EASTERN GREAT BASIN PROVINCE (019)

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INTRODUCTION

The Great Basin is that part of the Basin and Range physiographic province that comprises mainly the State of Nevada, western Utah west of the Wasatch Range, and a small part of southeastern Idaho, southeastern Oregon, and eastern California (Hunt, 1979). The Eastern Great Basin Province of this report includes eastern Nevada, western Utah west of the Wasatch Mountains, and southeastern Idaho west of the thrust belt and south of the Snake River Plain. The western boundary of the province is long 117¡.

The geology of the region is complex and involves a great diversity of sedimentary facies, major episodes of orogenic and igneous activity, and extensive block faulting (Stewart, 1980; Miller and others, 1983). The complex structural features include (1) a middle to late Paleozoic thrust belt (Antler orogenic belt, Golconda thrust, Sonoma thrust) extending across south-central and northeastern Nevada into south-central Idaho; (2) low- and high-angle Late Tertiary extensional faults and Basin and Range-type faulted deep graben valleys bounded by elongate high mountain range horst blocks; (3) metamorphic core complexes; (4) Tertiary, Cretaceous, and Jurassic intrusive rocks; and (5) extensive Tertiary extrusive volcanics, particularly widespread in central and southern Nevada and south-central Idaho. The region is one of exceptionally high heat flow, in places with frequent hot springs throughout the area. Metallic and nonmetallic ore deposits are present throughout most of the region.

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TECTONIC SUMMARY

The tectonic development of eastern Nevada can be briefly summarized as a series of regional events (Stewart, 1980).

1.. Precambrian-- Tectonic, metamorphic, and intrusive activity that produced the crystalline basement in the southern part of the State, and the Late Precambrian Continental Margin to the west in western Nevada.

2. Early and Middle Paleozoic-- Probable minor tectonic activity in Early Paleozoic time, followed by development of the Antler Orogeny in Late Devonian and Early Mississippian time, with folding, faulting, and eastward thrusting of Early Paleozoic rocks.

3.. Late Paleozoic and Early Triassic-- Continued tectonic development and uplift of the Antler Orogenic Belt and associated foreland basins filled with coarse debris from the Antler highland (Antler flysch); Late Permian and Early Triassic development of the Sonoma Orogeny to the west of the earlier Antler Orogenic Belt.

4.. Mesozoic-- Mainly compressional folding and thrusting combined with regional uplift in eastern Nevada accompanied by development of metamorphic core complexes; low-angle ("denudation") faults, of uncertain age but which may be as old as Jurassic or as young as Tertiary; folding and thrusting in northeastern Nevada, which may be of Late Jurassic or Early Cretaceous age; and possible strike-slip faulting in northeastern Nevada (Wells Fault). Plutonic bodies of Jurassic and Cretaceous ages are recognized at several places in eastern Nevada.

5. Early and Middle Cenozoic-- Faulting and compressional folding during this time has been documented (Stewart, 1980).

6. Late Eocene and Early Oligocene-- Regional igneous activity producing widespread ash flow sheets began.

7. Middle Miocene-- Approximately 17 Ma, the period of crustal extension and faulting that created the Basin and Range structural complex began, along with extrusion of basalt and rhyolite. Graben valleys, locally containing as much as 10,000 ft of valley fill, and horst mountain ranges developed in a generally north-south direction. Structural relief between the base of the valley fill and adjacent mountain crests may be from 6,000 ft to as much as 15,000 ft (Stewart, 1980).

STRATIGRAPHIC SUMMARY

The original sedimentary cover of the Eastern Great Basin Province is primarily Late Precambrian to Permian in age, comprising as much as 50,000 ft of mostly shallow-water marine carbonate and clastic deposits typical of the classic miogeosyncline of Kay (1951). Lacustrine and fluvial beds ranging in age from late Cretaceous to Early and Middle Tertiary are present over a large area of central, northeastern, and southeastern Nevada. Late Tertiary lacustrine and fluvial beds are widespread in northern Utah and part of southeastern Idaho. As a consequence of Late Tertiary Basin and Range faulting and erosion, Paleozoic rocks are extensively exposed in the mountain ranges, and the Tertiary lacustrine section in the ranges is present as remnants of Late Tertiary uplift and erosion. As much as 10,000 ft or more of horst-derived Late Tertiary and Pleistocene fluvial, lacustrine, and volcanic fill is present in some valleys.

