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GEOLOGY OF THE NORTHERN NEEDLE RANGE MILLARD COUNTY, UTAH

by
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GEOLOGY OF THE NORTHERN NEEDLE RANGE
MILLARD COUNTY, UTAH

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the Faculty of the Department of Geology

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Master of Science

Submitted by

Wilburn James Gould

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ABSTRACT

The Needle Range lies in the extreme southwestern part of Millard County, Utah, approximately 25 miles south of Garrison, Utah. State Highway 21 bounds the area on the north, Antelope Valley on the east, the Millard-Beaver County line on the south, and the Utah-Nevada state line on the west.

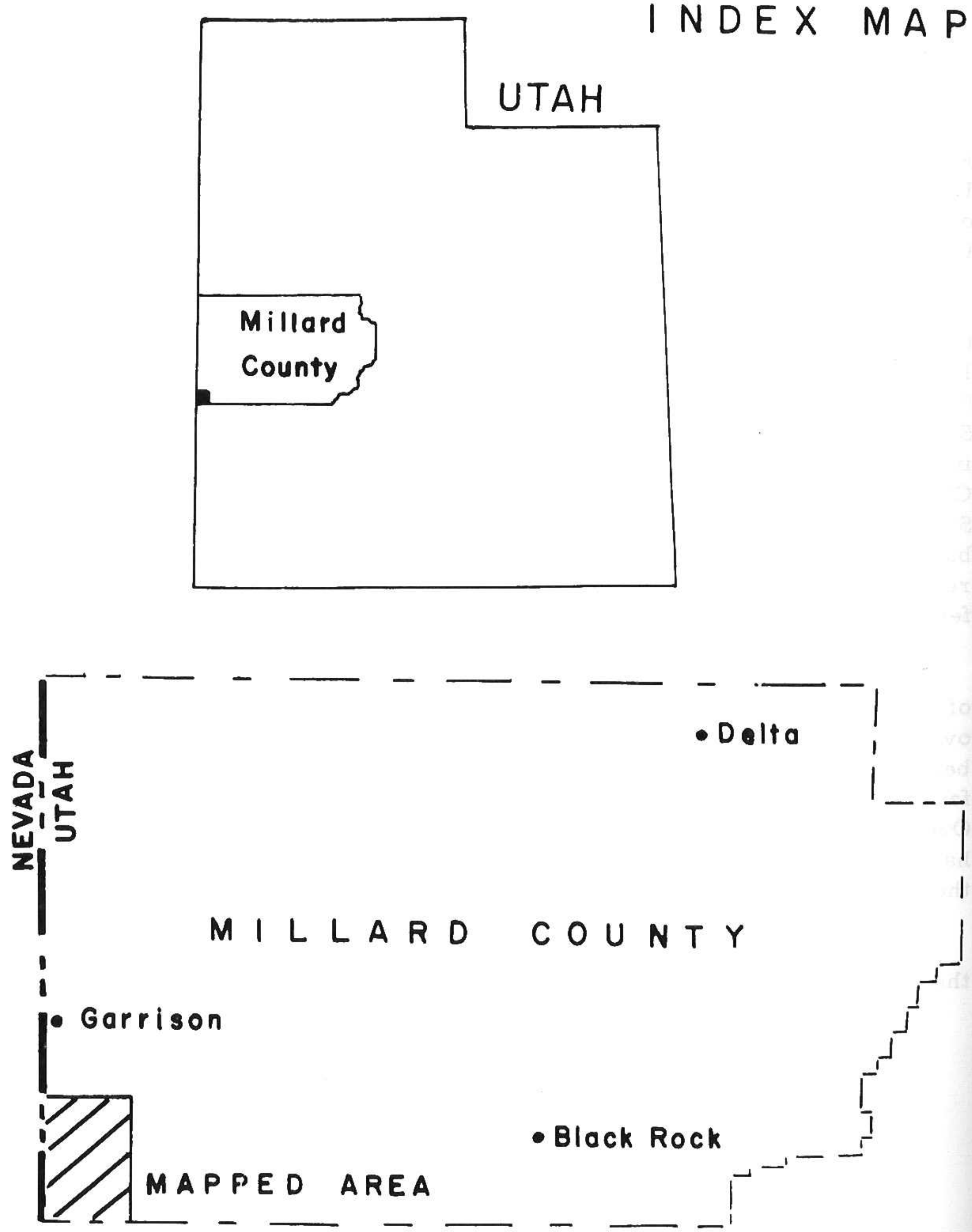
The exposed stratigraphic section, aggregating slightly more than 8,000 feet, includes rocks from Middle Devonian to Lower Permian age. The upper part of the Guilmette Limestone and Pilot Shale, a combined thickness of 1,800 feet, represents the Devonian System. Mississippian strata aggregate more than 3,000 feet, and include the upper part of the Pilot Shale, Joana Limestone, Chainman Shale, and the Illipah Formation. The Pennsylvanian System includes the lower 2,000 feet of Ely Limestone. Only the basal Wolfcampian part of the Permian System is present, represented by 690 feet of the upper Ely Limestone and 1,000 feet of the Arcturus Limestone.

An asymmetrical syncline forms the major structural feature of the range. Thrust plates moving in a northeast direction have over-ridden the west limb. The northwestern part of the range has been involved in a major fan fold. The folds and accompanying thrust faults probably formed during the various phases of the Laramide Orogeny. Numerous normal faults occur throughout the range, but have only minor displacement. Flow rock in the southeast part of the range indicates a slight eastward tilting of the region.

Structural complexities that exist in the range possibly make the immediate area unfavorable for accumulation of gas and oil.

PLATE 2

INDEX MAPS



INTRODUCTION

Previous Work

Much of the Great Basin is little known geologically, except in general reconnaissance. This is particularly true of western Utah where most of the published information is based either on detailed studies of small areas or on reconnaissance of extensive areas. To the writer's knowledge the only information which specifically concerns the Needle Range is a generalized map published by the Intermountain Association of Petroleum Geologists, 1951.

Early workers in near-by areas were G. K. Gilbert (1890), who reported on geographical and geological explorations and surveys west of the 100th Meridian, and B. S. Butler (1913), who studied ore deposits of the San Francisco and adjacent areas. Later C. S. Bacon (1948) and N. D. Newell (1948) published the stratigraphic succession of the Confusion Range. R. W. Rush (1951) concerned with the petroleum possibilities of the Great Basin, published a stratigraphic section of the Burbank Hills. Harald Drewes (1958) studied the geology of part of the Southern Snake Range, Nevada.

Although more extensive work has been accomplished by petroleum geologists working within this part of the Great Basin, this information has not been published.

Purpose and Scope of Investigation

Structural and stratigraphic complexities, accompanied by the economic aspect of petroleum and gas possibilities, involve the Needle Range as an area of considerable geologic interest.

Because only a generalized geologic map of the Needle Range has been published, it is the main objective of this thesis to provide detailed geologic information concerning structural and stratigraphic relationships accompanied by a detailed geologic map of the northern part of the Needle Range.

The writer hopes that this study will not only contribute to the increasing knowledge of Great Basin geology, but also increases further interest for more extensive work by economic and petroleum geologists exploring its oil and gas possibilities.

Location and Accessibility

The Needle Range, located in the extreme southwestern part of Millard County, Utah, lies approximately 25 miles south of Garrison, Utah. The thesis area is bounded on the north by State Highway 21, on the east by Antelope Valley, on the south by the Millard-Beaver County line, and on the west by the Utah-Nevada State line.

The area encompasses approximately 100 square miles and includes all or parts of Townships 24, 25, and 26 South, Ranges 18, 19, and 20 West. Parallels 38°35' and 38°43' and Meridians 113°52' and 114°05' enclose the area.

The range is accessible by means of State Highway 21, from which unimproved dirt roads and trails extend westward into nearly every valley of the range.

Physical Features

In a fashion typical of Basin and Range structure, the Needle Range comprises an east-tilted fault-block with a regional north-south trend. The terrain of the area is abruptly mountainous with little transition between the range and valley floors. The maximum altitude in the northern part of the range is 8,850 feet above mean sea level, giving a relief of 2,250 feet above the valley floor.

The range consists of near-parallel north-south trending ridges separated by erosional strike-valleys. Though the morphology of the range is youthful, the eastern slopes exhibit less sharp and angular features than does the erosional, deeply dissected backslope of the western side of the range.

Although the area has no perennial streams, springs occur in the southeastern and northwestern parts of the range. The climate is semi-arid, with annual rainfall less than 9 inches. None of the snow is retained in the mountains, and much of that which falls disappears in the early spring by direct evaporation and seepage rather than by run-off.

Characteristic of semi-arid climate, the vegetation includes pines, cedars, and junipers in the higher elevations, while sage brush and rabbit brush characterize the lower slopes and valley floors.

Present Study

The thesis area was pointed out by Dr. Lehi F. Hintze in October, 1958. The field work for the problem began in the spring of 1959, and the bulk of the field work was completed during the summer of 1959.

Aerial photographs, scale 1:20,000, were used for the geologic mapping. Stratigraphic sections were measured by the use of Brunton compass, Abney hand level, and steel tape.

Laboratory work consisted of preparation of thin sections, acetate peels, insoluble residues, and grain size analysis. Fossil specimens were collected, studied and classified. Some of the more typical and characteristic fossils are illustrated.

SEDIMENTARY ROCKS

General Section

This part of the Great Basin was an area of sedimentation during most of the Paleozoic. Continued deposition resulted in the accumulation of a great sequence of sedimentary rocks. The bulk of the sediments of the Needle Range consist of limestone, shale, and sandstone.

Sedimentary formations, seven in number, range in age from Middle Devonian to Lower Permian, and have an aggregate thickness slightly greater than 8,000 feet. At the bottom of the exposed section is the Devonian Guilmette Limestone, the base of which is buried by the alluvium of Antelope Valley. The Pilot Shale, which is Upper Devonian and in part Lower Mississippian, overlies the Guilmette Limestone. Three formations of Mississippian age succeed the Pilot Shale, the Joana Limestone, Chainman Shale, and Illipah Formation. The Illipah Formation is overlain by the Pennsylvanian Ely Limestone, the upper part of which is considered to be Lower Permian (Hose, personal communication to Dr. L. F. Hintze). Only the basal Wolfcampian part of the Permian System is present, represented by the upper part of the Ely Limestone (Hose, personal communication to Dr. L. F. Hintze) and Arcturus Limestone (see Plate 3).

The entire stratigraphic section is exposed on the eastern slopes of the range. The formations trend in a general north-south direction with westward dips not in excess of 30° (see Plate 1).

Formational contacts are based primarily on lithologic changes.

Devonian System

Guilmette Limestone

Nolan (1930) applied the name Guilmette to limestone exposures in Guilmette Gulch, located near the Gold Hill District of western Utah. At Gold Hill the thickness ranges from 900 to 1,200 feet.

The oldest exposed formation in the Needle Range is the Guilmette Limestone. It crops out on the eastern side of the range, where slightly more than 1,300 feet is exposed forming low rounded foothills which grade into the alluvium of Antelope Valley.

The lower units of the formation consist of thin to medium bedded, dark grey limestone, with minor beds of dolomite and brown weathering sandstones. Grading upward in the section, the limestones become thick to massive bedded, these grade into sandy limes and finally into prominent sandstone and quartzite units. The sandstones are highly calcareous, with sub-rounded to rounded, frosted, coarse to medium grained quartz grains. These units are light tan to pinkish-white and weather dark brown. Some weather with a black iron oxide stained surface. The sands and quartzites constitute up to 10 per cent of the upper Guilmette Formation. They are not found in such abundance elsewhere within the Confusion Basin. The source of these sands is not known.

The contact with the overlying Pilot Shale is gradational and is arbitrarily placed at the beginning of thin bedded limestone step-ledges and argillaceous, shaly limestone slopes.

Abundant *Amphipora*, "spaghetti beds," and other varieties of stromatoporida characterize the lower two-thirds of the exposed formation. Gastropod and brachiopod beds, unidentifiable, accompany the stromatoporida. The fossil assemblage indicates Upper and Middle Devonian.

Pilot Shale

Spencer (1917) named the Pilot Shale for exposures at Pilot Knob, located in the western part of the Ely Quadrangle where it ranges from 100 to 400 feet in thickness.

