BRIGHAM YOUNG UNIVERSITY RESEARCH STUDIES

GEOLOGY SERIES VOL. 7 NO. 5 APRIL 1960

STRATIGRAPHY OF THE FERGUSON MOUNTAIN AREA ELKO COUNTY, NEVADA

by

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STRATIGRAPHY OF THE FERGUSON MOUNTAIN AREA

ELKO COUNTY, NEVADA

A Thesis

Submitted to the

Faculty of the Department of Geology

Brigham Young University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

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April 1960

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LIST OF ILLUSTRATIONS

ACKNOWLEDGEMENTS

In the course of this study several individuals have helped in giving the writer technical assistance. Drs. Harold J. Bissell and William Revell Phillips served in an advisory capacity during this thesis study. Their enthusiasm and encouragement are appreciated. Dr. Harold J. Bissell was especially helpful in suggesting the problem and in helping solve some of the stratigraphic and structural problems, particularly on field conferences.

The writer is grateful for the cooperation of Mr. Lyle M. Slade with whom most of the field work was accomplished, including the measuring and sampling of the stratigraphic section. Messers Thomas Clark and Thomas Cahill also assisted in measuring the upper portion of the stratigraphic section.

Vertical aerial photographs, of scale 1:18,000, of the area were made available by Mr. Walter Smith, district geologist of Shell Oil Company, Ely, Nevada. Gratitude is expressed for this kindness.

Particular thanks are extended my wife, Maye, for encouragement and help in typing the manuscript.

ABSTRACT

Ferguson Mountain area is located in the east-central sector of the Goshute Mountains, Toana Range block in east central Nevada and the Utah border approximately 21 miles south of Wendover, Nevada-Utah. It seemingly sits out slightly to the east of the main mountain mass, but actually is a discrete part.

Exposed stratigraphic section, aggregating slightly more than 5,000 feet, includes rocks from Devonian to Quaternary and Recent ages.

Within the studied area occur strata of Devonian and Mississippian ages which include the Guilmette limestone and Pilot shale (Devonian), Joana limestone and Chainman shale (Mississippian) with combined exposed thickness of approximately 400 feet. These formations are not considered in detail in this report, however.

At the base of the measured section is the Pennsylvanian Ely limestone with a thickness of 1411.4 feet. Four formations of Permian age succeed the Ely limestone in ascending order as follows: Ferguson Mountain formation, Pequop formation, Kaibab limestone, and Plympton formation with a combined thickness of 3324.8 feet. Within this section carbonates predominate varying from dense marine limestones and silty and platy limestone varieties to biohermal and biostromal types.

The Ferguson Mountain formation which constitutes the principal Permian formation has been redefined to include only rocks of the Wolfcampian and lower Leonardian series.

Study of carbonate lithology of the Ely limestone and Ferguson Mountain formation demonstrate the cyclic and rhythmic nature of these sediments. These rhythmic cycles occurred within a transgressive-regressive sea, and reflect many tectonic and depositional changes.

Overlying the Permian sequence of rocks is the Triassic Thaynes limestone with an approximate thickness of 260 feet of limestones, some of which contain Meekoceras.

The Tertiary Humboldt formation, characterized by a tuff member in conglomerates, shales and sandstones, is found in the lower elevations.

Existing complexities, both structural and stratigraphic, make the immediate area unfavorable for oil and gas accumulation. Surrounding areas, however, may offer petroleum potential. Gossans of low-grade ores of copper and iron are observed throughout the mountain. Ores of lead, zinc, and precious metals (gold and silver) have been mined from this area, but the future is not encouraging.

Structural features of Ferguson Mountain are similar to Basin Range patterns in which folding involving the upper Paleozoic strata occurred prior to the block faulting. Numerous normal faults of longitudinal and transverse fault systems occur throughout the area with displacements ranging from 60 feet to 4,500 feet.

Because of the vast amounts of cherts found in the Permo-Pennsylvanian carbonate sequences within the miogeosyncline of the Basin Range and the difficulties and inconsistencies of terminologies in the literature, a simplified chert classification has been proposed. This is suggested for a more scientific description of miogeosynclinal chert beds both in the field as well as in subsequent publications or reports.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The Ferguson Mountain Area is located in the Central Sector of the Goshute Mountains of the Toana Range in east central Nevada, near the Utah border. This location is approximately twenty-one miles south of Wendover, Nevada-Utah, and one hundred and fifty miles north of Ely, Nevada.

The area studied includes parts of Sections 16, 17, 22, 28, 29, and all of 20 and 21 (unsurveyed), Township 30 North, Range 69 East, Elko County, Nevada.

U. S. Highway 50, paralleling the east face of the Toana Range, is a major route from Wendover to central and western Nevada, and is therefore the main access road to Ferguson Mountain. The studied area lies to the west of U. S. Highway 50 and is accessible by many dirt roads and jeep trails which lead to the east face of the mountain and traverse much of the area.

PHYSICAL FEATURES

Toana Range includes Ferguson Mountain and is essentially a north-south trending block in the eastern Great Basin. Relief varies from 4,300' to 4,800' above mean sea level in the lower elevations to a maximum of 7,690' (approximately) for two prominent peaks encompassed by the area. The range is typical of Basin and Range topography and structure with a west tilted fault block and a regional north-south trend.

Terrain is mountainous and rises abruptly from the Salt Flats and the lowland area on the east face of Ferguson Mountain.

The geomorphology of the area would be classified as youthful with steep rugged limestone cliffs found in all sectors of the area. On the southwestern end of the area, however, there are more slopes which exhibit subdued and less rugged features than the prominent cliffs of the eastern face.

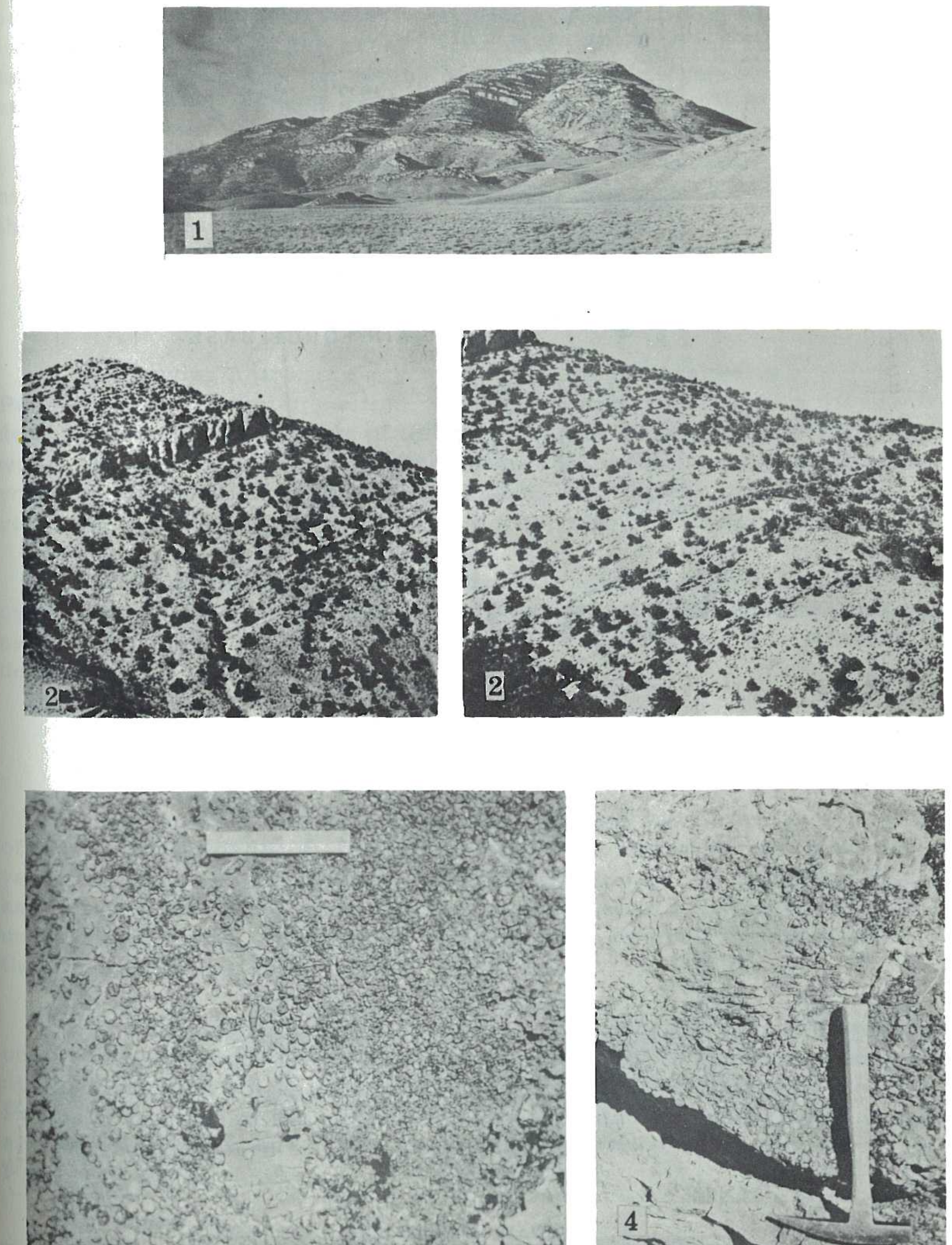
Explanation of Plate 1

1. View of northeastern face of Ferguson Mountain.

2. View of the Wolfcampian section of Ferguson Mountain formation along line of stratigraphic section.

3. & 4. Biostromal Corwenia (?) coral bed of the Leonardian Pequop formation near crest of Ferguson Mountain.

PLATE 1



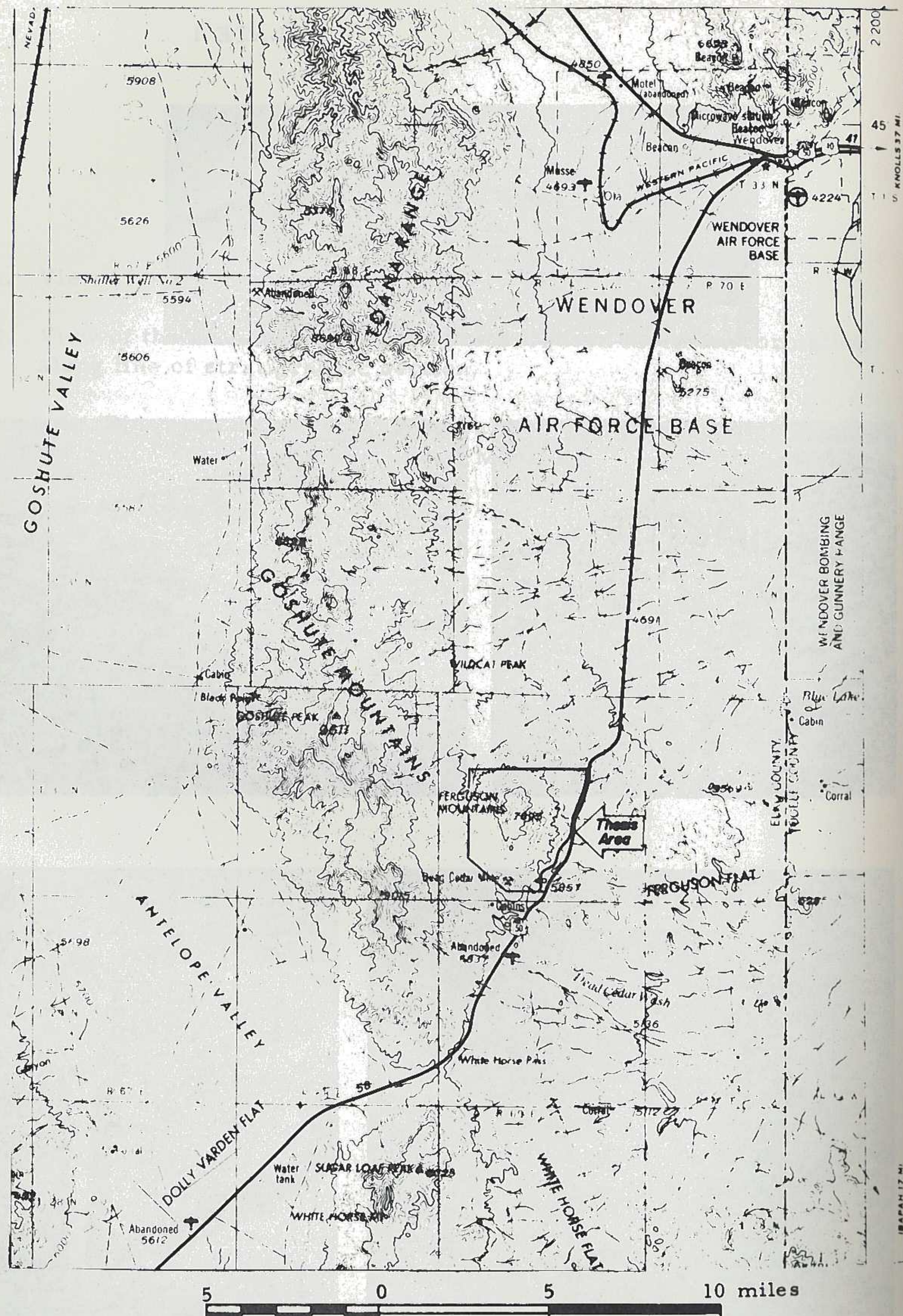


Figure 1 Index map

Climate is semi-arid, with an annual rainfall of less than ten inches. The area has no perennial streams, however an abundant and excellent source of good water is available at the spring which is located to the south of the area. None of the snow which falls annually is retained longer than the spring of the year and is removed by seepage and direct runoff, as well as by evaporation.

Characteristic of a semi-arid climate, the vegetation in the higher elevations includes junipers, while sagebrush is dominant in the lower slopes and valleys.

PURPOSE AND SCOPE

Following a preliminary reconnaissance* of this fine Pennsylvanian-Permian section, the author decided to make a more detailed stratigraphic study of this area. This stratigraphic study would include a study and interpretation of the sedimentary and igneous rock units within the area, the description and identification of these rock units, mapping of area, and the correlation of stratigraphy.

Within this stratigraphic study is an attempt to discuss the cyclic deposition of sediments of the Pennsylvanian Permian systems, as well as a synopsis of the stratigraphic environments, and structural development.

PREVIOUS WORK

Few publications deal with the Pennsylvanian-Permian systems of the Millard Belt (Kay, 1947, p. 1291) of the Great Basin. In recent years, studies ranging from reconnaissance to detailed investigations have been made of this excellent sedimentary section by oil companies, university groups, or individual students, but generally, results of their research are unpublished.

Until recently there was a complete lack of published information on any aspect of the geology of this area. Steele (1959) wrote a Doctorate dissertation on stratigraphic interpretations of the Pennsylvanian-Permian systems of the eastern Great Basin; the Ferguson Mountain area is included in this study, and a measured section of the Late Paleozoic strata is given.

*March, 1959, with Drs. Harold J. Bissell and J. Keith Rigby.

Several papers have appeared discussing the geology of adjacent areas in the eastern Great Basin. The Fortieth Parallel Survey (Hague and Emmons, 1877; Meek, 1877; King, 1878), published reports of general geologic features and brief descriptions of the Pennsylvanian-Permian outcrops within this area.

Nolan (1935), working in the Gold Hill Mining District which lies approximately eighteen miles southeast of Ferguson Mountain, applied the name Oquirrh formation (Gilluly, 1932) to a sequence of interbedded limestones, quartzites, and sandstones of Pennsylvanian and Permian age. He recognized a central facies, and a western facies in that area for the Oquirrh formation. Strata above this were referred to what he named the Gerster formation.

Pennsylvanian and Permian strata in the Confusion Range is discussed by Newell (1948), Bacon (1948), Campbell (1957), and Kraetsch and Jones (1951). Hose and Repenning (1959) applied the Basin and Range terminology for rock units of Pennsylvanian, Permian, and Lower Triassic age within the Confusion Range, Utah. This region, however, lies approximately seventy miles southeast of Ferguson Mountain.

Douglass (1952) in a fusulinid study made a preliminary fusulinid zonation of the Pennsylvanian and Permian rocks of northeastern Nevada.

Larson (1954) presented a summary of the formation in Nevada, and Dott (1954) discusses at some length Pennsylvanian rocks of the Elko area.

Clark (1957) investigated Triassic stratigraphy of the eastern Great Basin, documenting his studies with paleontologic and stratigraphic data.

FIELD WORK

Dr. Harold J. Bissell suggested the problem in the winter of 1959, and after a reconnaissance was made in March of that year, investigation of the problem was begun. Field work commenced in April, and was carried on intermittently until June. The major part of the field work was accomplished in June, and was completed in November, 1959.

Field investigation consisted of detailed measurement and description of the stratigraphic section, using steel tape and Brunton

Compass. Detailed sampling of units within the stratigraphic section was also effected.

Geologic information was plotted on vertical aerial photographs having an approximate scale of 1:18,000 as observations were made in the field. Contacts of formations were drawn on the photographs with the aid of a stereoscope after being located along traverses made in the field. A geologic map was subsequently drafted from data plotted on aerial photos. No detailed topographic map is available, so the map shows principally the geology of the area.

Color descriptions of fresh and weathered rock surfaces conform to that of the National Research Council rock color chart.

Wentworth's grade and size scale was used for grain size analysis when applicable.

A combination of bed thickness terminology and weathering structure by McKee and Weir (1953), and Kelley (1956) was used as given in the following chart: (See also Moyle, 1959, p. 4)

Name	Thickness	Weathering Structure
Massive	$>$6 feet	Massive
Thick	3 to 6 feet	Blocky
Medium	1 to 3 feet	Slabby
Thin	1 inch to 1 foot	Flaggy
Laminae	2 mm. to 1 inch	Platy (or Shaly)
Thin laminae	$<$2 mm.	Papery

Cooper (1958) suggested that a lithostratigrapher and paleontologist team together in solving stratigraphic problems. In this study of the Ferguson Mountain Area, Lyle M. Slade has undertaken the systematic paleontology and the various phases of paleoecology; stratigraphic studies were made by the present writer.

