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GEOLOGY OF THE SOUTHERN INDEPENDENCE MOUNTAINS

ELKO COUNTY, NEVADA

GEOLOGY 930

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ILLUSTRATIONS

INTRODUCTION

The present report outlines the geology of the southern portion of the Independence Mountains. The geology of this range has not been systematically mapped in detail although a regional report has been published (Granger and others, 1957). This summary is a compilation of data extrapolated from nearby areas and extracted from published reports on portions of the area. The surface geology and geophysics are described and problems of testing the subsurface geology are outlined.

LOCATION

The Independence Mountains are located in the western portion of Elko County in northeastern Nevada. For purposes of this report the southern Independence Mountains are considered to lie between Taylor Canyon on the north and the southern end of the range at Swales Mountain on the south. This range lies north of the town of Carlin between Maggie Creek on the west and Susie Creek and the North Fork of the Humboldt River on the east (see figure 2).

GEOLOGY

The southern Independence Mountains and adjacent valleys are underlain by Paleozoic rocks ranging in age from Ordovician to Devonian and by Tertiary to Recent strata. The Paleozoic rocks are sedimentary strata of two distinct facies, a western eugeosynclinal facies and an eastern miogeosynclinal facies. The Independence Mountains are near the facies boundary at the time of deposition of these strata as the westernmost exposure of eastern facies strata at this latitude is in the Tuscarora Range, the range immediately west of the Independence Mountains. Rocks of the two facies have been superimposed by eastward thrust faulting of the western facies units.

Paleozoic rocks have been mapped in detail, in published literature, in only a single area in the southern Independence Mountains, at Lone Mountain in T. 37 N., R. 53 E. (Lovejoy, 1959). Here the eastern facies beds are divided into two sequences, an underlying McClellan Creek sequence and an overlying Coal Creek sequence. These sequences are believed to be separated by a minor thrust fault (Lovejoy, 1959, p. 542). The McClellan Creek sequence is exposed on the western, northern, and southern flanks of Lone Mountain where it consists of thin-bedded to massive limestone and is considered to be autochthonous. It has an estimated thickness of 1000 feet and tenative fossil identifications indicate a Devonian age although it cannot be lithologically correlated with other Devonian sections in eastern Nevada.

Lovejoy (1959, p. 543) considers the Coal Canyon sequence to be allochthonous and he infers the presence of a minor thrust fault between these two sequences. He also subdivides the Coal Canyon sequence into an upper and lower plate separated by another minor thrust fault and considers the upper plate to have been thrust eastward over the lower plate. The Coal Canyon sequence is found on the south flank of Lone Mountain where the upper plate consists of limestone, shale, and calcareous siltstone and the lower plate consists of limestone with minor amounts of altered gabbro in the form of small lenses. The argillaceous nature of the Coal Canyon sequence, the presence of interlayered gabbro, and its eastward thrusting would indicate that it had an origin near the boundary between the eugeosyncline and miogeosyncline. The sequence has an estimated thickness of 500 feet. No fossils have been found in the lower plate but the upper plate has been dated on firm faunal evidence as Upper Devonian in age. Lovejoy (1959, p. 545) correlates the Coal Canyon sequence with the Devils Gate Limestone of the Eureka area.

why?

In the Lone Mountain area western facies Paleozoic rocks are of Ordovician and Silurian age; the Ordovician portion is termed the Basco Formation with a type area along Basco Creek on the southwest side of Lone Mountain. It consists, in ascending order, of a calcareous siltstone member with lenses of altered peridotite, a chert member, a shale member, and an uppermost chert member. A thickness of 1750 feet is present although the base and top are not exposed. The Basco Formation contains definite Lower and Middle Ordovician fauna and possible Upper Ordovician strata are present. The Ordovician beds are believed to be conformable with overlying siltstone, chert, and shale of Silurian age. Lovejoy (1959, p. 551) considers the Basco Formation to be temporally equivalent to the Vinini, Valmy, and Comus Formations of central Nevada (see figure 1).

