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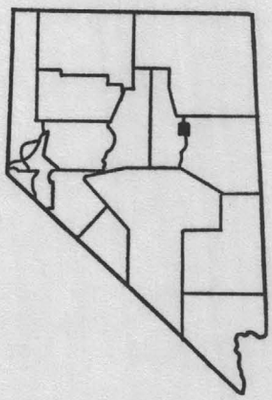
DIAMOND SPRINGS QUADRANGLE

NEVADA BUREAU OF MINES MAP 20

NEVADA BUREAU OF MINES
MAP 20

PRELIMINARY GEOLOGIC MAP
OF THE
DIAMOND SPRINGS QUADRANGLE, NEVADA

BY E. R. LARSON and JOHN F. RIVA



MACKAY SCHOOL OF MINES
UNIVERSITY OF NEVADA
1963

Price 75 cents

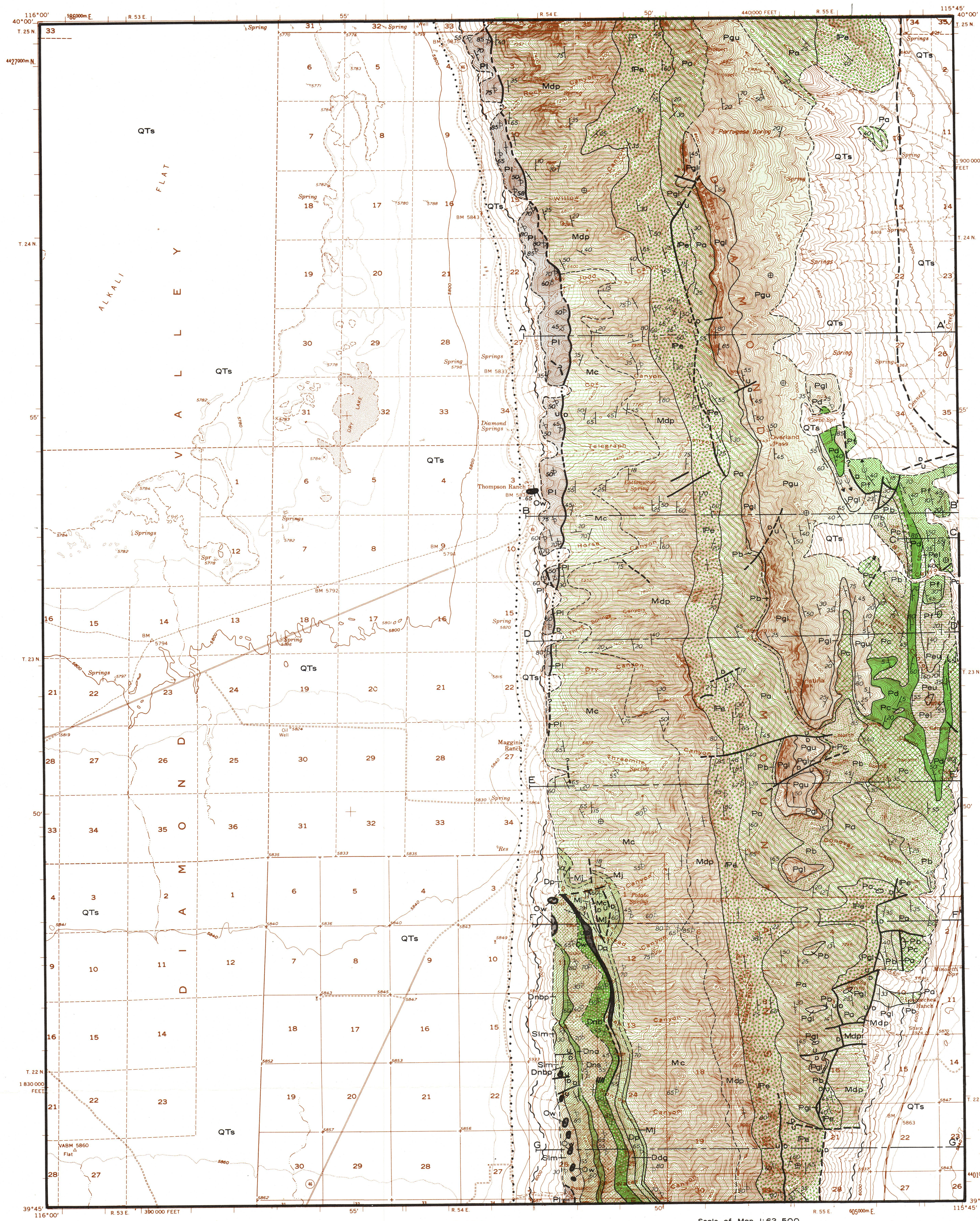
NEVADA BUREAU OF MINES

MAP 20
DIAMOND SPRINGS
QUADRANGLE, NEV.