LABORATORY WORK

Laboratory work included preparation and study of thin sections of limestones, preparation of fossils for identification (primarily fusulinids) and age dating, as well as other laboratory investigations incident to particular problems, which will be discussed in the text.

STRATIGRAPHY

GENERAL STATEMENT

Present site of the Toana Range was an area of sedimentation during most of upper Paleozoic time. Deposition was, more or less, continuous except for part of Middle Pennsylvanian. This resulted in the accumulation of a thick sequence of sedimentary rocks, the majority of which are various types of limestones, and calcareous siltstones with some fine grained orthoquartzites.

This thesis deals with seven sedimentary formations, ranging in age from Lower Pennsylvanian to Tertiary. The measured thickness is approximately 5, 000 feet; carbonates predominate.

At the base of the measured section is the Ely Limestone, which is largely of Early and Medial Pennsylvanian age. Four formations of Permian age succeed the Ely limestone in ascending order as follows: Ferguson Mountain formation, Pequop formation, Kaibab limestone, and Plympton formation. A small outcrop of Lower Triassic is present, represented by the Thaynes (?) limestone. The last formation of importance is the Humboldt formation of Tertiary age.

Formational contacts are based on lithologic changes, and were walked out; age-dating is accomplished by means of fusulinids.

Regional structural strike is in a north-south direction and dip is generally west. The stratigraphic section is superbly exposed on the east side of Ferguson Mountain.

Within the Ferguson Mountain area occur strata of Devonian and Mississippian ages. Formations include the Guilmette limestone, Pilot shale, Joana limestone, and Chainman shale with an approximate combined exposed thickness of about four hundred feet. Devonian Guilmette limestone appears to be in fault contact with the Mississippian Chainman shale on the eastern slope; however, a normal sequence appears to be exposed west of the mapped area. Illipah formation of Late Mississippian and Early Pennsylvanian age which normally overlies the Chainman shale (Meramecian and lower Chesterian), is absent locally, possibly indicating that this area was emergent during Late Mississippian time. Evidence does not favor the interpretations that

post-depositional erosion removed the formation. Fault relations are not entirely clear, but evidence of juxtaposition of Ely against Chainman near the area of the measured section is shown. Elsewhere in the mapped area, data strongly suggests that Ely was deposited upon Chainman in this region.

MISSISSIPPIAN-PENNSYLVANIAN CONTACT

The contact between the Mississippian-Pennsylvanian appears to be gradational, except where distrubed by outcropping igneous dikes. There is a break in slope, marking the lower contact of the Ely limestone and the upper limit of the Chainman shale. The Chainman shale is characterized by brown to olive colored shales, but near the contact the slope is covered by limestone fragments from the Ely formation. Directly overlying this shaly sequence is a prominant limestone ledge of yellow gray color with an abundance of thick bedded (three feet) chert. Fossils were not found in the Chainman shale so the age could not be determined. However, it is felt by the writer that the Chainman shale was deposited continuously up to the Chesteran epoch and, because of tectonic unrest and uplift, the Chesteran and Springeran epochs of Mississippian and Pennsylvanian, respectively, are missing. This belief is based on the fact that the Illipah formation of Chesteran and Springeran ages is not found in this area.

With the exception of an epeirogenic uplift during medial Pennsylvanian time, the eastern Nevada-western Utah area was essentially a basin in which a thick carbonate section accumulated. The Pennsylvanian was a period of spasmodic unrest and undoubtedly there were periods of slight sedimentation and non-deposition, but in general, this was a period of thick sediment accumulation. Coarse to medium textured arenaceous sediments from the Antler Orogenic Belt to the west, as well as from the West Central Utah uplift to the east, and Northeast Nevada High to the north, in the form of silts and cherty material, were copiously deposited in the Ely Basin alternately and mixed with the carbonates. Throughout the basin a blanket, 1, 000 to 2, 500 feet or more in thickness, of Ely limestone was formed.

PENNSYLVANIAN SYSTEM

Ely Limestone

Lawson (1906, p. 295) named the Ely limestone for a well stratified, thick bedded, cherty limestone sequence in the Ely District of Nevada. Spencer (1917, pp. 26-27) redefined the formation as a

Period	Epoch	Formation	Thickness	Description
Quat.	Pliest. Recent	Alluvium Colluvium Slope Wash		Unconsolidated to poorly stratified mantle, fanglomerates, colluvium, and poorly cemented conglomerates.
Tertiary	Mio?	Humboldt fm.	250' to 500'	Paleozoic derived pebble conglomerate interbedded with a white vitric tuff, overlain by gray-orange slightly calcareous sandstone.
Tertiary	Eoc?	Volcanics		Hypabyssal dikes predominantly composes of medium dark gray latites.
		uncon.		
Triassic	Lower	Thaynes ls.	250' ±	Dark brown crystalline limestone containing the characteristic Meekoceras sp. zone overlain by a yellowish variegated shaly limestone
		uncon.		
Permian	Guadalupean	Park City Gp. Plympton fm.	237.8'	Light gray dolomites predominate, coarse to fine crystalline, expressed in massive bedded cliffs, with cherts.
Permian	Guadalupean	Park City Gp. Kaibab ls.	420' ±	Yellowish-gray, fine crystalline limestone, which occurs as massive bedded round cliff units, abundant chert in lower unit.
Permian	Leonardian	Pequop fm.	681.5'	Interbedded calcareous quartzite and silty limestones. Characteristic color is yellow-brown. Quartzite & calcareous quartzite predominate & usually weathers platy.
Permian	Wolfcampain	Ferguson Mountain fm.	1985.5'	Predominantly limestones with dark gray to light gray color. Formation composed of alternating beds of cliff & platy slope forming limestones. Bedding varies from massive to laminae. Cherts are common throughout the formation. Fossils are abundant, characterized by excellent fusulinid zones.
Pennsylvanian	Vir.	Ely		Limestones predominate, occurring in a sequence of alternating resistant, thick bedded limestones cliffs & slope-forming platy limestones. Color is medium to light olive gray. Cherts and fossils common to abundant.
Pennsylvanian	Ms	uncon.		
Pennsylvanian	DM, Der, Mo	Limestone	1411.4'	
		uncon.		
Miss.	Mer.	Chainman sh.	350' ±	Sequence of light brown shale quartzite sandstone & silty cherty limestone.
Miss.	?	Joana ls.	15-20'	Thin ledge of crystalline dark to medium gray lithographic limestone.
Dev.	?	Guilmette ls.	unknown	Dark gray to black crystalline limestone, occurs as cliff forming unit.

Figure 2 - Summary Chart of the Stratigraphy of the Ferguson Mtn. area, Elko County, Nevada

PERIODS	EPOCHS	Steele U. of Wash. Ph.D Dis. - 1959 Eastern Facies	Shell Oil Co. Lloyd (ms - UCLA - 1959) White River Val.	Bissell AAPG Convention 1960 Moorman Ranch-- Butte Mountains	Nolan - 1935 USGS Prof. Pap. 117, Western facies, Gold Hill Utah	Hose & Repenning AAPG. Bull. Vol. 43, No. 9 Sept. 1959 Confusion Range	(This report) 1960 Ferguson Mtn.
Trias.	Lower	Thaynes ls.		Thaynes (?) ls.	un-named Lower Triassic ls.	Thaynes ls.	Thaynes ls.
PERMIAN	Guadalupe.	Park City Group: Gerster fm., Phosphoria fm., Kaibab ls., Evaporites		Park City Group: Gerster ls., Plympton fm., "Kaibab" ls.	Gerster ls.	Park City Group: Gerster ls., Plymptom fm., Kaibab ls.	Park City Group: Plympton fm., Kaibab ls.
PERMIAN	Leonard	Pequop fm.	known but not published	Moorman Ranch; Pequop fm.	Oquirrh fm.	Arcturus fm.	Pequop fm.
PERMIAN	Wolfcamp.	Ferguson Springs fm.	Robbers Roost; Butte fm.	Carbon Ridge fm.	Oquirrh fm.	Arcturus fm.	Ferguson Mtn. fm.
PENNSYLVANIAN	Vir, Mis, DM				Oquirrh fm.		Ely ls. (Strathern (?) equi.)
PENNSYLVANIAN	Der, Mo, Spr.	Ely ls.	Ely ls.	Ely ls.	Oquirrh fm.	Ely ls.	Ely ls.
MISS	Chester	White Pine sh.	Chainman sh.	Illipah fm.; Chainman sh.	Manning Canyon fm.; Ochre Mtn. ls.	Chainman sh.	Chainman sh.

Fig. 3 - Summary Chart of the Nomenclature of Upper Paleozoic Stratigraphy - E. Nevada and W. Utah

limestone unit between the White Pine shale and the Arcturus limestone, ranging in thickness from 2,000 to 2,500 feet. Dott (1955, p. 2275) proposed that the formation be elevated to group rank, but Steele (1959b, p. 27) suggests the Ely limestone be retained in formational status. From the writer's observations at Ferguson Mountain, Steele's suggestion is valid.

Distribution. Much of the eastern base of Ferguson Mountain contains outcrops of Ely limestone; continuous and good exposures extend northward where the formation disappears beneath Tertiary and Quaternary sediments. To the south, the Ely limestone is involved in complex faulting with hydrothermal alteration west of Ferguson Springs and on the extreme northeast slope. Large disconnected blocks of the formation also occur on the southwestern part of Ferguson Mountain, but these are in fault contact with west-dipping Medial Permian sedimentary rocks of the main mountain. It is not known to what extent Ely limestone continues to the north of the mapped area in other parts of the Toana Range. No exposures are known to the writer between Ferguson Mountain and White Horse Pass farther south; possibly outcrops occur in the Goshute Mountains south of White Horse Pass because Ely limestone is known to be present in the Gold Hill district to the southeast.*

Lithology. Ely limestone is dominated by carbonate units. The formation is a sequence of alternating resistant, thick bedded limestone cliffs (five to forty feet thick) and slope-forming platy limestones. Color varies from medium to light olive gray, weathering medium to light gray in the resistant limestones, whereas, the platy light gray slope-forming beds weather light brown to pale yellowish brown. These limestones are composed predominantly of fine to medium grain silt size material. The silty material is abundant in the thin bedded platy weathering units and does occur in the massive cliff-forming units, but in lesser amounts. It is rare that even a pure crystalline limestone has not received some silt size particles. Occasionally sand size quartz fragments are found to occur within this thick limestone sequence, but these are rare and are more or less restricted to the platy limestones. Organic detritus, consisting chiefly of bryozoan fragments, crinoid columnals and chipped or worn pieces of other fossil specimens, occur sporadically throughout the Ely limestone. This organic detritus occurs both in the platy and thick massive cliff units, but is more abundant in the platy beds.

*Personal communication, H. J. Bissell.

Chert* is common throughout the Ely limestone. Color of these cherts varies from light brown to dark brown and black. Generally the color is medium to light brown. These cherts consist of bedded and nodular varieties. Bedded varieties range from laminated to massive with many thin interbedded zones being prominant. A massive bedded chert (three to four feet) is found in the basal unit of the stratigraphic section with a few massive chert beds occurring in the lower part of the formation. Nodular varieties are common in much of the formation and vary from small to large. In many instances, the prominent chert beds can be used for correlation over a small area within the Ely limestone. In the upper part of the formation, cherts are less abundant, but, nonetheless, are prominant.

Fusulinids are abundant and locally compose entire beds. These fossils comprise the main fauna for age dating the Ely limestone in this range.

Rhythmic to cyclic patterns of deposition are apparent in the Ely limestone as shown by alteration of lithoclastic, bioclastic, biochemical, and orthochemical carbonates. Further discussion of this phase of sedimentation will appear in later pages.

Thickness. What is considered to be an accurate measurement** of the Ely limestone was made in the eastcentral part of Ferguson Mountain, in a locality that has not been affected by faulting, slumping, or folding. Total thickness for the Ely limestone is 1411.4 feet. Of this, the basal 111.8 feet is Morrowan age, followed by 262.2 feet of Derryan***, 120.4 feet of Desmoinesian, 745.6 feet of upper Missourian, and 171.4 feet of Virgilian.

Age and Correlation. Age of the Ely limestone is Pennsylvanian, and includes representatives, but not necessarily all time span, of the Morrowan, Derryan, Desmoinesian, Missourian, and Virgilian epochs. Age dating of the Pennsylvanian by fusulinids conforms to that of

* See chert classification p.

** Details of this and other measured sections for this study are on file at the Department of Geology, Brigham Young University.

***Derryan Epoch used in lieu of the Atokan Epoch.

Thompson's stratigraphic zonation (1948, pp. 23-25). Detailed study of these fusulinids is being completed by Mr. Lyle Slade in a contemporary Master's thesis.

A regional epeirogenic uplift is recorded in mid-Pennsylvanian time, in which rocks of Late Desmoinesian and Early Missourian were not deposited, or if deposited, were subsequently eroded in large measure. This regional uplift is not apparent by a profound lithologic break, and is detected largely by fusulinid paleontology. Upper Pennsylvanian strata rest on Medial Pennsylvanian rocks in a blended disconformity. Detailed studies of lithology reveal subtle changes to lacunas in the stratigraphic record, and equally detailed investigations of fusulinids point up hiatuses. The Permo-Pennsylvanian contact, for example, is discernible in the field only after careful search for physical and biologic breaks. In a regional study of Pennsylvanian and Permian systems in the Eastern Great Basin, Steele (1959) indicated that the Ely limestone at Ferguson Springs area (i. e. Ferguson Mountain) is only 404 feet thick, although he did restrict it to the Pennsylvanian system. However, he proposed the new name, Ferguson Springs formation, for a thick section, largely Wolfcampian-Permian, but partly Late Pennsylvanian in age, which disconformably overlies the Ely limestone. The present writer is at variance with this interpretation, and instead, regards all the rocks of Pennsylvanian age at Ferguson Mountain to be referable to Ely limestone. The possibility does exist, it must be admitted, that the Strathearn formation (or at least it's eastern lateral equivalent) is present at Ferguson Mountain. This is one hundred miles east of its type area, fifteen miles west of Elko, Nevada, however, and no evidence was found to permit mapping this formation. Therefore, Ely limestone is the only Pennsylvanian formation shown in this study.

Upper limit of the Ely limestone is not everywhere the same in eastern Nevada and western Utah. Normally, Late Derryan or Early Desmoinesian strata are disconformably overlain by Wolfcampian carbonates and/or siltstones and orthoquartzites.*

Hose and Repenning (1959, pp. 2168-2174) consider the Ely to range from Late Mississippian into Early Permian. Steele (1959b, pp. 27-28) suggests a restriction of the contact beneath the regional Middle Pennsylvanian unconformity. The present writer concurs with the interpretations of Steele and Bissell. The Permo-Pennsylvanian contact is marked by change from silty and cherty limestones of upper

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*Personal communication from H. J. Bissell.

Ely, to massive bioclastic limestones of the Wolfcampian. Characteristic Virgilian species of <u>Waeringella</u> and <u>Triticites</u> occur relatively high in the Ely, and species of <u>Schwagerina</u> and robust <u>Triticites</u> characterize Lower Permian rocks.

Correlation of the Ely limestone within the Ely Basin is a relatively simple matter. Snelson (1957, p. 124) has identified and mapped Ely limestone in the northern Ruby Mountains and East Humboldt Range where he estimated a minimum thickness of 2,500 to 3,000 feet. This formation is traceable through the Pequop Mountains where a very thick section was recently examined in reconnaissance fashion on a field conference.* Mr. Gerald Robinson, a graduate student at Brigham Young University, is currently studying the stratigraphy of the Central Pequop Range. This information will be available at a later date. Characteristic cliff and slope-forming, medium gray limestones are present, with some chert pebble-conglomerate beds low in the Ely. Nolan (1935, pp. 33-35), in the Gold Hills district, eighteen miles to the southeast of Ferguson Mountain, described a central and a western facies of Pennsylvanian and Permian rocks which he referred to the Oquirrh formation. Within the western facies he described a section of which the basal portion was a "moderate thickness of light colored sandstone" overlain by a 3,000 foot thick bedded limestone. Overlying this limestone sequence is a 4,500 foot dolomite sequence of Permian age. Undoubtedly a part of the thick bedded limestone sequence is correlative to the Ely limestone of Ferguson Mountain.

Still farther south of the Gold Hill district, in the Confusion Range, Hose and Repenning (1959, pp. 2167-2173) assigned fifteen to sixty feet of the Ely to the Mississippian, 1,850 to 2,000 feet to the Pennsylvanian, and 200 to 350 feet to the Permian. Their description of the Ely corresponds well with the stratigraphic description made by the writer at Ferguson Mountain.

Gould (1959, p. 10) assigns a limestone sequence slightly greater than 2,600 feet to the Ely limestone in the Needle Range, Millard County, Utah.

Spencer (1917, pp. 26-27), redefining the Ely limestone in the Ely district, assigned 2,000 to 2,500 feet to the limestone unit between the Mississippian White Pine shale below, and the Permian Arcturus limestone above.

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*March, 1960, with Drs. Harold J. Bissell and David L. Clark and graduate students of Brigham Young University.

To the north, in the Wendover area and near the Northeast Nevada High, a thick Pennsylvanian section is exposed within the Desert Range (Leppy Hills). Presently, Mr. Phil Cook, a graduate student at Brigham Young University, is making a regional correlation of the Pennsylvanian in areas surrounding Ferguson Mountain, in which measured sections of these Pennsylvanian rocks will be described and correlated.

