Figure 10. Diagrammatic structure sections of map area showing relative displacement along range marginal faults. Large arrow shows side of greater displacement.

APPENDIX

APPENDIX

Paleozoic Statigraphic Section, in descending order

		feet
Pennsylvanian-Permian:		
Strathern, Riepetown, Ferguson Springs, and Pequop Formations, undifferentiated (incomplete):		
	Limestone, thin- to thick-bedded, somewhat argillaceous, extremely bioclastic, medium-cyrstalline, dark gray and minor interbedded siltstone weathering dark brown; the unit is poorly exposed and a meaningful thickness cannot be obtained	400±
Fault		
Pennsylvanian:		
Ely and lower member Oquirrh Formations undifferentiated (incomplete):		
27.	Limestone, light to dark gray, chert and silt lenses common as are silt concretions, thin-bedded	13
26.	Limestone, as unit 14	55
25.	Quartzose sandstone, upper 24 feet is massive bedded and associated with pink chert, weathers pink-brown; lower 8 feet is a calcareous siltstone, fine-grained, weathering dull yellow orange	32
24.	Limestone, medium- to fine-crystalline, light to dark gray, somewhat argillaceous giving unit a pinkish hue,	

		feet
	numerous chert stringers and nodules; some interbedded calcareous silt lenses up to 2 inches thick are present	72
23.	Covered, possible fault	20
22.	Limestone, light to medium dark gray, fine- to coarse-crystalline, chert and silt lenses common; chert is very dark brown, dark gray to black on fresh fracture and occurs occasionally as nodules; one silt concretion measured 3 by 1 3/4 feet, weathers dark brown, tan gray on fresh fracture, is calcareous, and medium-grained unit is thick-bedded, forming bench and bluff topography	73
21.	Limestone, light medium gray, light tannish-gray on fresh fracture, coarse-crystalline, thick-bedded, some fossil hash; minor chert as nodules, light brown weathered and on fresh fracture; unit forms bench and bluff topography	14
20	Limestone, siltstone, chert interbedded (2-3 feet); limestone, medium light gray, fine-crystalline, dark gray in fresh fracture; siltstone, calcareous, weathers yellow brown to dark brown, medium tan-gray on fresh fracture, bedding ranges from 1/8 inch to 2 feet; chert, nodules and stringers, weathers bright red-pink, pink-gray on fresh fracture, occurring principally with limestone and silty limestone beds; entire unit has a pinkish-red, yellowish, or brownish cast	33
19.	Limestone, argillaceous, fine-crystalline, weathers medium brown	7

		feet
Fault		
18.	Limestone, argillaceous, light gray, fossil hash common, fine-crystalline, red-gray on fresh fracture with fossils preserved in white; unit is very thin-bedded, has a pinkish cast, contains some silt as concretions and nodules, forms bench and bluff topography	11
17.	Limestone and siltstone; limestone, light gray, medium gray on fresh fracture, thin-bedded, fine-crystalline; siltstone, thin-bedded, weathers medium orange brown	12
16.	Limestone, light gray, coarse- to medium-crystalline, thin- to thick-bedded argillaceous, has a pinkish cast, forms bench and bluff topography	12
15.	Siltstone, calcareous, weathers light tan-yellow, dark gray on fresh fracture, fine-crystalline, forms slope	10
14.	Limestone, light gray, light tan-gray on fresh fracture, smooth-weathering, medium- to coarse-crystalline, slightly argillaceous, some chert nodules, unit forms bench and bluff topography	20
13.	Quartz pebble conglomerate, weathers dark brown, pebbles up to 2 inches and are both black and yellow-white	4
12.	Limestone as upper part of unit 1	7
11.	Conglomerate and limestone; conglomerate, argillaceous limestone matrix with quartz and chert pebbles up to 3/4 inch in diameter, matrix is grayish green, pebbles are dark brown; lower 1½ feet is dark green-weathering limestone with	