PRELIMINARY GEOLOGIC MAP AND SECTIONS OF THE DIAMOND SPRINGS QUADRANGLE, NEVADA

By

E. R. Larson and John Riva



Topographic base by U.S. Geological Survey, 1957
Geologic cartography by Barbara Webb

Scale of Map 1:62,500 — 0, 5,000, 10,000, 15,000 feet

Scale of Cross Sections 1:31,250 — 0, 2,500, 5,000, 7,500 feet

TRUE NORTH, MAG. NORTH, 17°. Approx. Mean Declination, 1957

EXPLANATION

AUTOCHTHONOUS ROCKS

Quaternary-Tertiary
- QTs — Sedimentary rocks

Permian — Guadalupian
- Pgu — Unit G upper - sandstone and conglomerate
- Pgl — Unit G lower - conglomerate

UNCONFORMITY

Permian — Leonardian
- Pf — Unit F - limestone conglomerate

UNCONFORMITY

- Peu — Unit E upper - red conglomerate and sandstone
- Pel — Unit E lower - red silt and sand
- Pd — Unit D - sandy limestone
- Pc — Unit C - massive limestone
- Pb — Unit B - pebbly limestone

Permian — Wolfcampian
- Pa — Unit A - silty arenaceous limestone

Pennsylvanian — Springer-Atoka
- IPe — Ely Limestone

Mississippian — Upper
- Mdp — Diamond Peak Formation
- Mc — Chainman Shale

DISCONFORMITY

Mississippian — Lower
- Mj — Joana Limestone

Devonian — Upper
- Dp — Pilot Shale

Devonian — Middle
- Ddg — Devils Gate Limestone

Devonian — Lower
- Nevada Formation
  - Dnb — Bay State Dolomite member
  - Dns — Sentinal Mountain Dolomite member
  - Dno — Oxyoke Canyon Sandstone member
  - Dnbp — Beacon Peak Dolomite member

DISCONFORMITY

Silurian
- Slm — Lone Mountain Dolomite

ALLOCHTHONOUS AND PARAUTOCHTHONOUS ROCKS

Permian
- Pl — Leonardian rocks

Ordovician?
- Ow — Western assemblage

Contact—solid where known; dashed where approximately located

Fault—solid where known; dashed where approximately located; dotted where concealed

Thrust fault—sawteeth on upper plate

Strike and dip of beds

Strike and dip of overturned beds

Strike of vertical beds

Horizontal beds

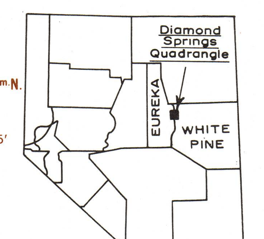
Plunge of minor anticline

Plunge of minor syncline

Ancient shoreline

Unconformity or disconformity (in cross sections)

INTRODUCTION



Permian sequences exposed in the central Diamond Mountains are a link between the well-studied formations seen to the east and incomplete Permian sequences further west. Structural relationships seen in the Diamond Mountains help in the understanding of Permian or post-Permian deformation of Paleozoic rocks in the region.

A reconnaissance map of most of the area of the Diamond Springs quadrangle was prepared by Dott (1955). Detailed mapping of part of the eastern side of the range was accomplished by Divens (1957) and by the junior author, Riva (1957). Overall study of the range was carried on by the senior author between 1953 and 1962.

Students of the University of Nevada's summer field geology course have mapped key areas in great detail. Conversations with David Brew and Ralph Roberts have been most helpful. John Sales and Abdulaziz Futaih have acted as field assistants.

The senior author is particularly grateful to Mr. and Mrs. Lee Griswold and Mr. and Mrs. Ted Thompson whose generous hospitality has aided greatly in this work. Several grants-in-aid from the Research Committee of the University of Nevada made this study possible.

STRATIGRAPHY

Autochthonous rocks

SILURIAN

Lone Mountain Dolomite

The Lone Mountain Dolomite is exposed only in a northward-narrowing triangle extending from Water Canyon to Sheep Canyon.

It is a light-gray, coarsely crystalline dolomite. Exposures of the formation are characteristically ledgy, and weathered surfaces are also light gray.

Nolan and others (1956, p. 38) describe the contact of the formation with the overlying Beacon Peak Dolomite Member of the Nevada Formation as being sharply disconformable in exposures near the Phillipsburg mine immediately south of this quadrangle. The base is not seen.