The Ely limestone is fossiliferous, with faunal units being extremely abundant, alternating with less fossiliferous to non-fossiliferous beds. The following Pennsylvanian species were collected: Dictyoclostus sp., D. americanus Dunbar and Condra, Linoproductus? sp., Dictyoclostus cf., Solenoporoid algae, Syringopora sp., spiriferid brachiopods, Derbyia sp., Juresania? sp., Chonetes sp., Composita sp., rugose corals, Penniretopora sp., fenestrate (Lioclima?) bryozoans, Caninea sp., rhomboporoid bryozoans, fenestellid bryozoans, crinoid columnals, echinoids with ambulacral plates; fusulinids of varied species: Millerella sp., Profusulinella sp., Fusulinella sp., Wedekindellina sp., Triticites hobblensis Thompson, Verville, and Bissell, and T. cullomensis Dunbar and Condra.

Chaetetes sp. was not found within the Ely limestone. Other workers (Hose and Repenning, 1959, p. 2174; Steele, 1959b) have reported biostromal sequences of Chaetetes in adjacent areas, indicating widespread occurrence of this "hair coral" in lower Derryan strata. Dott (1954) has called this a "synchronous time-stratigraphic marker" which he regards as Derryan (Atokan) age by the association of microfossils. Profusulinella spp. occur with one zone of Chaetetes, and Fusulinella spp. are found in an upper zone of this coral. Presence of Lower Derryan and Upper Derryan is thus confirmed.

The Strathearn formation, which was described by Dott (1955, pp. 2248-2255) in the Elko-Carlin area for a sequence of quartzose silty limestones with thin, cross-bedded, chert pebble conglomerates, may be present in part, at least, north of Wendover.* Because of the nearness of Wendover (25 miles to the north) there is a possibility that the Strathearn formation is present at Ferguson Mountain. At the type locality the middle five hundred feet is a series of medium gray limestones alternating with sandy quartzose granular-chert and

*Personal communication to H. J. Bissell from Fred Schaeffer, graduate student at University of Utah working the Desert Range and Leppy Hills as a Ph. D. Thesis.

limestone chert conglomerates. The Strathearn formation is dated Medial Missourian by Triticites cf., T. irregularis (Dunbar and Condra); the upper two hundred to three hundred feet of argillaceous and several thin fusulinid bearing beds are referred to the Virgilian. This age determination is made on the basis of occurrence of Triticites cf., Triticites cullomensis Dunbar and Condra, T. cellamagnus Thompson and Bissell, and T. meeki Moller.

In the Upper Pennsylvanian of Ferguson Mountain two thin orthoquartzite and quartzose limestone units of twenty-eight feet occur 397.3 feet below the Pennsylvanian-Permian boundary. These quartzitic beds are Virgilian in age, as shown by the presence of Schubertella sp., Waeringella sp., and T. cullomensis Dunbar and Condra. Because of these fine grained arenaceous units, there may be a thickness slightly in excess of one hundred feet of Strathearn formation in the Ferguson Mountain area. However, because of the characteristic color, lithology (medium gray limestone, slope-cliff former) of the Ely limestone, the writer is referring all exposed Pennsylvanian to the Ely limestone. Later workers within eastern Nevada may find that the Strathearn formation extends into the Ferguson Mountain area. For the present, however, the reservation is retained to not assign any strata at Ferguson Mountain to this formation.

Environment of Sedimentation. With the transgressive seas inundating the Ely Basin, a thick limestone sequence was accumulated. Two positive areas, the Northeast Nevada High of Steele (1959a, p. 1105) to the north, and the West Central Utah High to the southeast, shed enormous amounts of silt and sand size sediments into this depositional basin during Pennsylvanian time. The Manhattan geanticline (Nolan, 1943) of the Antler Orogenic Belt (Roberts 1949a, p. 95) appears to have been too far to the west to greatly affect the sediment of the immediate area. Pulsations from this tectonic belt directly influenced sea level, local relief, and variations in types of limestones, silt content, and the types of bedding.

The Ely limestone appears to have accumulated in an oscillating sea which fluctuated from open marine to shallow marine within the neritic marine environment. Rhythmic and cyclic deposition are apparent throughout the Ely, with massive cliff-forming, dense, finely crystalline limestones alternating with platy, fossiliferous and silty limestones. Non-fossiliferous, massive cliff-forming units suggest a deeper environment than the fossiliferous platy limestone lithotope. Detrital silty particles are found throughout the Ely, but are more abundant in the platy, thin-bedded units. The insoluble residues, leached from the limestones of the Ely, show that bioclastic fragments, silts, and fine grained sands are more abundant than in the Wolfcampian Ferguson Mountain formation.

Fossils abound in the Ely, being most commonly found in the platy limestone units. These fossils which range from abundant in some unit, to few in other units, are indicative of shallower waters of the inner neritic marine environment.

The numerous fossil hash units, which are encountered throughout the Ely, indicate that the bottom currents were slightly more intense and vigorous than during Wolfcampian time where fewer of the hash zones occur. These periods of intense bottom currents were intermingled with relatively quiet bottom conditions, reflected by the numerous corals, bryozoans, and algae that occur in restricted biozones.

PERMIAN SYSTEM

Ferguson Mountain Formation

Ferguson Mountain formation is herein named for a thick carbonate sequence overlying the Ely limestone at Ferguson Mountain, Elko County, Nevada. Steele (1959b, pp. 62-69) termed part of this the Ferguson Spring formation, but the name and type locality he selected are ill chosen. The present writer, therefore redefines this formation and proposes that the new name, Ferguson Mountain formation, be used. This proposal is based on the applicability of the name to topographic sheet (Elko NK 11-12) of the area. The area on the topographic sheet is referred to as Ferguson Mountain, not the Ferguson Springs Mountains. This is a minor point, but before the name is approved by the American Stratigraphic Committee, it should be corrected to fit provincial circumstances.

The type section is located in Sections 21 and 22, Township 30 North, Range 69 East, Elko County, Nevada. The measured section was obtained on the east side of Ferguson Mountain on a prominent spur directly north of the principal east-trending canyon on this part of the mountain (See Plate 4).

In the adjacent areas surrounding the springs area (see Plate 4), southeastern side of the Ferguson Mountains near U. S. Highway 50, no Ferguson Mountain formation is present. The geology there consists,

instead, of Guilmette limestone, Ely limestone, Tertiary volcanics, and Quaternary and Recent alluvium. The area is complexly folded, and is fractured by faulting. Seventeen hundred feet to the west in the southern part of the mountain, a fault block of Ferguson Mountain formation is juxtaposed against various rock types, but certainly cannot be considered a type section.

Steele (1959b, p. 67) dates this section Upper Lower Missourian to Upper Upper Wolfcampian with a total thickness of 3,085 feet, of which 1,111 feet is Pennsylvanian age and the remaining 1,974 feet is assigned to Lower Permian. He also extends the lower part of his formation to the Mid-Pennsylvanian disconformity with the upper limit in contact with the Pequop formation of Leonardian age.

Distribution. Ferguson Mountain formation has a greater exposed distribution within the area than any other of the Paleozoic formations.

More than one-half of the exposed upper eastern face of the mountain is Ferguson Mountain formation extending from slightly above a line extending through local mine diggings (on the measured section) to the top of the north peak. To the north, the formation plunges under the sediments of Tertiary and Quaternary ages. From this north peak, the formation is continuous to the south with only minor displacements due to transverse faults. In the extreme south end of the mapped area, the Ferguson Mountain formation is exposed on the surface in a series of fault blocks. Generally, the strike of the formation is in a north-south direction with dips varying from 25° to 37° to the west and southwest.

Lithology. Ferguson Mountain formation is predominantly a limestone (chemical and bioclastic) with an occasional calcareous sandstone and orthoquartzite. Color varies from dark gray and brown-gray to light olive gray to light tan gray, weathering predominantly to medium gray. The formation is composed of alternating beds of resistant limestone beds which form prominant cliffs, and platy slope-forming silty limestone and calcareous siltstone units. Resistant limestone cliffs vary from ten to ninety feet thick, but most are from twenty to thirty feet thick. Bedding in the ledge-cliff forming units vary from thin to massive with thick and medium bedding dominating the other types. In the platy units, the bedding generally consists of laminae to thin beds, with the former more typical. Cherts that are dark brownish-black to light brown of a host of nodular, discontinuous lenticular, and bedded varieties are common. Much of the chert is case hardened siliceous limestone, and therefore is deceiving for actual percentage estimations if careful attention is not paid to freshly fractured surfaces.

In the cliff sequences commonly small nodular and thin to medium bedded chert is abundant in beds up to four to six feet thick, then it completely disappears, not to occur until found in the next higher unit or basal portion of the next cliff sequence. In the Upper Wolfcampian and Lower Leonardian the chert is not abundant, and is essentially lacking in many units.

Above the Pennsylvanian Ely formation, the lithology contrasts in being less detrital, more chemical and biostromal with a crystalline matrix texture. Due to these distinct lithologic differences between the Pennsylvanian and Permian sediments, the writer proposes that Ferguson Mountain formation be considered essentially a time-rock unit, bounded at the base with early Wolfcampian, and at the top by early Leonardian. Strata enclosed are representative of Early, Medial, and Late Wolfcampian to Early Leonardian.

The upper limit of the Ferguson Springs formation of Steele (1959b, pp. 62, 126) has been picked at the base of a coral biostrome of Corwenia (?). This biostromal unit is characteristic, areally extensive, yet averages only four feet thick. The present writer, however, has located Early Leonardian fusulinids in beds having distinct lithologic variations over beds below forty feet below this coral biostrome. There is a gradual, but perceptible and important, change in the lithology from the extremely massive limestone (unit 72 on stratigraphic section) four hundred and fifty-six feet below the north mountain top, stratigraphically and topographically, up to the north peak. This change is reflected both in the limestone matrix with its increasing silt content, as well as the more typically gray color of the upper Ferguson Mountain formation.

Species of Parafusulina were found in a thin bedded brownish gray, cliff-slope forming unit two hundred and sixty-eight feet below the Corwenia (?) biostrome. These Parafusulina spp. are primitive forms, are abundant, and indicate that the Ferguson Mountain formation transgresses the time line and extends into early Leonardian.

Coral biostromes, not common in the Pennsylvanian Ely limestone in this area, are typical and areally extensive in Permian rocks. These coral biostromes are composed chiefly of Syringopora sp. heads and other colonial types, some of which are colonial varieties. However, solitary corals are abundant, and locally concentrated in beds so as to be termed biostrome; some small reef patches (bioherms) of corals are noted. Thickness ranges from six inches to four feet with one to two feet more or less average.

Some of the larger massive cliffs in the Middle and Upper Permian should be considered bioherms; some are reef patches. Reconnaissance investigations were made but no detailed studies, nor thin sections, were cut of the hand samples taken from the possible reef areas.* These biostromes and bioherm (?) strongly indicate areas of less intense tectonic activity, at least within discrete basins in the miogeosyncline.

Thickness. Total thickness of the Ferguson Mountain formation is 1985.5 feet, of which 1717.5 feet is assigned a Wolfcampian age and two hundred and sixty-eight feet to the Lower Leonardian. A partial section was measured in the south mountain block, and this correlates favorably with part of the main stratigraphic section, indicating only slight lateral variation during Wolfcampian time with only slight thickening and thinning for the exposed beds.

Age and Correlation. As sedimentation apparently was continuous from Pennsylvanian into Permian time, it is difficult to draw a precise physical or lithologic boundary. Generally, the Pennsylvanian Ely limestone is more detrital and bioclastic as compared with the more chemical, biochemical, and reefoid Permian limestones. The age is defined by guide fusulinids.

The Lower Wolfcampian is called on the first occurrence of Schwagerina sp. and Triticites cellamagnus Thompson and Bissell. Dunbarinella sp., Pseudoschwagerina sp., Paraschwagerina sp., Pseudofusulinella sp., and Pseudofusulina sp. all occur in the Wolfcampian in abundance.

The Ferguson Mountain formation is fossiliferous, with faunal units being extremely abundant, alternating with less fossiliferous to non-fossiliferous beds. The following fossil species were collected from the Ferguson Mountain formation: fusulinids of following species; Triticites cellamagnus Thompson and Bissell, Schwagerina spp.,

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*H. J. Bissell, Am. Assoc. Petrol. Geologists annual convention in Atlantic City, April 27, 1960, discussed some of these and illustrated with thin-sections.

Schubertella sp., Dunbarinella sp., Pseudoschwagerina spp., Pseudofusulina sp., Paraschwagerina spp.,; rugose corals; Syringopora sp., colonial corals (?), crinoid columnals, echinoids ambulacral plates; Dictyoclostus sp., Squamularia (?) sp., Juresanis sp., Marginifera (?) sp., Composita sp., Hustedia sp., spiriferid brachiopods, productid brachiopods; fenistrate bryozoans, fenestellid bryozoans, and rhomboporoid bryozoans.

The Lower Leonardian boundary is defined on the first occurrence in abundance of species of Parafusulina sp., considered diagnostic.

Steele (1959b, p. 62) has correlated his Ferguson Springs formation over a known areal extent of approximately 3,300 square miles. He has extended the formation name into the northern Cherry Creek Range, forty-five miles southwest of Ferguson Mountain where approximately 1,100 feet has been measured by him. In the Pequop Range* the writer walked over a portion (over approximately 1,000 feet thick) of the Ferguson Mountain formation. No measurement is available in this area at present, but a correlation on similar lithology is apparent.

Snelson (1957, p. 125) estimates a minimum thickness of 4,000 feet of Permian strata in the Ruby Mountains and East Humboldt Range, of which the lower 2,600 feet of Permian strata are correlated with the Arcturus formation farther south in Nevada. This sequence consists of normal marine limestones, arenaceous and argillaceous limestones, siltstones, and sandstones, and is dated by fusulinids. Snelson's description of the Lower Permian strata is difficult to interpret, but it appears the Ferguson Mountain formation does exist in the area he investigated. In the Gold Hills, Steele has assigned 1,600 feet of a limestone sequence to his Ferguson Spring formation, and it is apparent the Ferguson Mountain formation is there.

Other localities where Steele has identified his formation are Lava Capped Hills (forty feet), Knoll Mountains (one hundred and twenty-five feet), east of Hidden Well (two to three hundred feet), Wild Hoss Canyon (two hundred and eighty feet) and two miles southeast of Wells, Nevada (one hundred feet plus).

Environment of Sedimentation. Tectonically pulses of the Antler Orogenic Belt were in evidence progressively eastward with time (Nolan, 1943; Harris, 1959, pp. 2636-2640), partially controlling

*Field conference, March, 1960.

the area of sedimentation. This orogenic belt, coupled with the Northeast Nevada High, and the West Central Utah High, continued to shed fine silty clastics into the Ferguson trough or basin.* Slight pulsations of the local relief and fluctuations in sea level had widespread effect on the depositional environment.

Within the Ferguson Mountain area many environmental conditions can be inferred from a study of the sediments of the Wolfcampian series.

The environment under which limestones of the Ferguson Mountain formation accumulated appear to have been shallow marine to open marine within slightly oscillating seas. The fossil fauna suggests epineritic to shallow infraneritic clear waters, substantiating study of lithologic associations. Massive cliff forming units of dense, hard finely crystalline limestone, which are largely devoid of fossils, suggest possibly a deeper marine lithotope near the outer edge of the shelf for some, and very shallow "Bahama-Type" banks for others. Platy fossiliferous limestone beds are present throughout the Wolfcampian in a rhythmic to cyclic repititous pattern indicating a fluctuation between epineritic and infraneritic conditions, with variation in amount of silt and very fine grained quartz sand that was washed in.

Orthoquartzites, although not abundant, do occur and suggest that silt and fine sand size quartz fragments were being washed into the Ferguson trough (or basin) at a faster rate than the area was stabilizing. Insoluble residues were leached from some of these limestones in the laboratory, and they show minor amounts of detrital silty material. The silt-sized quartz fragments generally are well rounded with no argillaceous material indicating the area was influenced, but not too greatly by the Antler Orogenic Belt, and the high areas to the north and east from which these fine silts were derived. That is, medium and coarse textured sediment is negligible.

Possibly this was a relatively restricted basin or bank, similar in some respects to the Andros Bank.

Interspersed throughout the Pennsylvanian and Permian in thin-bedded and platy silty limestone are cryptostome bryozoans with delicate lacelike parts of the colony still intact. These bryozoans, with other fossils, occur much of Early Permian time. Biostromes of corals and algae further indicate periods of quiesence.

*Writer prefers basin as it appears that Ferguson Mountain area was restricted to a specific type limestone deposition.

Within certain beds, enclosed fusulinids show (in thin section) fractures in the antetheca, indicating compression or being torn apart by the bottom current. These fractures occur mostly in robust fusulinids. Orientation of the fusulinids is visable, not only in the thin sections, but in the hand samples picked up in the field from certain fusulinid zones. This, the writer feels, is an indication of the bottom currents, in which these protozoans were rolled back and forth across the floor of the limy, oozy muds until covered by the accumulating sediments.

Beginning with Leonardian time, transgressive seas began to wane with increasing amounts of silt being deposited up to the Pequop formation. Beginning with the time of the formation or the Pequop formation a regressive sea developed for a time, in which fine grained quartzitic sediment became predominant, but was succeeded later by carbonate sedimentation.

Cyclic Deposition

Weller (1930, p. 99) defined a cycle as a recurrence, repetition or returning to the starting point, and rhythm as a cycle without a time consideration.

Dott (1958, pp. 3-14) recognized cyclic patterns in the Pennsylvanian limestones of northeastern Nevada, as has Stokes (1958, p. 17) in Utah and the Great Basin. McKee (1938, p. 130) working in the Toroweap and Kaibab formations has described what he has considered true cyclothems.

In the Ferguson Mountain area approximately 3,500 feet of Pennsylvanian and Wolfcampian limestones have a cyclic or rhythmic appearance. These cyclic limestones of massive cliff forming units of dense finely crystalline limestones alternate with platy, fossiliferous, silty limestones forming slope and covered intervals. The platy units are made up of detrital and bioclastic zones, whereas the cliff forming units are normal marine limestones which contain an occasional biostrome of corals, or of fossil hash material. Silt content within the massive bedded limestones is relatively slight.

Bedded and nodular cherts are common throughout this carbonate sequence but are more pronounced within the massive dense limestones and are virtually absent in the platy silty limestones that form the slope units. These cherts are cyclic.