The only detailed description of Paleozoic rocks, available to the writer, in the southern Independence Mountains outside of the Lone Mountain area is in the Swales Mountain area at the southern end of the range. Mr Keith B. Ketner (oral communication, 1968) reports that the Swales Mountain area is a window through Ordovician western facies strata which exposes Silurian and Devonian eastern facies beds. The western

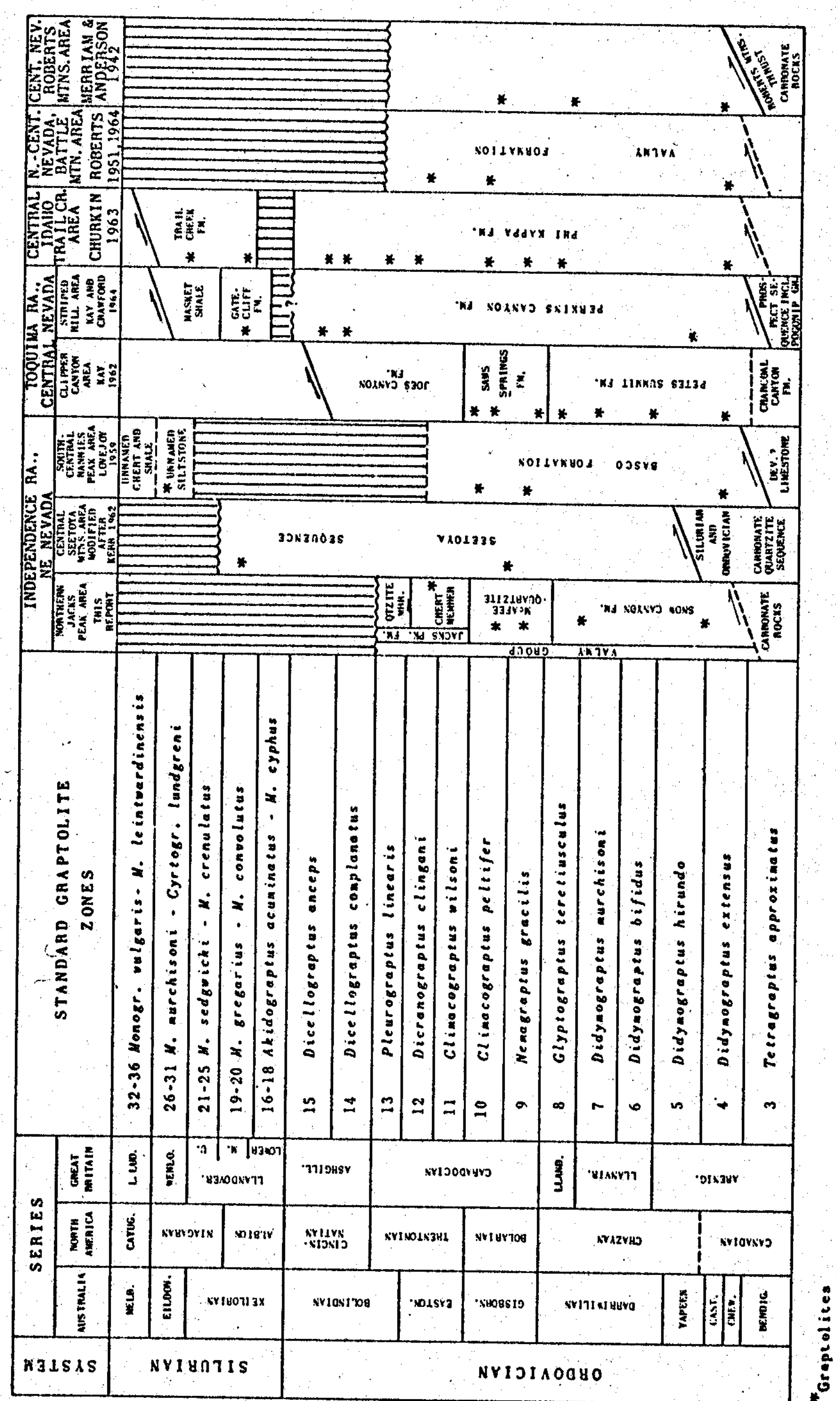

Figure 1 Correlation of graptolitic rocks in Nevada and Idaho

Source - Churkin and Kay, 1967, fig. 3, p. 658

facies rocks are tenatively correlated with the Vinini Formation whereas the eastern facies rocks (do not resemble named units in other areas.) probably transitional The Silurian beds at Swales Mountain are a black limestone and Ketner believes they are equivalent to the Roberts Mountains Formation. The Devonian strata resemble eastern facies beds of the same age in the Lynn window in the Tuscarora Range to the west which have been informally termed the "Popovich Limestone".