The formation is 200 feet thick in partial exposures on the northern side of Water Canyon.

DEVONIAN

Formations of Devonian Age are exposed in a belt approximately four miles long on the western side of the Diamond Mountains. A complete Devonian sequence is present in the more southernmost exposures, but some units have been structurally eliminated northward, so that only portions of the Nevada Formation and the Pilot Shale are found at Walters Canyon.

Formations in the quadrangle range from the Lower Devonian Nevada Formation, to the Upper Devonian Devils Gate Limestone and the Pilot Shale.

The presence of Stringocephalus in the Bay State Dolomite Member of the Nevada Formation indicates its Middle Devonian Age, and the presence of Martinia nevadensis in the Devils Gate Limestone in adjacent areas indicates its Upper Devonian Age (Nolan and others, 1956, p. 46, 50). Fossils from the Pilot Shale at exposures south of the quadrangle in the Packer Basin are also of Devonian Age (Nolan and others, 1956, p. 52).

Nevada Formation

The Nevada Formation consists principally of dolomite with lesser amounts of quartz arenite. Although lithologic differences permit division of the formation into five members in the vicinity of Eureka, only four were recognized in this area: the Beacon Peak Dolomite, the Oxyoke Canyon Sandstone, the Sentinel Mountain Dolomite, and the Bay State Dolomite.

Nolan and others (1956, p. 42) report about 2,900 feet of the Nevada Formation in the vicinity of the Phillipsburg mine to the south, but structural complexities within the quadrangle prevent accurate measurement of the various members in most places.

Beacon Peak Dolomite Member. This lowest member of the Nevada Formation is between Water Canyon and a point half a mile south of Sheep Canyon. It is principally finely crystalline and light brownish gray. Exposed surfaces of the rock weather to a light gray. At the base of the member is light-gray to bluish-white, well-bedded to cross-bedded orthoquartzite that contains lesser dolomitic quartz arenite and quartz arenaceous dolomite. Osmond (1962, p. 2035) gives an excellent description of the unit, which he has identified as the Dolomite Member of the Sevy Formation.

The lower contact of the member is disconformable. The contact with the succeeding Oxyoke Canyon Sandstone Member is at the base of the latter's continuous quartz arenite.

The member is 940 feet thick at the Phillipsburg mine (Nolan and others, 1956), but only about 150 feet are seen near Sheep Canyon, evidently because of tectonic thinning. Approximately 100 feet of the basal arenaceous beds have been measured at the Phillipsburg mine and near Sheep Canyon.

Oxyoke Canyon Sandstone Member. The Oxyoke Canyon Sandstone is easily recognized because of the jagged ridge which it forms in most areas of its outcrop. It is dominantly a brown, weathering light-gray to light olive-gray, heavy-bedded to cross-bedded, dolomite-cemented orthoquartzite. Portions of the member are completely siliceous, particularly in mineralized areas. The detrital fragments are medium- to fine-textured, well-rounded, and well-sorted quartz grains.

The lower contact of the Oxyoke Canyon Sandstone is gradational with the Beacon Peak Dolomite Member. The upper limit was placed at the lowest bed of dark dolomite above the continuous quartzite of the member.

The member is about 450 feet thick throughout much of its area of outcrop.

Sentinel Mountain Dolomite Member. The Sentinel Mountain Dolomite Member, as defined here, is composed principally of dark-gray, fine- to medium-crystalline dolomite, with alternating layers of dark- and light-gray dolomite in the lower part and somewhat coarser dark-gray dolomite in the upper. The distinctive lower portion, composed of alternating light- and dark-gray dolomite, is the Sentinel Mountain Dolomite as defined by Nolan and others (1956, p. 43). The coarser grained upper dark-gray dolomite portion corresponds to the Woodpecker Limestone Member of Nolan and others (1956, p. 44). The persistence of a traceable marker bed at the base of the overlying Bay State Dolomite Member serves to separate dark-gray dolomite of the revised Sentinel Mountain from the lithologically similar Bay State Member.

The thickness of the revised Sentinel Mountain is approximately 800 feet in exposures on the south side of Water Canyon. It is impossible to establish precisely the position of the Sentinel Mountain-Bay State boundary at its northernmost exposures.

Bay State Dolomite Member. The Bay State Dolomite Member, uppermost member of the Nevada Formation, is principally heavy-bedded, dark-gray medium-crystalline dolomite, with some light-gray beds similar to those in the Sentinel Mountain.

