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THE GEOLOGY OF THE PAHRANAGAT RANGE
LINCOLN COUNTY, NEVADA

PART I
INTRODUCTION

PART II
PALEOZOIC AND CENOZOIC STRATIGRAPHY

by
Anthony Reso

A dissertation submitted to the Faculty in partial fulfillment of the requirements for the Degree of

Doctor of Philosophy

Approved
April 30, 1960

Houston, Texas
April 1960

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NOTICE

Readers who have no intention of visiting the area under discussion should consider the section on Vegetation (pp. 65-75), the chapter on Political and Cultural History (pp. 76-99) and the chapter on Field Methods (pp. 116-117) as Appendices.
EXPLANATION OF PLATE III

FRONTISPICE

The Pahranagat Valley with the town of Alamo (pop. 250, elev. 3450) in the foreground, is seen in contrast to the relief of the east face of the Pahranagat Range whose highest elevation in view is 8038 feet (see Figure 2, p. 46, for location).

In this view the east face of the Pahranagat Range is composed of the Tertiary Curtis Canyon ignimbrite dipping 15° eastward toward the observer. Inliers of westward dipping Mississippian Joana limestone are exposed in the canyons (Box Canyon location a, and Hells Bells Canyon location b). Where the Curtis Canyon and other Tertiary formations have been completely eroded the Joana limestone is well exposed, (location c upper right of photograph).

An alluvial fan issues from Box Canyon onto the broad alluvial pediment surface of the valley (location d).

The Pahranagat airport, seen about one mile west of Alamo, is a graded north-south dirt strip 2600 feet long that may be used for light planes and emergency landings.
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ABSTRACT

This report defines and describes all exposed rock units in the Pahranagat Range, southeastern Nevada. The 600 square mile subject area, located in one of the most isolated regions of the United States, has not received previous detailed investigation.

Geographic, economic, and geological reasons are cited for the long delay in consistent interest in the area. Regional physiographic setting and physical geography of the Pahranagat Range and adjacent valleys is discussed. The Range is a typical Basin and Range feature extending about 48 miles north-south and having a maximum east-west width of approximately 16 miles. Relief is well over a mile. The political and cultural history of the Pahranagat area over the past 100 years is reviewed. A brief silver "boom" at Mount Irish in 1865 resulted in the establishment of Lincoln County and several towns in the area. Hiko, now only a farm, was the first county seat.

Thirty-four references that allude to Pahranagat Range
geology over the past 95 years are reviewed. Only 3 references, resulting from this research, refer to the Pahranagat Range by title. The remainder are essentially brief remarks in other works.

More than 18,200 feet of Paleozoic strata ranging in age from early late Cambrian to late early Pennsylvanian are exposed in the Pahranagat Range. Nineteen formations and 33 members belonging to 12 of the formations are described. Included are near maximum thicknesses of virtually all known Paleozoic time rock units in the eastern Basin and Range Province. The sequence is typical of a miogeosynclinal sedimentary tectonic framework being composed primarily of dolomite, limestone, and orthoquartzite with a minor amount of shale. Petrogenesis, depositional history, and paleoecology of each stratigraphic unit is discussed and integrated with marine oscillations resulting from regional diastrophic episodes. Relationships between source and reservoir characteristics applicable to petroleum exploration are discussed for each stratigraphic unit.

Up to 3000 feet of exposed Tertiary rocks are represented in the Pahranagat Range primarily by a sequence of welded tuffs (ignimbrites) of the glowing avalanche type, other pyroclastics,
and minor amounts of water worked tuffs, lacustrine beds, basalt flows and alluvium. The major volcanic sequence is considered Oligocene-Miocene.

Major Pahranagat Range structural features are illustrated. The general geological history is reviewed. No major late Paleozoic structural deformation is apparent. Uplift of the Pahranagat area as part of the Sevier Arch took place in Mesozoic time. The area was thrust faulted during the late Cretaceous and Block faulted during late Tertiary time.

All pertinent data relating to present and future research in the subject area is presented.
THE GEOLOGY OF THE PAHRANAGAT RANGE

LINCOLN COUNTY, NEVADA

by

ANTHONY RESO

PART I

INTRODUCTION

GENERAL REMARKS

The United States owes its industrial success to the development of its natural resources. For this reason there are few areas which have not received some geological study no matter how remote or inaccessible they may be. Nevertheless recent Index Charts of the United States Geological Survey on the Status of Topographic and Geological Mapping in the United States indicate vast areas which are unsurveyed or unmapped. The geology of these areas is understood only in terms of their broad tectonic features and physiography.
For example, it is known that such areas constitute a pre-Cambrian meta-
morphic terrain rather than a province of Mesozoic folds. Limited ad-
ditional information can usually be found in the literature but detailed
studies, if any, are usually restricted to unpublished files of Petroleum,
Mining and Exploration Companies.