Paleozoic strata have been described in the northern Independence Range by several workers and this data is summarized by Churkin and Kay in a study of the Jack Creek area (Churkin and Kay, 1967). They found evidence of post-Carboniferous thrust faulting involving allochthonous western facies rocks superimposed upon eastern facies beds. The western facies in the Jack Creek area consists of Ordovician chert, quartzite, and argillaceous beds equivalent to the Valmy Formation. Churkin and Kay elevated the Valmy to group status and subdivided these Ordovician rocks into the Snow Canyon Formation, McAfee Quartzite, and Jacks Peak Formation. These are correlated with the Basco Formation farther south (see figure 1). The Valmy Group in the Jack Creek area is unconformably overlain by chert, mudstone, conglomerate, and volcanic rocks of the Schoonover Formation of Carboniferous and Permian ? age. The eastern facies rocks in the northern Independence Mountains have been correlated with the Pogonip Group, Eureka Quartzite, and Hanson Creek Formation of Ordovician age and the Roberts Mountains Formation of Silurian age. In the northeastern portion of the Jack Creek area the eastern facies consists of Cambrian carbonate beds unconformably overlain by 4000 feet of calcarous sandstone, siltstone, and minor limestone of Carboniferous ? and Permian age.

In the Carlin Canyon area a few miles south of the southern end of the Independence Mountains Fails (1960, p. 1692-1693) found a thick sequence of Carboniferous and Permian strata unconformably overlying the Vinini Formation. These beds, in ascending order, are termed the Tonka Formation of Mississippian and Pennsylvanian age, Moleen Formation and Tomera Formation of Pennsylvanian age, Strathearn Formation of Pennsylvanian and Permian age, and the Buckskin Mountain, Beacon Flat, and Carlin Canyon Formations of Permian age. The Tonka Formation consists of chert-pebble conglomerate and the Moleen and Tomera Formations are composed of calcareous sandstone. An unconformity separates the Tomera and Strathearn Formations. The Buckskin Mountain, Beacon Flat, and Carlin Canyon Formations are calcareous siltstone, calcareous sandstone, and chert. All of these Carboniferous and Permian units are considered to be part of the overlap assemblage (Fails, 1960, p. 1693). The chert in the Carlin Canyon Formation may be derived from volcanic ash and represent Permian orogeny to the west.

Mesozoic rocks have not been noted in the southern Independence Mountains in published literature. Tertiary time in this area is represented by granitic intrusive bodies, volcanic rocks, and sediments of continental origin. Late in Tertiary time block faulting developed the pattern of fault block mountains that characterizes the Basin and Range province; the Independence Mountains are one of these fault block ranges.

In the southern Independence Mountains granitic intrusive bodies are known at Lone Mountain and Swales Mountain. The intrusion at

Swales Mountain is a stock of biotite granodiorite porphyry with an aphanitic groundmass. Potassium-argon and lead-alpha dating indicate an age of 38 and 40±10 million years respectively, ie., a probable Oligocene age (Coats and others, 1965, p. D11). At Lone Mountain there are several stocks and dikes ranging in composition from diorite to quartz monzonite; textures vary from porphyritic to non-porphyritic. Radiogenic dating by the potassium-argon method on the largest of these bodies gives an age of 12±20 million years, ie., a probable Miocene age (Schilling, 1965, p. 31).

The flanks of the southern Independence Mountains and adjoining valleys of Susie Creek and Maggie Creek are underlain by interlayered sedimentary and volcanic rocks ranging in age from late Miocene to Recent. This sequence has been studied in the area around the town of Carlin by Regnier (1960) who noted at least six episodes of volcanic activity and four periods of block faulting. Regnier's work would seem to indicate a continuum of tectonic activity expressed by recurrent volcanism and structural development characterized by high-angle faults. On the east flank of the Independence Mountains in the vicinity of Swales Mountain Regnier described the Raine Ranch Formation of late Miocene age which consists of lapilli tuff, volcanic breccia, a basalt flow, alluvial sediments, and vitric tuff. It is downfaulted against the Paleozoic rocks along a north-northeast trending high-angle fault. Along the south end of the range the Paleozoic rocks, Raine Ranch Formation, and bounding fault are overlapped by tuffaceous sandstone, siltstone, and conglomerate of the Carlin Formation of early Pliocene age. The contact between the Raine Ranch Formation and

Carlin Formation is marked by a slight angular unconformity. These units have previously been included within the Humboldt Formation (Sharp, 1939, p. 133).

The structure of the southern Independence Mountains is dominated by thrust faults of Paleozoic age and high-angle faults of Tertiary to Recent age. Some of the thrust faulting probably occurred during the Late Devonian-Early Mississippian Antler orogeny but the presence of post-Carboniferous thrust faulting in the northern portion of the range suggests that a second period of thrusting may have occurred farther south in the area of this report. The east boundary of the range is marked by a high-angle fault at the latitude of Swales Mountain and in the Jack Creek area to the north. The rectilinear nature of the southern portion of the range and adjoining drainage of Susie Creek would seem to indicate that the east boundary of the southern Independence Mountains is a continuous fault or zone of faulting. Mineralized normal faults dipping westward are exposed in mine workings on the west flank of Lone Mountain. Again physiographic evidence suggests the presence of a range front fault on the west although none has been noted in published reports. Alternatively the range front on both the east and west sides could be the locus of a series of step faults.