The base of the member is at the base of a unit of medium-gray-weathering, medium-dark-gray doloarenite, which locally contains pebbles and boulders of lighter gray-weathering dolomite and siltstone (Nolan and others, 1956, p. 45). The basal beds, approximately 95 feet thick in exposures on the south side of Water Canyon, thin northward but can be traced as far as Homestead Canyon. This marker provides the only means of separating the lithologically similar Bay State and Sentinel Mountain Members. The contact of the Bay State and the overlying Devils Gate Formation is gradational.

The Bay State characteristically contains abundant white cylindrical corals of the Cladopora type commonly referred to as "spaghetti rock." Some beds are crowded with Stringocephalus which can usually be seen only as arcuate sections, though more complete specimens are sometimes found.

The thickness of the member on the south side of Water Canyon is 850 feet. Reliable thicknesses were not measured in more northerly sections because of structural complications in the form of minor folds and faults. The member has been faulted out north of Walters Canyon.

Devils Gate Limestone

The Devils Gate Limestone is composed almost entirely of heavy beds of medium-dark-gray to dark-gray calcite limestone, which generally weather pale yellowish brown. The formation characteristically has a "cliffy" outcrop with many small caves.

The contact of the Devils Gate Limestone and the underlying Bay State Dolomite Member of the Nevada Formation is gradational through a 50-foot zone of interbedded limestone and dolomite. The base of the Devils Gate is defined as the base of the lowest bed of calcite limestone. The contact with the overlying Pilot Shale is gradational through a narrow zone.

The thickness of the formation to the east of the Phillipsburg mine, half a mile south of the quadrangle, is 675 feet (Nolan and others, 1956, p. 48). Reliable thicknesses were not obtained further to the north because of faulting.

Pilot Shale

The Pilot Shale, uppermost formation of the Devonian seen in the quadrangle, is present in a narrow band on the western side of the Diamond Mountains. The formation is composed of a medium-gray to dark-gray or brownish, somewhat calcareous shale below and a darker gray shale above. The rock weathers to a pale-reddish or light-yellowish brown, and in some places to a light gray.

The contacts of the formation are generally covered but can be seen east of the Phillipsburg mine, as previously described. The thickness of the formation is about 350 feet.

Collections made from the lower part of the formation indicate a Late Devonian Age (Nolan and others, 1956, p. 53). No fossils were found in the upper portion which may be Mississippian in part (Nolan and others, 1956, p. 53).

MISSISSIPPIAN

Joana Limestone

The Joana Limestone is, in general, poorly exposed in the quadrangle, and was studied principally from its float and from discontinuous outcrops. The formation is typically a medium-dark-gray to dark-gray limestone. Texturally it varies from finely crystalline laminated calcite rock to a coarsely crystalline calcarenite. Detailed examination of the calcarenite shows it to be composed almost entirely of small crinoid columnals.

Because the Joana was measured principally either from the map pattern or from poorly exposed sections, no positive statement can be made relative to the contacts of the formation; but rapid variations in thickness seem to require that at least one of the contacts be a disconformity. Langenheim (1960, p. 78) has recognized disconformities both above and below the formation in the more easterly portions of Nevada.

Nolan and others (1956, p. 55) cite a gradational contact between the Joana and the underlying Pilot Shale in the Diamond Mountains and report a thickness of 115 feet, east of the Phillipsburg mine. The senior author measured 250 feet, apparently at the same locality, and Brew (1961, p. C-115) has found both of these thicknesses in that area. Within the quadrangle, the formation is 411 feet thick in fair exposures one mile to the north in Water Canyon. It is 165 feet thick in the saddle between Sheep and Monroe Canyons, and 170 feet thick in an apparent continuous section on the east side of the saddle between Homestead and Walters Canyons.

No collections were made from the Joana Limestone in the Diamond Spring quadrangle, but Nolan and others (1956, p. 55) report an Early Mississippian faunule from Tollhouse Canyon to the southeast.

Chainman Shale and Diamond Peak Formation

These formations are separated only provisionally because a reliable boundary horizon was not found. In general the Chainman contains more fine-grained clastics and the Diamond Peak more conglomerate, but units of similar lithology are present in each. A tentative line of demarcation was established at the base of the first laterally consistent conglomerate above the Joana Limestone. Faunas found in other areas point to an Upper Mississippian Age for both the Chainman Shale and the Diamond Peak Formation (Nolan and others, 1956, p. 58).

Chainman Shale. The Chainman is 3,950 feet thick between Homestead and Walters Canyons where the lower portion of the formation is a medium- to dark-gray brittle siltstone. Successively higher beds consist of subgraywacke, pebbly mudstone, a thick conglomerate, yellowish and greenish quartz arenite and greenish-gray shale.