In the Needle Range the Pilot Shale forms either a prominent strike-valley or a talus slope between two more resistant limestone formations. Where it crops out along the eastern slopes of the range, it aggregates 470 feet in thickness.

The contact with the underlying Devonian Guilmette Limestone is conformable and has been placed at the beginning of the first limestone step ledges and slopes. The contact with the overlying Mississippian Joana Limestone has been placed at the base of a two foot bed of pink weathering quartzite. Whenever the quartzite is not exposed, the contact is placed at the base of the first prominent massive limestone cliff of the Joana Limestone.

The Pilot Shale has been divided into two units. The lower unit consists of argillaceous, mottled, dark grey to drab-brown weathering limestones which form step ledges and shaly slopes. The upper unit forms a prominent talus slope with poor exposures. Where exposed, the unit consists of thin bedded, dark grey siltstones and papery olive green shales. When observed from a distance, this formation has a characteristic pinkish color which helps distinguish it from other shaly formations in the area.

The Mississippian-Devonian boundary lies within the upper unit of this formation. Because of insufficient fossils, the exact location was not accurately established in the mapped area. Elsewhere within the Confusion Basin, Upper Devonian fossils have been reported within 100 feet of the lower unit of the Joana Limestone. Based primarily on microfossils, the Pilot Shale has been assigned to the Upper Devonian and Lower Mississippian (J. H. Becker, Personal communication to L. F. Hintze, 1959).

Mississippian System

Joana Limestone

The Joana Limestone was named by Spencer (1917) from exposures at the Joana mine, on the south side of Robinson Canyon, two miles west of Ely, Nevada. Spencer considered its thickness to range from 250 to 400 feet.

Exposed on the eastern side of the Needle Range as a cuesta between two non-resistant shale formations, the Joana Limestone forms an easily mappable formation. It aggregates 375 feet.

The formation consists of thin to massive bedded, dark to medium grey, clastic to crystalline limestone. In the upper unit, black and brown weathering chert occurs in thin bands and irregular nodules. The chert constitutes up to 10 per cent of the total unit. Weathered surfaces of the limestone are light to medium grey, and have raspy, meringue texture. Upon fracture, the encrinites emit a fetid odor, while some of the darker, crystalline limestones emit a moderate to slight hydrocarbon odor.

The contact with the underlying Pilot Shale has been placed at the base of a two foot bed of pink weathering quartzite or at the base of the first prominent limestone cliff. The contact with the overlying Chainman Shale has been placed at the top of the upper chert-bearing unit of the Joana Limestone.

Based on fossil content, the Joana Limestone is of Kinderhookian and Lower Osagean age, and considered to be in part equivalent to the Madison Limestone of the Rocky Mountain region.

Fossils collected by the writer along the line of traverse through section 24, T. 25 S., R. 19 W., include the following:

Spirifer cameratus Morton
Spirifer centronatus Winchell
Triplophyllites subcrassus Easton and Gutschids
Triplophyllites paucicinctus
Caninaphyllum incrussatum
Amplexocarina sp.
Caninia sp.
Camarotoechia sp.
Composita sp.
Rhynchopora sp.
Marginifera wabashensis (Norwood and Pratten)
Lithostrotion whitneyi Meek
Syringopora surcularia Girty
Euomphalus sp.
Loxonema sp.
Schuchertella lens (White)
Syringothyris textus (Hall)
Eumetria costata Weller
Dielasma formosum (Hall)
Leptanena sp.
Juresania nebraskensis (Owen)
Leiorhynchus sp.

Chainman Shale

Spencer (1917) named the Chainman Shale from exposures near the Chainman mine located in the eastern part of the Ely Quadrangle, near Lane, Nevada. There it ranges in thickness from 250 to 200 feet.

Exposures of the Chainman Shale which crop out on the eastern side of the Needle Range aggregate slightly more than 2,000 feet in thickness. Because of the presence of incompetent shales and limestone, this formation forms a well defined strike-valley. The upper chert-bearing unit of the Joana Limestone forms the lower contact. For field mapping purposes, the intention has been to draw the upper boundary just above the uppermost shale units, at the base of red weathering sandy limestones of the Illipah Formation.

The Chainman Shale is composed of soft, fissile, carbonaceous black shales, interbedded with thin to medium bedded, dark grey to black limestones. Upon fracture, the limestones emit a slight to moderate hydrocarbon odor. Frequently liquid and solid hydrocarbons are found in fossils and in the nuclei of concretions. In the lower part of the formation two sandstone units contain "dead" oil which can be observed with the aid of a hand lens. Minor amounts of black and brown chert occur in the upper units.

Fossils occur as poorly preserved hash and encrinite beds in the lower part of the formation. The upper units contain a few, well preserved fossils which indicate Chesterian age.

Fossils collected by the writer along the line of traverse through section 26, T. 25 S., R. 19 W., include the following:

Dictyoclostus inflatus (McChesney)
Dictyoclostus burlingtonensis (Hall)
Dictyoclostus americanus Dunbar and Condra
Dictyoclostus portlockianus (Norwood and Pratten)
Linoproductus ovatus (Hall)
Naticopis altonensis?
Cravenoceras sp.
Derbyia sp.
Bellerophon sp.
Fenestella sp.
Rhombopora sp.
Chonetes granulifer (Hall)
Phillipsia sp.

Illipah Formation

Reference to the Illipah Formation in geologic literature is limited. Christiansen (1951), in a cursory manner, refers to the Illipah as a tongue of sandstone and conglomerate that grade eastward into Upper Mississippian shales. This brief description of the formation has been recognized by the U. S. Geological Survey for it is tabulated in the list of "Geologic names of North America introduced in 1935-1955" by Wilson et al. (1957, p. 176). Christiansen's usage apparently stemed from the fact that the name has been used informally for the past decade by petroleum geologists and other field parties working in this part of the Great Basin.

Recently, Humphrey (1956) in an unpublished thesis, used the name Illipah to refer to Eocene sediments in the White Pine District of Nevada. Inasmuch as the name is preoccupied by Christiansen's usage, it is unlikely that Humphrey will publish the name for an Eocene unit. Accordingly the present paper follows Christiansen in using the term Illipah for Upper Mississippian strata.

H. J. Bissell (personal communication, 1959) has measured sections of the Illipah Formation in the White Pine Range, North Spring Mountains, Egan Range, and other areas of eastern Nevada. Bissell considers the formation to range in thickness from 120 to 270 feet, and to possibly contain the Mississippian-Pennsylvanian boundary.

In the Needle Range, the Illipah Formation aggregates 660 feet. Although the measurement may include part of the Upper Chainman Shale, the writer feels what he is calling Illipah represents a distinct, mappable formation throughout the range.

The writer has divided the formation into three units. The lower unit consists of thin bedded, black, sandy limestones. The most outstanding feature of this formation, especially the lower unit, is the brick red and yellow ocher colors of the weathered limestones. Upward in the section, the limestones become medium bedded, form step ledges and slopes, and weather medium grey. The upper most unit consists of medium bedded crinoidal limestones which weather yellow-brown to brown. Throughout the upper unit partially silicified fossils are abundant and tend to weather free. Red and maroon sandstones and quartzites are commonly exposed above the crinoidal limestones. The sands consist of quartz grains, sub-rounded to rounded, medium to coarse in size.

The contact with the underlying Chainman Shale is placed at the base of the red weathering limestones. The top of the brown crinoidal limestones, or whenever exposed, the top of the red-maroon sandstones form the contact with the overlying Pennsylvanian Ely Limestone.

Because the fossil assemblage in the upper unit of this formation indicates either a high Chesterian or low Springeran age, Bissell considers the formation to possibly contain the Mississippian-Pennsylvanian boundary. The writer was unable to determine the transgression of the time line, and has shown the Illipah Formation as Mississippian on the geologic map (Plate 1).

Fossils collected by the writer along the line of traverse through section 23, T. 25 S., R. 19 W., include the following:

Spirifer rockymountanus (Marcou)
Spirifer occidentalis (Swallow)
Spirifer leidyi Norwood and Pratten
Punctospirifer kentuckyensis (Shumard)
Neospirifer triplicatus (Hall)
Dictyoclostus inflatus (McChesney)
Dictyoclostus burlingtonensis (Hall)
Dictyoclostus americanus (Dunbar and Condra)
Dictyoclostus portlockianus (Dunbar and Condra)
Dictyoclostus portlockianus n. var. crassicostatus Dunbar and Condra
Linoproductus ovatus (Hall)
Diaphragmus elegans (Norwood and Pratten)
Cliothyridina orbicularis (McChesney)
Pugnoides sp.
Wellerella cf. W. osagensis (Swallow)
Archimedes sp.
Ambocoelia sp.
Allorisma sp.
Eumetria acuticosta Weller

Composita subtilita (Hall)
Composita ovata Mather
Composita trilobata
Derbyia sp.
Juresania nebraskensis (Owen)
Chonetes granulifer (Owen)
Marginifera sp.
Orbiculoidea capuliformis (McChesney)
Orbiculoidea missouriensis Shumard
Rhipidomella sp.
Schizophoria sp.
Phillipsia sp.
Rhombopora sp.
Paleococrinus

Pennsylvanian System

Ely Limestone

Lawson (1906) named the Ely Limestone for the lowest formation of Pennsylvanian age in the Ely District of Nevada. In 1917, Spencer considered the formation to range in thickness from 2, 000 to 2, 500 feet. Newell (1948) correlated the Ely Limestone with the Bird Springs Formation of southern Nevada.

In the Needle Range, the Ely Limestone forms a prominent structure with massive limestone summits and slopes that are marked by cliffs and terraces. It attains an aggregate thickness slightly greater than 2, 600 feet.

The writer is aware of the problem that exists concerning the contact of the Upper Ely Limestone with the overlying Permian Arcturus Formation. Hose (personal communication to Dr. L. F. Hintze) working in the Confusion Range, places the contact at the first appearance of the sandstone units of the Arcturus Formation. Hose considers the Ely Limestone to be in part Lower Permian. Easton (personal communication to Dr. H. J. Bissell), mapping in the Illipah and contiguous quadrangles, and doing stratigraphic and paleontologic research in the Ely District of Nevada, places the Ely Limestone within Lower and Middle Pennsylvanian only. The contact with overlying Lower Permian strata is marked by a definitive lithic change and appearance of guide Wolfcampian fusulinids and corals. Tentatively, there, Wolfcampian rocks are referred to a new formation named only in manuscript (Ehring, 1957) and in part, the Arcturus Limestone.

Two alternatives seem to be present. The contact can be placed either on one lithologic break, making the upper part of the Ely Limestone Permian; or based upon an equally good lithologic break with diagnostic Wolfcampian fossils above, thus placing the Ely Limestone in the Pennsylvanian.

The writer has placed the lower contact at the top of a brown crinoidal limestone unit of the Illipah Formation. The contact with the overlying Permian Arcturus Formation appears gradational in localities. The massive Ely limestones grade into thin bedded, shaly limestones which contain species of Schwagerina and Pseudoschwagerina, lower Wolfcampian fusulinids. The upper contact is placed approximately 600 feet above the first appearance of Wolfcampian fusulinids, at the beginning of the first sandstone units of the Arcturus Formation.

The units of the Ely Limestone represent cyclic deposition. They consist of massive bedded, encrinitic limestones which alternate with thin to medium bedded, oolitic, sandy limestones. Large amounts of black and brown weathering chert, in irregular nodules and ribbon beds, occur in a cyclic pattern. The abundance of chert increases upward in the section, with nodules up to 4 feet in diameter, comprising up to 50 per cent of the total rock. Upon fracture the encrinites emit a fetid odor while the crystalline limestones emit a slight to moderate hydrocarbon odor.

Only Lower and Middle Pennsylvanian rocks from Springeran to Desmoinesian are present (Bissell, personal communication, 1959). The Lower Wolfcampian rocks overlie the Pennsylvanian in a blended disconformity.

Fossils occurring in the lower units are partially silicified forms which weather free. In the middle units, fossils occur mainly as encrinites and poorly preserved hash. The fusulinids of the upper units are excellent correlation markers, occurring only in specific beds throughout the formation.