GEOPHYSICS

Published geophysical data on the Independence Mountains is limited to aeromagnetic maps of the Swales Mountain area at the extreme southern end of the range. These maps show prominent magnetic high anomalies over

Swales Mountain and an area five miles to the southeast in the valley of Susie Creek. These anomalies have reliefs of 170 and 130 gammas respectively and their form and magnitude would appear to indicate the presence of sizeable subsurface intrusive bodies (U.S. Geological Survey, 1967, open file aeromagnetic maps). Gravity surveys in Pine Valley to the south of the Independence Mountains have been interpreted to mean that the thickness of Cenozoic valley fill in that area is about 12000 feet (Mabey, 1966, p. 77). The fault block nature of the Independence Mountains would indicate that the thickness of valley fill in the valleys of Susie Creek and Maggie Creek has a thickness of the same decimal order of magnitude, ie., a hypothetical thickness of X000-X0000 feet.

RÉSUMÉ OF THE GEOLOGIC HISTORY

The southern Independence Mountains are in the area of miogeosynclinal deposition from Cambrian through Devonian time although the boundary between the miogeosyncline and eugeosyncline lay only a short distance to the west (see figure 3). Deposition was probably continuous over this interval but later tectonic events have masked the record. The area of this report is north of the position of the Cortez-Uinta axis and east of the Antler orogenic belt, both of which became active in Late Devonian time during the Stansbury disturbance and Antler orogeny respectively (Roberts and others, 1965, p. 1928). Erosion of the Antler orogenic belt shed clastic debris into the area of the Independence Mountains during Carboniferous and Permian time. The coarse clastic sediments of Mississippian age were deposited in the Chainman-Diamond Peak trough which in this area was the forerunner

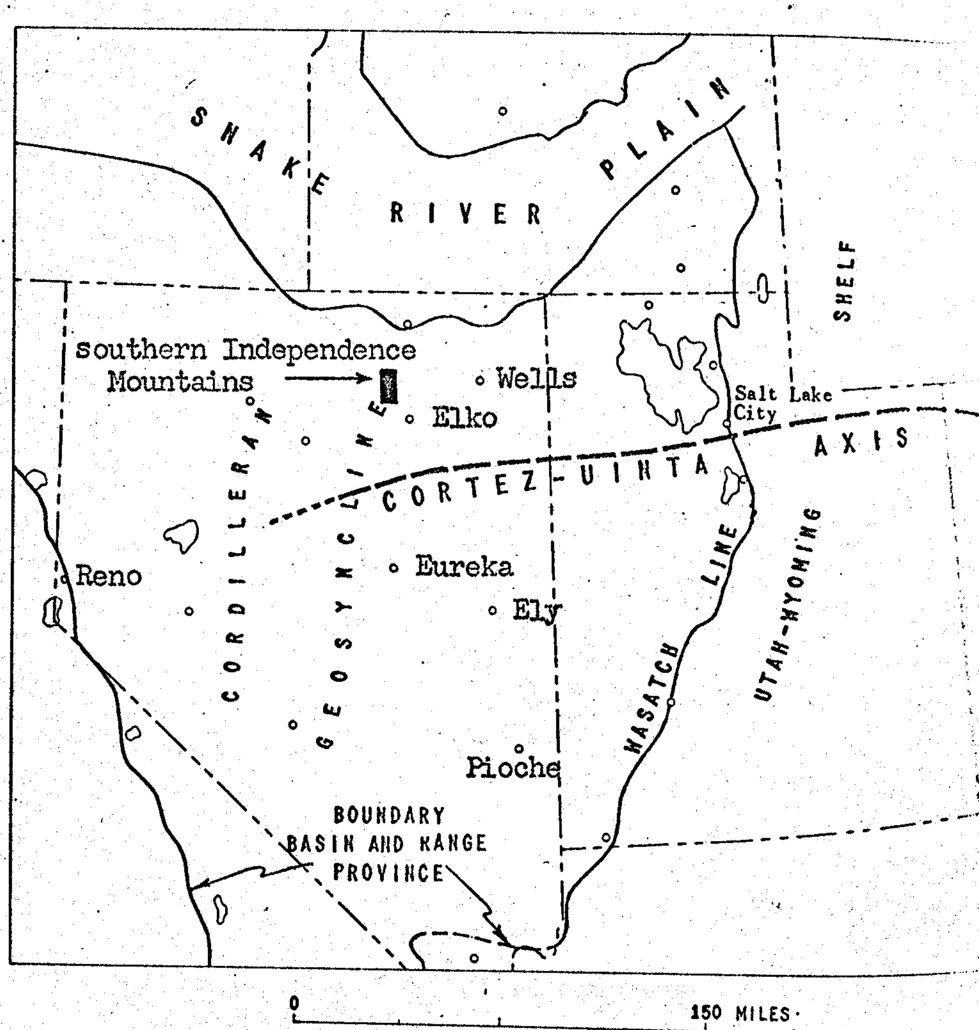

Fig. 2.—Map showing Cortez-Uinta axis and boundary between Utah-Wyoming shelf and Cordilleran geosyncline.