Minor cyclic changes in the formation are evident in the fossils, which vary from abundant to non-existant within this limestone sequence. Fossil associations were noted as the stratigraphic section was being described. Elias (1957) has assigned depths and general ecological associations to the characteristic fossils (i. e. corals, bryozoans, etc.). The writer finds fusulinids associated with corals, brachiopods, crinoid columnals, bryozoans and therefore questions the validity as to the fossil depth association. Generally the fossils were collected from the platy units but fossils were not restricted to these platy units. Coral biostromes, possibly bioherms, fusulinid and fossil hash units occur within the massive cliff units.

The limestone cycles had observable variations in color of sediments, insoluble residues.

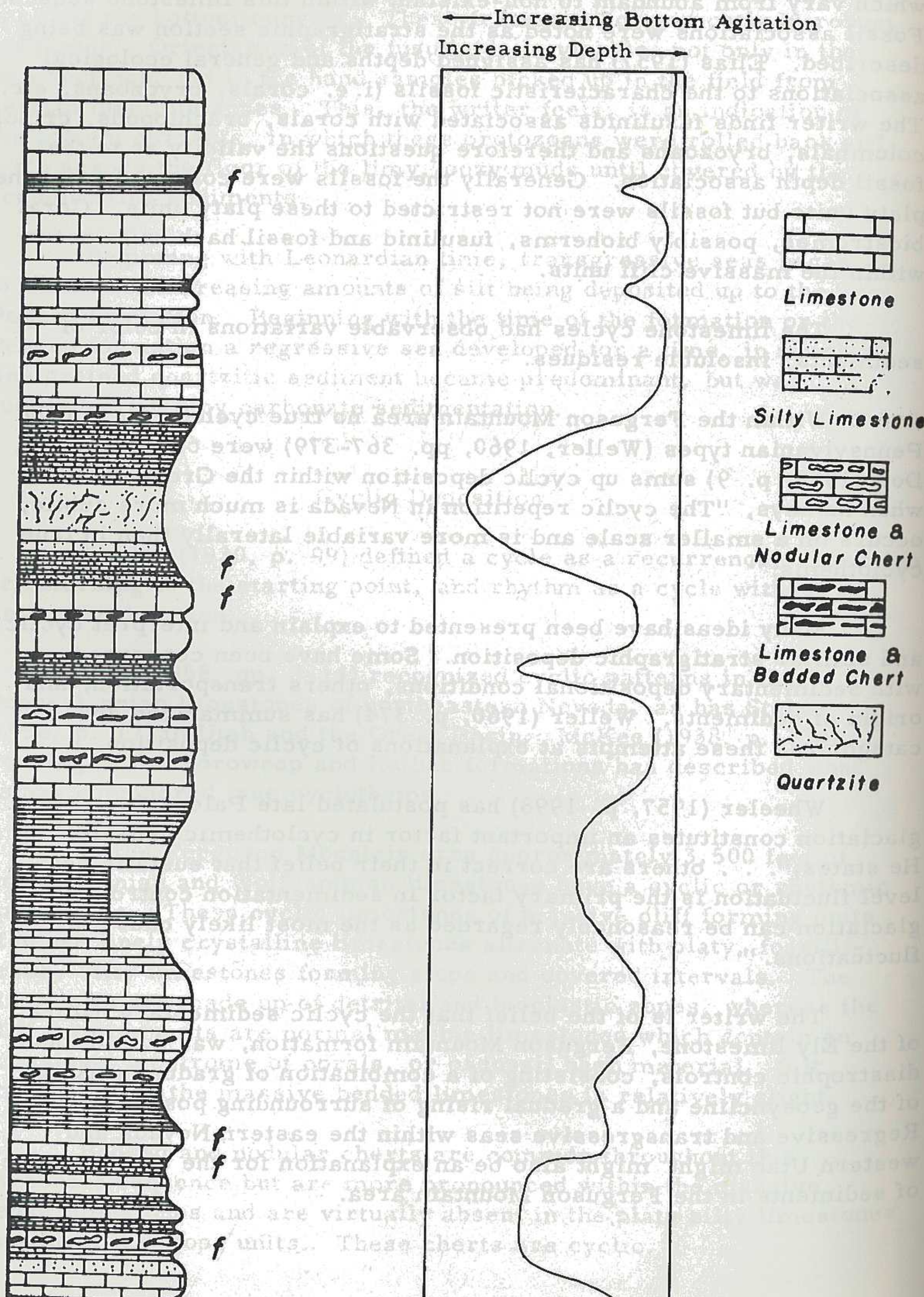
Within the Ferguson Mountain area no true cyclothems, of the Pennsylvanian types (Weller, 1960, pp. 367-379) were observed. Dott (1958, p. 9) sums up cyclic deposition within the Great Basin when he says, "The cyclic repetition in Nevada is much more subtle, occurs on a smaller scale and is more variable laterally than in true cyclothems."

Many ideas have been presented to explain and interpret cyclic and similar stratigraphic deposition. Some have been concerned with sedimentary depositional conditions, others transportation, and origin of sediments. Weller (1960, p. 374) has summarized and categorized these attempts at explanations of cyclic deposition.

Wheeler (1957, p. 1998) has postulated late Paleozoic glaciation constitutes an important factor in cyclothemic genesis. He states,". . . others are correct in their belief that eustatic sea level fluctuation is the primary factor in sedimentation control, glaciation can be reasonably regarded as the most likely cause of fluctuations."

The writer is of the belief that the cyclic sedimentary nature of the Ely limestone, Ferguson Mountain formation, was due to local diastrophic controls, consisting of a combination of gradual sinking of the geosyncline and a gradual rising of surrounding positive areas. Regressive and transgressive seas within the eastern Nevada and western Utah might might also be an explanation for the cyclic nature of sediments in the Ferguson Mountain area.

RHYTHMIC SEDIMENTATION OF THE UPPER WOLFCAMPIAN SECTION OF THE FERGUSON MOUNTAIN FORMATION - (Units 59 through 72)



Pequop Formation

Steele (1959a, p. 1105) named the Pequop formation for a thick sequence of thin-bedded fusulinid bearing limestones which were studied one and one-half miles north of the Jasper railroad tunnel in the Pequop Range, Elko County, Nevada. He determined the age of the Pequop formation as Lower Leonard to Lower Guadalupean age by the fusulinids Parafusulina spp. He also identified the Pequop formation in the Ferguson Mountains and made correlation throughout eastern Nevada.

Distribution. The Pequop formation is found principally in the central part of the main mountain overlying the west dipping slope. The Pequop formation-Ferguson Mountain formation contact is found on the crest of the northern-most peak (same as used for stratigraphic section) and from here trends into the canyon and is covered by Recent soils and the Tertiary Humboldt formation. Between the northern and southern peaks, a transverse fault cuts the formation with the Pequop upthrown in the south block. The formation extends westward from the higher elevations into the western valley where it is in fault contact with the Permian Plympton formation of Guadalupean (?) age. No Pequop formation is found in the southern end of the area.

Lithology. The Pequop formation consists of interbedded calcareous quartzites and bioclastic limestone with silty limestone in less abundance. Color of the limestone rocks on fresh fracture is light olive-gray to medium gray, weathering brownish-gray to yellowish-brown. The quartzitic units on a fresh fracture are generally light olive-gray, weathering to a grayish orange to yellow-brown gray color. Generally, exposures are good, although the steep dipping western slope is partially covered by the quartzitic fragments weathered from above. Sand-size quartz detritus is present in most carbonates. Few carbonate units are thick to massive bedded. Texturally, these carbonate beds are fine to medium crystalline and are commonly silty. Most of the platy, weathering, thin-bedded limestones are aphanic to fine, sandy, and silty.

Quartzite and calcareous quartzites predominate within the Pequop at Ferguson Mountain. These quartzites are aphanic to fine grained and form prominant slope weathering beds on the west slope.

Fusulinids are found in many of the lower beds of the Pequop and are characterized by Parafusulina spp. and Schwagerina spp. It is felt by the writer that the quartzitic environment was a strong deterrent for growth of the fusulinid faunas in the upper beds, as their occurrence is rare in the upper section of the Pequop formation where the quartzites abound. This is because the quartzites and sand-sized particles indicate a littoral to very shallow marine environment which was not conducive to growth of the fusulinids (Elias, 1937).

Age and Correlation. A basal, orange to pale yellowish-brown calcareous siltstone (four hundred and ninety-eight feet thick) is present in this area. The writer believes that the Pequop formation-Ferguson Mountain formation contact should be taken at this distinct lithologic unit instead of at the Corwenia (?) coral biostrome fifty feet higher. Others (Steele, 1959b, p. 126; Snelson, 1957, p. 133) have used the biostromal Corwenia (?) coral bed to mark the Wolfcampian-Leonardian boundary. However, as stated previously, the Wolfcampian-Leonardian Pequop formation is Lower Leonard to Lower Guadalupean age. Diagnostic fusulinids found in the lower part of the formation include Parafusulina spp. and Schwagerina sp. The writer did not find Medial and Late Leonard fusulinids in this area and believes these intervals to be faulted out as compared to the type section of the Pequop in the Pequop Mountains. A total thickness of 681.5 feet of Pequop formation was measured in the Ferguson Mountain area.

In northeastern Nevada and adjacent Utah the Pequop formation is distributed over some 10,000 square miles (Steele, 1959b, p. 126). From the type locality the formation can be traced in various directions. Snelson (1955a, p. 7), in a study of the southern Pequop Mountain, referred to a sequence of pre-Kaibab (?) rocks which Steele recognizes as the Pequop formation.

The formation is known in the Leppy Range where seven hundred feet is found on the back slope of Pyramid Peak. A thick section of 1,380 feet rests on the Ferguson Mountain formation in the northeast end of the Silver Island Range in Lost Canyon.

Of interest in the Newfoundland Range in north Utah, is a thick sequence of 2,450 feet of calcareous silts, silty limestones and fine grained sands of Leonardian age, which rests unconformably on truncated Lower Paleozoic rocks of Devonian and Mississippian age.

In the Confusion Range of western Utah, the Arcturus formation (2,700 feet) is considered to be Permian by Hose and Repenning (1959, pp. 2174-2178). Gould (1959, p. 11) working in the Northern Needle Range, identified Schwagerina sp. and Psuedoschwagerina sp. of Wolfcampian age from the upper six hundred feet of a unit he has called

the Ely. It is possible that the Arcturus of the Confusion Range is also of Medial Wolfcampian or Leonard, which may indicate that much of the sandstones, calcareous sandstones, silty sandstones, and limestones in the upper Arcturus of the Confusion Range correlate with the Pequop formation.

Environment of Sedimentation. A gradual transition in the rocks is noted from the massive limestones to the calcareous siltstones during Late Wolfcampian-Early Leonard. However, sedimentation appears to have been continuous during this gradational change and during the Leonardian epoch.

Sediments were possibly deposited within a regressive sea on a relatively stable shelf near adjacent deeper zones of the trough areas. Bioclastic and matrix limestones, as well as the silty limestone varieties, occur in the basal portion of the Pequop formation. This suggests that the area was passing from the outer neritic into the inter neritic as the area was being filled with sediments.

Quartzitic units in the upper portion of the Pequop formation suggest a near-shore zone of deposition, with sediments of fine sand and silt size accumulating faster than the basin was stabilizing or sinking. The quartzite, calcareous quartzites, and siltstones appear to be areally extensive, suggesting a zone of very shallow water in which blanket beds of fine grained sand and silt size particles were deposited.

Source of sediments continued to be from the positive areas within the eastern Nevada area, namely, the Antler Orogenic Belt, and the West Central Utah High. These positive areas supplied the silts and sands that were deposited into the trough during the Leonardian time.

Park City Group

McKelvey, et al., (1956) proposed new nomenclature for the Pennsylvanian and Permian systems of the Park City and equivalent formations of the northern and central Wasatch Mountains. Phosphoria formation was retained for the sequence of phosphorites, cherts, and mudstones, whereas, the Park City formation is used for strata of carbonate lithology.

Hose and Repenning (1959, p. 2178) have used this terminology in the Confusion Range for a carbonate sequence that is considered correlative with the Park City formation of the type area. The Park City group is divided into three formations, which, in ascending order are: Kaibab limestone, Plympton formation, and the Gerster limestone. Of this group only the Gerster limestone is not found in the Ferguson Mountain area.

Kaibab Limestone

Darton (1910, pp. 21, 28, 32) named the Kaibab limestone for a cherty limestone sequence overlying the Coconino sandstone, which formerly was defined as the upper member of the Aubrey group. This limestone also caps the Kaibab Plateau on the north side of the Grand Canyon. Noble (1928, p. 41) described and defined a complete section of Kaibab limestone in Kaibab Gulch near the abandoned town of Paria, Utah. This is now recognized by the United States Geological Survey as the type section (Lexicon of Geologic Names of the United States, p. 1063).

Newell (1948) in the Confusion Range applied the name to a 1,000 foot limestone formation overlying what is now known as the Arcturus formation.

Distribution. A linear belt of Kaibab limestone crops out on the northeastern lowlands between the Bonneville salt flats and Ferguson Mountain. This belt is continuous along the entire east side of Ferguson Mountain, forming a series of small hills of low relief. One small outcrop of Kaibab limestone, underlying the Plympton formation, is exposed due west of Ferguson Springs on the northwestern flank of the south mountain.

Faulting is prominant in all outcrops of the Kaibab limestone.

Lithology. The Kaibab limestone is composed of a thick to massive bedded cliff-forming limestone. Texturally, these massive bedded units vary from a fine crystalline to a medium crystalline limestone. Color on the fresh fracture ranges from a yellowish-gray to light gray, weathering yellowish-gray to a light olive-gray color. The limestone units range from a normal marine matrix limestone to a bioclastic limestone containing fragments of crinoid columnals, bryozoans, brachiopod shells, and oolites. Only a few poorly preserved, spiriferid brachiopods and Dictyoclostus sp. were collected from this formation.

Dark brown to light brown chert, of the bedded and nodular varieties are abundant in the lower exposed part of the Kaibab. These cherts, which are so abundant in the lower units, diminish in the upper units becoming almost non-existant. The nodular cherts, composed of all sizes, forms, and coalesing networks, are more common than the bedded varieties. Of interest to the writer are concretionary masses six to twelve inches thick, which are four to five feet long, lensing on each end. These lensing chert forms are common in the basal bed.

Thickness. The maximum measured section for the Kaibab limestone is approximately four hundred twenty feet.

The writer did not measure the complete formation, as the base is covered by sediments of the Tertiary Humboldt formation and Quaternary alluviums. Only in the fault block of Kaibab and overlying Plympton formation in the southwestern end of the area, is uppermost Kaibab present. No correlation of the Kaibab in this area with the Kaibab in the northeast end of the area is feasible, therefore, it is inferred that a portion of the upper Kaibab is missing from the normal sequence.

Age and Correlation. Steele (1959b, p. 182) considers the Kaibab to be Upper-Lower Guadalupean to Upper Guadalupean in age. Hose and Repenning (1959) are more cautious, and leave the dating of the Kaibab to the "Permian" period of time. The writer prefers to regard it as Late Leonardian to Wordian.

The Kaibab formation of the Ferguson Mountain area is the correlative of the massive limestone sequence near the top of Nolan's "Oquirrh formation" in the Gold Hills mining district, eighteen miles to the southeast. Approximately forty miles south of Gold Hills district, the Kaibab is prominently displayed in the Confusion Range, where Newell (1948, pp. 1953-1958) reported 1,000 feet of Kaibab sediments resting conformably on the Supai formation. Hose and Repenning (1959, p. 2178) have revised this figure to four hundred eighty feet of Kaibab sediments. The Kaibab can be traced into southwestern and southern Utah and the northeastern Nevada area where it is exposed in varying amounts up to approximately eight hundred feet.

North of Ferguson Mountain, the Kaibab is exposed on the south end of the Leach Mountains where Steele (1959b, p. 185) reports 1,580 feet of section. This is possibly the largest section of Kaibab within the Basin Range. Other outcrops are found rimming the northwestern end of the Great Salt Desert (Steele, 1959b).

Deposition of Sediments. Kaibab sediments were deposited within a transgressing sea moving slowly northward into the Ferguson trough area from the Arizona-southern Utah region. A shallow to open marine environment is inferred by the thick bedded and massive, cliff-forming limestones. These hard, dense, medium grained to crystalline limestones, which are generally devoid of fossils (other than crinoid-stem "hash") suggest an outer neritic zone of the shelf to a deeper marine lithotope.

Bioclastic limestones are indicative of the transporting power of the seas in which the limestones were deposited. These bioclastic beds suggest slightly stronger underwater currents during their deposition.

Plympton Formation

Newell (1948), working in the Confusion Range, applied the name Phosphoria formation to the Permian rocks above the Kaibab limestone. Inasmuch as the Phosphoria formation has been retained by McKelvey and others (1956) for the sequence consisting of mudstones, cherts, and phosphorite, lithologic differences necessitate new terminology. Hose and Repenning (1959, p. 2181) recommended the term Plympton formation for the predominantly dolomite sequence overlying the Kaibab limestone and underlying the Gerster limestone. This recommendation has been followed by the present writer.

Distribution. Within the Ferguson Mountain area the Plympton formation is found only along the lower elevations and the southwestern side of Ferguson Mountain.

Lithology. The Plympton formation at Ferguson Mountain is composed predominantly of light gray dolomites. Texture of the dolomites varies from finely crystalline to coarse crystalline. In general, the rocks are not so finely crystalline as the limestones of the Ferguson Mountain formation of the Ely limestone. Thick to massive bedding predominates giving a rounded irregular cliff expression. Dark brown to light gray cherts are prominent throughout the formation in amounts usually less than 10 per cent. These cherts are usually of

a nodular variety varying in size from small to medium nodular with most shapes, such as spherical lenses and elbows being present. Bedded chert is less common with small to medium bedded cherts being most abundant.