Original thickness of Paleozoic rocks ranges from approximately 20,000 ft on the eastern border of the region to more than 35,000 ft in the Oquirrh, Sublett, and Bird Spring-Butte Basins. These rocks underwent substantial regional erosion in post-Triassic time, particularly during the early stages of development of the Late Mesozoic Sevier orogenic belt, and were subjected to severe local structural erosion in uplifted blocks during development of the Basin and Range horst and graben structural complex in Late Tertiary time. In most areas, they also have undergone moderate to severe metamorphism and thermal alteration during several stages of igneous and thermal activity, primarily during Late Tertiary time. The entire Paleozoic section is continuously exposed in only a few mountain areas.

PETROLEUM EXPLORATION HISTORY

Intermittent exploratory activity for petroleum took place in the Eastern Great Basin Province during the late 1940's and early 1950's, when several relatively deep wells were drilled on surface structures. In 1954, after several months of seismic work, Shell Oil Company drilled the Eagle Springs No. 1 well in Railroad Valley south of Ely, Nev., to test a seismic anomaly. The Eagle Springs discovery, Nevada's first producing well, yielded high pour-point waxy oil from Tertiary volcanics beneath approximately 6,500 ft of valley fill.

The Eagle Springs discovery stimulated a relatively strong burst of exploratory activity in the Eastern Great Basin Province during the 1950's, which gradually subsided when no further discoveries were made. Following the increase in price of oil in the mid-1970's, activity greatly increased, resulting in the discovery of several additional small fields in Railroad Valley and to the north near Elko, Nev. In recent years, numerous deep wells, mostly in the Railroad, White River, Diamond, Steptoe, Huntington, and Pine valleys have been drilled and several accumulations have been found. Most significant of these is the 1983 Grant Canyon field in Railroad Valley, producing from Devonian carbonate reservoirs beneath the valley fill, and the 1983 Blackburn field discovery in Pine Valley, producing from Devonian carbonate, Mississippian clastic, and Tertiary volcanoclastic reservoirs. As of 1994, the eastern Great Basin area contained 10 oil fields, some of which are marginally commercial. Cumulative production from these fields through 1992 was approximately 38 MMBO and a small amount of gas. All fields are located in Late Tertiary graben basins, Railroad Valley south of Ely, and Pine Valley north of Eureka. Characteristics common to all the fields are (Bortz, 1983): (1) traps are associated with a Tertiary valley-fill unconformity; (2) reservoirs have a relatively thick oil column; and (3) fractures usually enhance the reservoir quality. Numerous oil and gas seeps and subsurface oil or gas shows also are documented. To date, 350–400 exploratory wells have been drilled in the Eastern Great Basin Province, approximately 125 of which are located in Railroad Valley.

Six conventional plays were defined, two confirmed and four hypothetical. They are Unconformity "A" Play (1901), Late Paleozoic Play (1902), Early Tertiary–Late Cretaceous Sheep Pass and Equivalents Play (1903), Younger Tertiary Basins Play (1905), Late Paleozoic–Mesozoic (Central Nevada) Thrust Belt Play (1906), and Sevier Frontal Zone Play (1907).

CONVENTIONAL PLAYS

1901. UNCONFORMITY "A" PLAY

This play is a confirmed play based on the presence of an unconformity seal (Unconformity "A") at the base of the valley fill in most eastern Great Basin valleys. The unconformity overlies rocks ranging in age from Early Paleozoic to Middle Tertiary–rocks of varied lithology, from marine dolomites and limestones, sandstones, siltstones, and shales of varying degrees of metamorphism, and volcanic and plutonic igneous rocks. Unconformity "A" is the seal for all the more important known oil accumulations in the eastern Great Basin.

Reservoirs: Reservoirs are fractured and porous Paleozoic carbonate beds; lacustrine sandstone, siltstone, and carbonate beds of the Tertiary Sheep Pass and equivalents; and Middle Tertiary volcanic rocks (ignimbrites), all of highly variable thickness.