Source - Roberts and others, 1965, fig. 2, p. 1928

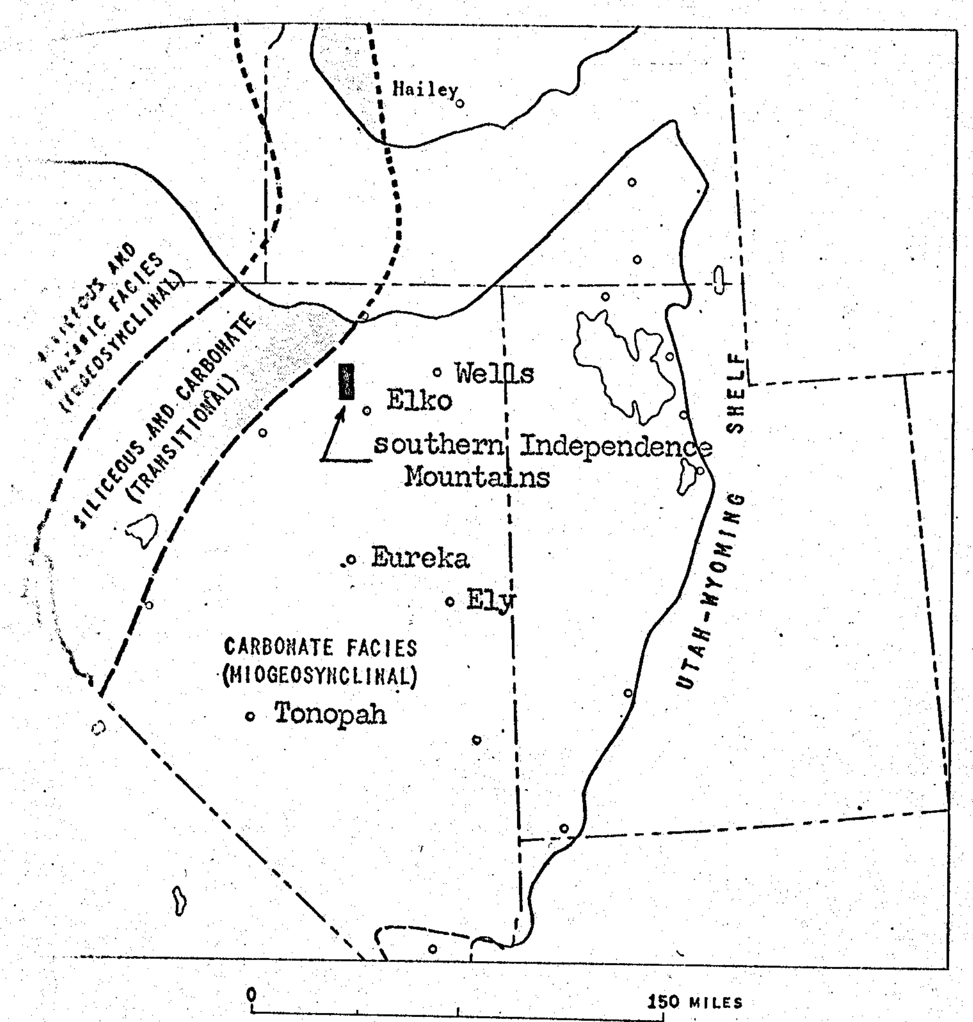

FIG. 3.—Map showing original distribution of facies in Cordilleran geosyncline.

Source - Roberts and others, 1965, fig. 3, p. 1929

of a deeper Pennsylvanian and Permian basin, the Oquirrh basin. The southern Independence Mountains were on the western margin of the basin and received coarse clastic sediments whereas farther east sand and carbonate deposition prevailed. The area has been affected to some degree by at least three orogenies, in Late Devonian-Early Mississippian , Permian (?), and Tertiary times. The first and second were characterized by extensive thrust faulting and the third by high-angle faulting.