Diamond Peak Formation. The Diamond Peak Formation is exposed on the western side of the Diamond Mountains throughout the length of the quadrangle, and in a small area in its southeasternmost portion.

The name, as used here, refers to a sequence of heavy-bedded, chert, pebble and cobble conglomerates with interspersed shales, sandstones, and some limestones. Though the conglomerates constitute only about 25 percent of the formation, they are the most obvious beds as they tend to form prominent "walls" where erosion has removed intervening less resistant material.

In the section measured between Homestead and Walters Canyons, the formation consists of 2,200 feet of clastic sediments. The lower 120 feet is a thick-bedded unit of chert and quartz small cobble conglomerate in a coarse arenite matrix. Some pebbles or small cobbles of limestone are present. Overlying beds consist of somewhat finer conglomerate with dark-gray quartzites and siltstones. The upper half of the formation consists of dusky-red and grayish-green shales and siltstones, with intervening units of chert and quartz pebble and cobble conglomerate. Light-gray-weathering limestone phenoclasts are present in many of the siltstone beds and are abundant in an 80-foot-thick grayish-green siltstone unit 600 feet below the top of the formation. Thin limestone units, clearly the source of the phenoclasts, occur at irregular intervals through the upper half of the formation, but no thick limestone sequence was seen.

The contact of the Diamond Peak Formation and Ely Limestone is somewhat gradational. The boundary is placed at the base of the continuous sequence of dark-gray limestone above the conglomerate of the Diamond Peak.

The Diamond Peak is considered to be Upper Mississippian for the most part but the upper portion is probably Lower Pennsylvanian (Dott, 1955, p. 2268).

PENNSYLVANIAN

Ely Limestone

The Ely Limestone, called the Ely Group by Dott (1955, p. 2268), is exposed near the crest of the Diamond Mountains throughout the length of this quadrangle. The formation can be recognized from a distance by the characteristic growth of pinon pines and by the ledgy character of the outcrops.

The Ely Limestone is a sequence of medium-dark-gray limestone with chert concretions. Much of the limestone is quartz arenaceous and contains scattered chert pebbles. Thin pebble beds occur in the formation and a 20-foot bed of chert pebble conglomerate is present in the lower portion of the section at Judd Canyon. A zone of the distinctive coral Chaetetes in the upper portion of the formation is an excellent horizon marker.

Dott (1955) indicates that beds of the Ely Group are about 1,300 feet thick at Judd Canyon on the western side of the Diamond Mountains and states that the thickness of the Ely is relatively uniform throughout the range.

The Ely is of upper Springeran through lower Atokan Age (Dott, 1955, fig. 13) and is paraconformably overlain by Wolfcampian beds.

PERMIAN

The principal rocks exposed on the eastern side of the Diamond Mountains, and those in upthrust blocks on the western side of the range, are Permian. Seven stratigraphic units, here called Units A through G, have been mapped in the quadrangle.

A study by Riva (1957) of fusulines from the Permian units on the east side of the Diamond Mountains, indicates that they range in age from younger Wolfcampian into at least the upper Leonardian. Correlation of the highest units with adjacent areas allows their classification as Guadalupian.

The Permian section is remarkable for the rapid change in both the lithology and thickness of its units. The latter is due both to variation in the amounts deposited and to the presence of unconformities in the section.

Unit A

Unit A is principally chert-bearing light-brown calcareous siltstone with beds of medium-gray coquinite and calcarenite. Riva (1957) has divided the unit on the basis of lithology into a lower portion of flaggy to massive quartz siltstone with lesser amounts of quartz and chert arenaceous calcarenite, and an upper portion of calcareous quartz siltstone (or silty limestone) with thin beds and nodules of dark chert. The lower portion, seen principally on the western side of the range, weathers pale red but the higher portions produce a brownish cover.

Unit A lies paraconformably on the Ely Limestone and is overlain, perhaps unconformably, by Unit B or Unit G. The entire unit is 2,500 feet thick on the eastern side of the range, but only its lower 540-foot-thick portion is seen on the western crest near the head of Conover Canyon. It is about 1,350 feet thick at the northern end of the quadrangle; where silty and arenaceous limestones, faunally like Unit B, are included.

A fusuline fauna containing Schwagerina aff S. elkoensis, S. puovidens, S. youngquisti, and S. wellsensis indicates the upper Wolfcampian Age of the Unit. Bissell has elsewhere (1962, p. 1101) identified Unit A as the Arcturus Formation.