		feet
	rose red to dark orange-brown silt nodules	2½
10.	Siltstone, calcareous, fine-crystalline, weathers dark orange-brown; dark brownish gray on fresh fracture	4
9.	Limestone, light yellow-green; dark gray on fresh fracture, rough weathering, thick-bedded, some chert nodules present, forms bench and bluff topography	17
8.	Limestone, dark gray, slightly darker on fresh fracture, medium- to fine-crystalline, fossil hash common, has a pinkish cast, forms cliff	16
7.	Limestone, dark to medium gray, fine-crystalline, thin- to thick-bedded, somewhat argillaceous, has a pinkish cast, forms cliff	32
6.	Limestone, slope-forming; lower 30 feet is quite argillaceous, weathers olive brown, the remainder is gray limestone; at 12 and 40 feet above the base are 3-foot beds of limestone and siltstone	59
5.	Quartz pebble conglomerate as in Diamond Peak Formation	12
4.	Covered, possible fault	132
3.	Limestone, dark medium gray, fine-crystalline, thin- to very thin-bedded, forms slopes and cliffs; at 45-65 feet and 78-103 feet above the base the unit consists of black limestone, fine-crystalline, thin- to thick-bedded; forms slope	208
2.	Limestone, dark gray to black, medium- to fine-crystalline, no chert, thin-	

feet

to thick-bedded, forms slope 38

1. Limestone, medium- to coarse-crystalline, dark to medium gray, very fossiliferous; at 25 and 105 feet above the base there are 3-foot beds of half limestone and half siltstone; the unit forms a slope 127

Total . . . . 1042+

Mississippian-Pennsylvanian:

Diamond Peak Quartzite (incomplete):

1. Quartz pebble conglomerate and interbedded medium gray coarse-grained quartzite; conglomerate contains pebbles up to 1 3/4 inch, clasts are subangular to subrounded and predominantly light colored, although 20% are black; the unit is thin- to thick-bedded, weathering very dark brown . . . . 425+

Fault

Chainman Formation:

8. Limestone, dark to medium gray, medium-crystalline, fossiliferous, argillaceous, weathering light orange brown . . 55+

7. Limestone, medium- to coarse-crystalline, thin- to thick-bedded, fossiliferous, dark medium gray, weathering tan-grey . . 18

6. Limestone and siltstone (half and half); limestone, dark gray, fine-crystalline, thin-bedded; siltstone, calcareous, weathers tan-gray 13

5. Limestone, medium-crystalline, thin-bedded, medium dark gray, weathering tan-gray . . 16

		feet
4.	Limestone, dark gray, weathering light orange-tan and dark gray-tan, fine- to medium-crystalline, slightly argillaceous, thin-bedded	12
3.	Quartz pebble conglomerate, pebbles up to one inch and subrounded; unit is gray-green to yellow-white and weathers dark orange-brown	6
2.	Limestone, as unit 4	45
1.	Limestone, dark gray to black, thick-bedded, fine-crystalline, smooth-weathering	15+
	Total	180+

Base Covered

Fault

Devonian

Guilmette Formation

7.	Limestone, as unit 1	80+
6.	Sandstone, calcareous, medium-grained, medium gray, weathering dark brown to tan, friable, uneven bedding planes	3
5.	Limestone, argillaceous, fine-crystalline, medium gray, weathering light tan-gray, thin-bedded	10
4.	Limestone, dark gray to black and medium gray, darker beds predominate, thick-bedded, to platy, fine- to medium-crystalline, forms steep slope	150
3.	Quartzite, very calcareous, medium-grained, medium brown gray weathering brown	2