One of the last such "Frontiers" of American Geology is the
Basin and Range Province, and in particular its Paleozoic and later
history in Eastern Nevada. Only pioneer settlements existed in this
area a hundred years ago when portions of the New England Paleozoic
had already been subject to 50 years of detailed mapping and controversy.
A combination of geographical, economic, and geological considerations
are responsible for the long delay in the development of consistent
interest in the Basin and Range, notwithstanding the 20th century works
of Edwin Kirk, T. B. Nolan, C. W. Merriam, and Chester Longwell.

Geographical Considerations

Most areas of the immense Basin and Range Province are ex-
tremely rugged, and still difficult of access. Paving of highways and
building and maintenance of new roads has only occurred since the end
of World War II. Even so, the 1958 Nevada Road Map still shows great
areas without roads. The arid-hot summer climate and severe winters
is extremely unfavorable especially in the lower elevations of South-
eastern Nevada and Western Utah. One must be a little venturesome
to assault this land even in 1960. A hundred years ago it took no small
quantity of daring and a lust for wealth to attract nomadic prospectors.
When the nation spread westward the arid Basin and Range was by-passed because new settlements were dependent upon fertile agricultural lands available in California. The resulting, and continuing sparse population has contributed little in the way of academic geological speculation or accidental discovery that normally occurs in more populated regions.

New roads, the availability of the jeep, and accelerated competition among "industrial" as well as "academic" geologists for new areas of geological investigation have been partly responsible for increased activity in the Basin and Range Province since 1946.

**Economic-Geological Considerations**

There has been a notable deficiency in Basin and Range studies on the part of California geologists, in spite of their relative closeness to the region. This is best explained by the fact that West Coast geological emphasis, stimulated by the Petroleum Industry, has long been directed chiefly toward the investigation of Mesozoic and Cenozoic stratigraphy in their unique structural province, which contains few Paleozoic exposures. Even when West Coast geologists ventured across the Sierra Nevada they applied their knowledge and experience to additional post-Paleozoic stratigraphic and structural problems leaving the eastern Basin and Range Paleozoic region essentially untouched.

Discovery of petroleum from Tertiary volcanic rocks in eastern Nevada in 1954 resulted in several years of activity on this specific,
but previously neglected, area of study. The vast majority of information gathered on Basin and Range Tertiary volcanic sequences has been held unpublished by companies and private consultants. Economic interest in this subject is currently dormant. There have been no Paleozoic Petroleum discoveries in the Province to stimulate any concentrated study in the face of the geographical difficulties.

Detailed mapping and study of eastern Basin and Range Paleozoic areas have been limited to Mining Districts where the structure is complex and rock alterations commonly profound. In the majority of cases these areas have not proved favorable for regional stratigraphic synthesis since faunules are rare and sections incomplete; thus making inter-Range correlations speculative.

Geological Considerations

Studies on middle Paleozoic history are especially lacking. This is probably due to the fact that there were no early definitive classic studies by experts upon which to base new investigations. Western Cambrian faunas for example became rather well known in the late 19th and early 20th century through the vigorous efforts of Charles D. Walcott and the same may be said for the Carboniferous faunas under the inspiration of G. H. Girty. Intermediate systems remained almost untouched from the days of the Federal Exploratory Expeditions until C. W. Merriam's Devonian work in 1940. Additional
work by Merriam or other investigators was delayed by World War II. Except for the coral studies of Stumm (1937, 1938, 1949) and Duncan (1956, 1957) the Eureka District U.S.G.S. Professional Paper of Nolan, Merriam and Williams (1956) represents the only significant published contribution to mid-Paleozoic Basin and Range geology in the past 20 years.

Cambrian and Carboniferous faunas are cosmopolitan and can be correlated successfully throughout North America. This aided the early workers and still stimulates modern students. The result is that a great proportion of Basin and Range publications continue to concern these systems whereas Silurian and particularly Devonian work has been avoided. The inference is that it is easier to work with familiar faunas upon which there is significant literature rather than on incompletely known faunas.

It is generally understood, but rarely emphasized, that middle Paleozoic faunas are provincial in North America. For example, many guide fossils of the New York Devonian type section, notably those of the arenaceous facies, are not found in Devonian rocks exposed elsewhere in North America--especially in the western carbonate facies. There was a land barrier of great extent in the Rocky Mountain region during the early and medial Paleozoic that separated seas of the present Basin and Range area from eastern North America. Far western Silurian-Devonian faunas are related to northwest Canadian,
Arctic, and European forms from which they are considered to have been derived. Thus systematic descriptions of Silurian-Devonian faunas in the far west cannot be directly compared with those of time equivalent eastern faunules of the North American type sections but must take into account European and Arctic literature. It is significant that in describing the new western Richmondian index coral, *Bighornia*, Duncan (1957) lists 22 foreign and only 8 American references in the bibliography.