Unit B

Unit B is exposed almost exclusively on the eastern side of the Diamond Mountains. The unit is 1,500 feet thick near USC&GS triangulation point Simonson, but has been bevelled by an unconformity and is only about 300 feet thick on the western crest of the range near triangulation point VABM Birch. It is absent at Overland Pass, and in the southernmost part of the quadrangle.

A 750-foot section of the unit seen one mile southwest of Simonson is mostly of dark-gray, quartz-and-chert-arenaceous, chert pebble-bearing calcarenite with discontinuous beds of chert small-pebble conglomerate up to 1 foot thick. Dusky red-weathering silty partings occur on many of the bedding planes. The unit is thinner near the eastern edge of the range and the clastic content of the rock is finer grained and less abundant.

Unit B contains an abundant fusuline fauna which includes Parafusulina sp., Schwagerina cf. S. gumbeli pseudoirregularis, suggesting a middle Leonardian Age.

Unit C

Unit C is a massive- to thin-bedded medium- to dark-gray limestone with some grayish-red layers. At many localities the weathered surface is pale grayish red to pale yellowish brown because of contained silty material. The crystalline texture ranges from very fine to coarse, the latter having many crinoid columnals and fusulines.

The unit is present only on the eastern flank of the Diamond Mountains in the central portion of the quadrangle where it forms prominent cliffs. It is 800-850 feet thick in the east-central portion of the quadrangle but thins westward, where it is unconformably overlain by conglomerates in the higher portion of the range. It is absent on the western side of the range and in the southern portion of the quadrangle.

A fauna, abundant in some places, of Parafusulina sp. A. Knight P. aff P. apiculata, Schwagerina aff S. gumbeli, S. sp. indicates that the unit is of middle Leonardian Age. Megafossils include Fenestrellina sp., Rhabdomeson sp., Dictyoclostic sp., Derbya sp., and Omphalotrochus.

Unit D

Unit D crops out only in the east-central portion of the quadrangle and includes the rocks above the massive, dark-gray limestone of Unit C, and below an easily recognizable sequence of light-brown limestones and dusky-red siltstones and sandstones.

The lowest 10 feet of the unit consist of chert and quartz coarse arenite, and pebble conglomerate. Succeeding beds are dark-gray limestone with some layers of chert pebble conglomerate and quartz arenite, and several horizons of oolitic dark-gray limestone. The quartz arenite content of the unit increases upward so that the upper portion of the unit is a pale-orange-weathering, calcite-cemented, quartz medium arenite in some places, which grades laterally into gray quartz-arenaceous limestone within a few feet. The contact with the overlying unit is sharply gradational.

Unit D is 412 feet thick at Little Canyon but only 100 feet thick three-fourths of a mile to the west, and is absent in exposures on the western side of the range.

Fusulines found in the lower portion of the unit appear to belong to the genus Parafusulina. Bissell (1962, p. 1100) has misinterpreted the structure of the area but apparently refers to these beds and dates them as mid-Leonardian.

Unit E

Unit E is an easily seen sequence of red-weathering, light-brown and dusky-red calcareous quartz arenite and siltstone which grades upward into a medium- to dusky-red-weathering sequence of dusky-red quartz arenite, chert coarse arenite, and chert pebble conglomerate.

The unit is present only on the eastern edge of the Diamond Range between Spring Canyon and Big Canyon.

Unit E is 850 feet thick in an incomplete section at Little Canyon, 700 feet of which are the "red bed" portion. Further north near Horse Canyon, a more complete section is about 1,350 feet thick and the "red beds" about 300 feet. South of Big Canyon the unit is only about 150 feet thick and includes 100 feet of the lower unit.

As Unit E is traced northward from Little Canyon it is seen to have been bevelled by a surface of unconformity, so that only the lower portion of the sequence is present north of Horse Canyon. It, too, is obscured by the basal beds of Unit F, half a mile further north.

The gradational contact with Unit D suggests that it is of late Leonardian Age.

Unit F

Unit F is exposed only on the easternmost border of the Diamond Mountains between Big Canyon and Connors Canyon.

The major portion of the unit is composed of pebbles and small cobbles of medium-gray, weathering dark-gray, limestone and pebbles of light-gray chert, all in a calcite-cemented chert and quartz-arenite matrix. The chert clasts are subrounded to rounded, the limestone fragments are plate-like and suggest an intraformational conglomerate. Thin beds of medium-dark-gray and light-pinkish-gray limestone and fine quartz arenite occur in the unit.

The basal beds of Unit F are 10 to 40 feet of silica-cemented chert pebble conglomerate overlain by approximately 200 feet of laminated calcareous sandstone, and sandy, dark-gray limestone. The total thickness of F is not known but it is estimated to be more than 350 feet.