Fossils collected by the writer along the line of traverse through section 34, T. 25 S., and section35, T. 24 S., R. 19 W., include the following:

Orbiculoidea capuliformis (McChesney)
Orbiculoidea missouriensis (Shumard)
Derbyia sp.
Caninia sp.
Dictyoclostus americanus (Dunbar and Condra)
Linoproductus ovatus (Hall)
Marginifera muricata (Norwood and Pratten)
Juresania nebraskensis (Owen)
Fenestella sp.
Spirifer cameratus (Morton)
Spirifer occidentalis (Girty)
Neospirifer triplicatus (Hall)
Chaetetes milleporaceous
Composita subtilita (Hall)
Paleococrinus
Fusulinella sp.

Fossils collected from the upper 600 feet include Schwagerina sp., and Pseudoschwagerina sp.

Explanation of Plate 4

(All figures X 1)

Fig. 1 *Cliothyridina sublamellosa* (Hall)
1a, Brachial view
1b, Pedicle view

Fig. 2 *Chonetes granulifer* (Owen)
Pedicle view

Fig. 3 *Composita trilobata* Dunbar and Condra, n. sp.
Pedicle view

Fig. 4 *Juresania nebraskensis* (Owen)
Pedicle view

Fig. 5 *Dictyoclostus burlingtonensis* (Hall)
5a, Pedicle view
5b, Lateral view

Fig. 6 *Derbya* sp.
Pedicle view

Fig. 7 *Diaphragmus elgans* (Norwood and Pratten)
7a, Pedicle view
7b, Lateral view

Fig. 8 *Dictyoclostus portlockianus var. crassicostatus* Dunbar and Condra, n. var.
8a, Pedicle view
8b, Brachial view

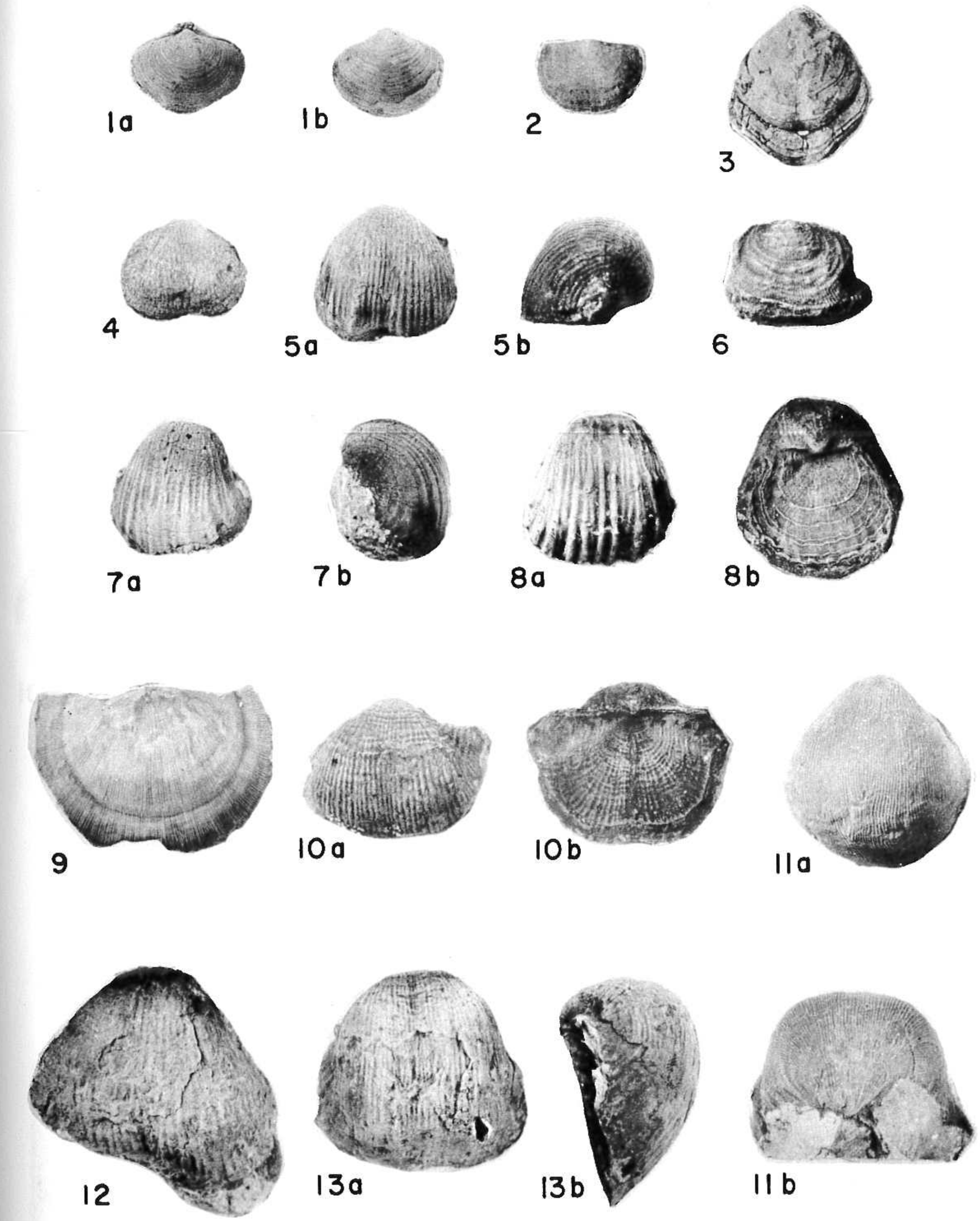
Fig. 9 *Schuchertella lens* (White)
Pedicle view

Fig. 10 *Dictyoclostus inflatus* (McChesney)
10a, Pedicle view
10b, Brachial view

Fig. 11 *Linoproductus ovatus* (Hall)
11a, Pedicle view
11b, Posterior view

Fig. 12 *Dictyoclostus americanus* (Dunbar and Condra)
Pedicle view

Fig. 13 *Dictyoclostus portlockianus* Dunbar and Condra
13a, Pedicle view
13b, Lateral view



Explanation of Plate 5

(All figures X 1)

Fig. 1 Spirifer occidentalis (Swallow)
1a, Brachial view
1b, Pedicle view

Fig. 2 Spirifer cameratus Morton
Pedicle view

Fig. 3 Punctospirifer kentuckyensis (Shumard)
Pedicle view

Fig. 4 Spirifer rockymountanus (Marcou)
Pedicle view

Fig. 5 Orbiculoidea missouriensis (Shumard)
Pedicle view

Fig. 6 Naticopis altonensis

Fig. 7 Eumetria costata (Hall)
Brachial view

Fig. 8 Dielasma formosum (Hall)
Pedicle view

Fig. 9 Orbiculoidea capuliformis (McChesney)
9a, Pedicle view
9b, Brachial view
9c, Lateral view
9d, Brachial view

Fig. 10 Allorisma sp.
Left valve

Fig. 11 Syringopora surcularia Girty
Cross section view

Fig. 12 Septimiolena sp.
Right valve

Fig. 13 Euomphalus sp.

Fig. 14 Loxonema sp.
Apical view, weathered surface

Fig. 15 Bellerophon sp.

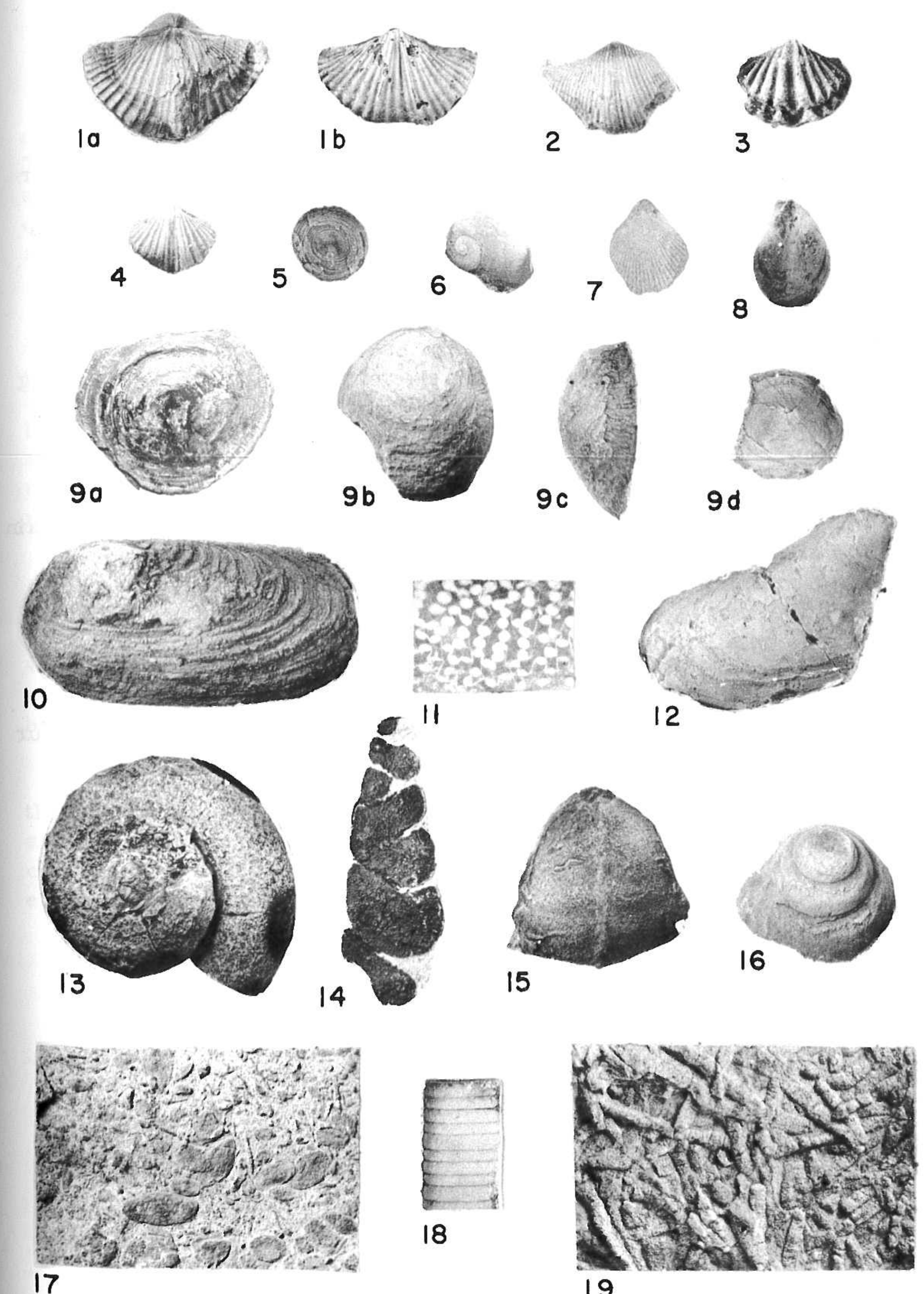
Fig. 16 Upper Devonian gastropod

Fig. 17 Pseudoschwagerina sp.
Weathered surface

Fig. 18 Paleococrinus sp.

Fig. 19 Amphipora sp. "spagetti beds"
Weathered surface

PLATE 5



Permian System

Arcturus Limestone

Spencer (1917) named the Arcturus Limestone for exposures near the Arcturus mining claim, located in the southwestern part of the Ely Quadrangle. Spencer considered its thickness to be approximately 400 feet.

The Arcturus Limestone is the youngest exposed sedimentary formation in the Needle Range. Only the basal Wolfcampian part is present, cropping out in the northern parts of the range and aggregating slightly more than 1,000 feet. Although slightly more of the formation may be exposed, structural complexities limit its measurement.

The formation consists primarily of thin to medium bedded sandstones and limestones. The sands are highly calcareous and contain up to 60 per cent lime. They consist of quartz grains that are sub-rounded to rounded, frosted, and fine to medium in size. Although these sand units have an array of colors, the color when observed from a distance is pale yellow.

Except for the Wolfcampian fusulinids, Schwagerina sp. and Pseudoschwagerina sp. in the lower part of the formation, fossils occur as poorly preserved hash beds. Based on fusulinids, the Arcturus Limestone is Lower Wolfcampian in age, and considered to be in part equivalent to the Supai Formation of northern Arizona.

IGNEOUS ROCKS

Porphyritic andesites and vitrophyres crop out in the northwestern and southeastern part of the mapped area (see Plate 1). The northern exposure is an isolated flow which has extruded along a belt of strong deformation. The outcrops in the southeastern part of the area are only a part of a series of flows which extend southward into Beaver County.