Studies concerning Basin and Range Ordovician strata have likewise been delayed, but in general, they possess somewhat less severe faunal restrictions. A large amount of stratigraphic synthesis has been accomplished in the past decade through the persistent efforts of Marshall Kay and his Columbia associates. The U.S.G.S. and U.S. National Museum specialists have also been active on Ordovician Basin and Range stratigraphic and faunal problems.

**Summary**

The major contributions to Basin and Range geology over the past 100 years have been small scale mapping projects limited to isolated Mining Districts, regional studies on a particular formation, or upon structural features of limited areas. At this time there is no published detailed study of a large scale area in the eastern half of Nevada that integrates stratigraphic, faunal, and structural data from which the interpretation of the Paleozoic and later history can
be made and which might serve as a standard for comparison else-
where. There is no Nevada State Geological Map.
HISTORY OF THE INVESTIGATION

The writer has been interested in Basin and Range geology for some time having presented in 1955 a thesis for the Masters Degree at Columbia University entitled "The Geology of the June Canyon Region, Toquima Range, Central Nevada." This work was directed by Marshall Kay, the writer having spent the summer of 1954 in field research with the aid of a Columbia University grant.

During 1956 the writer continued to work in the Basin and Range terrain of the Davis and Barrilla Mountains, West Texas, while employed by the Atlantic Refining Company.

In 1957, when the writer was a graduate student at the University of Cincinnati, he became interested in Devonian stratigraphy and paleontology through the influence of Kenneth E. Caster. The Correlation Chart for Devonian Rocks of North America (Cooper et al, 1942) contains 80 columns of which only 15 are devoted to the 10 western states and 8 to western Canada and Alaska. These columns are inadequate in that they do not do justice to the vast distribution of western Devonian strata in the light of present knowledge. The California column, for example, is a composite of sections 600 miles apart and of different facies. The writer therefore embarked on a
project to construct a separate Correlation Chart for the Devonian of the Western States that would contain some 60 columns and an up-to-date glossary of terms.

The type section and faunal zones for the Devonian strata of the Western United States were established in 1940 by C. W. Merriam whose classic report soon became the basic reference for all "Western Devonian" investigations. This resulted from the fact that Merriam's type section was the most nearly complete, relatively undisturbed Devonian sequence (4500 feet) described up to that time. This column was therefore used as the Standard for the Western Devonian Correlation Chart.

Over 200 references were consulted. However, it soon became apparent that because of vast deficiencies in Devonian stratigraphic and faunal descriptions, (due to the reasons previously discussed), it was not possible to correlate the numerous known Devonian sections against the Western Standard entirely from the literature with assurance. Except for detailed distribution and refined nomenclature the Chart soon began to take the shape that was not much better in time-stratigraphic value than the published correlation chart. A re-evaluation of the Devonian localities as well as the type section would be necessary in order to make any further contribution.

In the course of this investigation the writer became impressed with Merriam's remarks (1940, pp. 40-41) that Devonian sections
in the Pahranagat Range, Nevada, may have an even greater thickness
than the type section but had received little attention since visited by
Walcott at the time of the Eureka Survey (Hague, 1892, p. 196). A
faunal list for the Upper Devonian of the Pahranagat Range also contains
species not typical of Merriam's type section. Hence Merriam con-
cluded, "that a study of this fine Pahranagat section would be of great
significance in furtherance of knowledge of the Western Devonian."

It was decided that the Pahranagat Devonian section should be
investigated prior to further work on the Correlation Chart because
if it did prove to be of greater time-stratigraphic value any further
correlations of Devonian localities against Merriam's type section
might be obsolete before the study began. Moreover, the writer was
not completely satisfied with the Standard Column.

Consultation with the literature, various information depart-
ments of the United States Geological Survey, and correspondence
with Dr. Merriam and with Dr. Vernon Scheid of the Nevada Bureau
of Mines, confirmed the fact that relatively little additional work had
been done in this specific Western Devonian area.

Study of this Devonian problem was pursued while the writer
was a Graduate Fellow in Geology at the Rice Institute during the
academic years 1957-1959 spending the summers of 1958 and 1959 in
the field. During the second year the study was broadened to include all
phases of Paleozoic and later stratigraphy and general geology of
the Pahranagat Range area. During the 1959-1960 academic year
the results of the three years of stratigraphic work were brought
together for this presentation.
SCOPE AND PURPOSE OF THE WORK

This report presents the first two parts of a projected definitive work on the Geology of the Pahranagat Range, Nevada. This 600 square mile area entirely lacks previous detailed investigation.

Part I introduces the subject area and presents remarks on all phases of inquiry in the scope and style of organization of pre-1940 U. S. Geological Survey Professional Papers.