		feet
2.	Limestone, as unit 1 except weathers lighter gray	33
1.	Limestone, medium-crystalline, medium gray, weathering dark gray to black, thick-bedded, forms steep slopes with cliffs	290+
	Total	568+
Fault		
Simonson Formation upper member		
23.	Dolomite, calcareous, light tan-gray, interbedded with dolomitic limestone, dark gray, fine-crystalline, laminated, slightly mottled	25
22.	Limestone, dark gray to black, medium-crystalline, laminated	24
21.	Dolomite, calcareous, thick-bedded, upper 6 feet is dark medium gray, lower 7 feet is light gray	13
20.	Dolomite, upper 7 feet is tan gray, fine-crystalline; middle 7 feet is dark gray, extremely laminated, slightly calcareous; lower 4 feet is dolomitic limestone, dark gray, weathering light gray, cross-laminated, fine-crystalline	18
19.	Dolomite, calcareous, dark gray, weathering light gray, fine-crystalline	6
18.	Limestone, dark gray to black, fine-crystalline, laminated, thick-bedded, forms cliff	24
17.	Limestone, dolomitic, basal 8 feet and upper 5 feet weather light gray to tan-	

		feet
	gray, fine-crystalline, non-laminated; middle part is limestone, dark gray, laminated, fine-crystalline	21
16.	Limestone, dark gray, laminated, fine-crystalline; basal 1-foot consists of fossil hash; unit contains two 6 inch interbeds of light gray, laminated limestone	12
15.	Dolomite, calcareous, light brown-gray, weathers light gray, fine-crystalline, slightly arenaceous; at 5 and 9 feet above the base there are 8-inch black, fine-crystalline, laminated, limestone beds; unit forms bench and bluff topography	11
14.	Limestone, dolomitic, dark gray, weathers light gray, thin-bedded; upper 3 feet is limestone, dark gray, laminated, fine-crystalline, slightly argillaceous giving unit a red cast	9
13.	Limestone, slope-forming, platy, red argillaceous partings common, dark gray on fresh and weathered surfaces, fossil hash common	17
12.	Dolomite, calcareous, light gray, non-laminated, fine-crystalline, upper 2 feet is argillaceous limestone, dark gray, fine-crystalline	9
11.	Limestone, black to dark gray on fresh and weathered surfaces, platy, red argillaceous partings, fine-crystalline	4
10.	Limestone, slope-forming, platy, red argillaceous partings, numerous gastropod remains poorly preserved, fine-crystalline	23

		feet
9.	Limestone, dark gray, weathering dark gray to almost black, fine-crystalline, numerous poorly preserved brachiopod shells	9
8.	Limestone, locally dolomitic, alternating light and dark units, thin- to thick-bedded, red argillaceous partings 1/16 - 1/8 inch thick; dark gray units are laminated, light gray are not, all are dark gray on fresh fracture; forms cliff	19
7.	Dolomite, calcareous, dark gray, weathering medium gray, cliff-forming, laminated, fine-crystalline	8
6.	Limestone, dark gray and light green, coquina zone of gastropods and pelecypods, forms bench and bluff topography	16
5.	Limestone, lower 3 feet are alternating light and dark gray; upper 2 feet are platy, with red argillaceous partings . .	5
4.	Limestone, dark gray, weathering dark gray to black, laminated, thin-bedded, fine-crystalline	8
3.	Limestone, dolomitic, dark gray, weathering pink-gray	1
2.	Limestone, dolomitic, dark medium gray weathered and fresh, laminated, no chert, thick-bedded, fine- to medium-crystalline	8
Fault		
lower member		
1.	Dolomite, alternating light and dark gray bands average 2 feet in thickness, fine-	

	feet
crystalline, forms cliff	75+
Total	365+
Fault	
Silurian	
Laketown Dolomite:	
upper (?) member (incomplete):	
4. Dolomite, light gray to white, medium- to coarse-crystalline, locally argillaceous	150±
Fault	
lower (?) member (incomplete):	
3. Dolomite, as unit 1	100±
2. Dolomite, calcareous, argillaceous, fine-crystalline, medium-gray, slope-forming	40
1. Dolomite and calcareous dolomite, thin- to thick-bedded, medium-crystalline, medium gray to black, cliff-forming; the upper 100 feet is commonly laminated	250+
Total	540+
Fault	
Ordovician	
Fish Haven Dolomite	
upper member (incomplete):	
9. Limestone, dolomitic, platy, medium dark gray and maroonish, fine-crystalline, argillaceous, slope-forming; upper 15 feet is calcareous dolomite, fine-crystalline, dark gray weathers medium gray, no silt, forms bench and bluff topography	120+