Unit F is unconformable on older units, but the basal conglomerate is subparallel to conglomerates of the upper portion of Unit E on the south side of Big Canyon, and lies on Unit D one mile north of Big Canyon.

Bissell (1962, p. 1101) reports Leonardian and lower Wordian fusulines in a limestone layer in the Newark Canyon Formation at Southgate, 32 miles to the south of Big Canyon, thus changing the age assignment of this formation from Cretaceous (Nolan and others, 1956, p. 69) to Permian. The Newark Canyon Formation at Southgate is chert and quartz pebble and cobble conglomerate below, and chert pebble-bearing limestone conglomerate above. The latter is limestone conglomerate lithologically like Unit F.

If Unit F is equivalent to the fusuline-bearing beds at Southgate, it is of upper Leonardian or lower Wordian Age.

Unit G

Unit G, the youngest of the Permian units, forms the prominent crest of the Diamond Mountains throughout most of the quadrangle. The lower beds of the unit are a reddish-brown to gray-weathering conglomerate of light-gray quartz and chert, with lesser gray quartzite and some green chert. Unit G lies unconformably on Units A through D, at places with marked angularity. The lower conglomerate is about 1,500 feet thick near VABM Birch but is only 200 feet in width one mile to the east and only 10 feet thick one mile east of that. The thickness of the conglomerate also varies along its strike, being 200 feet at Overland Pass but 1,000 feet thick in exposures to the north. It is completely absent near the northern edge of the quadrangle.

The upper beds of Unit G are yellowish-brown quartz arenites with lenses of conglomerate. Overlying these are dusky-red quartz arenites and mudstones with some chert pebble conglomerate. The higher portion of Unit G is more than 2,500 feet thick in its northern exposures.

Unit G is correlated with the third member of the Garden Valley Formation (Nolan and others, 1956, p. 67) because of lithic similarity and stratigraphic position.

Steele (1960, p. 112) dates the third member of the Garden Valley as upper Guadalupian because of regional stratigraphic relationships. This age designation is accepted for Unit G.

CENOZOIC DEPOSITS

Alluvial fans of probable Tertiary and Quaternary Age are seen at the base of the Diamond Mountains. The earlier fans have been notched by the shore lines of separate lakes which earlier lay in Diamond Valley and in Newark Valley to the east of this quadrangle. The central portion of the valley is covered by lake sediments, playa clays, and saline deposits.

Allochthonous and parautochthonous rocks

ORDOVICIAN

Western Assemblage Rocks

The presence of western assemblage rocks at Walters Canyon was first suggested by Roberts and others (1958, fig. 4, p. 2823).

Dark- and light-gray quartzites and argillites of the western assemblage are seen in klippen and fault slices at several places along the western base of the Diamond Mountains. These exotic rocks are tentatively assigned to the Ordovician because of their resemblance to certain beds within the Vinini Formation, and to exotic Ordovician? rocks seen on the western side of Diamond Valley.

1. In a small klippe at Thompson's Ranch the western facies rocks are lying on the Permian. The allochthonous rocks are dark calcareous orthoquartzite, with some dark-gray completely silicified rock having a breccia of platy (argillite?) fragments.

2. Light- and dark-gray quartzites and some dark limestones form the main portion of small klippen on the Sentinel Mountain Dolomite at the mouth of Walters Canyon. Lesser amounts of red-weathering, sheared phyllitic rock are under the ore bin at the mine and at a mined area half a mile to the south.

3. In a fault sliver extending from Walters Canyon to Sheep Canyon the western facies rocks lie between the Pilot Shale and the Devils Gate Limestone or Bay State Dolomite. The most westerly lowest? beds are fine-grained, reddish-weathering quartz arenite. Succeeding beds are reddish-weathering dolomite and light- to dark-gray quartzite of well-rounded grains. The youngest beds are badly sheared dark-gray quartzite.

4. In a chain of seven small klippen in the extreme south of the quadrangle, western facies rocks lie on the surface of the steeply westward-dipping Lone Mountain Dolomite from Water Canyon to a point half a mile north of Monroe Canyon.

PERMIAN

Leonardian Beds

Fusuline-bearing Leonardian rocks are in reverse fault contact with both the Diamond Peak Formation and the Chainman Shale on the western side of the Diamond Mountains in a belt extending from Maggini's Ranch to the northern boundary of the quadrangle. The section is believed to be inverted in these exposures because of relationships seen on the northern side of the mouth of Box Spring Canyon just beyond the limit of the map. Similar limestones and conglomerates, in fault contact with the Lone Mountain Dolomite at the southern edge of the quadrangle at Water Canyon, can be traced into the northern portion of the Eureka quadrangle.