The first means of approach in studying a new area is the establishment of superposition and definition of stratigraphic units that may best be utilized in geological mapping. These basic determinations must precede any geological interpretation. Thus Part II presents the stratigraphy of all exposed rocks in the Pahranagat Range area. Remarks concerning petrogenesis, depositional history, and paleoecology, that can be determined solely from the strata and fauna are introduced.

It is not the purpose of this report to present geologic history (the ultimate goal of all geological interpretation), which can only be deduced from integrated stratigraphic and structural studies.
However, at this stage of development the criteria have been established, and this report documents the data from which structural synthesis and geologic history can be determined. It is hoped that this work may serve as a standard for comparison in future similar integrated studies of nearby regions.

Future subjects of the Pahranagat Range project will be entitled: Part III - Structural Geology; Part IV - Geologic History; and Part V - Economic Geology (Mining, Petroleum, Ground Water, Soil Geology and Agriculture). Plate I is offered with this report solely as an index chart. It is the base upon which the geology is being mapped.

The definition and description of time and rock units as presented in Part II has direct application in petroleum exploration. In wildcat, as well as development drilling, the identification, thickness and correlation of stratigraphic units and the knowledge of their desirable physical properties of porosity and permeability are of ultimate importance in the consideration of possible reservoirs.

A larger theoretical consideration in petroleum exploration is also involved in the scope of this and impending studies. The area under investigation lies along the approximate axis of a tectonically deformed Paleozoic miogeosyncline. The goal of every comprehensive petroleum effort is an integrated picture of the distribution and sequential development of environments of deposition with respect to
contemporaneous and later structural history of the sedimentary basin. Presently, however, there are few comprehensive studies of sedimentary basins. For this reason stratigraphic, faunal, and structural studies to determine the geologic history of sedimentary basins is listed in first rank in research needs in Petroleum Geology by the A.A.P.G. Research Committee (1957). Such an approach is envisaged in the scope and purpose of the present and subsequent parts of this investigation.
ACKNOWLEDGMENTS

The writer wishes to thank first and foremost his faculty advisor, Professor Carey Croneis of The Rice Institute, for continuous encouragement and support throughout all phases of this investigation.

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LOCATION AND EXTENT OF THE AREA

Regional Physiographic Setting

The Basin and Range Province embracing over 300,000 square miles, extends from southern Oregon southward through Nevada and western Utah, across southern Arizona and New Mexico, West Texas, and part of old Mexico. The Province as a whole is characterized by hundreds of more or less parallel north-south trending isolated mountain ranges of the Block Mountain type separated by basins (Figure 1, p. 40).

The mountain ranges vary in size but lengths of 50-75 miles are common as are widths of 6-15 miles. The ranges attain elevations up to 14,000 feet above sea level and rise from 3000-5000 feet or more above the broad alluvium filled basins between them which actually cover as much area as do the mountains themselves.

Throughout most of its area the Basin and Range is arid with a rainfall of less than 5 inches a year due to the higher Pacific Ranges that rob the prevailing westerlies of much of their water.
Figure 1. Physiographic Diagram of the Nevada Basin and Range Area. (From Raisz 1957 Landforms of the United States)

Approximate position of the Boundary between the Great Basin and the Colorado River Basin in Eastern Nevada.
Nevertheless most of the area is at times subject to torrential downpours. These sudden rains carry vast quantities of detritus from the mountains onto the adjacent plains. Extensive alluvial fans are thus formed around the margins of the inter-montane basins. Sheet flood erosion accompanies these floods and is a factor in producing broad slope rock pediments especially at the foot of the older ranges. At times of rain the basin plains become temporarily covered with small lakes or "playas."

The Basin and Range is the most sparsely settled part of the United States. Its density of population is less than one person per square mile.

The Basin and Range Province as outlined is divided into five sections of unequal size (Fenneman, 1930, p. 328; Lobeck, 1950, p. 12). The major subdivision has long been known as the Great Basin. Fremont (1845) defined this area on the basis of drainage as the region from which no water flowed to the sea. The term Great Basin is misleading as this sub-province is not an area surrounded by a rim but rather an area within which there are over a hundred separate basins (Fenneman, 1930, p. 348). Moreover if there were enough water the result would be eventual overflow from one basin to another and the water would escape to the sea long before the entire "basin" was covered.
The hydrographic definition is also unsatisfactory because, as pointed out by Nolan (1943, p. 142), a boundary drawn solely on the basis of drainage would exclude a considerable area drained by the Colorado River that is geologically and physiographically closely related to the undrained regions. For this reason Nolan (1943, p. 143) redefined the limits of the Great Basin as follows: The western boundary is formed by the eastern front of the Sierra Nevada and the eastern boundary is made up by western borders of the Wasatch Range and the Colorado Plateau. On the north Nolan selected an arbitrary boundary line running essentially along the northern borders of Nevada and Utah. The Colorado River defined the southeastern boundary and the San Andreas Fault the southwestern boundary (Figure 1).