PREVIOUS SUBSURFACE EXPLORATION

Little subsurface exploration has been performed in the southern Independence Mountains according to published literature and no deep drilling has been described. A single diamond drill hole was collared in the western facies strata at the Monarch mine on the northwest flank of Lone Mountain in 1957. It was abandoned at a depth of 235 feet after it presumably had passed into limestone of the McClellan Creek sequence. (Lovejoy, 1959, p. 559). During 1967 the U.S. Geological Survey drilled three shallow diamond drill holes near the edge of the window at Swales Mountain (Keith B. Ketner, 1968, oral communication). Two of these holes were collared in the eastern facies limestone of Silurian age and the third hole was drilled through western facies strata, intersecting limestone and the presumed thrust fault at a depth of about 200 feet. No petroleum wells have been drilled in the southern Independence Mountains (Lintz, 1957 and Garside and Schilling, 1967). Mine workings are relatively shallow and not extensive (Emmons, 1910).

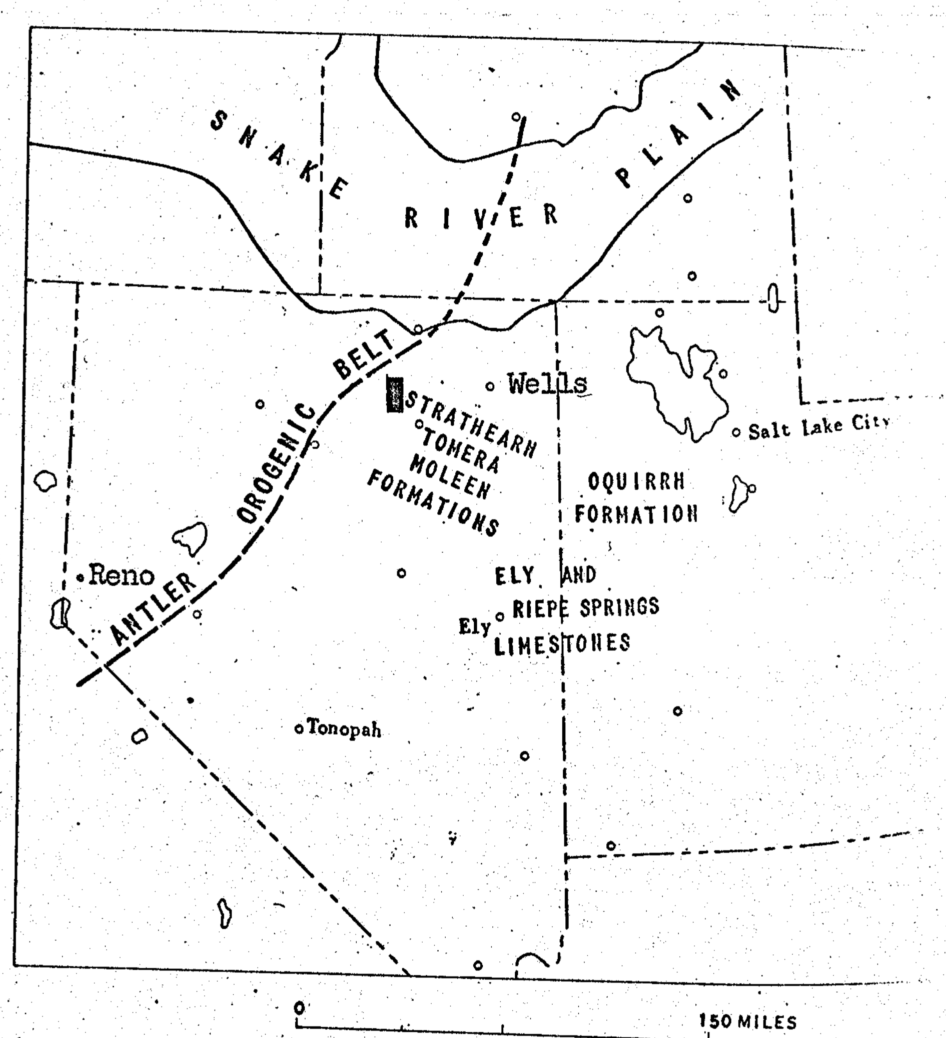

FIG. 4—Map showing Pennsylvanian and Permian basins bordered on west by clastic Moleen, Tomera and Strathearn Formations (Carlin sequence).