The Leonardian beds are a heterogeneous assemblage, principally of dark-gray limestone with varying amounts of chert and quartz arenite as well as discontinuous beds of small chert pebbles. In places, as at Thompson's Ranch, small chert pebble conglomerate is an important part of the sequence. In other areas the unit contains thick sequences of medium chert pebble conglomerate with some flat siltstone or shale fragments.

Fusulines contained in the Permian rocks at Thompson's and at Box Spring Canyon have been identified as Parafusulina. The similarity of both faunas and the general lithology of the beds, favors correlation of these beds with the second unit of the Garden Valley Formation.

STRUCTURE

The Diamond Mountains are bordered on the east and the west by north-trending faults typical of the Basin and Range province. Evidence that Diamond Valley has dropped, relative to the range, is seen in the presence of thick accumulations of Cenozoic sediments in the valley.

The main portion of the range is a northward-trending asymmetric syncline, the western limb of which is vertical or slightly overturned. Smaller angular asymmetric anticlines and synclines are present on both flanks of the range (see sections).

Minor structural complications were introduced by disharmonic folding of the Diamond Peak Formation and Ely Limestone, principally on the western side of the range. Extreme disharmonic folding has affected the Ely Limestone on the south side of Judd Canyon. Beds which dip 45 degrees eastward can be followed continuously to points where they are overturned and dip 35 degrees or less to the west. No fault marks this transition. The disharmonic folding was mistaken for reverse faulting by Dott (1955, fig. 15) but no fault is present (see sec. A-A').

Southeast of Judd Canyon, at hill 9215, conglomerates of Unit G are almost vertical, but north and south of that point they dip 40°-50° to the east. This steepening is due to a reverse fault which forced an asymmetric anticline of the Ely Limestone and the Diamond Peak Formation against the Permian formations (see sec. A-A'), forcing Unit G upward and eastward.

The reverse fault and the oblique fault which cut the crest of the range north of Judd Canyon, outline a trap door fault block, the absolute movement of which was upward (Larson, 1959), and which was rotated around a northeast-trending horizontal axis slightly east of the present range crest. Movement of the reverse fault block and the trap door block were synchronous.

A large reverse fault which can be traced almost continuously for 25 miles along the western base of the range, places the Leonardian beds against older rocks. Leonardian rocks are in contact with either the Diamond Peak Formation or the Chainman Shale in the northern part of the quadrangle, and are in contact with the Lone Mountain Dolomite at Water Canyon. Extreme elongation of contained fusulines and chert pebbles indicates the compressive nature of the fault. As stated, the Permian beds are the overturned limb of a fold.

Klippen of western facies rocks seen both at Thompson's Ranch and Walters Canyon, are remnants of a former thrust sheet. Small klippen of the same thrust sheet are present south of Monroe Canyon, and similar rocks are present in a fault-bounded sliver between Walters and Sheep Canyons.

The sliver is a segment of a thrust sheet of western facies rocks which has been cut off by a rotational reverse fault present between Walters and Monroe Canyons. The latter fault eliminates the Devils Gate Limestone and brings the Bay State Dolomite Member against the overthrust western facies rocks (see sec. F-F'), which had already been in contact with the Pilot Shale.

The progressive elimination of Devonian units northward from Monroe to Walters Canyon, and the abrupt structural differences on opposite sides of that canyon, are related phenomena. The Devonian units were eliminated by a rotational reverse fault (mentioned above), the displacement on which increased northward. The axis of rotation was evidently in the vicinity of Monroe Canyon. At Walters Canyon, movement took place on several intersecting planes, resulting in an imbricate structure.

The structural differences seen on the opposite sides of Walters Canyon are interpreted as the result of rotational upward movement on a vertical fault. This fracture allowed an anticline to form north of the canyon while beds to the south were being folded as a part of the general syncline of the Diamond Mountains.

The Permian formations, the Ely Limestone, and the Diamond Peak formations are cut by an easterly directed vertical fault at the head of Threemile Canyon. Detailed study shows that this fault movement has been oblique, the northern block having moved eastward approximately 700 feet and upward approximately 3,500 feet. The fault displaces neither the lower portion of the Diamond Peak Formation on the western side of the range nor the older Permian beds on the eastern base.

The faulting was confined principally to the more brittle Permian conglomerate in the core of the syncline at the present range crest and in the asymmetric anticline to the west. Similar east-trending faults have displaced the rocks of the upper portion of the range both north and south of Threemile Canyon.

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