Lobeck (1950, p. 12) distinguished a Closed or Northern Basin from the Open Great Basin Area, the latter being drained by the Gila, Colorado and Rio Grande Rivers. He recognized that the ranges of the Open Basin and Southern Basin and Range subdivisions are rounded and more eroded than those of the Closed Basin. Basin filling between the Ranges of New Mexico, for example, is much greater than between ranges of Nevada and the mountains have less relief. He concluded that the Open Basin was of greater structural age and that there had been progressive migration of fault movements from south to north.
The problem of physiographic terminology is discussed because the Pahranagat Range area is not in the "Great Basin" as defined by Fremont (1845) but is in the "Great Basin" of Nolan (1943) and Open Basin of Lobeck (1950), since it is drained by the Colorado River system (Figure 1). To avoid confusion the term Great Basin is not used in this report and the phrase Basin and Range Province is used exclusively to describe the physiographic region in which the Pahranagat Range is located. The abbreviated term Basin Ranges is also employed.

The processes by which the physiographic features of the Basin Ranges were formed have been discussed by many investigators. One of the earliest views formulated was that of Clarence King (1870) who suggested that the north-south mountain chains were the tops of folds whose deep synclinal valleys were filled with Tertiary and Quaternary detritus. Spurr (1901) also advanced the belief that the present form of the ranges is due primarily to long-continued erosion of a much folded and faulted region. Along with this assumption goes the idea that the climate was more humid and that aridity is relatively recent. Keyes (1909) believed that a general peneplain existed somewhere near the present mountain tops and that the basins have since been excavated on the weaker rocks, primarily by wind.
Soon after King published his explanation of the Basin Ranges, G. K. Gilbert (1874) suggested that the region had been broken, mainly along north-south lines, into blocks that had been tilted at various angles. Basin and Range topography would thus have been caused directly by late Tertiary and Quaternary faulting whose effects are still manifest in the modern landscape. Gilbert's theory of the Origin of the Basin Ranges with some modification was adopted by the early workers in the province namely by Powell, Dutton and Russell, as well as by Clarence King (1878) who changed his views, and came to agree with Gilbert.

Basin and Range topography and its structural implications has been debated in great detail by Joseph Le Conte (1889), W. M. Davis (1901, 1903, 1905, 1930), G. D. Louderback (1904, 1923, 1924), B. S. Butler (1913, 1920), A. C. Lawson (1915) and Eliot Blackwelder (1928). The history of the "Basin Range Problem" is reviewed in a posthumous paper by Gilbert (1928).

The question continued to be reviewed and discussed by Fenneman (1930), Nolan (1943) and more recently by Longwell (1945, 1949, 1950), Lobeck (1950), Cotton (1950) and P. B. King (1959). It is clear that fundamental Basin and Range problems are far from solved and that... "we continue to devote our interest and our energies to finding out exactly what is to be explained"...

...Longwell (1950, p. 432).
No further discussion on the origin of the Basin and Range Province is intended in this report. The structural history of the Pahranagat Range will be the subject of future investigation in conjunction with detailed mapping. It can be shown that the Pahranagat Range is bordered on both sides by normal faults. However, the area has also experienced removal of large quantities of basin fill during the more pluvial climatic conditions of the Pleistocene through the Colorado River drainage system.

Physical Geography of the Pahranagat Area

The Pahranagat Range is located in western Lincoln County, southeastern Nevada (Figure 2, p. 46 - Plate I, Caliente Quadrangle map). It is a typical Basin and Range feature that extends some 48 miles north-south and has a maximum east-west width of approximately 16 miles. The town of Alamo, population 250, is located on the eastern side of the range in the Pahranagat Valley (Plate III - Frontispiece p. 3) and with the exception of the towns of Caliente, Panaca, and Pioche, 55 to 80 road miles to the northeast, is essentially the only community within a radius of 100 miles, (Caliente Quadrangle - Map pocket).

Relief and Drainage. The highest elevation in the Pahranagat Range is Mount Irish which rises to 8741 feet. Thus there is well over a mile of differential relief in the area, the elevation at Alamo being 3450 feet and the lowest point on the map area less than 3200 feet,
Figure 2.- Index map showing the Pahranagat Range and surrounding area, Lincoln County, Nevada, with outline of Index Base Map (Plate I).
(Plate III; IV, Figure A and Caliente Quadrangle).

It has been emphasized that the Pahranagat Range is within the Colorado River Drainage area and is so designated in all U.S. G.S. and Nevada State Water Supply Reports, (Carpenter, 1915, p. 8; Maxey, 1949, p. 10; and Miller et al, 1953, p. 12). This area is outlined in Figure 1.