Source rocks: Source rocks are organic-rich marine shales of Mississippian and Late Devonian age; lacustrine oil shale and bituminous shale and shaly carbonates of Early Tertiary–Late Cretaceous age, in unconformity or fracture communication with overlying reservoirs. Hydrocarbons are mainly oil ranging between 15 and 40¡ API.

Timing, and migration: Because of complicated burial and thermal history, thermal maturity of source rocks varies widely, from mature to overmature to immature, sometimes over short distances. In most areas, Devonian and Mississippian source rocks probably reached the oil-generation stage by Permian or Triassic time, and probably earlier in the strongly subsiding foredeep area east of the Antler Orogenic Belt. Early stratigraphic and structural traps formed contemporaneously with the Late Devonian–Mississippian development of the Antler Thrust Belt. Most earlier accumulations were remigrated and (or) destroyed during complex Cenozoic structural movements. Generation was restored in Late Cenozoic time with subsiding of the graben elements of the Basin and Range structural complex, at which time most preserved accumulations formed.

Traps: Traps are folds, faulted folds, block-faulted beds, slide blocks, stratigraphic pinchouts, and buried hills beneath the valley fill.

Exploration status and resource potential: Drilling depths are highly variable. The play is moderately well explored in Railroad Valley, where more than 100 exploratory wells have been drilled, but it is relatively lightly explored in most other valleys. Existing fields range in size from a few hundred thousand barrels to approximately 20 MMBO (table 1).

Further exploration will require high-resolution geophysical data, aided by high-caliber Rock-Eval and maturity data on source-rock distribution. There should be numerous undrilled structures beneath the valley fill in several valleys containing difficult-to-find targets similar in size to those of Railroad Valley.

1902. LATE PALEOZOIC PLAY (HYPOTHETICAL)

This hypothetical play is based on the possibility that early-formed traps in carbonate and sandstone reservoirs may be preserved within the upper Paleozoic (Devonian through Permian) section, sealed by interbedded or overlying shales and shaly carbonates or faults, independent of the unconformity "A" trapping system. The play involves differing post-Paleozoic structural styles but is based primarily on the presence or absence of reservoirs, seals, and thermally preserved source rocks of upper Paleozoic age.

Reservoirs: Marine and deltaic marine sandstone and siltstone beds of the Mississippian-Pennsylvanian Diamond Peak, Scotty Wash, and Chainman Formations; dolomitized carbonate beds, in part reefoid or moundlike, of the Devonian Guilmette and Simonson Formations, the Mississippian Joana and Monte Cristo Formations, and the Pennsylvanian-Permian Ely, Bird Spring, Arcturus, Park City, and Oquirrh Formations. Accessory reservoirs, related to leakage from earlier traps, may be remnants of eroded pre-Cretaceous Mesozoic clastics.

Source rocks, timing, and migration: Primary source rocks are the organic-rich marine Mississippian Chainman, Mississippian-Pennsylvanian Manning Canyon, and Permian Phosphoria and equivalent rocks; secondary potential sources are dark marine shales and shaly carbonates of Pennsylvanian and Permian age. Source rocks are overmature in much of the region but may be mature to immature in specific areas. Oil generation and migration from Mississippian source rocks probably began by Permian time in much of the area and earlier in areas of thick Permian–Pennsylvanian basins, such as the Oquirrh-Sublett basins of Utah and Idaho and the Butte basin belt in eastern Nevada. Timing and generation in Manning Canyon and Phosphoria source rocks is uncertain because of post-Permian erosion in the entire area of the play and the lack of data on the quality of these rocks as source rocks.

Traps: Traps are pre-Tertiary folds, thrusts, and vertical fault blocks; sandstone and (or) carbonate stratigraphic traps; zones of lateral porosity change and carbonate buildups. Seals are upper Paleozoic shales, argillaceous carbonates, rare evaporates, and fault-associated seals in thrusted areas.

Resource potential: Depth range of reservoirs is highly variable because of several post-depositional periods of structural growth and erosion and the great thickness of Paleozoic rocks in basinal areas. This play can be subdivided into several subplays mainly on the basis of the TOC content and maturity quality of Late Paleozoic potential source-rock facies. The play has reasonably good exploration potential for at least moderate-sized accumulations in selected areas of favorable source rock maturity and structural styles.