Fossils are rare in the Plympton. Only an occasional crinoid columnal was observed by the writer.

Contact between the lower Kaibab limestone and Plympton is delineated by a change in lithology from the light colored resistant dolomite and the ledge-slope forming less resistant Kaibab criquinas.

Thickness. A total thickness of 237.8 feet was measured in this area. Because the Plympton in the lower slopes is covered by Quaternary/Recent colluvium, a complete section is not exposed. The Plympton in the fault blocked south end is faulted against the Ferguson Mountain formation so that a complete section is not present there either.

Age and Correlation. No age dating is attempted as only crinoid columnals were found in this sequence of dolomite. However, the writer is of the opinion that the Plympton formation possibly is of Guadalupean age. In the Gold Hills district, Nolan (1935, p. 35) records 4,500 feet of a dolomitic sequence overlying a thick limestone sequence of what he terms the Oquirrh formation. On the basis of this lithologic similarity and its stratigraphic position, his "upper Oquirrh formation" is correlative with the Plympton formation of the Ferguson Mountain area.

In the Confusion Range south of the Gold Hills an aggregate thickness of 690 feet of Plympton formation is recorded.

Gerster Limestone

Nolan (1935, p. 39) first used the name Gerster formation in the Gold Hills district for a sequence of cherty limestones overlying the Kaibab limestone.

The writer did not find any characteristic Gerster rocks in the Ferguson Mountain area.

Steele (1959b, p. 193) says:

"Northwest of the type area, at Ferguson Springs Mountain, the Gerster formation is poorly exposed and complicated by faulting and several small igneous dikes. Overlain by the Dinwoody formation the Gerster formation is extimated to be 450 to 500 feet in thickness before the lower beds are covered by valley fill."

TRIASSIC SYSTEM

Thaynes Limestone

J. P. Smith (1932, pp. 9-10) was first to record presence of Triassic rocks in Elko County, Nevada. He identified these rocks on the basis of the "Meekoceras Zone."

Nolan (1935, p. 42) described an outcrop of Triassic strata in the Gold Hills district of western Utah, southeast of Ferguson Mountain.

Other workers (Newell, 1948; Wheeler, 1949; Scott, 1954) have described or otherwise made note of presence of Triassic rocks in eastern Nevada and western Utah. Hose and Repenning (1959, pp. 2185-2189) described Triassic strata in the Confusion Range of the west-central Utah area, and provisionally referred them to the Thaynes limestone. The present writer follows these geologists in applying the name Thaynes limestone, to Triassic marine rock near Ferguson Mountain.

A small outcrop of Thaynes limestone is found in the southern tip of the mapped area, west of the U. S. Highway 50, in Section 3, T. 29 N., R. 69 E. Scott (1954) was first to report occurrence of these Triassic sediments at this locality. The lower parts consist of crystalline limestone containing the characteristic cephalopod Meekoceras sp. overlain by variegated shaly limestones. Its exposed thickness is less than two hundred feet.

Clark (1957, p. 2192) has given a tentative division for Triassic strata in the eastern Great Basin as follows:

(1) lower shaly limestone
(2) Meekoceras limestone zone
(3) upper shaly limestone
(4) upper thick bedded limestone

Portions of units (2) and (3) appear to be present in this area.

The Triassic-Permian contact is disconformable with the Thaynes of Lower Triassic age resting on Wolfcampian Ferguson Mountain formation or locally upon Guadalupean Kaibab limestone, at most places the contact is covered by Quaternary alluvium and colluvium.

Perhaps the most distinctive features of the Thaynes in this area are its color and fossils. The characteristic color of beds of Meekoceras zone is a dark yellowish brown which distinguishes it from all other lithologic units within this area. Overlying this limestone is a platy, silty limestone with a distinctive yellowish gray color.

Within the Thaynes limestone the following fossils were collected:

(1) Meekoceras gracilitus
(2) Meekoceras sp.
(3) pelecypods

Because of the small and almost isolated nature of the Thaynes limestone in the mapped area, it is not known with certainty how it accumulated. Possibly it formed in a small marine embayment in a small topographic low that formed over eroded Permian sediments after withdrawal of seas of Guadalupean time, and during advance of Early Triassic marine waters. Such an explanation could account for its relationship to Leonardian and Guadalupean rocks of the area. The epoch of time represented in the hiatus may be great or relatively small. Knowledge of equivalency of the Ochoan epoch within the eastern Great Basin is not fully known, so only an approximation of the time interval represented as post-Early Guadalupean and pre-Early Triassic can be arrived at.

TERTIARY SYSTEM

Humboldt Formation

King (1878, pp. 434-443), during his exploration of the 40th parallel, described friable gray, white and drab sandstone, marly limestone, reddish gravels, marly sands, and loosely compacted pumaceous tuffs, extending in patches from the western base of the Wasatch Mountains, in Utah, to the Humboldt River and Humboldt Mountains, in Nevada. Merriam (1914, p. 278), Sharp (1939, pp. 143-44), and McDonald (1949), have redefined and restricted the Humboldt formation.

Distribution. Rocks, tentatively assigned to the Humboldt formation, crop out in the lower elevations on the west and north of the main mountain. These outcrops are mingled with Quaternary alluvium and Recent colluvium which to a degree, mask the Humboldt, leaving poor exposures. The Humboldt is usually best observed along the sides of deeply cut gullies and draws.

Lithology. This formation consists of an interbedded series of tuffs, conglomerates, mudstones, siltstones, and calcareous sandstones. The basal conglomerate is composed of Paleozoic limestones and cherts, which are subangular to subrounded and range in size from six to eighteen inches in diameter. These conglomerate beds appear to be lenticular.

Overlying the conglomerate beds is a white to light gray tuff, with an abundance of subhedral to euhedral crystals which can be viewed using high magnification. Overlying these laminated tuff beds, is a grayish orange, fine grained, slightly calcareous sandstone.

The Humboldt formation was not measured by the writer but appears fairly thick in the northern end of the Ferguson Mountain where it is the most extensive. A conservative estimate would be from two hundred fifty to five hundred feet.

Contact relationships of the Humboldt are not clearly understood, nor well exposed. On the west side of the mountain, the Humboldt rests unconformably on older Upper Paleozoic formations. This unconformity is angular, being deduced by the variation in the dips between Humboldt and older formations.

Age and Correlation. King (1878, pp. 434-443) has dated the formation as Pliocene, however, it is also considered Upper Miocene in age (Merriam, 1914, p. 278). No fossils were collected by the writer from the Humboldt in the Ferguson Mountain area. However, Sharp (1939) and McDonald (1949, p. 176) in a study of the Humboldt near Contact, Nevada, collected a Clarendonian fauna of earliest Pliocene age.

Van Houten (1956), in a reconnaissance study of the Cenozoic rocks of Nevada, correlated the Humboldt from Battle Mountain to Wendover and the Salt Flats in the east and from near the Idaho border in the north to near Eureka in central Nevada. The Ferguson Mountain was not considered in this regional correlation, possibly

because outcrops of the tuff unit were not known by Van Houten. The writer, however, concludes, on the basis of lithologic similarity and stratigraphic position that this information is correlative to the Humboldt of northeastern Nevada.

TERTIARY SYSTEM

Volcanics

Igneous activity occurred peripheral to the Ferguson Mountain area. Outcrops of igneous rocks are found primarily in the lower elevations on the eastern and southern slopes of the mountain, but limonite gossons, which are suggestive of igneous activity in that area, are numerous and scattered throughout the mountain irrespective of elevation. These outcrops are generally small, but do occur in linear belts trending in a north-south direction along the fault on the east side of the mountain.

Igneous rocks are of two primary varieties:

(1) latite
(2) tuff

Latite predominates, occurring in hypabyssal dikes. In most observed outcrops, the rock is porphyritic with prominent plagioclase phenocrysts, and fine aphanitic (felsitic) groundmass. The rock, medium gray on fresh fracture, weathers darker gray. Petrographic analysis of a rock taken from an outcrop shows the following mineral composition:

	per cent
Quartz	2
Orthoclase	55
Plagioclase (zoned)	25
Magnetite	1
Apatite	1
Chlorite	10
Calcite	5
Zircon	1

Secondary Alterations. Ferromagnesium minerals are altered to chlorite, calcite, magnetite, and biotite, whereas, plagioclase alters to sericite and albite.

The groundmass appears as a devitrified glass. Ferromagnesium minerals of hornblende and pyroxene, before alteration, possibly make up of ten per cent of the mineral composition.

In the southern end of the mapped area, near the Triassic sediments, there is an outcrop of what appears to be quartz latite. Attempts have been made to thin-section rock specimens from this outcrop with no success because of thorough alteration.

In the hand sample it is grayish pink with phenocrysts of orthoclase, quartz, and biotite which help to distinguish from the latite which is nearby. This rock contains in excess of ten per cent quartz and a highly decomposed matrix.

Two outcrops of tuff were observed. Northeast of Ferguson Mountain and a hundred yards west of U. S. Highway 50, a tuff is exposed in an old prospect hole. This tuff is white to very light gray, well stratified, and laminated. The entire mass is composed of euhedral quartz crystals which are visible only under high-power magnification. On the western side, in the Tertiary Humboldt formation, another stratified tuff was observed which has a duller light gray appearance, but is composed of the euhedral quartz crystals. This tuffaceous sequence is interbedded with conglomerates and is capped by coarse textured, slightly calcareous sandstone.

On the northeastern slope of the mountain is a large zone of igneous alteration in which carbonates of Devonian through Lower Mississippian systems have been altered.

A large zone of hydrothermal alteration is located on the northeastern slope of Ferguson Mountain. Within this zone of alteration occur Devonian and lower Mississippian limestones that are so badly altered that it is extremely difficult to identify formations involved.

Igneous activity is found in many localities within the Toana Range and Gold Hill district. Three to four miles north of Ferguson Mountain is Wildcat Peak, a volcanic cinder cone.

The age of the volcanics is difficult to determine with surety. Beds of Tertiary age occur in the area but are not in contact with the volcanics. In the south, outcrops of latite and quartz latite (?) cut the Permian (Wolfcampian) sediments and appear to invade the Triassic Thaynes limestone.

Lloyd (1959) has called attention to the water-worked tuff and glowing avalanche deposits of White Pine County, Nevada, which he

dates as Eocene and Early Oligocene. This was a period of volcanism and it is possible that the igneous tuff around Ferguson Mountain is of this age. This is purely speculative. The writer sampled the sedimentary units above, below, and contiguous with the tuffs for microfossils, but none were found after screening and after treatment with weak acid.

Igneous activity in which the tuffs were deposited may be dated only as possibly Eocene to Pliocene.

Since deposition of the tuffs, there has occurred movement and tilting. Presently, the tuff bed strikes north 5^{o} west and dips 30^{o} west.

QUATERNARY SYSTEM

Relatively unconsolidated sediments comprise the Quaternary age material in the Ferguson Mountain area. These sediments consist of gravels and fan sediments as well as Recent alluvium, colluvium, and slope wash.

Drainage within the area is intermittent. Because of this condition the valleys are covered with thin amounts of alluvial sediments with gravels being deposited in the stream beds. Large fans occur on the east and the southwestern side of the mountain, spreading apronwise from the mountains, being mantled with fan gravels and sediments of Pleistocene and Recent ages. Full exposures of these large fans are not present except for the western side where eroding streams have breached a sizeable gap.

Recent slope wash and alluvium occur in the small upper entrapped basin areas. These areas of slope wash are mantled areas of soil and fragments of the upper Paleozoic rocks.

No measured thickness was made, but may be in the order of a few feet to as much as one hundred and fifty feet in the centers of the valleys.

Quaternary sediments are mingled with re-worked Tertiary Humboldt formation and are extremely difficult to distinguish.

ECONOMIC GEOLOGY

PETROLEUM

Existing complexities, both structural and stratigraphic, make the immediate area unfavorable for oil and gas accumulation. The exposed Permo-Pennsylvanian section is thick, but there are no seepages or surface indications of gas or petroleum, but some limestone rocks, generally those of Permian age, do emit hydrocarbon odors on a fresh fractured surface. With the exception of the Pequop formation, there are few sandy to quartzitic units within the entire stratigraphic section. The Pequop formation is found in the highest elevations of the mountain and the other arenaceous units are thin, exhibiting a tight porosity and not ideal for petroleum reservoir rocks. Some of the bioclastic limestone, however, have excellent reservoir qualities. The numerous dikes that outcrop, indicate that the fissure-fracture pattern of the limestones are possibly filled with igneous material or vein filling ore minerals of later age. Recently, much interest has been given the Mesozoic and Tertiary rock systems of the Nevada area by the petroleum companies. In the Ferguson Mountain area, both the Triassic Thaynes limestone and the Tertiary Humboldt formation are exposed on the surface and appear to be unsatisfactory for oil accumulation.

The Mississippian Chainman shale and the Devonian system possibly could serve as petroleum reservoir rocks. However, this is doubtful because they are exposed in the area and appear to lack the necessary elements for a reservoir.

The writer would not recommend a drilling program for Ferguson Mountain. However, this does not preclude the possibility of oil within the northern and eastern parts of the Great Basin. It is felt that there is a definite need for an expanding exploration program by the oil companies to review and study the miogeosynclinal sediments of the Great Basin.

Subcrops of rocks having comparable qualities to those exposed in Ferguson Mountain in areas surrounding, or even removed moderate distances from this region, possibly have excellent oil and/or gas potential.

Four oil wells have been drilled by various companies within the adjacent areas. To the north of Ferguson Mountain, two wells were drilled. The Last Frontier Oil Company drilled #1 Ferguson Springs, Section 23, Township 31 North, Range 69 East; and Western Osage drilled #1 Ferguson Springs, Section 14, Township 31 North, Range 69 East. No information is available at this time on these two wells. In a communication from Dr. John S. Osmond, area geologist of Gulf Oil Corporation, the following information is given for two wells drilled near Ferguson Mountain.

> "Gulf Refining Company #1 Dennison-Government was drilled in the NE/4 NW/r SW/4 of Section 20, Township 26 North, Range 70 East, White Pine County, Nevada. The ground elevation was 5,492', and the well was spudded on October 4th, 1953. The well was plugged and abandoned March 4th, 1954, after reaching a total depth of 4,498'. The Tertiary sedimentary rocks and volcanics were penetrated to a depth of 2,215', at which point the Kaibab formation was encountered. The Supai formation was topped at 4,100', and the well was still in it when abandoned. No shows of oil or gas were encountered in this well. Electric logs were run, and these are obtainable from Riley Reproduction Company in Salt Lake City. However, in an area of such widely scattered wells, this material has only a documentary, and not an interpretive, value. No typical lithologies were encountered from those exposed in the immediate area.
>
> "Gulf Refining Company #1 Dolly Varden was drilled in the NE/4 SE/4 of Section 36, Township 30 North, Range 64 East, Elko County, Nevada. The well was spudded on January 7th, 1953, and was plugged and abandoned at a total depth of 3,158' on April 29th, 1953. This well was drilled through lower Triassic rocks having a thickness of 291', where it topped the Gerster member of the Kaibab formation. The Tyrone Gap member was encountered at 675', and the Phosphoria member at 2,795'. There were no shows of oil or gas in this hole. Electric logs were run; however, they are of little value in interpreting the geology here."

METALS AND MINING

A search for ores of copper, iron, lead, and zinc, as well as the precious metals of gold and silver, has been undertaken in the past on Ferguson Mountain.

Limonite gossans without boxworks principally in the southern end, are exposed throughout the area, regardless of elevation. These gossans are generally small and overlie the fissures from which the mineralization occurred. Limestones covered with malachite are frequently found in diggings on the mountain.

A sample of high grade galena and sphalerite was found on the mountain, but it is not known if this ore is from mineralized veins on Ferguson Mountain or hauled in from another source.

To the south are two abandoned mine sites from which a great deal of ore appears to have been recovered. One mine, the "Dead Cedar Mine" was, at one time, a center of much activity. Miners and prospectors have searched the area, centering their activities around the limonite gossans, leaving behind mine shafts, adits, many prospector's diggings, and small claims. It is doubtful that much ore has been recovered from these abandoned digging and it appears that mostly lease work has been accomplished.

OTHER PRODUCTS

Within this area are additional economic products which have been used, or could be used, when the economics warrant their exploitation. These would include the following: gravel, building stone, tuffs and pumice, which could be used for abrasives and cleansing powders, and cinder clocks. Dolomite, with its magnesium content (21.7%), could be used in the manufacture of certain cements and of magnesium for use in refractory linings of the converters in the basic steel process.

STRUCTURAL GEOLOGY

GENERAL STATEMENT

Structural features of Ferguson Mountain seemingly resemble Basin and Range structural patterns in that they are characterized by fault blocks involving upper Paleozoic rocks that were folded prior to the block-faulting. However, Ferguson Mountain lacks a prominent scarp or fault line scarps on the west side. Minor faulting occurs throughout the area with the principal faults occurring on the east and south parts of the mountain. Fault systems of this area consist of normal faults, transverse faults, strike-slip faults, and slump blocks. No thrust faulting or direct evidence of thrusting was observed in this area, but considered on a regional scale this area possibly has experienced such diastrophism to a small degree, at least. Some fault systems are concealed by Tertiary sediments and Quaternary alluvial debris which have accumulated in the valleys.

Two systems of structural events appear to be present. The first was characterized by Nevadan-Laramide folding, whereas the later system involved Tertiary Basin and Range block faulting.

FOLDING

Upper Paleozoic formations forming this part of the Toana Range were warped into a gentle anticline with a north-south trending axis. However, this folding is not apparent to the casual viewer, as the western limb of the anticline appears to be part of a regional fault block segment. A well defined anticline involving Devonian Guilmette limestone is exposed near the east base of the stratigraphic section; this feature can be seen near the principal dirt road which extends west from Highway 50 to this location. These Devonian rocks are part of a horst and are in fault contact with the Mississippian Chainman shale to the west, and Permian Kaibab limestone to the east. Dips on the Guilmette vary from a few degrees to 37 degrees to the west, to almost 50 degrees east near normal faults on the eastern flank of the small anticline.