feet

middle member

8. Dolomite, calcareous, medium-crystalline, light medium gray, weathers medium gray, argillaceous, thick-bedded, upper 45 feet is slightly lighter and tannish; unit forms steep slope . . . . 135+

lower member (incomplete):

7. Dolomite, calcareous, fine-crystalline, black, chert common as stringers, thick-bedded, locally it is a dolomite breccia . . . . 48+

6. Dolomite and calcareous dolomite, fine-crystalline, black, thin-bedded, some chert present as stringers and nodules weathering dark brown; weathered surfaces show distinctive 'brecciated' form; unit forms small cliffs . . . . . . 67+

Fault

5. Dolomite, medium gray, medium-crystalline, thick-bedded 20

4. Dolomite, black, medium-crystalline, thick-bedded 20

3. Dolomite, calcareous, black, fine-crystalline, interbedded silt and chert stringers (25%) 4

2. Dolomite, calcareous, dark gray, fine-crystalline, interbedded with silt and sand (75%) with some chert stringers present near the top; unit weathers dark brown 7

1. Dolomite, calcareous, dark gray to black fresh and weathered, fine-crystalline, contains numerous black chert nodules weathering orange-brown and occasionally associated with silt stringers 1/8 inch

	feet
thick; unit is thin-bedded	30
Total	451+
Eureka Quartzite	
4. Quartzite, calcareous, medium-grained, alternating light and dark gray beds, weathers yellow-brown and gray, thin-bedded	25
3. Quartzite, grades upward from dark gray, medium-grained, thick-bedded unit to thin-bedded, light gray quartzite; southward, the unit becomes white, cliff-forming, thick-bedded, medium-grained, clean quartzite, weathering light tan to brown	105
2. Quartzite, fine- to medium-grained, light gray, weathering rusty brown, thin- to thick-bedded forms bench and bluff topography	110
1. Quartzite, medium- to fine-grained, medium to light gray, weathers rusty brown, thick-bedded, forms cliff	20
Total	260
Crystal Peak Formation	
5. Limestone, platy, mottled red and orange, fine-crystalline, medium dark gray, weathers medium gray	25
4. Limestone, silty, and calcareous siltstone interbedded, dark gray, weathering tan-gray to orange-brown, fine-crystalline; upper 5 feet is calcareous sandstone, grains well-rounded, dark gray on fresh fracture	40

	feet
3. Limestone as unit 1 but more massive	125
2. Limestone, medium dark gray, weathering medium gray, thin-bedded to platy, orange mottled, contains numerous calcite veinlets	30
1. Limestone, dark gray fresh and weathered, platy to thin-bedded, orange and red mottled, forms slope	100
Total	320

Swan Peak Quartzite

northwest facies

1. Quartzite, very fine-grained, dark to light gray, weathers dark rusty brown; upper 2 feet is fine- to medium-grained, weathers medium brown; unit is thick-bedded, forms cliff	46

southeast facies

2. Quartzite, as northwest facies	15
1. Limestone, silty, and calcareous siltstone, interbedded with numerous silt layers; limestone fine- to medium-crystalline, dark gray, weathers light orange-brown; some quartzite beds 1-2 feet thick are present, quartz is fine-grained, dark gray, weathers dark brown; unit forms slope	35
Total	50