Most abundant of the flows are the red colored, porphyritic andesites. The primary minerals consist of approximately 30 per cent plagioclase, 50 per cent glass groundmass, 5 per cent quartz, and minor amounts of orthoclase. Accessory minerals consist of biotite, magnetite, and minor amounts of zircon. The groundmass appears to be a partially devitrified glass, showing a structure resembling glass shards. The flows contain fragments of foreign rocks, suggesting a field classification of ignimbrite.

The black colored vitrophyres contain as primary minerals, approximately 63 per cent glass, 20 per cent plagioclase and 2 per cent quartz. Accessory minerals consist of 10 per cent hornblende, 4 per cent biotite, 1 per cent magnetite, and minor amounts of augite, apatite, and zircon. Secondary process includes augite altering to hornblende.

The flows found in the southeastern part of the area, and those exposed in Beaver County, have an eastward dip, suggesting a slight east tilt of the area after their occurrence. Nolan (1943) considers the flows to be of Tertiary age, accompanying the faulting epochs of Basin and Range structure.

STRUCTURAL GEOLOGY

General

The larger topographic features of the Needle Range are, to a marked degree, expressive of the type of structure which is commonly designated "Basin and Range Structure." The north-south trending range is limited on both sides by great fault breaks. The faults are concealed and the valleys filled with debris from the adjacent upthrown blocks. Because the major faults are inferred to occur outside the mapped area, they are not shown on the geologic map (Plate 1).

Structurally, the range is an asymmetrical syncline and anticline plunging to the north. The eastern limb of the syncline is unbroken and has gentle and constant westward dips. The western limb, however, has been folded and overthrusted, causing stratigraphic discontinuities and structural complexities.

Two systems of structural events are present. The Laramide System which includes the folding, thrusting, and some normal faulting, and the Basin and Range System which involves the block faulting.

Faulting

Thrust Faults

Overthrusting occurs along the western side of the Needle Range. The thrust plates extend from section 4, T. 25 S., R. 19 W., along the entire length of the range, beyond the mapped area and into the northern part of Beaver County. After completely tracing out the thrust plates, both in the northern and southern parts of the range, it becomes evident that the thrusting is of a local nature. It is also evident that the thrust plates moved in an east-northeast direction.

When the thrust plates were traced into Beaver County, the writer observed that the thrusts began first as bedding plane movements along the western limb of the anticline. Gradually the thrusts began

to break through the anticlinal structure and overturn the west limb of the syncline. As the thrust plates are traced north into the mapped area they become more pronounced, completely overturning and overriding the west limb of the syncline as they move eastward.

When the Laramide System of folding began within this part of the Great Basin, the area was formed into a syncline and anticline. When the intense compressional phase of the System developed, the anticlinal structure became so compressed that it could yield no more. As pressure increased a steep angle thrust fault formed. The thrust plates rose to the surface, breaking through the more incompetent beds, and overriding the syncline toward the east.

Two major thrust plates and one minor imbricate thrust occur and are characterized by slickensides, gouge, breccia, mylonite, and angular unconformable contacts. (see Plates 6, and 7).

The lowest major thrust is the Mountain Home Thrust. The thrust plate includes the Devonian Pilot Shale and Mississippian Joana Limestone. It crops out in the southwestern part of Townships 26 and 26 South, Range 19 West, and extends into Beaver County. The incompetent Pilot Shale acted as a lubricant over which the thrust plate moved. The shale pinches out along the front of the thrust plate, and the Joana Limestone rests with angular unconformity upon the Mississippian Chainman Shale (see Plate 1, cross section C' - C).

The Needle Thrust is the second major thrust to occur. This is the most extensively exposed thrust present, cropping out along the western side of the range, extending through the western part of Townships 25 and 26 South, Range 19 West, and into Beaver County. The thrust plate includes the Devonian Guilmette Limestone, Devonian Pilot Shale, and Mississippian Joana Limestone. In section 9 the Guilmette Limestone, the sole of the thrust plate, rests unconformably upon the Pennsylvanian Ely Limestone, and in section 32, upon the upper plate of the Mountain Home Thrust, the Joana Limestone (see cross-section B - B').

The third thrust involves only the Guilmette Limestone as a small imbricate thrust which overrides the upper part of the formation. It crops out in section 5 of Township 26 South, Range 19 West, and continues into Beaver County.

The age of thrusting can be dated from the mapped area only, as post-Permian and pre-Basin and Range faulting; it may be fitted into the regional picture as part of the diastrophic events of the Cretaceous Laramide Orogeny.

Normal Faults

Two systems of normal faults are present in the Needle Range. In the northwestern part of the mapped area, section 3, Township 25 South, Range 19 West, normal faults pre-date the flow rock. This would infer that the normal faults of the northwestern part of the range are part of the Laramide System. These faults can be dated as post-folding and thrusting and pre-Basin and Range.

Normal block faults are commonly associated with the borders of the ranges within the Great Basin. It is inferred that major block faults occur along both flanks of the Needle Range, just outside the mapped area. The principal normal fault is probably on the west for extrusives in the mapped area have been tilted eastward. The magnitude of displacement of this fault is probably many thousands of feet. The movement involved a fault or series of faults which are now completely buried and obscured by debris from the flanking mountains. The flow rocks which crop out in the southeastern part of the mapped area and extend into Beaver County obscure the major block fault and are cut by later normal faults. These normal faults of the Basin and Range System may be fitted into the regional picture and tentively dated as Middle and Late Tertiary and Quaternary (Nolan, 1943).

In general, the exposed normal faults within the range are not of great magnitude, and have only minor displacements. They follow the general north-south trend of the range and have little modifying effect on the overall structure.

Folding

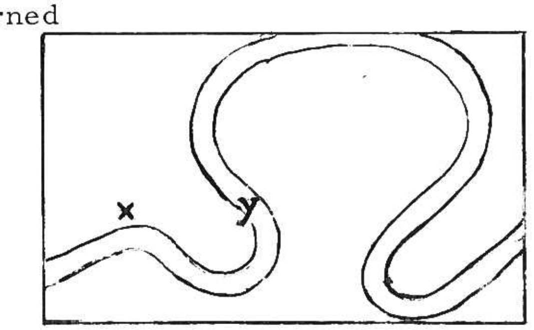
Needle Anticline

The Needle Anticline occurs in the northern and western parts of the range. The structure extends throughout most of Township 24 South and into the northern part of Township 25 South, Ranges 19 and 20 West (see Plate 1, cross section A - A'), and is interpreted as an asymmetrical fan fold. This fold is similar to many of those which have been described in the Jura Mountains of Europe.

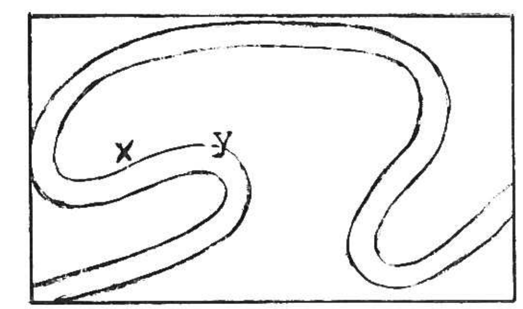
The eastern limb of the structure is well exposed and the inclined isoclinal fold is evident. In the northern part of the east limb the Pennsylvanian Ely Limestone is dipping east into the major syncline.

As the beds are traced south, they become vertical and finally overturned dipping west. The complete interpretation of the western limb, however, depends on the attitude of the extreme western exposures of the Permian Arcturus Limestone. It is evident the major part of the west limb is overturned with the Ely Limestone overlying the Arcturus Limestone, but the writer could find no conclusive evidence to substantiate overturning the extreme western exposures. They are inferred to be right side up at point x (Interpretation A) and form an isoclinal fold similar to that exposed on the eastern limb. In section 2, Township 25 South, Range 19 West, the beds are completely overturned and dip east. In the southern part of the section they become vertical, and in section 11 they are in normal sequence and dip west.

The writer postulates two possible interpretations of the western limb of the Needle Anticline. Interpretation A is favored by the writer. In this interpretation the extreme western exposures (point x) would not be overturned, and the isoclinal fold (point y) would only involve overturning of 130° to 150°. Interpretation B, however, suggests a decollement fold which would overturn the western outcrops 196° at point x.



Interpretation A



Interpretation B

Plate 8

The writer is inclined toward the first interpretation for two reasons. First, the inferred isoclinal fold would fit into the regional pattern of folding, and the intense stress would not have to be so great to form it. Second, the beds in the south part of the area are in normal sequence, and as they are traced north they begin to overturn and form the inferred isoclinal fold.

The Needle Anticline suggests a shallow surface structure. The compressional forces were probably transmitted through the weak rocks at the surface and did not involve those at depth. The forces are inferred to be directed east-northeast.

The intense compressional stress necessary to form this structure probably occurred during the folding and thrusting phases of the Laramide

System. After the initial formation of the anticlinal structure, the compressional forces intensified. The Chainman Shale, through which the axis of the major fold extended, was able to absorb and withstand the compressional stress by independent flowage and squeezing within the more incompetent beds. With the Chainman Shale acting as a lubricant, the anticline did not break and form thrust plates as it did to the south. Instead, the anticline was only intensified and modified into an asymmetrical fan fold with isoclinal fold on both flanks.

Needle Syncline

The Needle Syncline forms the major structural feature of the east part of the Needle Range. The asymmetrical syncline plunges north from the northern part of Beaver County, through the mapped area, and into the Burbank Hills. The eastern limb is unbroken and exposes the entire stratigraphic section with westward dips not in excess of 30. The western limb, however, has been overturned and overthrusted causing the many structural complexities of the range.

The outcrop pattern on the geologic map (Plate 1) shows the development of the synclinal pattern. In the central part of Township 25 South, Range 19 West, the Permian Arcturus Limestone, the youngest formation, forms the center of the structure. To the south, the Ely Limestone and Illipah Formation begin to change attitude and swing into the general synclinal pattern. This pattern continues into the northern part of Beaver County until the oldest formation, the Guilmette Limestone, forms the apex of the syncline.

The dating of the syncline may be fitted into the regional picture as one of the early phases of the Laramide System.

PLATE 6

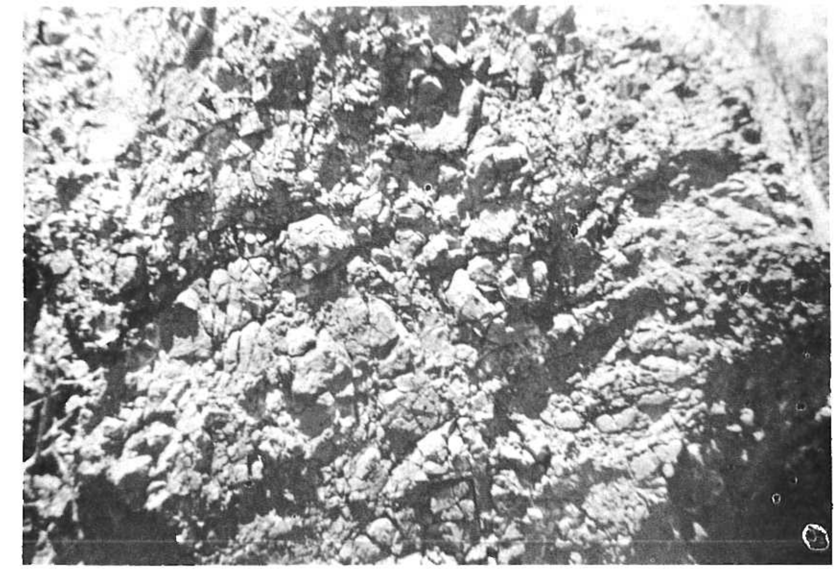


Fig. 1 Brecciated quartzite of the Guilmette Formation found along zones of thrusting.