Interpretations of the fold are subject to speculation. The anticline was possibly symmetrical before faulting. On the western limb, the dips vary from 20 degrees in the lower part of the section to 37 degrees in the upper beds, with an average of 30 degrees. Intense compressional forces necessary to form this structure probably occurred during a phase of folding of Late Nevadan-Laramide system. Dating of this anticlinal flexure is not precisely known, as most sediments affected by the fold are older than Triassic age. All rock systems from Devonian to Triassic have been buckled by this folding. However, regional studies strongly suggest this structure to be part of an early phase of the Late Nevadan to Laramide orogeny (Gilbert, 1928, p. 3).

THRUST FAULTING

Thrust faulting has been reported in areas adjacent to Ferguson Mountain in eastern Nevada and western Utah. Nolan (1935) has called attention to thrusting on both the east and west sides of the Gold Hills district; Roberts (1958, p. 2820) reports thrusting near Carlin, Nevada; Gould (1959, pp. 18-19) mentions thrusting in the Needle Range; and Wheeler (1950, pp. 1513-1514) made note of two thrust faults, one in the Spruce Mountains, which is thirty miles to the southwest of Ferguson Mountain, and the other thrust fault east of Knoll Mountain. Hazzard and Moran (1952, pp. 844-856) have more recently presented evidence discrediting validity of these two latter thrust faults.

Inasmuch as the Ferguson Mountain area lies within or near this area of reported thrusting, diligent search was made for evidence of low-angle thrust faulting. In this area, there is a total lack of such evidence of tectonic deformation, thrust plates, breccias, slickensides, low angle shearing and similar intense compressional activity. Because of the lack of evidence for thrusting, the writer concluded that no major thrust fault or faults affected Ferguson Mountain, and the western limb of the anticline is part of an autochthonous mass of sediments.

NORMAL FAULTS

Normal faulting occurs throughout the studied area, but many of these major normal faults are located predominantly in the lower elevations on both sides of the mountain. A system of parallel normal faults are present in the Ferguson Mountain area.

The major normal faults are longitudinal, striking parallel to the mountain (also regional) structure. The longitudinal faults on the eastern flank of the mountain have greater vertical displacement than

any other place throughout the studied area. On the eastern side of the anticline involving Devonian Guilmette limestone (Section 21) a normal fault with a vertical displacement of a magnitude of 4, 500 feet is recorded here where the Permian Kaibab carbonate sequence is in juxtaposition with sediments of Upper Devonian Guilmette. Dips on the eastern limb of the anticline of the Guilmette reflect this normal faulting. These dips vary from 40 degrees to 50 degrees, having been folded by the movement of the thick sedimentary column and pressures of the hanging block wall. The longitudinal fault system farther to the east of this major normal fault reflects much less vertical displacement where generally Permian Kaibab is in fault contact with other Kaibab sediments or Lower Permian rocks.

Longitudinal faults with vertical displacements of approximately 400 feet to 2, 500 feet occur on the western limb of the major anticline. The easternmost longitudinal fault on this side has carbonates of the Permian Plympton formation abuting the Pequop formation and Wolfcampian Ferguson Mountain formation. Progressing to the west, the next longitudinal fault of major proportions involves Pennsylvanian Ely limestone in juxtaposition with the Permian Pequop formation, with a total displacement of approximately 2, 500 feet.

Vertical displacements of 2, 500 feet and 4, 500 feet are large and indicative of major faults. These normal faults are not to be considered anomalous as normal faults of much greater displacement are recorded in, and adjacent to, the Great Basin. Gilbert (1928, p. 52) estimates the probable net slip along the normal fault on the west side of the Wasatch Range of Utah as 17, 900 feet.

Movement along the footwall of these longitudinal normal faults has been generally to the east. Two exceptions to this rule are noted in this area. On the eastern side of the mountain, the Devonian Guilmette is in fault contact with the Mississippian Chainman shale. Possibly the western limb of the anticline is the hanging wall and has dropped Ely limestone to the west down over the Chainman, which acted more or less as a lubricant. An alternate explanation of a reverse fault in which Ely limestone was thrust over the Chainman shale is also feasible and should not be completely overlooked; however, the writer considers normal faulting with the west limb having been moved down compatible with facts.

Normal faults, some of which are transverse faults in the mapped area, strike perpendicular and diagonally across the mountain; canyons have been eroded in the weak belts so created. There are five prominant transverse faults within the mapped area. Vertical displacement varies from 60 to 300 feet in the northern and central parts of the area. A major transverse fault is evident in the extreme south end where Devonian Guilmette is in contact with Permian Kaibab and Ferguson Mountain formation, for a total displacement of approximately 3,500 to 4,000 feet.

Transverse faulting occurred at a later time than the longitudinal fault system, as evidenced by one set displacing the older one.

Dating the faulting is not a matter of percision; however, these normal faults of the Basin and Range may possibly be fitted into the regional picture and tentatively dated as Middle and Late Tertiary to Quaternary (Nolan, 1943, pp. 178-85). Louderback (1923, p. 346) was aware of no definite evidence of block-faulting of the Great Basin Range type in Early Tertiary or Cretaceous faulting to be very difficult, or even impossible, to recognize.

One normal fault (northeastern end of area) is more recent than the longitudinal and transverse fault systems, as these fault systems are covered by Tertiary Humboldt formation, whereas, this normal fault displaces this Tertiary lake sediment. The writer is of the opinion that block faulting began as early as Mid-Tertiary and has continued intermittently to the present.

STRIKE-SLIP FAULTS

Minor strike-slip faults occur in the hills of Kaibab limestone to the northeast of the Ferguson Mountain area. These strike-slip faults experienced displacement chiefly parallel to the strike of the fault with lateral displacement varying from 50 to 350 feet. Both right-lateral and left-lateral strike-slip faults occur in this series of faults. At the crest of the mountain, to the south of the stratigraphic section, a right-lateral strike-slip fault occurs, which laterally displaces the Corwenia (?) coral biostrome bed at the base of the Pequop formation 1,600 feet to the southwest.

SUMMARY OF GEOLOGIC HISTORY

Although the oldest sediments exposed in the Ferguson Mountain area are Devonian in age, it is believed that a full sequence of Cambrian, Ordovician, Silurian, Devonian, and Mississippian rocks was deposited in this area, but is now buried. Eardley (1951, p. 16) indicates that the Cordilleran miogeosyncline was an area of great subsidence in which Early Paleozoic sediments (Cambrian through Silurian) were accumulated in great thickness. Cambrian strata alone have thickness of approximately 15,000 feet in eastern and southern Nevada. Sandstones, shales, limestones, and dolomites are characteristic of Lower Paleozoic sediments.

During Devonian time the Cordilleran miogeosyncline was broad, but the axial part centered in Nevada where the most complete Devonian section is found (Eardley, 1951, p. 17). In the Gold Hills district adjacent on the southeast to Ferguson Mountain, approximately 2,300 feet of Devonian sediments were deposited, of which the upper 900 feet are Guilmette formation. The writer estimates a thickness of approximately 900 to 1,000 feet for the Guilmette within this area, of which only the upper part outcrops east of Ferguson Mountain. Elsewhere in the Toana Range, full sections of the Guilmette can be found. The record of structural events began after this sequence of Paleozoic deposition. The Antler orogeny, which received its initial pulsation in Late Devonian, continued intermittedly into Permian times (Nolan, 1943, p. 171). This orogeny, which created the Manhattan geanticline, was the first major orogenic movement known to involve the thick Paleozoic rock systems within the Great Basin (Roberts, 1958, pp. 163-168). Steele (1959a, p. 1105) believed this orogeny was responsible for the Northeast Nevada High, an east-west trending positive feature in northeast Elko County, Nevada. This high positive area later furnished sediments to the east and south. Contemporaneous with this orogenic movement was the deposition of the Chainman shale at Ferguson Mountain and coarse to medium clastics to the north near A-1 Canyon by Wendover.

In Late Mississippian time a local uplift existed in the Ferguson Mountain area, which was accompanied by non-deposition and erosion. This uplift continued throughout Springeran time into Morrowan time.

With the transgressing seas of Pennsylvanian (Morrowan) time the site of Ferguson Mountain became enveloped as a depositional basin of limestones and silts, in which the Ely limestone accumulated. During this period of limestone accumulation, areally extensive regions in part of Great Basin possibly were gently uplifted during Desmoinesian time (Steele, 1959a, p. 1105). This uplift was also accompanied by non-deposition and erosion locally and existed until Middle of Late Missourian. As the positive forces subsided and erosion was accelerated, the area again was inundated with a continuation in the deposition of the calcareous Ely through Missourian and Virgilian time. This depositional environment continued into Lower Permian.

The greater part of the Permian time was a period of continued deposition, within a transgressive sea during the Wolfcampian epoch, with only minor diastems, although situated in an area affected by the Cordilleran geanticline which lay to the west. The Cordilleran geanticline became emergent in Permian and lasted into Early Mesozoic. The Wolfcampian epoch was a time of spasmodic unrest, but structural conditions were favorable for the deposition of a thick limestone sequence (Ferguson Mountain formation). Subsidence continued into the Leonardian epoch, with oscillating seas depositing the silty limestones and calcareous quartzites of the Pequop formation. Later, but still in Medial Permian time, a transgressive sea, entering the area from the south, inundated the Ferguson Mountain area depositing the carbonate sediments of the Park City group.

During some part of Guadalupean time this part of Nevada was again uplifted. This uplift persisted into the Triassic period when the area was again unundated, for the last invasion. It was during this deposition that the Thaynes limestone, a relatively thin calcareous sequence, was deposited within a small depositional basin, possibly formed as a topographic low eroded in Permian sediments.

During the Jurassic and Cretaceous periods, the Nevadan orogeny and later the Laramide orogeny of the Cretaceous and Tertiary periods subjected the Basin and the Range to tectonic paroxysms. During these orogenic pulsations or spasms, compressive forces buckled the Paleozoic sediments and possibly the Ferguson anticline was formed at this time.

Early to Middle Tertiary time (Eocene and Oligocene) was a time of volcanism in the Ferguson Mountain area with numerous dikes, and low-grade ore deposits being formed in and around the mountain. In Middle Tertiary time (Miocene) the Basin and Range region was again subjected to major deformational forces. Sedimentary sequences were

faulted by these forces into characteristic Basin Range block-fault. During Pliocene time there was a period of aggradation and locally lacustrine sedimentation around Ferguson Mountain of the Tertiary Humboldt formation, which consists of conglomerates, sands, and calcareous muds interbedded with a welded tuff. Sedimentary rocks of Upper Miocene through Pliocene possibly accumulated to great thickness high on the slopes of the fault blocks only to erode away during Pleistocene time. Waters of ancient Lake Bonneville extended up to the Toana Range; evidence of its former existence is shown as wave-cut cliffs and embankment deposits in the lowlands to the north of Ferguson Mountain. Lake Bonneville sediments are not known to be present in this area.

CHERT CLASSIFICATION FOR MIOGEOSYNCLINAL SEDIMENTS

Chert commonly is associated with Permo-Pennsylvanian miogeosynclinal carbonate rocks of the eastern Great Basin. These cherts vary in color from black to light gray (almost white), but commonly are dark brown to light brown. Total per cent of chert in individual limestone units observed in the Ferguson Mountain area varies from zero to as high as fifty per cent; approximate average for limestone units is five per cent. Chert generally occurs as relatively thin beds or layers a few inches to one foot in thickness, or as irregular nodules a few inches across maximum dimensions, flattened normally into oblate spheroids, lenses, and disk shaped bodies which extend parallel to bedding planes. Tarr (1917, pp. 409-452), Twenhofel (1919, pp. 272-280) and Barton (1918, pp. 361-374) have described nodular chert in limestone formation and have given excellent descriptions of this variety. Bissell (1958, pp. 150-185) called attention to chert and other forms of silica, mode of occurrence, and nature of the silica, as well as the source of the siliceous material of Upper Paleozoic sediments within the Cordilleran area, and more specifically the Rocky Mountain trough of Eardley (1951, p. 43) or Millard Belt of Kay (1947, p. 1291). Photos of chert beds are included in Bissell's work, depicting numerous ways chert can occur within limestone beds.

Study of published works, which refer to cherts in Upper Paleozoic sediments within this Cordilleran region, make evident the lack of uniformity in terminology. Nodular varieties have been referred to as blebs, blebby, gobs, gobby, blobs, blobby, nodular, spherical, rounded, irregular shaped; whereas, the bedded chert types have been called ribbon, layered, lunch-meat, bedded, undignified masses, interlayered, wavy, stringers, etc. Such chert terminology is burdensome, confusing and unwieldy. Because of these difficulties and inconsistencies, the writer has sensed a need for a more organized, simplified, and usable classification. With it, more scientific description could be given, both in the field when investigating stratigraphic sections, as well as in subsequent publications or reports. The following chert classification is suggested for use in the field with the intent that it might prove of value to geologists working with miogeosynclinal sediments, particularly in the Cordilleran area. Obviously, it needs testing for use elsewhere.

Chert in outcrops generally occurs in one or more of these four circumstances: bedded chert, nodular chert, clastic chert, and cemented detrital chert.

I. Bedded chert is abundant in Upper Paleozoic carbonate sediments (Bissell, 1958, pp. 150-185) of the Millard Belt of the Cordilleran, while in other areas, formations such as the Monterey formation (Miocene) and the Franciscan formation (Jurassic and Cretaceous) of California, also include enormous amounts of chert in great thickness. Generally within the Millard Belt, this variety of chert occurs in beds commonly less than one foot in thickness. Therefore, a modification of the bedding terminology of McKee and Weir (1953) and Kelley (1956) is made in order to be applicable for use with the bedded cherts.

Bedded Chert

Massive	> 12"
Thick bedded	6" to 12"
Medium bedded	2" to 6"
Thin bedded	1" to 2"
Laminated	< 1"

Variations of bedded chert may occur within a limestone unit. Modifying terms, such as laminated to thin beds, thin to thick bedded, etc., will be the geologists' natural recourse in description.

When a massive chert bed is encountered which is much thicker than normally expected, this bed would be listed as massive with the exact or estimated measurement given in feet. To describe an interbedded sequence, for example, of chert and limestone (listed in the literature as "lunch-meat" and interlayered chert) would be described as inter-layered thin bedded, or thick bedded chert (which applied) in laminated or thin bedded limestone.

Bedded cherts are, in general, laterally continuous, and can be used locally as marker beds in correlation.

A geologist working a carbonate-chert stratigraphic section may find measuring each linear chert bed of greater accuracy, efficiency and value. However, this chert classification is submitted for ease of description to give the general appearance of the cherts in outcrop.

Explanation of Plate 2

1. A prominent bed of large bedded chert with scattered medium nodular chert varieties.

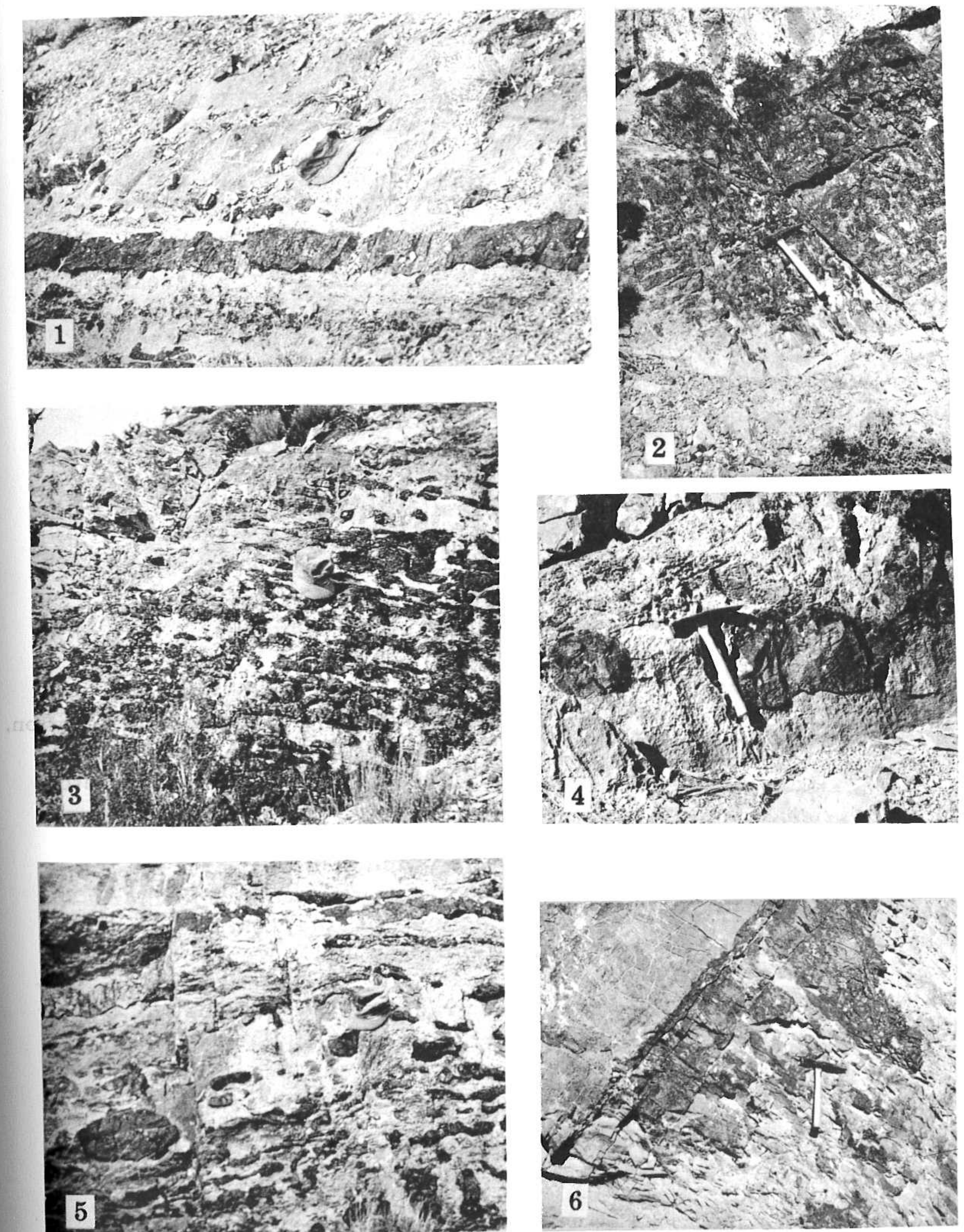
2. Massive bedded chert (3 to 4 feet thick).