The Pahranagat area is drained by the White River Basin which extends from about the latitude of Ely to the head of the Muddy Valley near Glendale, (Figure 1, p. 40). The Muddy River is a tributary of the Colorado River. This drainage basin includes the White River, Pahranagat, Coyote Spring Valley and the area now known as the Upper Moapa Valley. The total length of the basin is about 175 miles and its total area about 3000 square miles including all the mountain and valley tracts that drain into it. The trace of highways 38 and 93 from north to south through the Pahranagat Valley runs essentially parallel with the White River, (Figure 2 and Plate I).

Physiographic evidence indicates that the ancient White River was a stream of considerable magnitude. During the humid Pleistocene epoch, when the region received more abundant rainfall than at present, it carved a channel through the drainage basin from Preston, Nevada (about 25 miles south of Ely) to the present confluence of Meadow Valley Wash and the Muddy River. Throughout
the length of the valley the channel is cut into the easily erodible partly consolidated sediments, (which at one time filled the valley to a higher level than at present), to a depth ranging from a few feet to 50 feet or more and an average width of 1/4 mile..

In the Pahranagat Valley the channel is cut 50 feet deep and one fourth of a mile wide for 40 miles. Alluvial slopes bordering the old river channel and terraces formed by the degraded stream as it flowed over the plain in Pahranagat Valley have been greatly dissected by marginal drainage, (Plate IV, Figure B, pp. 49-50; Plate V, Figure A, pp. 54-55). In a few places the White River cut entirely through the alluvium and deeply incised bedrock. An example of this erosion is exhibited at Hiko Narrows (about 10 miles north of Hiko between Fossil Mountain and the Hiko Range where the stream cut into Volcanic Rock and Limestone, (Plate IV, Figure B). Seven miles south of Alamo the White River cut a channel 75 feet deep in welded tuffs and at Maynard Lake it cut another also in volcanic rocks which is estimated to be about 500 feet deep (Carpenter, 1915).

The change in climatic conditions and the consequent drying up of the ancient river has resulted in debris being washed in from the mountains partly silting up the old channel in many places. An example of this silting occurs about a mile north of
EXPLANATION OF PLATE IV

Figure A

The Pahranagat Valley is a ribbon of irrigated land some 40 miles long ranging in width from a few hundred feet to less than a mile. It is essentially the bed of the ancient White River which drained this area to the Colorado River and thence to the Gulf of California.

The hill just southeast of the town of Alamo in the foreground is a hogback of the Alamo Range formation (Tertiary volcanics). A broad pediment surface of alluvium is seen in the distance and on the skyline about 25 miles away is Mount Irish, the highest point in the Pahranagat Range (8741 feet).

Figure B

A view of the northern part of Pahranagat Valley looking south from Fossil Mountain. The Hiko Range is on the left. Terraces formed by dissection of alluvial slopes due to marginal drainage into the White River are shown at the lower right (Location a), and deeply incised volcanic rocks are seen in the Hiko Narrows at the lower left (Location b).

The trace of a major fault is considered to run between the eastern edge of the Pahranagat Valley and the Hiko Range.
Hiko, where a canyon from the Hiko Range joins the main valley.

Drainage in the White River Basin and Pahrangat Valley is at present limited to the runoff from the mountains. The old River channel is dry throughout the year except during the rather rare times of flood when considerable water may come down the channel. Five such floods are recorded at Hiko between 1887-1910 (Carpenter 1915) and present inhabitants of Pahrangat Valley recall similar floods in recent times. Most of the water that leaves the mountains soon sinks into the loose gravel and soil on the upper parts of the alluvial slopes and only in exceptional downpours does water reach the central part of the valley.

Except for a few springs there is no permanent running water in the Pahrangat Range and adjacent valleys. Three major groups of thermal springs and several smaller springs in Pahrangat Valley supply water for domestic use and irrigation. These are Hiko Spring, Crystal Spring (about 4 miles south of Hiko), and Ash Springs (5 miles south of Crystal Spring) Plate I; Plate XXXVIII, Figure A. They produce a fairly constant flow of about 40 second feet of soft water. The water from these springs flows into five small lakes, (Lakes Hiko, Frenchy, Upper Pahrangat, lower Pahrangat and Maynard - Plate I and Caliente quadrangle). These lakes have been impounded in the Valley, partly by alluvial
cones from lateral washes and partly by artificial earth dikes. Water from the springs flow to the several lakes during the winter. In the summer months, when this flow is diverted for irrigation the lake levels drop considerably since they are not then fed by their own springs. After a flood, or when lower Pahranagat Lake has been filled, the water continues southeast and fills Maynard lake. The water table is very near the Pahranagat Valley surface in winter but may drop as much as 20-30 feet in the summer.