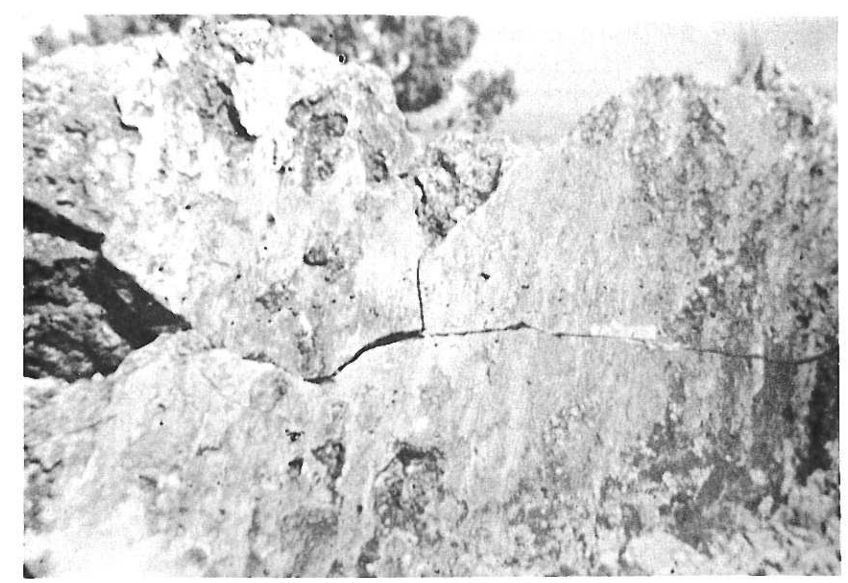


Fig. 2 Slickensides on the Guilmette quartzites found along zones of thrusting.

PLATE 7

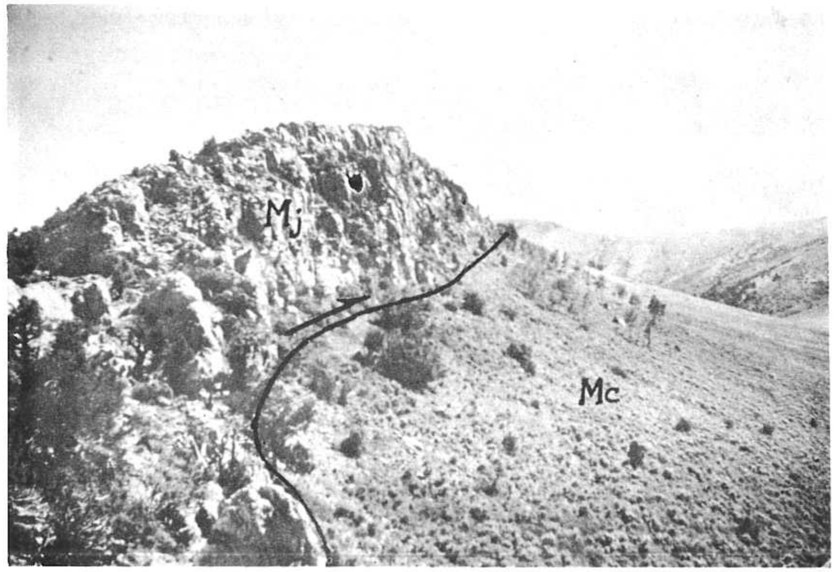


Fig. 1 Mississippian Joana Limestone thrust plate overlying the Mississippian Chainman Shale. Section 4, T 26 S, R 19 W.

Fig. 2 Devonian Guilmette Limestone thrust plate overlying the Permian Arcturus Limestone. Section 21, T 25 S, R 19 W.

SUMMARY OF STRUCTURAL HISTORY

In the Needle Range the record of structural events begins after a sequence of Paleozoic deposition, punctuated with some unconformities. The increasing abundance of clastic sediments in the later Paleozoic rocks reflect the beginning of tectonic events which were to develop. Although sedimentation continued into Early Mesozoic these sediments have been eroded and stripped from the area.

Because the younger sediments are not present, no direct evidence to precisely date the various folding and faulting epochs is available. Structural trends in the Great Basin and the phenomena observed in the mapped area direct the writer to relate many of the structural trends here to data collected by other investigators in the surrounding areas.

As far as known, the Antler Orogeny of Late Devonian to Early Pennsylvanian age was the first major orogenic episode known to have involved rocks of Paleozoic age within the Great Basin (Roberts, 1958). Others followed in Permian, Jurassic, Cretaceous and Eocene time (Nolan, 1943). Each younger orogeny affected the older rocks and structures, causing more pronounced folding of structures and perhaps reactivating some faults that originated previously. Recent studies (Roberts, 1958) seem to confirm Nolan's earlier postulate (1943, p. 177) that orogeny in the Great Basin was not confined to the late Jurassic or Laramide; these orogenic episodes were only "events in a long epoch of crustal activity that spasmodically affected the Great Basin throughout later Mesozoic and early Tertiary time."

The disturbance that began near the close of Jurassic time continued into and culminated in the Cretaceous, was the first major diastrophic episode that strongly folded and faulted the Paleozoic and younger strata of western Utah. Intense folding and overthrusting of major proportions occurred, and probably directly affected the Needle Range in the formation of its initial folded pattern.

The second major diastrophic episode of the Cretaceous occurred near the close of Colorado time (Early Laramide). The results of this orogeny are recorded at many localities in the eastern part of the Basin. The chief results were the intensification of the earlier structures, mainly folds (Christiansen, 1951). The compressional forces necessary to cause overthrusting of the western limb of the Needle Range syncline, may be directly related to this episode.

The final phase of the structural history of the area was the period of block faulting, which began as early as Middle Tertiary, and has continued intermittently to the present (Nolan, 1943). Associated with the period of block faulting are the numerous volcanic flows. The eastward dip of the flows suggest a slight east tilt of the region after their deposition.

OIL AND GAS POSSIBILITIES

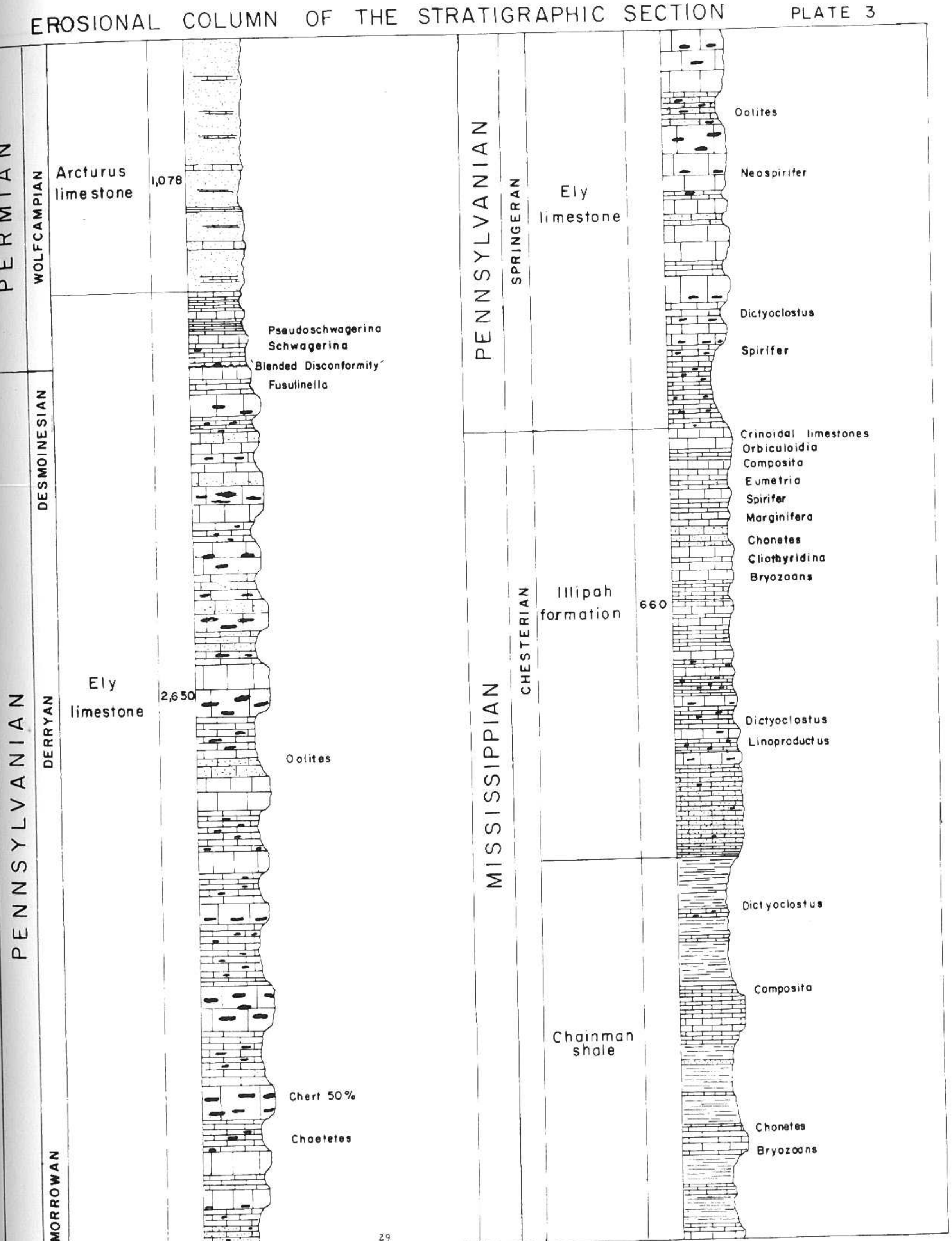
Structural and stratigraphic complexities that exist in the Needle Range possibly make the immediate area unfavorable for accumulation of gas and oil. However, the possibilities of gas and oil within this part of the Great Basin should not be overlooked.

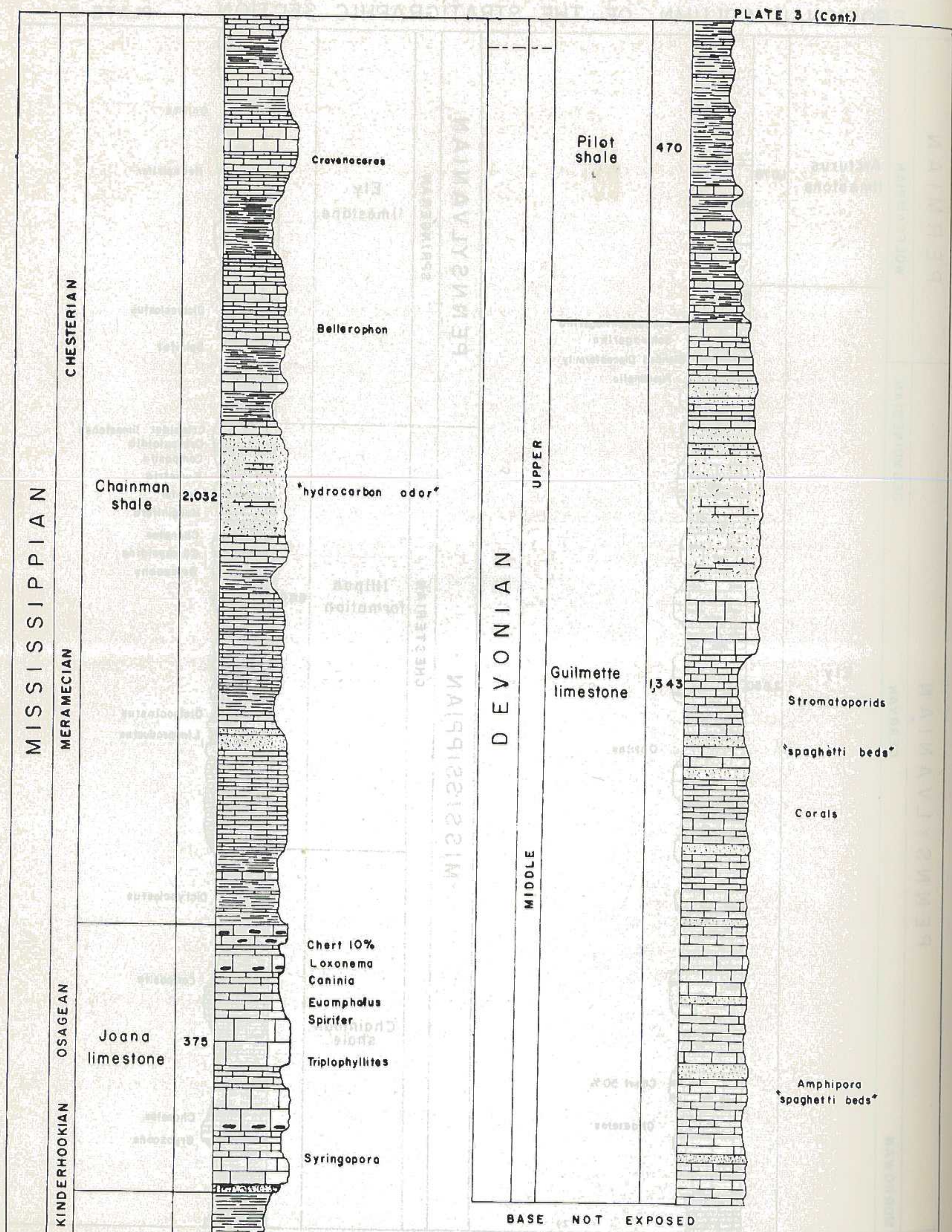
It is evident that petroleum was formed within this particular area in some fashion, and that source rocks, whatever their character, have been present and locally may still exist. Over 5,000 feet of sediments, from the Devonian Pilot Shale to the Permian Arcturus Limestone, contain varying amounts of hydrocarbons. This is particularly evident in the Chainman Shale where liquid and solid hydrocarbons are frequently found in fossils and in the nuclei of concretions.