Source - Roberts and others, 1965, fig. 6, p. 1932

PROBLEMS OF SUBSURFACE EXPLORATION

Published geology of the southern Independence Mountains is very limited and covers only a small portion of the total area. Because of structural complication resulting from the multiple orogenies it would be difficult and dangerous to extrapolate geologic relationships from nearby areas. The area of this report was near a major facies boundary during early Paleozoic time and on the edge of a depositional basin during late Paleozoic time and rapid variations in the nature of sedimentation, both laterally and vertically, are to be expected. The southern Independence Mountains have been the site of recurrent igneous activity. Granitic intrusive bodies are probably much more extensive beneath the present surface as evidenced by large magnetic high anomalies at the southern end of the range. The intrusive stock at Swales Mountain is relatively small and fine-grained but batholitic sized bodies of the same age and composition are present in nearby ranges, eg., the Harrison Pass pluton in the Ruby Range. Contact metamorphism of carbonate rocks might be a guide to subsurface intrusive bodies but the comparatively unreactive nature of siliceous rocks of the western assemblage could inhibit contact metamorphic effects. Basalt plugs have been noted in the Tertiary sedimentary sequence in Pine Valley and they could easily be present at depth on the flanks of the Independence Mountains. The nature of faulting in this area suggests that subsurface exploration would have difficulties. The thrust faulting has an imbricate nature in both the eastern and western assemblage rocks and the character of range front faults, if present, is not known.

Preliminary geophysical work could possibly resolve some of these unknowns but there are difficulties in this approach. The density of the western and eastern assemblage Paleozoic rocks is very nearly equal and gravity or seismic work to trace the subsurface extent of the thrust faults is difficult if not impossible at the present time. (Don R. Mabey, 1967, oral communication). Attempts at using electromagnetic methods for this purpose have not been successful to date in nearby areas such as the Cortez Mountains and Shoshone Range. Geophysical methods should have no difficulty in tracing the high-angle faults, particularly range front faults.

Drilling is difficult but not impossible in the hard, siliceous chert and quartzite of the western facies formations of Paleozoic age. Bit costs can be excessive particularly for diamond drilling and the brecciated zones associated with thrust faults can be very difficult to core. Down-the-hole hammer drilling is particularly applicable for drilling these siliceous rocks but is limited to dry drilling above the water table. Rotary drilling is applicable for drilling both above and below the water table but bit costs can be high in the harder rocks.

SELECTED REFERENCES

Churkin, Michael, Jr., and Kay, Marshall, 1967, Graptolite-bearing Ordovician siliceous and volcanic rocks, northern Independence Range, Nevada: Geol. Soc. America Bull., v. 78, p. 651-668

Coats, R.R., Marvin, R.F., and Stern, T.W., 1965, Reconnaissance of mineral ages of plutons in Elko County, Nevada and vicinity: U.S. Geol. Survey Prof. Paper 525-D, p. D11-D15

Emmons, W.H., 1910, A reconnaissance of some mining camps in Elko, Lander, and Eureka counties, Nevada: U.S. Geol. Survey Bull. 408, 130 p.

Fails, Thomas G., 1960, Permian stratigraphy at Carlin Canyon, Nevada: Am. Assoc. Petroleum Geologists Bull., v. 44, p. 1692-1703

Garside, Larry J., and Schilling, John H., 1967, Wells drilled for oil and gas in Nevada: Nevada Bur. Mines Map 34

Granger, Arthur E., Bell, Mendell M., Simmons, George C., and Lee, Florence, 1957, Geology and mineral resources of Elko County, Nevada: Nevada Bur. Mines Bull. 54, 190 p.

Lintz, Joseph, Jr., 1957, Nevada oil and gas drilling data, 1906-1953: Nevada Bur. Mines Bull. 52, 85 p.

Lovejoy, Donald W., 1959, Overthrust Ordovician and the Nannie's Peak intrusive, Lone Mountain, Elko County, Nevada: Geol. Soc. America Bull., v. 70, p. 539-564

Mabey, Don R., 1966, Regional gravity and magnetic anomalies in part of Eureka County, Nevada, p. 77-83 in Mining Geophysics, vol. 1: The Society of Exploration Geophysicists, Tulsa, Oklahoma, 492 p.

Regnier, Jerome, 1960, Cenozoic geology in the vicinity of Carlin, Nevada: Geol. Soc. America Bull., v. 71, p. 1189-1210

Roberts, R.J., and others, 1965, Pennsylvanian and Permian basins in northwestern Utah, northeastern Nevada, and south-central Idaho: Am. Assoc. Petroleum Geologists Bull., v. 49, p. 1926-1956

Schilling, John H., 1965, Isotopic age determinations of Nevada rocks: Nevada Bur. Mines Report 10, 79 p.