3. Medium bedded chert exposed in limestone cliff.

4. Large nodular cherts which are spheroidal and elongate, sub-spherical.

5. A fracture zone with medium to large bedded cherts intermingled with oblate spheroidal and lenticular small to large nodular chert.

6. Massive bedded chert (2 feet) with some case hardening chert in lower portion.



II. Nodular cherts derive their name from nodules which are round to sub-round masses, and some irregular curvilinear varieties. As explained previously, nodular cherts have been described in many ways and have projected speculation as to origin.

The following is a thickness subdivision for nodular chert:

Nodular Chert

Large nodules	> 6"	in
Medium nodules	2" to 6"	greatest
Small nodules	< 2"	dimension

The largest diameter of the observed chert nodule should be used as the thickness measurement. This is for two reasons:

1. from two of the three sides of the chert nodule, one is able to measure the longest diameter, whereas, for the other, the small diameter is obtained.

2. an incorrect and inadequate description is obtained from the measurement of the smaller diameter.

In the nodular chert portion of this classification, modifying adjectives should be utilized to explain the shapes for greatest description. These adjectives would generally be circular, spherical, lenticular, oblate speroidal, elbow, curvilinear, and sub-rounded to rounded, etc.

III. Weathering of clastic strata which contain cherts in bedded or nodular varieties will produce loose remnants of former existing cherts. This occurs within the area of study and can be picked up usually at the base of a cliff-forming unit. Wentworth (1922, pp. 377-392) provided a means of standardizing clastic rock terminology with the Wentworth grade scale. This grade scale will fit well for the clastic cherts in the larger rock sizes, with some slight modifications:

Clastic Chert

	Diameter in mm. (Wentworth Scale)	Present Modification
Boulder size	> 265	> 10"
Cobble size	64 to 265	$2\frac{1}{2}$ to 10"
Pebble size	16 to 64	0 to $2\frac{1}{2}$"

IV. Cemented detrital cherts are usually derived from a weathered limestone terrain in which the chert remnants are recemented to form chert pebble or pebble chert conglomerate (Krumbein and Sloss, 1958, pp. 125-126). For the larger detritals, cobble or boulder chert could be used. This description gives only the type and size of the rock, but does not refer to the type cement found cementing the rock.

Outline depicting chert classification:

Bedded Chert

Massive chert	> 12"
Thick bedded chert	6" to 12"
Medium bedded chert	2" to 6"
Thin bedded chert	1" to 2"
Laminated chert	0" to 1"

Nodular Chert

Large nodular chert	> 6"
Medium nodular chert	2" to 6"
Small nodular chert	< 2"

Cemented Detrital Chert

Boulder chert
Cobble chert
Pebble chert

Clastic Chert

Boulder	> 10"
Cobble	$2\frac{1}{2}$" to 10"
Pebble	0 " to $2\frac{1}{2}$"

Modifying Adjectives*

Curvilinear	Concretion
Circular	Elongate
Spheroidal	Boulder
Lenticular	Tabular
Sub-spherical	Concentric
Oblate spheroid	Elbow shaped
	Sub-round to round
Case hardening	
Liesegang banding or rings	

*Standard abbreviations from (Mitchel and Maher, 1957) followed where applicable. The other modifying adjectives are taken from Webster and are in general use among geologists.

APPENDIX

The following field note check list for describing stratigraphical sections of Dr. Lehi F. Hintze was used to describe the stratigraphic section at Ferguson Mountain.

LOCATION: Describe so that someone else can relocate the section easily. Adequately describe and mark the beginning point; state the direction taken from the beginning point, instruments used, names and duties of party members. Plot location on base map or photo.

ATTITUDE OF BEDS: Strike and dip; always record this at beginning of section and at places where attitude changes.

DESCRIPTION OF INDIVIDUAL ROCK UNITS: The following 6 features must be described for each stratigraphic unit:

1) Thickness of unit

2) Rock Name: clyst, mdst, sltst, ark, gywke, qtzt, ss, gvl, cgl, anhy, chk, cht, coq, dol, gyp, ls
   Mixture modifiers: shy, slty, sdy, bit, grty, pbly, intb, intfm, lmy
   Texture modifiers: vc, c, m, f, vf; sl-crystalline, gr-grained

3) Color: on fresh and weathered dry surface. Use color chart, common terms. bl, blk, brn, gy, gn, mar, olv, orng, pk, purp, wh, yel, vcol, dk, m, lt; stained, mottled, banded, homogeneous.

4) Bedding: thn lam, lam, v thn bdd, thn bdd, m bdd, thk bdd, v thk bdd, respectively under 1/8", 1/8"-1/2", 1/2"-2", 2"-1', 1'-2', 2'-4', 4' plus.

5) Splitting: papery, shy, flgy, slab, slab, blky, mas

6) Topographic expression: cliff (rnd, vert, ireg); ledgy-slopes; slopes.
   Exposure: g exp, fr exp, p exp, cov.
   Weathering products: rubble, soil, pitted surfaces, etc.

The following features are to be described where applicable:

7) Fossils: Name if possible. Number each specimen collected before wrapping. Record the following in the notes: Exact stratigraphic location, abundance (rr, c, abnt), orientation of fossils as found.

8) Clastic rock description:
   Grain shape-tabular, spherical, elongate, bladed
   Grain roundness-angular, subangular, subrounded, rounded
   Grain surface-dull, smooth, rough, polished
   Sorting-good, average, poor
   Components-estimate % of qtz, mica, femag, $CaCO_3$, clay, feld, rk frag. (type)
   Cement-Fe, sil, calc, cly, other; degree of cementation g, fr, p

9) Chert: give color, estimate % of rock it comprises, state form as layered, nodular, lenticular, irregular, etc.

10) Structures: ripplemarks, mudcracks, crossbedding; describe fully.

11) Contact with underlying unit: sharp - gradational; even - irregular; parallel - angular; covered

12) Rock samples and photographs: number systematically with exact location and significance recorded in notes.

Note: Abbreviations used above from Mitchell and Maher, AAPG, 1957.

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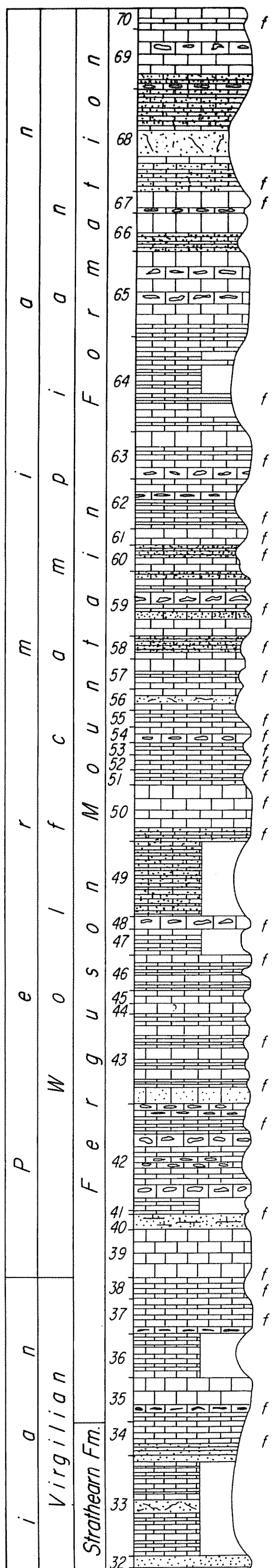


f 70 ls, aphan, brn blk wthrs med gy, platy & blocky, fus & crin com

69 ls, slty to cse xln, brn blk to gy blk wthrs lt olv gy fossil hash bd, brach r, chert, brn & blk lam & thn bdd

68 slty ls, w/f grn qtze, brn blk to lt olv gy wthrs med gy to gy orange, platy fus com, crin abnt, chert in upper portion of unit, blk, lam bdd.

f f 67 ls, xln to aphan, olv gy to lt olv gy, platy large crin near base, cor & fus occur, chert, lt gy to lt brn, intbd thn to med bdd

66 slty ls, brn gy wthrs brn blk, platy criquinite zone cor & bry occur, chert nt v com

65 ls, aphan almost sublith ls, gy blk to brn gy wthrs med lt gy, gast, crin, brach, & bryz occur, chert, med to dk brn, thk bdd, large nod, hydrocarb odor

f 64 ls aphan to xln, brn gy to lt olv gy, platy, Dictyoclostus, crin, fus com, cor & worm trails

f 63 ls, xln to aphan, lt olv gy to brn gy wthrs lt to med gy, criquinite zone, fus, fus, chert, dk brn thn bdd

f 62 ls, aphan, lt olv gy to med gy to blk wthrs lt to med gy, platy, Dictyoclostus, fus, Lioclema (?) com, chert med mod hydrocarb odor

f f 61 ls, aphan, lt olv gy wthrs lt gy, platy, Squamularia (?) Syringopora, Dictyoclostus, r, chert, lt brn med to thk bdd & incrusting

60 ls, slty, olv gy wthrs med gy, platy, fus bry com, Dictyoclostus, Juresania occurs, chert dk brn, thn bdd

f 59 slty ls, olv gy wthrs med gy, platy & flaggy, fus com to abnt, bry com, chert dk brn, med nod to thn bdd

f 58 slty ls, brn blk to olv gy wthrs med to lt gy, platy, productid brach, fus & fossil hash r to com, hydrocarb odor

f 57 ls, xln, sly slty, brn gy to olv gy, wthrs med by, platy, fus com, chert, lt to dk brn th bd

56 ls, w/intbd calc qtzte, olv gy wthrs med lt gy, chert dk brn

f 55 slty ls, brn blk wthrs lt olv gy, platy, bry & fus not com, hydrocarb odor

f f 54 ls, xln, lt olv gy wthrs med lt gy, fus com, chert, dk brn, thn bdd & small nod, hydrocarb odor

f 53 ls, gy blk to lt olv gy wthrs med gy, platy, fus abnt

f 52 ls, lt olv gy wthrs med gy, fus upper part of unit, Syringopora, chert dk brn, thn bdd hydrocarb odor

f 51 silty ls, lt olv gy wthrs yel gy, platy, fus com, Lioclema (?)

50 slty ls, olv gy wthrs med lt gy, fus com to abnt, Syringopora, productid brach, chert, lt to dk brn, thn bdd w/x bdd, hydrocarb odor

49 ls slty, olv gy wthrs yel gy, Hustedia

f 48 ls, brm gy to olv gy wthrs med lt gy, blocky, fus abnt up to biostrome of Syringopora, chert, dk brn small bdd & small nod

47 ls, slope covered w/ls frags

f 46 ls, silic, olv gy wthrs med lt gy, fus near top com, Juresania, chert, sly, drk brn small nod

45 ls (?), slope covered w/soil & float

44 slty ls, xln olv gy wthrs lt olv gy, mas

f 43 slty ls, olv gy wthrs lt olv gy, fus com, Composita, scaphopods, Linoproductus, carb matl near top

f

f 42 ls, dk gy to olv gy wthrs lt olv gy, flaggy to platy, fus & bry com, echinoid plates Juresania r, chert dk brn med bdd

f 41 ls, med dk gy wthrs med lt gy, fus abnt

40 ls (?), covered w/f grn qtzte, olv gy

39 ls, brn gy wthrs med lt gy, mas & blocky, fus v abnt

f 38 ls, lt olv gy to gy blk wthrs med gy, fus near top, not abnt

f 37 ls, dk gy to lt gy, wthrs yel gy to lt gy, slabby, fus & biostromal sequence Syringopora, 6' to 1' thick, chert brn to lt brn, thn bdd

36 ls (?) covered

35 ls, xln, brn gy wthrs lt olv gy, mas blocky & flaggy, fus, Caninia, Syringopora, chert, lt to dk brn, lam to thn bdd

f 34 slty ls, lt olv gy to brn gry wthrs lt olv gy, platy, fus v abnt, bry Syringopora

33 ls, (?) slope covered Syringopora, & fus abnt in float

32 Qtzte, f grn, slty cal, dk yel brn, wthrs v lt gy

31 Criquinite ls med dk gry wthrs med gy, crin hash, chert dk brn, small to med nod

f 30 ls, xln, olv gy wthrs lt olv gy, chert tan to brn lam to thn bdd

f 29 ls, aphan, brn gy wthrs med gy, fus, com to abnt, chert dk brn lam to thn bdd

28 ls, xln, olv gy wthrs med lt gy, flaggy, chert dk brn lam to thn bdd

27 Qtzte, sly calc, lt olv gy wthrs brn & blk gy, f grn, chert lt brn, small nod

26 ls, lt olv gy wthrs lt gy, mas, crin frags, chert med brn

25 ls (?) covered

f 24 ls lt olv gy wthrs lt gy, mas, bry crin com, solenoporoid algae, chert dk brn lam bdd

23 ls (?) covered

22 slty ls, lt gy wthrs lt gy, fossil hash & spiriterid brach com, chert, dk brn, lam to thin bdd

21 ls (?) no outcrop

f 20 ls med gy wthrs med gy, fus, bry Penniretopora abnt, echinoids, chert dk brn intbd & lam bdd

f 19 ls aphan, gy blk to med gy, platy & flaggy, fus com, Dictyoclostus & Chonetes spiriterid brach, bry, cherts, lt to dk brn

18 slty ls, dk to lt olv gy wthrs lt to med gy, platy, Dictyoclostus & Syringopora Chonetes

f 17 slty ls, lt olv gy wthrs med lt gy, platy

16 slty ls, med gy to yel gy wthrs lt gy, blocky & platy, fus, fossil hash, chert lt to dk brn to blk, lam & intbd

15 ls, xln, lt gy wthrs drk drn blk, splits blocky, chert lt to dk brn, lam bdd

14 ls sly slty, olv gy wthrs med lt gy wthrs slabby & flaggy, fossil hash of crin brach, bry & cor, chert lt to dk brn thn to med bdd w/small to med nod

13 slty ls, lt olv gy wthrs yel gy, wthrs platy, bry fenestrate & Lioclema (?) abnt, chert, dk brn, med bdd

f 12 ls, olv gy wthrs med lt gy, wthrs blocky & mas, bry Lioclema & other sps & fus com, cal brach r, chert lt to dk brn, lam bdd

11 ls (?) no visible outcrop, covered w/platy ls frags of overlying unit

f 10 ls, xln. lt olv gy wthrs lt med gy, wthrs platy & slabby, chert lt tan, small to med nod & lam bdd

9 ls, med brn gy wthrs lt olv gy, platy bry Lioclema, Penniretopora, Fistulipora com w/crin

8 ls, slty, lt olv gy wthrs lt olv gy, platy fus r, rug cor & crin com, chert, lt brn to brn blk

7 slty ls, lt olv gy wthrs lt gy, fus, Syringopora & crin com, chert lt gy to brn, intbdd w/l&s cherts

6 ls, xln, brn blk wthrs lt olv gy, rug cor, abnt bry, Lioclema (?), chert lt to dk brn, small to large nod, hydrocarb odor

5 ls, med gy wthrs lt gy, platy, rug cor, chert intbdd, dk to lt brn thn bdd, large nod

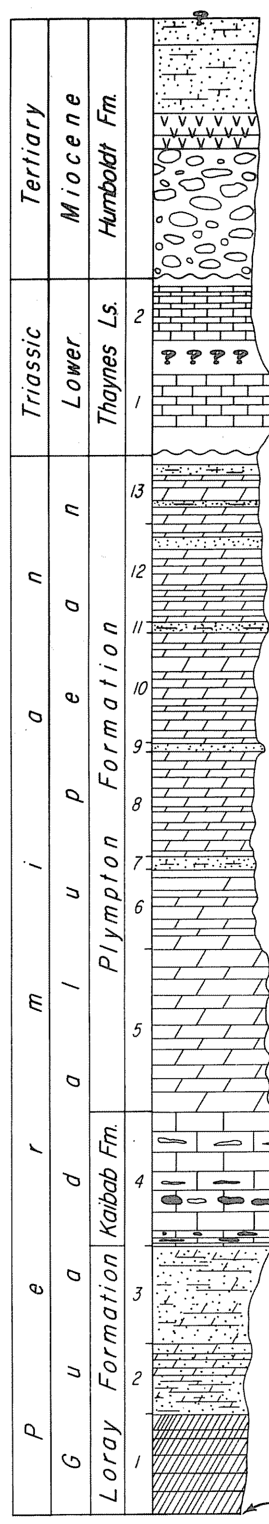
f 4 ls, med gy wthrs lt to pale brn, wthrs platy, fus, Dictyoclostus, chert, dk to lt brn lam to thn bdd

3 ls, aphan w/intbdd cherts, gy to med dk gy wthrs lt olv gy, rug cor, chert med bdd mass to thn bdd

f 2 ls aphan w/slt dk gy wthrs lt olv gy, lam bdd, fus

1 ls olv gy wthrs lt to med gy, w/intbd thn–med bdd chert dk brn to lt brn. Gradational contact w/Miss. Chainman sh

ls, w/intbd cherts, calc, sh, lt to med gy & brn.