Lehman Formation

10. Limestone, light to dark gray, fine-crystalline, some yellow-orange mottling, platy to thin-bedded, forms steep slope	150±

		feet
Fault, possible repetition of beds		
10.	Limestone as above	26+
9.	Limestone as unit 2, but without common red mottling	70
8.	Limestone as unit 2	115
7.	Limestone as unit 5	15
6.	Limestone as unit 2	25
5.	Limestone, fine-crystalline, thin-bedded, weathers lighter gray than previous units, forms steep slopes and cliffs	65
4.	Limestone as unit 2	85
3.	Limestone as unit 2 but with large amounts of fossil hash	25
2.	Limestone, dark gray, weathering medium gray, fine-crystalline, mottled red to orange brown, forms steep slope	250
1.	Limestone, dark gray to black, fine-crystalline, thin-bedded, dark orange-brown mottling	10
	Total	840±

Kanosh Shale

1. Mudstone, platy, thin-bedded, weathers dark red-brown with shades of green; upper 120 feet consists of interbedded dark yellow-green and yellow-orange weathering mudstone and dark gray, platy, fine-crystalline silty limestone which weathers medium gray; some bands (1-2 feet thick) of siltstone are present;

		feet
	unit forms slope	215
	Total	215

Garden City Formation
upper member (incomplete, faulted top):

20.	Limestone, as unit 14	160+
19.	Limestone, as unit 14, but with little mottling and chert	70
18.	Limestone, platy, argillaceous, some interbedded silt lenses as much as 6 inches thick, and weathering light green to rusty orange; limestone is fine-crystalline, dark gray, weathering medium gray, forms slope	25
17.	Limestone, medium- to fine-crystalline, tan-gray, weathering brown-gray, locally platy, argillaceous, contains no chert	13
16.	Limestone as unit 14, but less mottled and more cherty; upper 15 feet is limestone, black to dark gray, platy, fine-crystalline, no mottling	100
15.	Limestone as unit 14, except chert very common, forms cliffs	90
14.	Limestone, fine-crystalline, extremely mottled, in yellowish shades, cherty, argillaceous, weathers light and medium gray, although when viewed from a distance appears to be a dull yellow-tan; unit is thin-bedded and forms steep slope and cliff	225
13.	Limestone, fine-crystalline, dark gray fresh and weathered, platy, mottled yellowish tan	170

	feet
12. Limestone, platy, very argillaceous, yellow-mottled, medium gray, weathering light to medium gray, fine-crystalline, little chert, laminations of silt lenses are more resistant to weathering; unit forms cliff and steep slope	160
11. Limestone as unit 9	10
10. Dolomite, calcareous, white to light gray, weathering light gray, medium-crystalline, thin- to thick-bedded, forms slope	145
9. Dolomite, medium-crystalline, thin- to thick-bedded, dark medium gray on fresh and weathered surfaces; unit grades upward into dolomitic limestone; unit forms slope	92
8. Limestone, cherty, little mottling, fine-crystalline, dark gray, weathering medium dark gray, thin-bedded	75
7. Limestone, fine-crystalline, dark gray fresh and weathered, argillaceous, thin-bedded, forms slope	40
Total upper member	1370+
lower member (incomplete):	
upper part:	
6. Limestone and minor dolomite, dark medium gray, weathers medium gray, fine- to medium-crystalline, argillaceous partings up to 1/8 inch thick, slightly yellow-orange mottled, some fossil hash, no chert; unit is cliff-forming, very thick-bedded, locally slope-forming, thin-bedded units are present	465

	feet
Fault	
lower part:	
5. Limestone, dark gray, weathering dark gray to medium gray, medium-crystalline, slightly mottled, thick-bedded, forms cliff	75+
4. Limestone, very argillaceous, extremely mottled, thin-bedded, dark gray, weathering medium gray, fine-crystalline; appears tan-brown from a distance and has several 1-2 foot yellow bands near base	110
3. Limestone, fine- to medium-crystalline, white weathering yellowish white, contains increasing amounts of chert southward; basal 4-6 feet is mudstone weathering dull green, forms cliff and steep slope	50
2. Limestone, fine- to medium-crystalline, medium gray fresh and weathered, argillaceous, yellow and gray mottled, gray mottling predominates in upper 100 feet, forms slope	255
1. Limestone, fine-crystalline, smooth to rough weathering, very dark gray fresh and weathered, mottled yellow-orange, thin-bedded, forms bench and bluff topography, base not exposed	115+
Total lower member	605+
Total unit	2440+