1903. EARLY TERTIARY–LATE CRETACEOUS SHEEP PASS AND EQUIVALENTS PLAY

This hypothetical play is based on the probability that earlier-formed lacustrine deltaic or fluvial-deltaic, carbonate bank, or fracture zones may remain preserved and indigenous to the lacustrine section, independent of the valley-fill unconformity "A" seal.

Reservoirs: Deltaic, fluvial-deltaic, carbonate bank, and fracture zone units are potential reservoirs.

Source rocks: Source rocks would be organic-rich lacustrine oil shale and shaly limestone and siltstone beds of early Tertiary–Late Cretaceous age. Maturity of the source rocks varies because of complicated burial history, but much of the sequence is immature in large areas. In most areas, hydrocarbon generation did not begin until Late Cenozoic burial of the source rocks to sufficient depths in Basin and Range graben valleys. Maturation is still underway, but local sources of heat have greatly affected maturation in some valleys.

Traps: Traps are isolated reservoirs within the lacustrine fluvial-sequence.

Resource potential: This hypothetical play is lightly explored in Railroad Valley and is unexplored or lightly explored in the remainder of the region. The play can be subdivided into several subplays, on the basis of more localized basins of lacustrine deposition. Reasonable potential remains for small- to medium-sized accumulations in carbonate and clastic stratigraphic traps in areas of source rock maturity.

1905. YOUNGER TERTIARY BASINS PLAY (HYPOTHETICAL)

This hypothetical play is based on the possibility that biogenic gas, thermal gas, and some oil may have been generated in some of the Late Tertiary basin lacustrine-fluvial and volcanic beds, which are locally greater than 5,000 ft thick particularly in areas of higher heat flow where source rocks may become mature.

Reservoirs: Reservoirs are sandstone, siltstone, and fractured carbonate and other beds of Late Tertiary age.

Source rocks, timing, and migration: Source rocks are lacustrine shales, argillaceous limestone, and bituminous shales of Late Tertiary age. Thermal maturity of these rocks varies widely; they are mostly immature, but may be mature to overmature in areas of higher heat flow. Timing of hydrocarbon generation depends on a history of higher than normal heating in selected areas and amount of burial of earlier deposited beds in the lakes.

Traps: Traps are folds, faults, stratigraphic traps, and fracture zones sealed by Late Tertiary shales.

Exploration status and resource potential: Several cases of low oil recovery from beds of this age are documented in Pine Valley, although the source of these oils may be older Tertiary or Paleozoic rocks rather than late Tertiary. The Rozel Point oil seep and oil accumulation offshore in Great Salt Lake is interpreted as originating by high heat flow from interbedded basalts, which are the reservoir for this accumulation, estimated to be as much as 50–100 MMBO in place. There is potential for small stratigraphic accumulations, mainly biogenic gas, and a remote possibility of other Rozel Point–type accumulations.

1906. LATE PALEOZOIC–MESOZOIC (CENTRAL NEVADA) THRUST BELT PLAY (HYPOTHETICAL)

This unconfirmed play is based on the hypothesis that large structures may still be present where Devonian or other porous carbonate or sandstone reservoirs are thrust over organic-rich Mississippian or Late Devonian source-rock facies.

Reservoirs: Devonian-Silurian and other dolomitized carbonates and Mississippian-Pennsylvanian-Permian clastics are the reservoir rocks.

Source rocks, timing, and migration: Source rocks are middle to Late Paleozoic organic-rich shales. Thermal maturity of the potential source rocks varies widely, depending on local and regional thermal history. Generation and migration of hydrocarbons should have begun by Permian time in most of this play area, but areas of immature or only moderately mature Chainman rocks are documented.

Traps: Large folds, faulted folds, fault blocks, and stratigraphic pinchouts and facies changes are potential traps.

Resource potential: The main premise of this play is that Laramide or younger thrusting is extensive in central-eastern Nevada. However, thus far, little or no documentation of Laramide thrusting is at hand. Most data indicate a probable Late Paleozoic or Early Mesozoic age for thrusts involved. Age of thrusting is important because the older the thrusting the more likely that associated fold and fault structures will have been adversely affected by subsequent intense structural systems, including Late Cenozoic extensional faulting, thus tending to destroy or adversely remigrate any hypothetical early accumulations. Nevertheless, the play remains as a valid concept, depending heavily on the effects of post-thrusting tectonic and thermal history. Potential accumulations, which could be of moderate to large size, may also be related to the presence of the valley-fill unconformity seal.