An extended discussion of Ground Water in so far as it affects soil geology and agriculture is reserved for a future part of this study.

Geomorphology and Valley Features

Almost every type of physiographic feature of the Basin and Range province may be seen in the Pahranagat area.

The Pahranagat Range is physiographically sub mature. Sharp gorges and canyons as well as broader valleys occur in the Range. The drainage pattern is invariably fault controlled. Alluvial fans issue from the mouths of most drainage systems onto the broad pediment surfaces of the alluvial filled basins (Plate III). The most spectacular alluvial fan is seen on the western side of the Range in Desert Valley (Plate V, Figure B, pp. 54-55).

Pahranagat Valley lies along the larger White River Valley
for a distance of about 40 miles. It is a narrow strip of irrigated land ranging in width from a few hundred feet to less than a mile (Plate IV, Figure A, p. 50). This valley is of interest since it is affected geomorphologically by exterior drainage (as discussed) and the rather plentiful spring waters make it the only habitable place in the region.

Coal Valley borders the Pahranagat Range on the north and lies between the Seaman Range on the east and Golden Gate Range on the west (Figure 2, p. 46). Coal Valley is one of the driest basins in southeastern Nevada, only one small spring being present in an area of about 225 square miles.

The most interesting topographic features in the valley are distinct terraces and beaches, which were produced by the waves of an ancient lake, (Plate VI, Figure A, p. 59). At its period of greatest extension this lake was about 14 miles long and 6 miles wide. Its maximum depth at this period was about 75 feet. The ground surrounding the shore features extends to higher levels, showing that the lake had no outlet, although under exceptional conditions it could have drained through Seamans Wash to the White River and Pahranagat valleys (Plate I and Caliente Quadrangle map). The central part of the valley is flat and barren. The valley fill is composed of sand, clay, gravel, and boulders which have been
EXPLANATION OF PLATE V

Figure A

A view looking at the east face of Fossil Mountain in the upper Pahranagat Valley. Prominent terraces formed by the dissection of alluvial slopes during the more pluvial climatic conditions of the Pleistocene are seen in the center foreground. The East face of Fossil Mountain is a fault scarp. The formations exposed are (a) The Lehman formation (Ordovician), (b) The Eureka Quartzite (Ordovician), (c) The Fish Haven dolomite (Ordovician), (d) The Laketown dolomite (Silurian), and (e) The Sevy formation (Devonian).

Figure B

Prominent alluvial fan formed by an intermittent stream that issues from a valley cut in the west face of the Pahranagat Range in Desert Valley.
washed from the surrounding mountains and which extend to an
unknown depth below the surface. A hole drilled to a depth of 250
feet failed to reach bedrock or water. The material lying within
the shore lines is mostly fine clay and sand which was deposited in
the relatively quiet waters of the lake. This lake probably existed
in Pleistocene time and was correlative with Lake Bonneville. Un-
consolidated sediments exposed in the valley are Pleistocene and
Recent in age, but the underlying sediments may be Tertiary
(Carpenter, 1915).

Desert Valley borders the Pahranagat Range on the west,
(Plate VI, Figure B, p. 59). Extensive playa lakes occur along its
center the largest of which is Sheep Playa (Caliente Quadrangle map).
Coal valley is about 1400 feet and Desert valley about 600 feet
topographically higher than the center of Pahranagat Valley.

Accessibility and Trails

The Pahranagat Range area may be reached by U.S. highway
93 that connects Las Vegas and Ely, Nevada(Plate I, Figure 1, p. 40).
It enters the district on the south, follows Pahranagat Valley some
25 miles and turns eastward at Crystal Springs. This highway was
not paved until 1945-46. Nevada Highway 25 heads westward at
Crystal Springs to Tonopah by cutting through the Pahranagat Range
at Hancock Summit. This route was paved in 1956 for access to the
Tempiute Mine, (Figure 2, p. 46; Plate XXXVIII, Figure B). It serves as the primary means of access to all parts of the Pahranagat Range. Numerous crude trails take off in various directions from Highway 25 and they may be traversed by jeep or truck for access to the most remote exposures of the range. Nevada Highway 38 also leaves Crystal Springs and heads northward to Sunnyside. It is not paved north of Hiko. Paved routes, secondary gravel roads, and crude trails are located on Plate I.

The nearest railroad is at Caliente, 55 road miles northeast of Alamo, which is the main line of the Union Pacific railroad between Salt Lake City and Los Angeles. All mail and produce from Pahranagat Valley is transported by road to Caliente or to Las Vegas 115 road miles south.

A highline, transmitting electrical power from Boulder Dam passes within 15 miles of Pahranagat Valley, and a branch line to Alamo provides power there. This line was not constructed until 1938, up to which time inhabitants used kerosene lamps and battery generators.