Cambrian

Exposures of Cambrian sedimentary rocks in the southern Pilot Range are in many cases poor, and all but two units are extensively faulted or folded. As such,

feet

a useful thickness of several units was not obtainable. Described below are those units that were measured; for descriptions of the remaining units see text.

Notch Peak Formation
Faulted; see text.

Johns Wash Formation
Folded and faulted; see text.

Dunderberg Shale
Extremely folded; see text.

Unit 4

3. Limestone, fine- to medium-crystalline, light gray, weathering light medium gray, argillaceous seams, slightly laminated, thick-bedded 17

2. Limestone, fine-crystalline, medium gray, interbedded with brown siltstone 10

1. Limestone, fine- to medium-crystalline, light gray, weathering light medium gray, thin-bedded; some silt intercalations present, but account for less than 10% of rock; forms slope . . . 205

Total 232

Unit 3

5. Mostly covered; medium dark gray limestone, fine- to medium-crystalline, with minor silt laminations; forms slope 125

feet

4. Limestone, fine-crystalline, dark gray fresh and weathered, slightly argillaceous, smooth weathering, occasionally laminated with silt seams, very thin-bedded, forms slope 95

3. Limestone, thin- to thick-bedded, medium dark gray with tan casts, weathering dirty tan-gray, fine- to medium-crystalline, occasionally laminated 33

2. Siltstone, arenaceous, calcareous, fine-grained, gray with reddish-tan cast weathering orange tan to light tan . . . 50

1. Covered (probably includes much of Unit 2) . . . . 240+

Total . . . . 303+

Unit 2

Poor exposures, extremely faulted; see text

Unit 1 (incomplete, faulted on both ends):

upper member

13. Limestone, medium-crystalline, thin-bedded, white, occasional brown argillaceous seams, top not exposed . . . . 45+

12. Dolomite, calcareous, thin-bedded, black and white speckled, slightly argillaceous 35

lower member

11. Limestone, fine-crystalline, dark gray, weathering tan, argillaceous, extremely mottled 5

10. Limestone, fine-crystalline, dark gray, weathering brown, argillaceous, thin-

		feet
	bedded	30
9.	Limestone, dark gray, weathering medium gray, mottled yellow, fine-crystalline	10
8.	Limestone as unit 10	7
7.	Limestone as unit 9	45
6.	Limestone, dolomitic, medium-crystalline, white fresh and weathered, thin-bedded	10
5.	Limestone, dark gray, weathering rusty orange, fine-crystalline, argillaceous, mottled orange, thin-bedded; lower 25 feet is very thin-bedded; unit forms slope	70
4.	Dolomite, medium-crystalline, medium dark gray, weathering tan, thin-bedded, forms slope	20
3.	Dolomite as unit 4 except more silty	45
2.	Limestone, fine- to medium-crystalline, dark gray, weathering light medium gray, some yellow mottling, forms steep slope	250
1.	Dolomite, medium- to coarse-crystalline, white fresh and weathered, thin-bedded, forms slope	135
	Total	706+

Pioche Shale

Faulted and intruded by igneous stock; see text.

Prospect Mountain Quartzite (restricted)

Partially faulted, difficult to measure; see text.