Unconsolidated to poorly stratified mantle, fanglomerates, colluvium & poorly com congl

Section not measured – Estimated to be 250'-500' in thickness

Paleozoic derived pebble congl intbd w/a wh vitric tuff, overlain by gy orange sly calc ss

2 slty ls, dk yel brn wthrs yel gy, splits papery

1 ls, c xln, yel brn wthrs dk yel brn, flaggy, Meekoceras

13 dolo, calc dolo & slty dolo w/calc ss, aphan to xln near top, dk gy to gy brn wthrs lt yel gy to med brn gy, hydrocarb odor w/dead oil

12 dolo sly calc aphan to fn xln, dk gy wthrs lt to med gy, sly hydrocarb odor

11 calc & dolo ss, lt brn gy wthrs lt brn to lt gy, sdy

10 dolo to calc dolo, aphan to fn xln, w/zones of dolo & calc ss, dk gy wthrs lt gy, blocky, sly hydrocarb odor

9 calc ss, lt brn gy wthrs lt brn to lt gy, fn sdy

8 dolo, calc aphan to cse xln, lt to dk gy wthrs lt gy, flaggy to blocky, sly hydrocarb odor

7 calc ss slty lt brn gy wthrs lt gy, sdy

6 dolo, slty, calc, aphan to cse xln, dk gy to brn gy wthrs lt brn gy, crin com

5 dolo w/intbd calc dolo & dolo sltst w/basal 5' cong, v lt gy to pink gy wthrs lt gy, fn sdy, blocky, crin com, cherts, lt brn small nod

4 ls, cse xln, lt brn gy to med gy wthrs lt gy to lt brn gy, mas, crin abnt. brac r to com, chert dk brn, thn to thk bdd, small to large nod

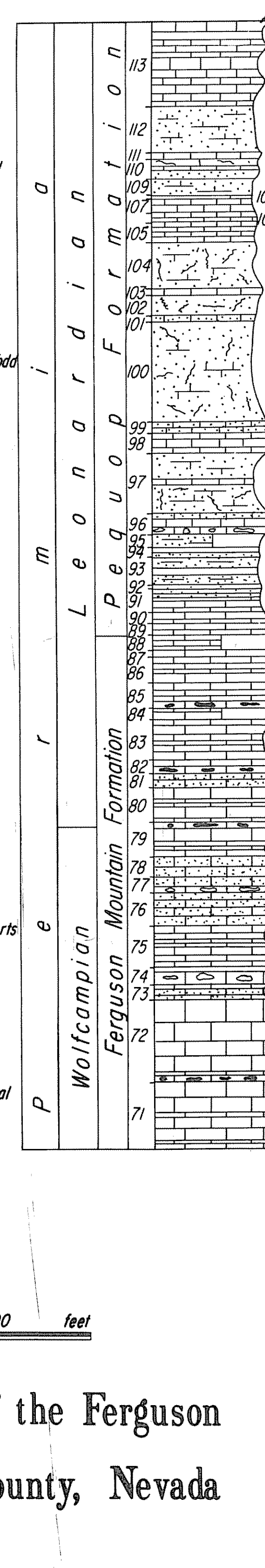
3 slty dolo, intbd w/calc dolo & sltst, lt gy to lt yel wthrs yel gy, fn xln to aphan, platy, flaggy

2 dolo, intbd w/slty dolo & dolo sltst, lt yel brn to lt & med gy wthrs pale yel brn to yel gy, platy

1 gyp, powder to xln, wh to bl gy wh wthrs wh, v lt gy earty to mas

Base covered by alluvium

Note: (Fault terminates section on west side of Ferguson Mountain. Remainder of Pequop fm. & all of Gerster ls. cut out)



113 ls, sly slty w/intbd qtzte, med gy wthrs lt med gy, chert med to dk brn small to med nod

112 calc qtzte, brn to dk gy wthrs yel gy, flaggy

111 ls, sly slty, med dk gy wthrs med gy, flaggy chert, lt to dk brn small to med nod

110 calc sltst same as above two intbd ls zones

108 f f 106 109 calc sltst, yel brn wthrs yel brn, platy, crin, bry abnt, fus com, productid brach r

f 108 ls, med dk gy wthrs lt olv gy, fus com Composita (?) Hustedia (?)

107 ls, slty, yel brn wthrs yel brn, fus com, Composita (?)

106 ls, slty, dk gy wthrs med dk gy, crin abnt

f 105 ls, slty, dk gy wthrs yel brn, fus, crin, Lioclema (?) abnt

104 qtzte w/intbd ls bds, yel brn wthrs lt olv brn, f frn, fus, crin, bryz

f 103 ls, gy blk wthrs yel brn, crin & fenestrate bry, hydrocarb odor

102 qtzte, lt olv gy wthrs gy orange, f grn

101 qtzte, calc, intbd w/thn bdd ls, lt brn wthrs lt olv gy, fus abnt, fossil hash zones

100 calc qtzte, lt olv gy wthrs tan, f grn, chert dk brn

f 99 slty ls, lt olv gy wthrs med gy, platy & flaggy crin

98 ls, xln, olv gy wthrs lt olv gy, crin

f 97 calc qtzte, f gr, lt olv gy wthrs tan gy fus abnt

96 ls, slty, dk gy wthrs med dk gy, chert blk to brn blk, intbd, med to thk bdd w/nod

95 calc qtzte, olv gy wthrs yel gy, Lioclema (?)

f 94 ls, xln, olv gy wthrs tan gy, fus abnt, zone of fn grn calc qtzte

f 93 intbd sequence of calc, qtzte & slty ls, brn gy to lt olv gy wthrs med gy, platy, fus abnt, small biostrome of rugose cor

f 92 ls, olv gy to brn blk, wthrs med dk gy, platy, flaggy, biostrome of rugose cor 3/4" dia 12 to 14 ins long

91 slty, ls, med dk gy wthrs lt med gy, platy, fus, crin com, hydrocarb odor

90 calc qtzte, lt olv gy wthrs yel brn, platy, fus abnt, gast

89 slty ls, lt olv gy wthrs dk to med gy, platy

88 ls, xln, olv gy wthrs med lt gy, chert, blk med nod

87 ls (?) slope covered

f 86 ls, xln, olv gy wthrs med gy, small biostrome near top, chert, dk brn, mid-portion 2ft calc-qtzte bd

85 ls, xln, sly, slty, med lt gy wthrs med gy, prominent cor zone, chert dk brn to tan intbd, med bdd

f 84 ls (?) slope covered

f 83 ls, xln, olv blk to olv gy wthrs lt olv gy

82 ls, xln, olv gy wthrs lt olv gy, fossil hash, gast, fus, chert brn small to med nod

81 ls, slty, aphan brn gy wthrs lt olv gy two biostromal zones of corals 1/2" dia 4 to 5 ins long

80 ls, xln, brn gy wthrs med gy, fus com, chert dk brn, intbd thn to med bdd, med to large nod

79 ls, aphan lt olv brn to brn gy wthrs med gy fus abnt chert, lt brn, intbd thn to med bdd, calc qtzte, brn gy wthrs yel brn, splits platy fus com

f 78 ls, slty, lt olv gy wthrs med gy, cor abnt

77 slty ls, lt olv gy wthrs med gy, colonial & rugose cor abnt, Syringopora biostrome 1 ft thk, chert, lt to dk brn, thn bdd, small nod

76 slty ls, aphan brn gy wthrs med gy, slabby, rugose cor com, col cor biostr of Syringopora

f 75 ls, aphan, sly slty, brn blk to olv gy wthrs med gy, cor, biost of Syringopora, chert,

74 ls, xln, sly slty, bas pt intbd w/plty calc sltst, olv gy wth med gy, criq zn, hydcarb odor

73 ls, xln, olv gy wthrs lt olv gy, fus & cri r, hydcarb odor

72 ls, xln, olv gy wthrs lt to dk gy, fus abnt at base, crin com, chert, brn, large nod

71 ls, xln to aphan, brn gy wthrs med lt gy, three biostromal bds of colo & rugose cor varying from .5 to 3.5 ft thk, Syringopora, chert dk brn, nod, thn to med bdd

Note:

1. f refers to fusulinid zones. Fusulinids are not referred to by specific name. Lyle M. Slade in a thesis in preparation has made a detailed systematic fusulinid study of Ferguson Mountain. A chart in Slade's thesis similar to the one above contains more information.
2. Subsequent detailed fusulinid studies indicate the Permo-Penn. boundary occurs at the base of unit 39
3. Grant Steele proposed the name Loray formation for strata which the writer has included as the Kaibab ls. (see Pennsylvanian–Permian Stratigraphy of East-Central Nevada & Adjacent Utah. in Intmn. Assoc. of Petrol. Geol. Guidebook 1960 p. 91; 106-107.)

100 0 100 200 feet

Stratigraphic Section of the Ferguson Mountain Area Elko County, Nevada

by

John S. Berge

1960

— LEGEND —

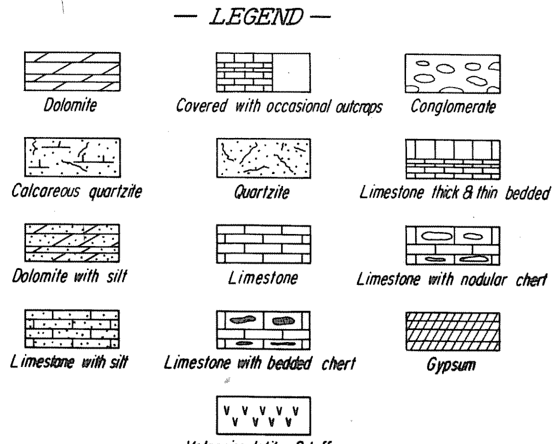
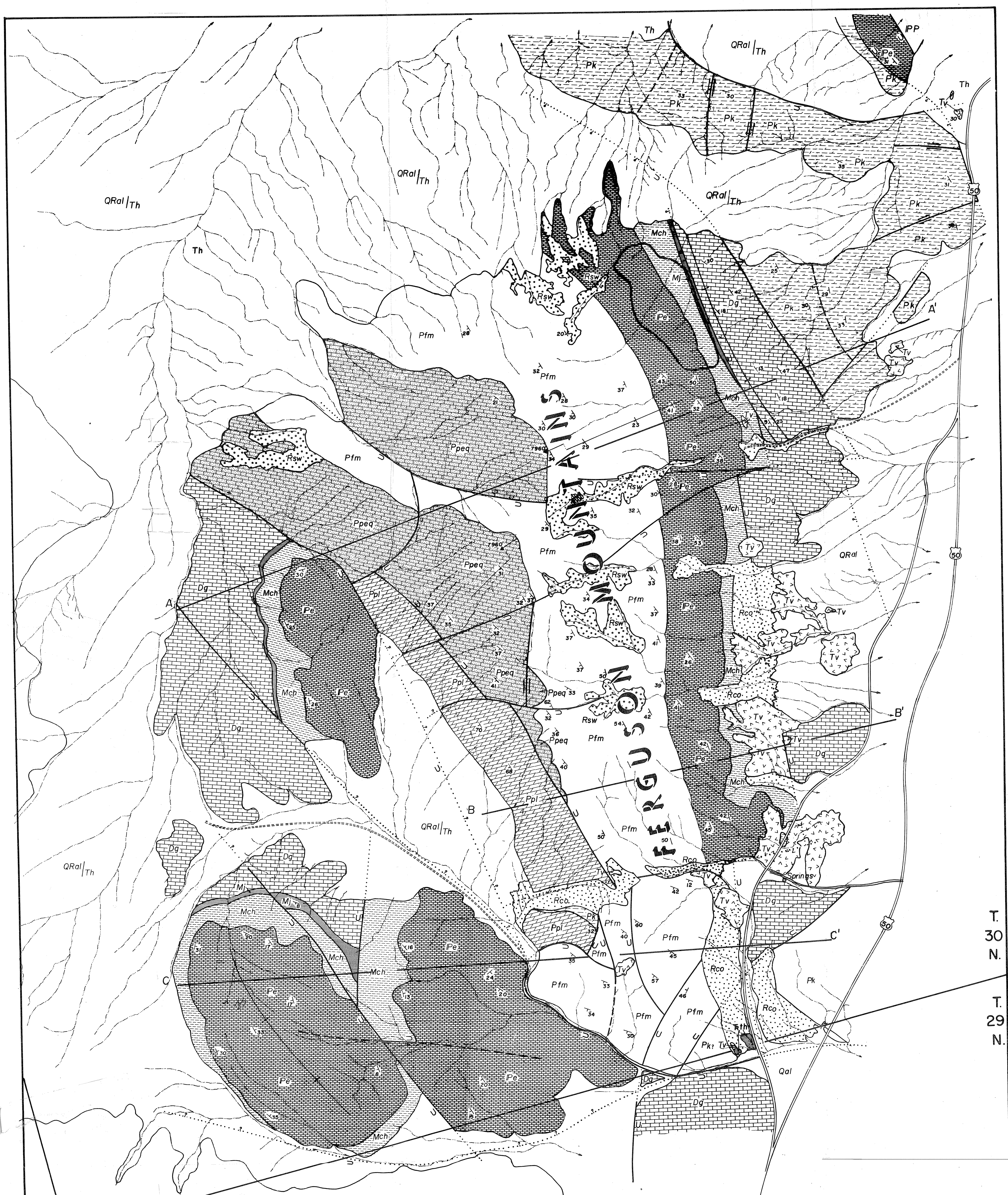


PLATE 4



EXPLANATION

QUATERNARY & RECENT
- Rsw — Recent slope wash
- Rco — Recent colluvium
- QRal/Th — Quat & Recent alluvium with Humboldt formation

TERTIARY
- Th — Humboldt formation
- Tv — Volcanics undifferentiated

TRIASSIC
- Ћth — Thaynes limestone

PERMIAN
- Ppl — Plympton formation
- Pk — Kaibab limestone
- Ppeq — Pequop formation

PENNSYLVANIAN
- Pfm — Ferguson Mountain formation
- ℙe — Ely limestone

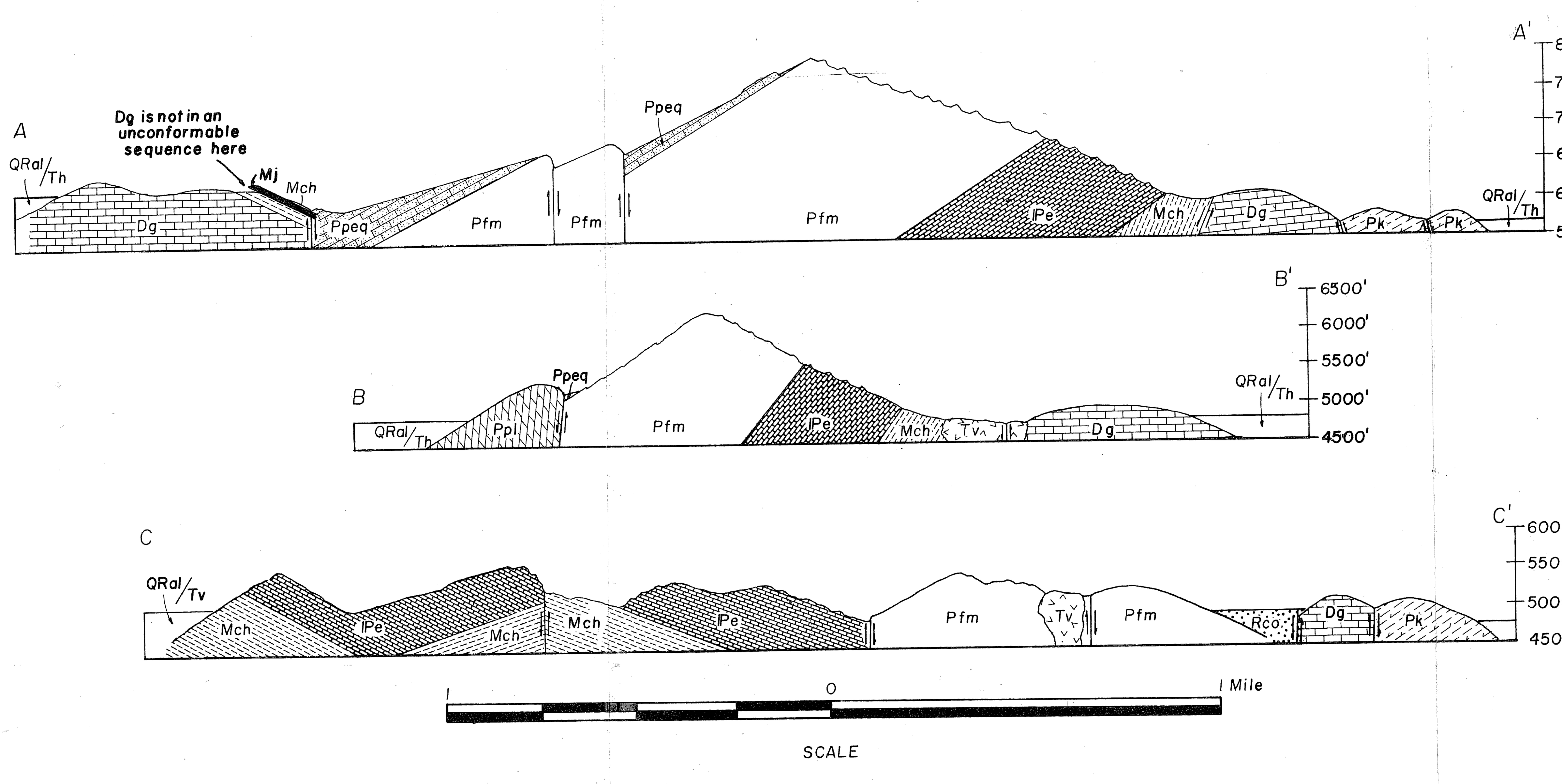
MISSISSIPPIAN
- Mch — Chainman shale
- Mj — Joana limestone

DEVONIAN
- Dg — Guilmette limestone

SYMBOLS

- Hydrothermal alteration
- Dip and Strike
- Anticline Syncline
- Faults, inferred, concealed
- Roads, paved, unimproved
- Contacts, inferred, concealed
- Stratigraphic Section

True North / Magnetic North 17°



GEOLOGIC MAP AND SECTIONS OF FERGUSON MOUNTAINS, NEVADA

JOHN S. BERGE

1960