With the Chainman and Pilot Shales as possible source beds, and the abundant sandstone and clastic limestone units as potential reservoirs, the implication of petroleum possibilities becomes favorable. This evidence becomes important when considering the oil and gas possibilities of a new and partially explored region.

APPENDIX

EROSIONAL COLUMN OF THE STRATIGRAPHIC SECTION PLATE 3





APPENDIX

Terminology

The writer used the following as standards to classify bedding, grain size, crystallinity, and color.

Bedding
(Modified after Kelly and Silvers, 1952)

Massive	greater than 6 feet
Thick	3 to 6 feet
Medium	1 to 3 feet
Thin	1 inch to 1 foot
Laminated	2 mm. to 1 inch
Thin laminae or papery . . .	less than 2 mm.

Grain Size
(Wentworth, 1922)

Very coarse	1 to 2 mm.
Coarse	1/2 to 1 mm.
Medium	1/4 to 1/2 mm.
Fine	1/8 to 1/4 mm.
Very fine	1/16 to 1/8 mm.

Crystallinity

Coarse crystalline . . .	more than 4 mm. across crystal face
Medium crystalline . . .	1 mm. to 4 mm. across crystal face
Fine crystalline	less than 1 mm. but distinguishable by unaided eye
Aphanic	if texture is visibly crystalline but individual crystals must be distinguished by hand lens

Color

A modified version of the National Research Council color chart was used for color classification.

Stratigraphic Section

The stratigraphic sections were measured and described on the eastern slopes of the range. The location and line of traverse for the various measurements are indicated on Plate 1. Fossil collections on file at B. Y. U. are indicated by numbers. Field identifications are not numbered.

Arcturus Limestone

(Measured: Section 34, T 24 S, R 19 W)

Unit	Description	Thickness
17	Limestone, medium grey, weathers light tan; thin to medium bedded, weathers slabby, forms small step ledges and slopes; crystalline to clastic, some dolomitic, no fossils; minor amounts of chert in upper part of unit. Because of structural complexities no further measurement was attempted	106
16	Sandstone, calcareous, light yellow, weathers light yellow to tan brown; thin to medium bedded, weathers spheroidal to blocky; forms step ledges on backslope; contains sub-rounded to rounded, frosted, well sorted quartz grains, fine to medium in size; minor amounts of black and brown chert	203
15	Dolomite, medium grey, weathers light grey; medium bedded, weathers blocky; contains fossil hash; forms small ledge	3
14	Sandstone, calcareous, light grey, weathers reddish grey; laminated to thin bedded near top of unit; forms ledge with rubble slope; grains consist of quartz, very fine grained, sub-rounded, well sorted, frosted . . .	8
13	Limestone, dolomitic, light to medium gray, weathers light grey; coarse crystalline to clastic; thin to medium bedded, weathers slabby; forms small ledges and slopes; brown weathering chert occurs throughout unit .	34
12	Sandstone, limestone, light greenish grey, weathers light buff to brown; thin to medium bedded, weathers slabby to blocky; grains consist of quartz, medium to coarse, sub-angular, poorly sorted; chert occurs in ribbon beds and nodules, constitutes up to 10% of unit .	61

Arcturus Limestone (cont.)

Unit	Description	Thickness
11	Limestone, sandy, light to medium grey, weathers light tan grey; thin to medium bedded, coarse crystalline to clastic; weathers blocky, forms slope with poor exposures	123
10	Limestone, light grey, weathers light grey; medium to thin bedded, crystalline to fine clastic, weathers blocky, forms step ledges and slopes	63
9	Limestone, medium tan to light grey, weathers dark grey; crystalline to coarse clastic, thick to massive bedded; forms cliff, contains 3% brown chert in ribbon beds.	12
8	Sandstone, calcareous, light yellow, weathers light yellow to tan brown; thin bedded, weathers spheroidal to blocky; forms small ledge; grains consist of quartz, sub-rounded, well sorted	4
7	Limestone, sandstone, light tan to medium grey, weathers light tan to light grey, medium to thin bedded, coarse clastic to crystalline; forms slope with poor exposures.	111
6	Limestone, light red to medium grey, weathers medium grey; medium to thin bedded, weathers slabby; forms prominent cliff with small slopes; contains fossil hash .	16
5	Limestone, light medium red to grey, weathers medium grey; thin to medium bedded, weathers slabby; forms small ledges and slopes; contains fossil hash and <u>Pseudoschwagerina</u> sp.; nodular chert constitutes 20% of unit (11503)	26
4	Limestone, medium grey, weathers dark grey; medium bedded, weathers blocky; forms ledge which contains <u>Pseudoschwagerina</u> sp. and 10% brown weathering chert in nodules and irregular beds	21
3	Sandstone, calcareous, light red to grey, weathers light tan grey; thin bedded, weathers flaggy; forms ledge and slopes; contains <u>Pseudoschwagerina</u> sp.; unit becomes medium bedded and contains limestones near top . . .	123

Arcturus Limestone (cont.)

Unit	Description	Thickness
2	Limestone, light medium grey, weathers medium grey; thin to medium bedded, coarse clastic to crystalline, weathers blocky; forms ledge; contains <u>Pseudoschwagerina</u> sp., <u>Schwagerina</u> sp., 10% dark red to brown weathering chert nodules	7
1	Sandstone, calcareous, light red to grey, weathers light tan to grey; thin to medium bedded, some laminated, weathers shaly with poor exposures; quartz grains, sub-rounded, medium to coarse; contains <u>Pseudoschwagerina</u> sp., <u>Schwagerina</u> sp. The contact with the underlying Ely Limestone is placed at the base of this first sandstone unit	161
	Total	1,078 feet

Ely Limestone

(Measured: Section 34, T 25 S, Section 35, T 24 S, R 19 W)

Unit	Description	Thickness
21	Limestone, sandy, light to medium grey, brown to light tan, weathers dark grey; medium bedded, weathers blocky, forms backslope; contains oolites, hash beds, and <u>Pseudoschwagerina</u> sp.	105
20	Limestone, dark to medium grey, weathers dark grey; medium bedded, weathers blocky; forms prominent cliff; contains 25% coarse sand, crinoidal hash beds . . .	50
19	Limestone, light to medium grey, weathers light grey; thin to medium bedded, coarse crystalline to clastic, forms slope with few step ledges; some of the thin bedded limestones weather with brown iron oxide stain, contains oolites, minor amounts of sand, crinoids, and <u>Pseudoschwagerina</u> sp.	160
18	Limestone, light to medium grey, weather light grey; medium to thick bedded, clastic; forms ledge, weathers blocky with meringue surfaces; contains abundant <u>Schwagerina</u> sp., <u>Pseudoschwagerina</u> sp., <u>Fenestella</u> sp., and crinoidal hash	50

Ely Limestone (cont.)

Unit	Description	Thickness
17	Limestone, light to medium grey, weathers light grey; coarse crystalline to aphanic, thin to medium bedded; forms slope, weathers shaly; contains hash beds of brachiopods, crinoids and bryozoans; base of unit marks first appearance of Pseudoschwagerina sp..	125
16	Limestone, light to medium grey, weathers light grey, some weathers brown; thin bedded, forms prominent shaly slope; contains unidentifiable brachiopod and crinoidal hash beds, and Schwagerina sp. Base of unit marks first appearance of Permian fusulinids	200
15	Limestone, medium to dark grey, weathers light grey, tan, to reddish brown; thin bedded near top, medium to thin bedded in lower part; crystalline to coarse clastic; weathers to shaly slopes and step ledges; abundant brown and black chert nodules in lower part; Schwagerina sp. found in talus, but comes from overlying unit; contains unidentified brachiopods and crinoidal hash beds; Fusulinella sp. are found in the upper 100 feet of unit .	240
14	Limestone, medium to dark grey, weathers light to medium grey; thin to medium bedded, coarse crystalline to clastic, weathers blocky to shaly; forms ledges and slopes; upper part contains 30% chert in ribbon beds and nodules; contains Juresania sp., Dictyoclostus americanus, and hash beds	250
13	Limestone, medium to dark grey, weathers light grey with interbedded light brown sandy limestones; coarse crystalline to crystalline, thin to massive bedded; forms prominent cliffs with step ledges and shaly slopes; brown and black chert in nodules and ribbon beds form 20% of lower, 60% of upper unit; contains encrinite and hash beds	355
12	Limestone, medium to light grey, weathers light grey with raspy, meringue surfaces; coarse crystalline to clastic, thick to massive bedded, forms prominent cliffs and small slopes; upper part contains chert nodules 2 to 4 feet in diameter, chert weathers brown with sandy surfaces; contains encrinite beds; emits moderate hydrocarbon odor	145

Ely Limestone (cont.)

Unit	Description	Thickness
11	Limestone, medium to light grey, weathers light grey; thin to medium bedded, weathers blocky to shaly; forms talus slope; contains encrinite beds, Marginifera sp., Linoproductus ovatus, Dictyoclostus americanus . .	100
10	Limestone, medium to dark grey, weathers light grey with few light tan to brown encrinite beds; crystalline to coarse clastic, medium to thick bedded, weathers massive; forms prominent cliff with minor talus slopes; contains 20% sandy, cross bedded and banded chert in lower part; upper part contains coarse crystalline limestones with oolites and hash	173
9	Limestone, medium to light grey, weathers light grey; crystalline to coarse clastic, thin to medium bedded; forms slope with one 15 foot cliff which contains 5% brown chert nodules, oolites, hash and encrinite beds . . .	150
8	Limestone, medium to light grey, weathers light grey with raspy meringue surfaces; white calcite patches give light appearance to unit; crystalline to clastic, medium to thick bedded; forms massive cliff, contains 2% brown chert; emits slight hydrocarbon odor . . .	35
7	Limestone, medium to dark grey, weathers medium to light grey; thin to medium bedded, forms slope with minor step ledges; contains 20% black, brown, and reddish brown chert in ribbon beds and nodules; contains Linoproductus ovatus, Dictyoclostus sp., Spirifer occidentalus, and Composita sp.	183
6	Limestone, medium to light grey, weathers medium to light grey with white calcite patches and raspy meringue surfaces; medium to thick bedded, weathers massive; forms cliff, top of unit contains chert nodules up to 2 feet in diameter; lower part contains Chaetetes sp. which weather a rusty brown	55
5	Limestone, medium to dark grey, weathers medium to light grey; crystalline to coarse clastic, medium to thin bedded; weathers blocky to slabby; forms talus slope; contains oolites, Spirifer occidentalis, Neospirifer triplicatus, and Composita subtilita	80

Ely Limestone (cont.)