1907. SEVIER FRONTAL ZONE PLAY (HYPOTHETICAL)

This is a hypothetical, conventional structural play in central Utah characterized by probable traps in thrust-imbricate duplexes, triangle zones, and anticlines of the Charleston-Nebo, Wasatch, Gunnison, and Pavant thrust systems. The play extends 200 mi south-southwest from 20 mi north of Provo, Utah, to Beaver, and thins from 50 mi wide in the north to zero in the south. It lies due south of the Wyoming Thrust Belt Province (036) and straddles the boundary between the Eastern Great Basin Province and the Uinta–Piceance and Paradox Basin Provinces (020 and 021).

Reservoirs: In the northern part, oil and gas shows have been encountered in several reservoir horizons from Mississippian, Permian, Triassic, Jurassic and Cretaceous strata. In the southern part of the play, much of the Triassic and Jurassic changes to a redbed and eolian sandstone facies and is evaporitic in places. Pre-Triassic reservoirs are primarily marine throughout the play.

Source rocks, timing, and migration: Potential source rocks include marine shales and mudstones of Upper Mississippian, Lower Pennsylvanian, Permian, Triassic, and Upper Cretaceous age. Coaly beds are present in the Cretaceous. The Upper Cretaceous rocks become more fluvial and nonmarine to the south and west, and probably are gas prone. Thrusting in this area is Cretaceous to early Tertiary in age, part of the Sevier Orogeny. Most of the hydrocarbon generation and migration probably occurred during this period. However, some hydrocarbon generation and migration probably began as early as Permian or Triassic time in the older rocks and as late as Tertiary time in Mesozoic rocks. Late Tertiary extension in this area may have disrupted the traps more than in the Wyoming Thrust Belt to the north (Province 036).

Traps: Structural traps probably include thrust-imbricate duplex zones, triangle zones, and low-amplitude anticlines in both the hanging walls and foot walls of thrusts. There is potential for updip pinchout and isolated stratigraphic traps in the Mesozoic section.

Exploration status and resource potential: Although it has been nearly 20 years since the discovery of 2- and 3-TCF gas fields in the Wyoming Thrust Belt Province (036) to the north, there are only a few dozen wells to date in the Sevier Frontal Zone Play. Some of these have had oil and gas shows, and a few additional wells are currently permitted. The southern boundary of the Utah-Wyoming Thrust Belt is controlled by the impingement of the belt onto the west end of the Uinta Mountain block, which causes intense faulting and hydrodynamic flushing problems that terminate production at the southern end of the Wyoming Thrust Belt Province (036). However, less disrupted thrust belt structures resume 10-20 mi south of the Uinta Mountains. Cretaceous source rocks become less marine to the south of the Wyoming Thrust Belt Province (036) and to the west of the Paradox Basin's Upper Cretaceous Play (2107), but the potential exists for oil or gas fields of variable sizes in the central Utah Sevier Frontal Zone play.

UNCONVENTIONAL PLAYS

There are no unconventional plays described in this province report. However, unconventional plays listed in the surrounding provinces may include parts of this province. Individual unconventional plays are usually discussed under the province in which the play is principally located.