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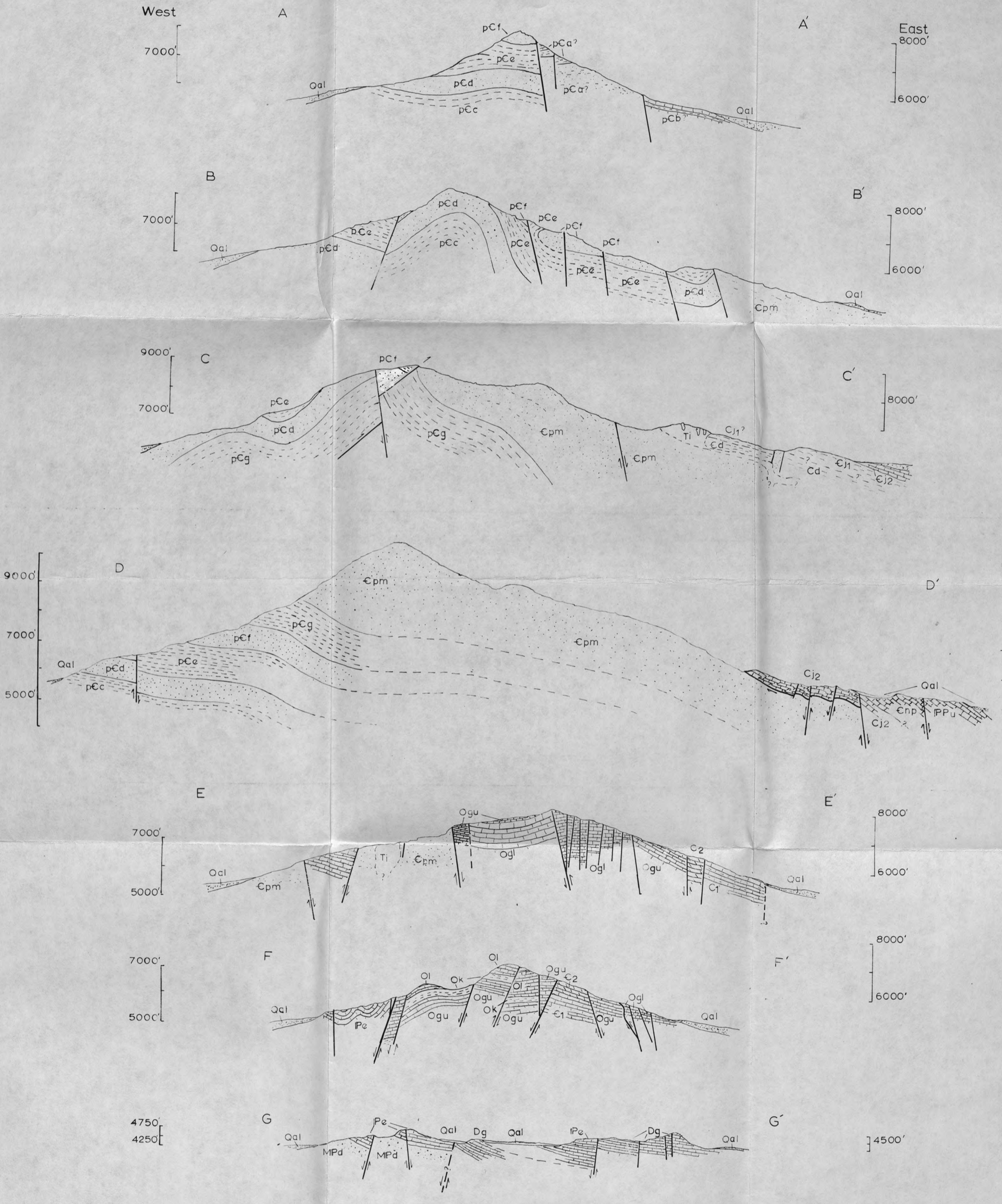
GEOLOGIC MAP OF THE SOUTHERN PILOT RANGE