Unit	Description	Thickness
4	Limestone, light to medium grey, weathers light grey with raspy meringue surfaces; white calcite patches give light appearance; dense, crystalline to clastic, thick bedded, weathers massive; forms cliff; contains minor amounts of chert	10
3	Limestone, medium to light grey, weathers light grey; thin bedded, weathers platy, forms talus slope; crystalline to coarse clastic; contains encrinite beds, Orbiculoidea capuliformis, O. missouriensis, Neospirifer triplicatus, Spirifer occidentalis, Dictyoclostus sp., Marginifera muricata (11504-1).	25
2	Limestone, medium to light grey, weathers light grey with white calcite patches and raspy meringue surfaces; thick bedded, crystalline to coarse clastic; weathers massive, forms first prominent cliff of Ely Limestone; contains encrinite beds, no chert	10
1	Limestone, light to medium grey, weathers light grey; medium to thin bedded, weathers platy; forms slope with minor step ledges; crystalline to coarse clastic; contains minor amounts of black and brown chert nodules, encrinite beds, unidentified bryozoans, Spirifer cameratus, S. occidentalis, Neospirifer triplicatus, Composita sp., Dictyoclostus americanus, Caninia sp., Derbyia sp., Chaetetes milleporaceous, Linoproductus ovatus, Paleococrinus (11504)	155
	Total	2, 656 feet

Illipah Formation

(Measured: Section 23, T 25 S, R 19 W)

Unit	Description	Thickness
4	Sandstone, dark brown to red, weathers brick red to maroon; medium to coarse grained, sub-rounded to rounded, frosted, well sorted; unit variable in thickness, not always exposed, no measurement.	0-5

Unit	Description	Thickness
3	Limestone, light to medium grey, weathers brown to yellow brown, medium to light grey; crystalline to coarse clastic, medium to thin bedded; forms step ledges and slopes; contains abundant partially silicified fossils which weather out; contains Spirifer rockymountanus, S. occidentalis, S. leidyi, Punctospirifer kentuckyensis, Diaphragmus elegans, Dictyoclostus inflatus, D. burlingtonensis, D. americanus, D. portlockianus, D. portlockianus n. var. crassicostatus, Linoproductus ovatus, Cliothyridina orbicularis, Pugnoides sp., Wellerella osagensis, Archimedes sp., Ambocoelia sp., Eumetria acuticosts, Composita ovata, C. subtilita, C. trilobata, Derbyia sp., Juresania nebraskensis, Chonetes granulifer, Marginifera sp., Orbiculoidea capuliformis, O. missouriensis, Rhipidomella sp., Schizophoria sp., Phillipsia sp., Paleococrinus (11505-1).	140
2	Limestone, medium to dark grey, weathers light grey, with interbedded thin sandy limestones which weather light brown to reddish orange; crystalline to coarse clastic; black and brown chert in nodules in lower part; forms step ledges and shaly slopes; emits slight hydrocarbon odor; contains Linoproductus ovatus, Cliothyridina orbicularis, Allorisma sp., Dictyoclostus inflatus, D. portlockianus (11505)	385
1	Limestone, dark grey to black, weathers brick red to yellow ocher; thin to medium bedded, sandy, dense, crystalline to aphanic; weathers blocky to platy, forms low resistant hills. Unit outstanding because of red weathering limestones; contains few unidentified brachiopod, crinoidal and encrinite beds	135
	Total	660 feet

Chainman Shale

(Measured: Section 26, T 25 S, R 19 W)

Unit	Description	Thickness
11	Limestone, medium to light grey, weathers light grey; coarse crystalline to aphanic, thin to medium bedded,	

Chainman Shale (cont.)

Unit	Description	Thickness
	thin to laminated; weathers platy to shaly; minor amounts of black and brown chert in upper part; contains hash and encrinite beds	180
10	Limestone, medium to light grey, weathers light reddish brown; thin bedded, weathers shaly; contains dense, sandy, aphanic limestones which break with sub-concoidal fracture	140
9	Limestone, medium to light grey, weather light to medium grey; fine clastic to aphanic, thin bedded; weathers shaly; contains fossil hash and encrinites . .	140
8	Limestone, medium to dark grey with interbedded reddish orange shales; minor amounts of black chert in upper part of unit, poor exposures	195
7	Limestone, medium to dark grey, weathers light grey to light tannish brown; medium to thin bedded with some laminated shales; crystalline to aphanic, coarse clastic to crystalline; weathers blocky to shaly; forms low resistant hills; contains *Dictyoclostus americanus*, *D. inflatus*, *D. burlingtonensis*, *Linoproductus ovatus*, *Naticopis altonensis*, *Fenestella* sp., *Chonetes granulifer*, *Rhombopora* sp., *Phillipsia* sp., *Bellerophon* sp., *Derbyia* sp., *Cravenoceras* sp.(11506)	280
6	Limestone, medium to dark grey, weathers light to medium grey with interbedded black, thin laminated shales; weathers shaly with minor step ledges; emits moderate hydrocarbon odor	380
5	Shale, dark grey to black, weathers light grey; thin to laminated with some thin bedded sandy limestones interbedded; limestones emit strong hydrocarbon odor, and contains hash beds	37
4	Sandstone, medium to dark grey, weathers light brown to light orange; medium to thin bedded, fine to medium grained, slightly calcareous; round cherty nodules occur in lower part; upper part contains purple colored concretions, 1 to 3 feet in diameter; thin beds weather platy, medium beds weather spheroidal to blocky; emits strong hydrocarbon odor, dead oil can be detected . .	180

Chainman Shale (cont.)

Unit	Description	Thickness
3	Limestone, dark grey to black, weathers medium grey to light brown; thin to laminated, crystalline to aphanic; sandy limestones near top; contains few unidentifiable brachiopod hash beds; emits strong hydrocarbon odor .	235
2	Sandstone, dark brown to black, weathers light brown to reddish brown, some maroon; thin to laminated, weathers shaly to platy; medium to fine quartz grains, well rounded, well sorted; emits strong hydrocarbon odor	30
1	Limestone, medium to light grey, weathers light to medium grey; fine crystalline to aphanic, medium to thin bedded, weathers blocky; emits a slight hydrocarbon odor, minor amounts of chert in upper part. Base of unit forms contact with underlying Joana Limestone . . .	235
	Total	2,032 feet

Joana Limestone

(Measured: Section 24, T 25 S, R 19 W)

Unit	Description	Thickness
8	Limestone, dark grey to dark blue grey, weathers medium to light grey; medium to fine clastic, coarse to fine crystalline; emits slight hydrocarbon odor; medium to thin bedded, forms step ledges and slopes; weathered surfaces are raspy meringue; brown weathering chert occurs in bands and nodules, 10%; contains *Caninia* sp.	100
7	Limestone, dark grey to dark blue grey, weathers medium grey, medium to coarse clastic; thin to medium bedded, forms backslope; contains *Spirifer cameratus*, *S. centronatus*, *Triplophyllites subatum*?, *Amplexocarina* sp., *Canina* sp., *Camarotoechia* sp., *Composita* sp., *Rhynchopora perryensis*, *Marginifera wabashensis*, *Lithostrotion whitneyi*, *Syringopora* sp., *Euomphalus* sp., *Loxonema* sp., *Schuchertella lens*, *Syringothyris textus*, *Eumetria costata*, *Dielasma formosum*, *Leptanena* sp., *Juresania nebraskensis*, *Leiorhynchus* sp., and unidentifiable crinoids and bryozoans(11507-2)	65

Joana Limestone (cont.)

Unit	Description	Thickness
6	Limestone, dark to medium grey, weathers light grey with raspy meringue surfaces; white calcite patches give light appearance; thick to massive bedded, crystalline to fine clastic; forms prominent ridge, no fossils . . .	35
5	Limestone, dark to medium grey, weathers medium to light grey; thin to medium bedded, fine crystalline to coarse clastic; forms slope with poor exposures; contains Triplophyllites subcrassus, Spirifer centronatus	32
4	Limestone, medium to dark grey, weathers light grey with raspy meringue surfaces; fine to medium clastic, thick to massive bedded; forms cliff, with 3% brown weathering chert nodules and beds in the lower part; no fossils, emits slight hydrocarbon odor	33
3	Limestone, medium to dark grey, weathers light grey, fine to medium clastic, some fine crystalline; thin to medium bedded, forms slope with poor exposures; contains Triplophyllites sp., Schuchertella lens, and Composita sp. (11507-1)	85
2	Limestone, medium grey, weathers light grey with meringue surfaces; fine to medium crystalline, fine to medium clastic; massive bedded, forms first prominent cliff; emits slight hydrocarbon odor; contains Syringopora surcularis, Triplophyllites sp. (11507) . . .	12
1	Quartzite, light red to pink, weathers same; forms base of Joana Limestone, not always exposed	2
	Total	374 feet

Pilot Shale

(Measured: Section 13, T 25 S, R 19 W)

Unit	Description	Thickness
2	Shale, calcareous, thin to laminated, weathers shaly; forms prominent talus slope with poor exposures; light to medium grey, weathers light grey with a pinkish appearance; no fossils	265

Pilot Shale (cont.)

Unit	Description	Thickness
1	Limestone, medium to dark grey, weathers light to medium grey; aphanic to fine crystalline with few clastic encrinite beds, thin to medium bedded, forms step ledges with calcareous, platy siltstone slopes, mottled surfaces near base of unit, contains unidentified gastropods, brachiopods and crinoidal hash beds	205
	Total	470 feet

Guilmette Limestone

(Measured: Section 13, R 19 W, SE¼ Section 18, R 18 W, T 25 S)

Unit	Description	Thickness
11	Limestone, black to medium grey, weathers light to medium grey, some weather with black and brown mottled surfaces; thin to medium bedded, coarse to fine crystalline with minor amounts of fine quartz grains; surfaces weather meringue to sandy; forms ledges and shaly slopes . . .	150
10	Sandstone, light tan to pink, weathers light brown with black and brown iron oxide; thin to medium bedded, coarse to medium quartz grains, well rounded, frosted, calcareous	25
9	Limestone, dark to medium grey, weathers light to medium grey; fine crystalline to clastic with fine quartz grains interbedded; weathered surfaces are sandy; white calcite patches give light appearance to unit; medium to thick bedded, forms prominent cliff	18
8	Sandstone, light tan to pinkish-white, weathers spheroidal with black and brown iron oxide stains; thin to medium bedded, crossbedded; fine to medium grained, sub-rounded, frosted; contains few thin bedded sandy limestones, light grey in color.	165
7	Limestone, medium to dark grey, weathers light to medium grey with meringue surfaces; crystalline to clastic, thick to massive bedded; contains dolomitic	

Guilmette Limestone (cont.)

Unit	Description	Thickness
	limestones near base; top of unit grades into sandy limes; Amphipora "spaghetti beds" characterize the lower part of unit (11508)	115
6	Limestone, light to medium grey, weathers light grey, with meringue surfaces; thin bedded, coarse clastic to crystalline; upper part contains black nodular limestones and interbedded limey sands, lower part contains abundant "spaghetti beds" and unidentifiable gastropods, forms talus slope with poor exposures	330
5	Sandstone, white to light tan, weathers tan to brown with black iron oxide stains; thin to medium bedded, crossbedded, frosted, medium to coarse grained; weathers spheroidal to blocky, forms ledge	10
4	Limestone, dark to medium grey, weathers light to medium grey, with white calcite patches and stringers; thick to medium bedded limestones at base; grades into thin bedded sandy limestones near top; forms ledges and slopes; contains abundant stromatoporids, gastropods, and the characteristic Amphipora "spagetti beds" . . .	285
3	Sandstone, light tan to brown, weathers tan to dark brown with black iron oxide stain; thin to medium bedded; medium to coarse quartz grains, sub-rounded to rounded, frosted; forms first traceable sandstone unit in the exposed section	5
2	Limestone, dark to medium grey, weathers medium grey with mottled meringue surfaces, some beds have reddish, burned surfaces; medium bedded, coarse crystalline to aphanic; forms step ledges and slopes; lower part of unit contains unidentified stromatoporids, brachiopds, and corals; contains abundant Amphipora "spagetti beds"	75
1	Limestone, dark to medium grey, weathers light to medium grey with meringue surfaces; medium to thin bedded, fine crystalline to aphanic; few interbedded quartzites and brown weathering sandstones in one and two foot beds; contains "spaghetti beds" and unidentified brachiopods; base of unit grades into alluvium	165
	Total	1,343 feet

Base not exposed

BIBLIOGRAPHY

Bacon, C. S. Jr., 1948, Geology of the Confusion Range, West Central Utah: Bull. Geol. Soc. Amer., Vol. 59, pp. 1027-52.

Campbell, Graham S., 1951, Permian System of Millard County, Utah: Utah Geol. Soc. Guidebook, No. 6.