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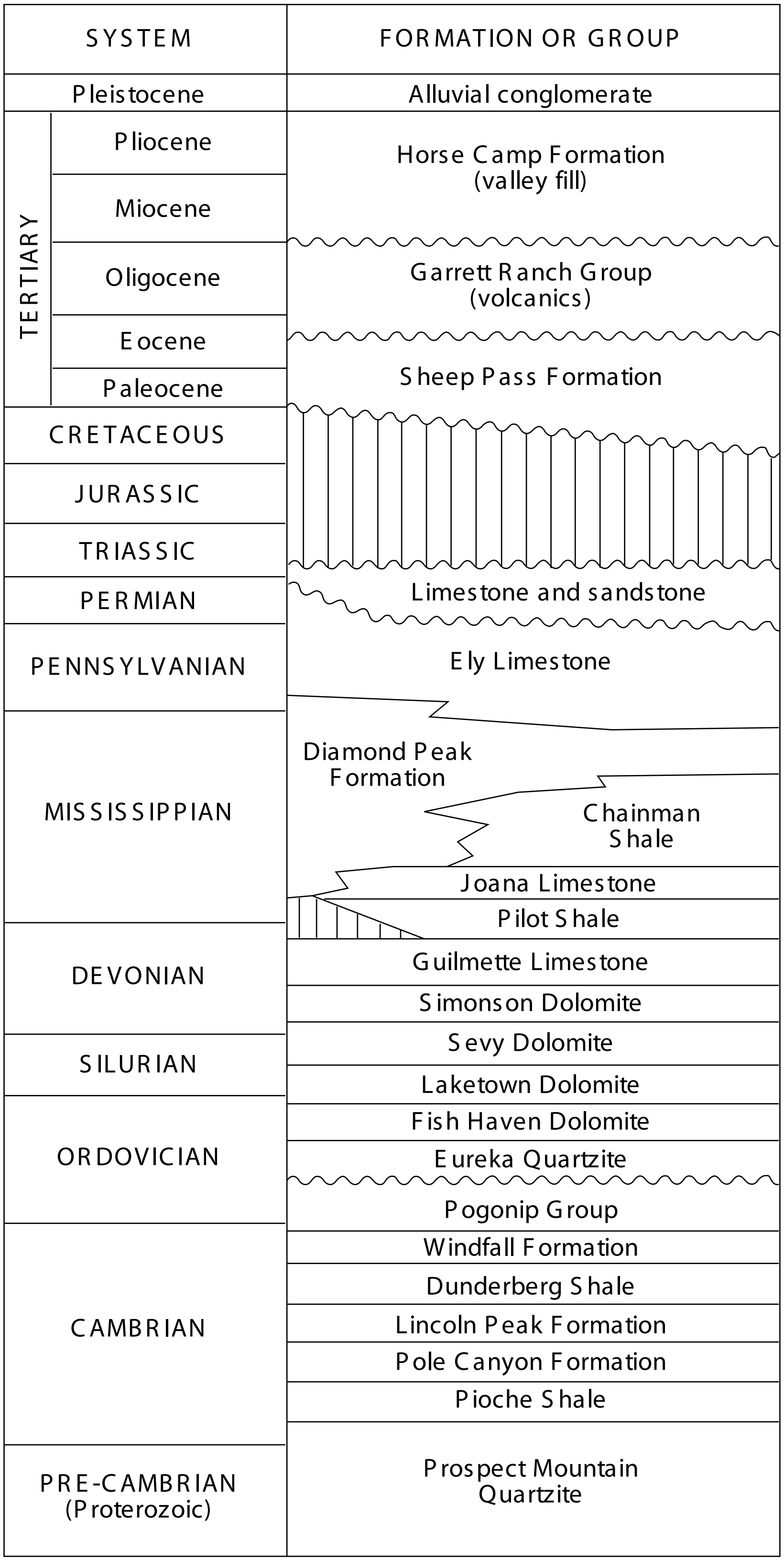
SYSTEM
FORMATION OR GROUP
Pleistocene
Alluvial conglomerate
TERTIARY
Pliocene
Miocene
Horse Camp Formation
(valley fill)
Oligocene
Garrett Ranch Group
(volcanics)
Eocene
Paleocene
Sheep Pass Formation
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
Limestone and sandstone
PENNSYLVANIAN
Ely Limestone
MISSISSIPPIAN
Diamond Peak
Formation
Chainman
Shale
Joana Limestone
Pilot Shale
DEVONIAN
Guilmette Limestone
Simonson Dolomite
Sevy Dolomite
SILURIAN
Laketown Dolomite
ORDOVICIAN
Fish Haven Dolomite
Eureka Quartzite
Pogonip Group
CAMBRIAN
Windfall Formation
Dunderberg Shale
Lincoln Peak Formation
Pole Canyon Formation
Pioche Shale
PRE-CAMBRIAN
(Proterozoic)
Prospect Mountain
Quartzite