J. M. O'Neill, 1968

GEOLOGIC CROSS SECTIONS OF THE SOUTHERN PILOT RANGE, UTAH-NEVADA

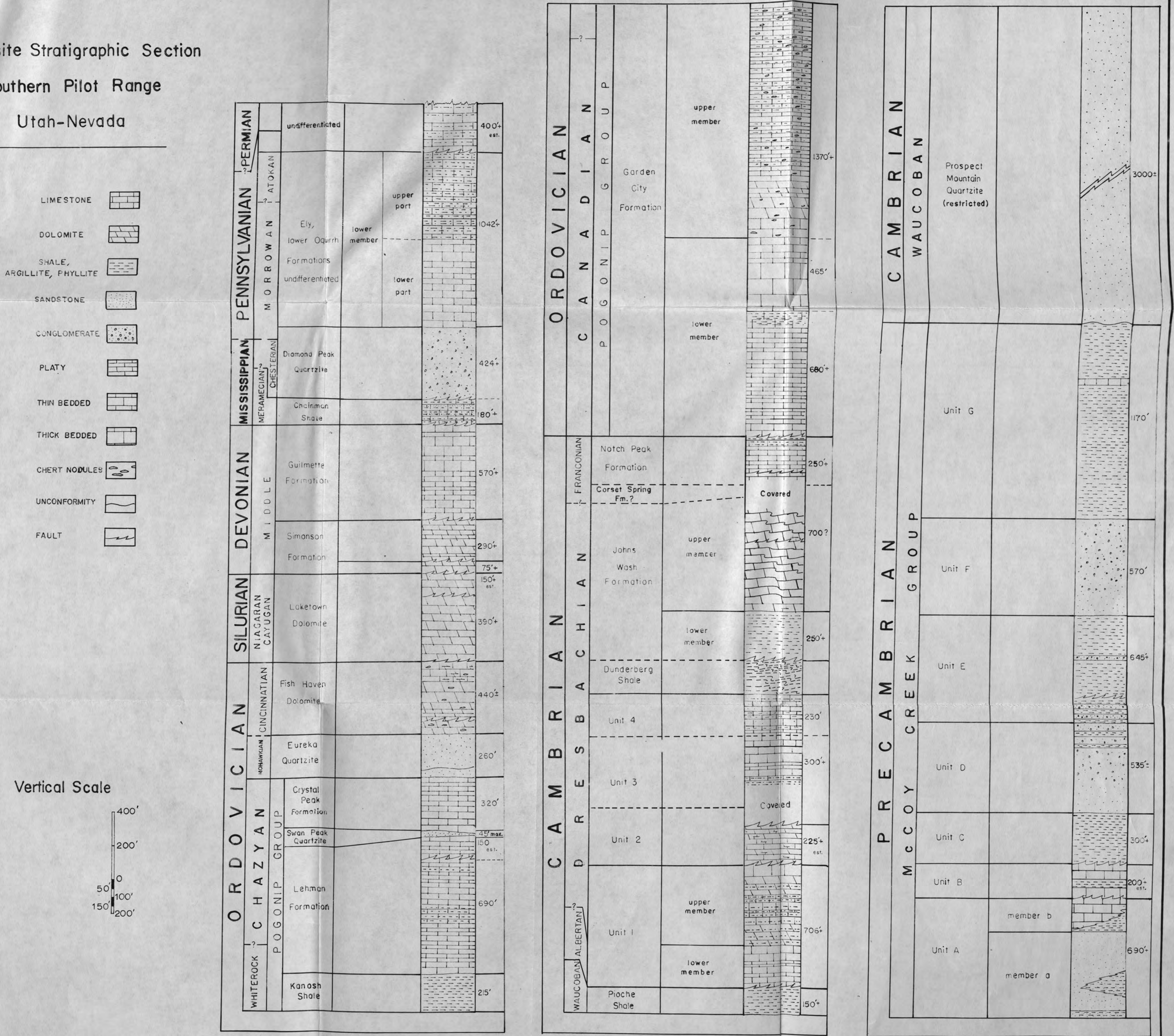


J.M. O'Neill

Composite Stratigraphic Section

southern Pilot Range

Utah-Nevada



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