Chilingar, George V., and Bissell, Harold J., 1957, Mississippian Joana Limestone of Cordilleran Miogeosyncline and Use of Ca?Mg Ratio in Correlation: Bull. Amer. Assoc. Petrol. Geol., Vol. 41, pp. 2257-74.

Christiansen, F. W., 1951, A Summary of the Structure and Stratigraphy of the Canyon Range: Utah Geol. Society Guidebook, No. 6.

Davis, Del E., 1956, A Taxonomic Study of the Mississippian Corals of Central Utah: Brigham Young University Research Studies, Geology Series, Vol. 3, No. 5.

Donovan, J. T., 1951, Devonian Rocks of the Confusion Basin and Vicinity: Utah Geol. Society Guidebook, No. 6.

Drewes, Harald, 1958, Structural Geology of the Southern Snake Range, Nevada: Bull. Geol. Soc. Amer., Vol. 69, pp. 221-240.

Dunbar, C. O., and Condra, G. E., 1932, Brachiopoda of the Pennsylvanian System of Nebraska: Nebraska Geol. Survey, 2d. ser., Bull. 5.

Eastern Nevada Geological Association Stratigraphic Committee, 1953, Revision of Stratigraphic Units in Great Basin: Bull. Amer. Assoc. Petrol. Geol., Vol. 37.

Ehring, Theodore W., 1957, The Murry Formation (Permian) Nevada: Unpublished M. A. Thesis, University of Southern Calif.

Gilbert, G. K., 1928, Studies of Basin and Range Structure: U. S. Geol. Survey Prof. Paper 153.

Humphrey, Fred L., 1956, Geology of the White Pine District, Nevada: Unpublished Ph. D. Thesis, University of Calif., L. A.

Intermountain Association of Petroleum Geologists, 1951, Geology of the Canyon, House, and Confusion Ranges, Millard County, Utah: Utah Geol. Society Guidebook, No. 6.

Kelly, V. C., and Silvers, Caswell, 1952, Geology of the Caballc Mountains: New Mexico Publication, Geol. No. 4, pp. 30-31.

Knight, Raymond L., 1956, Permian Fusulines from Nevada: Jour. of Paleo., Vol. 30, No. 4.

Kraetsch, R. B., and Jones, R. L., 1951, Pennsylvanian Rocks of the Confusion Range and Vicinity: Utah Geol. Society Guidebook, No. 6.

Misch, Peter, and Easton, W., 1954, Large Overthrust near Connors Pass in the Southern Schell Creek Range, White Pine County, Eastern Nevada: Geol. Soc. Amer. Bull., Vol. 65, p. 1347.

Morningstar, Helen, 1922, Pottsville Fauna of Ohio: Geol. Survey of Ohio, Fourth Series, Bull. 25.

Newell, N. D., 1948, Key Permian Section, Confusion Range, Western Utah: Geol. Soc. Amer. Bull., Vol. 59, pp. 1053-1058.

Nolan, T. B., 1935, Gold Hill Mining District, Utah: U. S. Geol. Survey, Prof. Paper 177.

________, 1943, The Basin and Range Province of Utah, Nevada, and California: U. S. Geol. Survey, Prof. Paper 197-D.

Ogden, Lawrence, 1951, Mississippian and Pennsylvanian Stratigraphy, Confusion Range, West Central Utah: Bull. Amer. Assoc. Petrol. Geol., Vol. 35, pp. 62-68.

Roberts, Ralph J., 1958, Paleozoic Rocks of North-Central Nevada: Amer. Assoc. Petrol. Geol. Bull., Vol. 42, pp. 2813-2857.

Rush, Richard W., 1951, Stratigraphy of the Burbank Hills, Western Millard County, Utah: Utah Geol. and Mineral. Survey Bull. 38.

Spencer, A. C., 1917, Geology and Ore Deposits of Ely, Nevada: U. S. Geol. Survey, Prof. Paper 96.

Verville, G. J., Thompson, M. L., and Lokke, D. H., 1956, Pennsylvanian Fusulinids of Eastern Nevada: Jour. of Paleo., Vol. 30, No. 6.

Weller, Stuart, 1914, The Mississippian Brachiopoda of the Mississippi Valley Basin: Illinois State Geol. Survey, Monograph 1.

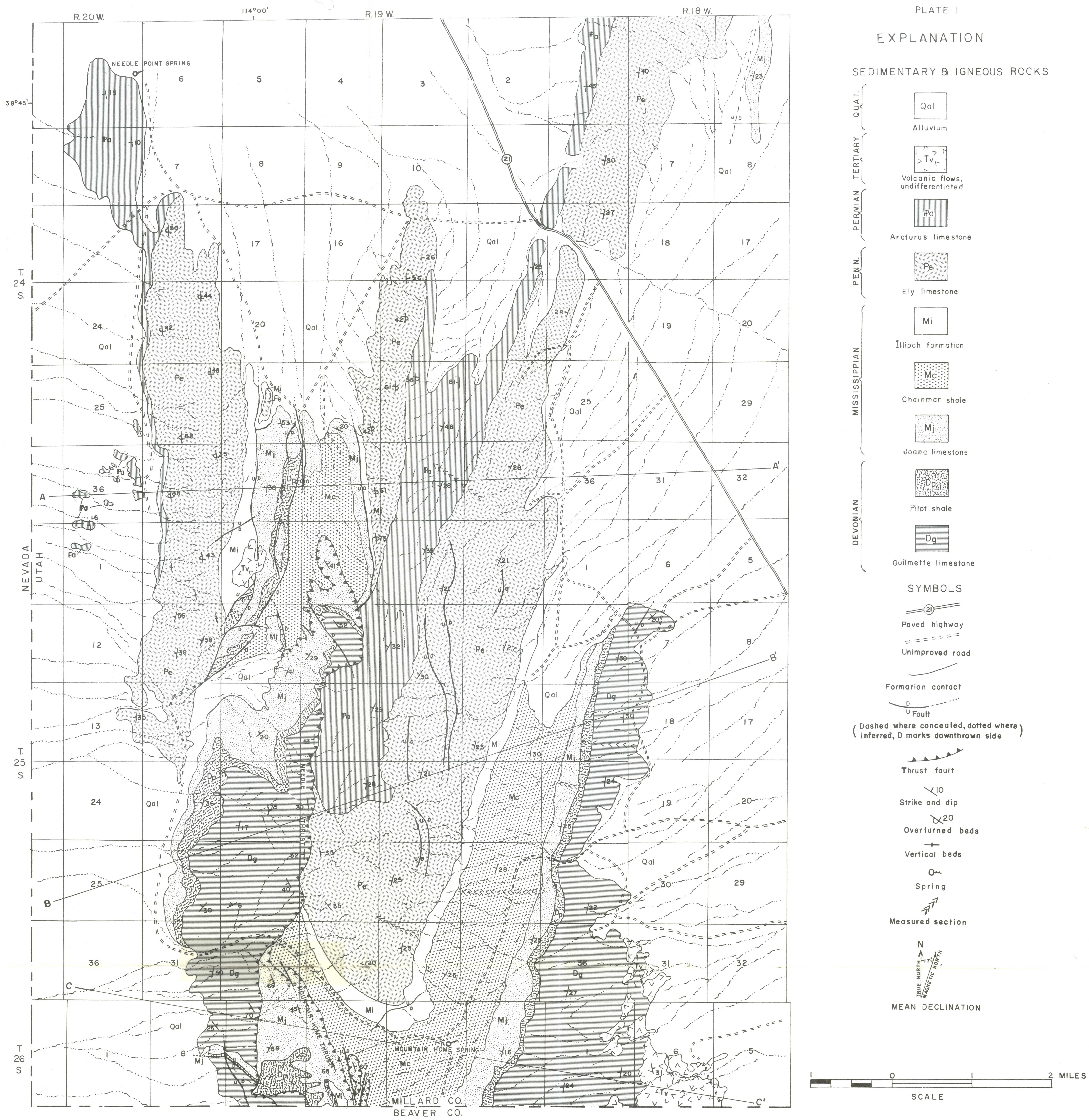
Wentworth, C. K., 1922, A Scale of Grade and Class Terms for Clastic Sediments: Jour. of Geol., Vol. 30, pp. 377-392.

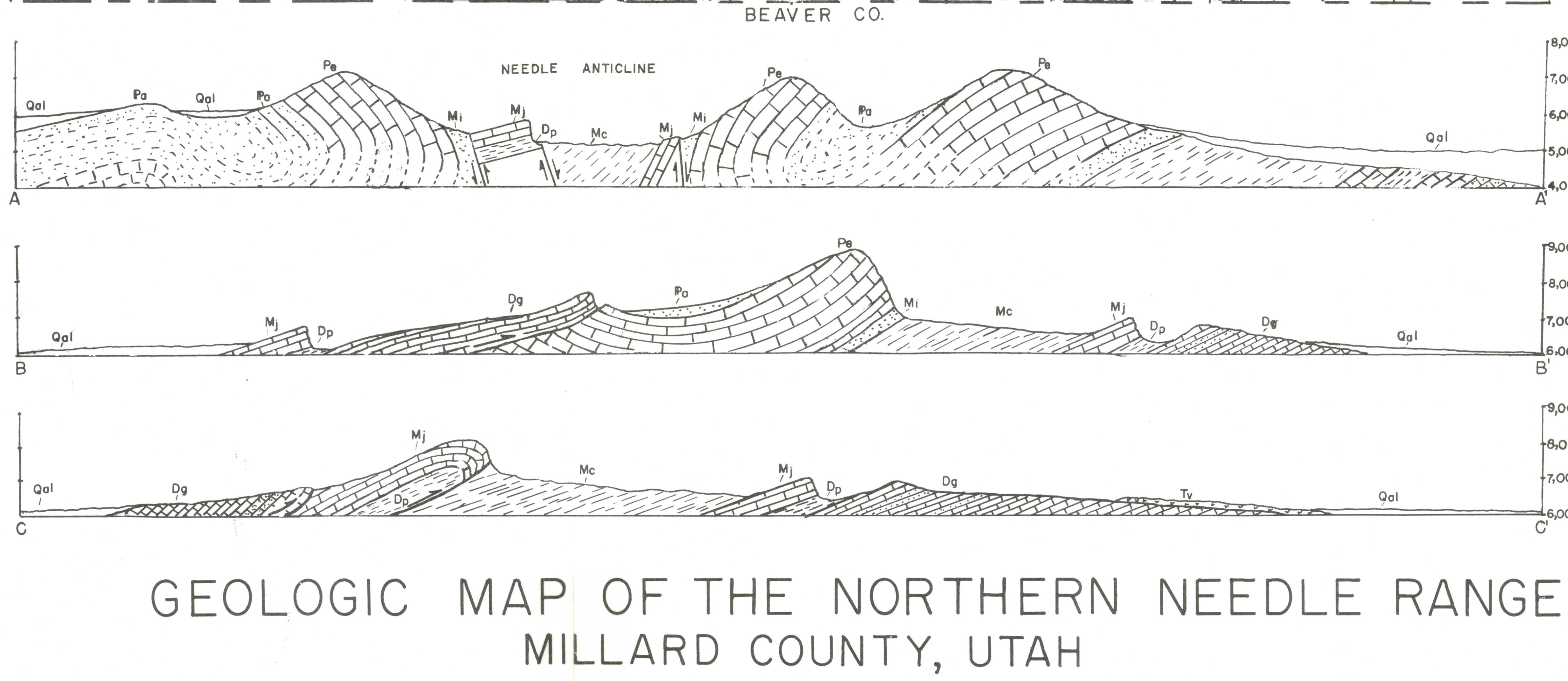
Westgate, L. G., and Knopf, Adolph, 1932, Geology and Ore Deposits of the Pioche District, Nevada: U. S. Geol. Survey, Prof. Paper 171.

Wilson, Druid, 1957, Geologic Names of North America Introduced in 1935-1955: U. S. Geol. Survey Bull. 1056A, p. 176.

Youngquist, Walter, 1953, Cephalopod Fauna of the White Pine Shale of Nevada, Supplement: Jour. of Paleo., Vol. 31, No. 4.

Zeller, Edward J., 1957, Mississippian Endothyroid Foraminifera from the Cordilleran Geosyncline: Jour. of Paleo., Vol. 31, No. 4.





GEOLOGIC MAP OF THE NORTHERN NEEDLE RANGE
MILLARD COUNTY, UTAH

by

WILBURN J GOULD

1959