Sharp, R.P., 1939, The Miocene Humboldt Formation in northeastern Nevada: Jour. Geology, v. 47, p. 133-160

U.S. Geological Survey, 1967, Aeromagnetic maps of the Dixie Flats and Elko 2 quadrangles, Elko County, Nevada and Palisade 1 and Palisade 2 quadrangles, Eureka and Elko Counties, Nevada: U.S. Geol. Survey open file maps

PRINCIPLES OF NEVADA GEOLOGY

The principles used in unraveling the geology of Nevada can be viewed from either the standpoint of geologic "principles" which are empirical concepts based primarily upon observation or the standpoint of physical and chemical laws and principles which are fundamental controls over the geologic processes which have formed the geologic record as we see it today. This summary is an attempt to outline the geologic "principles" and their underlying physical and chemical bases with examples based on Nevada geology.

The most fundamental principle involved is the philosophic concept termed the principle of the multiple working hypothesis. To correctly interpret Nevada geology any investigator must approach problems with this principle firmly in mind. Recent overemphasis on the role of overthrust faulting in north-central Nevada has no doubt resulted from the failure of some to consider alternative explanations such as rapid lateral facies variations in the Paleozoic sedimentary rocks.

Nevada geology can be unraveled by applying the principle of uniformitarianism and observing current processes to explain a geologic record which is static from our perspective. Observations of the effect of the Dixie Valley earthquake lead to an understanding of range front faulting and the development of fault block mountains.

Since the bulk of Nevada's surface exposes sedimentary rocks, principles which apply to sedimentary processes are discussed first. The principle of original horizontality of the tops of clastic sedimentary beds reflects the control of the law and force of gravity in geologic processes. This control is readily seen in Recent valley fill deposits which are horizontal. Stokes law, which governs the rate at which clastic grains settle in water, explains graded bedding as seen in the Harmony Formation at Battle Mountain. The principle of superposition of strata is basic to any study of sedimentary rocks in any conformable sequence such as the eastern facies Cambrian section in the Eureka mining district. The process of sedimentary dolomitization which probably formed most of the dolomite in units such as the Eldorado Dolomite and Hamburg Dolomite is controlled by the law of mass action and the second law of thermodynamics which governs free energy requirements. The principle of faunal succession is applied in geologic dating of sedimentary units and it permits correlation of units between areas. The trilobite genus Olenellus is used to date Lower Cambrian formations and to temporally distinguish them from units containing more highly developed trilobites. The principle of faunal succession is simply a geologic statement of the principle of evolution. The principle of unconformity states that the eroded bed at the unconformity is the older bed as evidenced by the unconformity between Silurian and Devonian strata in the Roberts Mountains. In that area Devonian beds lie on successively older Silurian rocks from north to south, thus indicating that the eroded Silurian beds are older and confirming the age relationship based on faunal data.

The law of unequal slopes has probably controlled development of ranges bounded on only one side by prominent high-angle faults. The Cortez Mountains may be a good example of this process and the divide line is probably migrating eastward away from the Crescent fault. The development of glacial landforms such as the cirques in the Ruby Range is a direct result of the law of gravity which caused movement of the glaciers and an indirect result of other physical laws such as the law of magnetic attraction which may have controlled climate and glacier development by varying solar radiation.

Several physical laws are used in the study of igneous rocks in Nevada. The principle of radioactive decay is used in the radiogenic dating of rocks such as the intrusive granitic bodies at Ely and also to correlate the intrusive process with economic mineralization by dating associated hydrothermal alteration. The principle of igneous intrusion states that cross-cutting igneous intrusive rocks are younger than their wall rocks. This relationship is used to give maximum ages for intrusive bodies.

In studying metamorphic rocks the principles of comparative deformation and metamorphism are used, ie., more deformed rocks are older than less deformed rocks in an area. This principle is particularly applicable in southernmost Nevada in separating highly deformed and metamorphosed Precambrian rocks from younger unmetamorphosed strata, all of which are unfossiliferous and therefore cannot be dated directly.

all things being equal

The application of geophysical methods to study Nevada geology involves the use of other laws. Ohm's law governing the electrical properties of rocks is the basis of electrical geophysical methods such as the resistivity method as used to trace faults. The law of gravity forms the basis of the gravity method as used to define the depth of valley fill in areas such as Crescent Valley.

It should be noted that these principles are not infallible and that there are important exceptions to some of them. The principle of superposition of strata is invalid where thrust faulting has superimposed older rocks upon younger rocks. The law of original horizontality does not hold for sediments deposited on sloping pediment surfaces where equilibrium under the force of gravity has not been reached. Stokes law does not hold for extremely fine grained particles. The law of faunal succession is invalid to the extent that faunal horizons are time transgressive, eg., the Palliseria biozone in the Ordovician section of southern Nevada. The principle of comparative deformation and metamorphism cannot be applied where metamorphic facies variations towards a source of thermal energy cause unequal deformation at the same time in rocks of the same age.

Good but what about facies distribution, the significance of coarse clastic rocks, the significance of breaks in the sedimentary record?