Climate

Climatically the Pahranagat area represents a transition between the true desert and semi-arid regions. The climate is characterized by light rainfall, little snow, a large proportion of
EXPLANATION OF PLATE VI

Figure A

A view across Coal Valley that borders the Pahranagat Range on the north from Murphy's Gap (Figure 2, text p. 46 and Caliente Quadrangle). In the background is the Seaman Range.

A 100 square mile lake occupied the Valley in Pleistocene time with a maximum depth of 75 feet. The playa surface is seen in the upper central part of the photo just below which are terraces and beaches. The road in the foreground cuts through Murphy's Gap and Cold Springs Wash which separates the Pahranagat Range from the Golden Gate Range.

Figure B

A view looking southwestward across Desert Valley on the western side of the Pahranagat Range. In the background is the Desert Range behind which is the site of the U.S. Atomic Testing grounds. The Desert Valley is uninhabited and only crude trails permit access to important Paleozoic exposures.
clear days. The summers are long, hot and dry, and the winters are short and mild. Strong winds, common throughout most of the year, become rather severe during the spring season. A high rate of evaporation greatly diminishes the benefits of the rainfall which occurs.

Records have been taken at weather stations near Alamo over a period of 38 years. The present station was established at the Alamo Post Office in 1947. This is located at 37°22' north latitude; 115°10' west longitude at an elevation of 3446 feet. Records from 1931-1952 are listed in Tables 1 and 2 with means and extremes for the period of record prior to 1931. Records for 1957 and 1958 are listed separately in Tables 3 and 4 respectively. The records from 1931-52 indicate a mean annual temperature of 57.3° F; a maximum temperature of 115° F and a minimum of -9° F. The average annual precipitation based on data covering the period 1931-1952 is 7.39 inches and that prior to 1931, 6.15 inches. This varies from a high of 11.15 inches to a low of 2.75 inches. Snowfall has varied from a trace to 11 inches.

The weather data shown do not present an entirely true picture of the climate over the area as a whole. The station is located near the lowest point in the district (3446 feet), where conditions are most severe; that is precipitation is lowest and temperatures are highest. These conditions become less severe with increasing
TABLE I

MONTHLY PRECIPITATION AT ALAMO, NEVADA

FROM 1931-1952 INCLUSIVE

(U.S. Dept. of Commerce)

(1957)

G - Means or extremes for period of record beginning with 1931

H - Number of years record used to obtain mean in (G)

D - Means or extremes for the period of record prior to 1931

F - Number of years record used to obtain means in (D)

- - No record

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TABLE 2
MEANS AND EXTREMES OF TEMPERATURE AND SNOWFALL AT ALAMO, NEVADA, 1931-1952 INCLUSIVE. (U.S. Dept. of Commerce 1957)

D: Means or extremes for the period of record prior to 1931.
G: Means or extremes for the period of record beginning with 1931.

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HIGHEST TEMPERATURE

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MEAN MINIMUM TEMPERATURE

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MEAN TEMPERATURE

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MEAN SNOWFALL
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<td>April</td>
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<td>June</td>
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<td>July</td>
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<td>August</td>
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<td>September</td>
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<td>October</td>
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<td>November</td>
<td>41</td>
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</tr>
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<td>December</td>
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*4 days Snow
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<td>November</td>
<td>79</td>
<td>37</td>
</tr>
<tr>
<td>December</td>
<td>71</td>
<td>51</td>
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</table>

Total Precipitation: 36 days, 6.33 inches

* Trace of Snow
elevation. Pinon, Juniper and Mountain Browse vegetation existing at elevations from 5000 to 8000 feet reflect considerably higher precipitation and lower evaporation than in the valleys. It is probable that precipitation at the higher elevations might exceed 12 inches annually.

Vegetation

Native vegetation consists chiefly of drought-resisting desert shrub types. These may be divided into two broad classes depending on soil characteristics, elevation, and rainfall.

Desert shrub vegetation characteristic of arid soils up to approximately 5000 feet elevation are dominated by the species Grayia spinosa (hopsage), Lycium andersonii (wolfberry), Chrysothamnus viscidiflorus (yellowbrush), Ephedra nevadensis (brigham tea), Tetrademia sp. (horsebrush), Atriplex confertifolia (shadscale), Atriplex canescens (four-winged salt brush), Eurotia lanata (winterfat) and Hilaria jamesii (galleta grass).

The lower limits of the sage (Artemisia tridentata or A. nova) is taken, somewhat arbitrarily, as the dividing line between the arid zone and the semi-arid zones above 5000 feet. The soils above this line have in general a higher content of organic matter than those of the lower elevations. They produce stands of greater density the dominant species being Artemisia tridentata (big sage), Artemisia nova (black sage), Coleogyne ramosissima (blackbrush), Yucca brevifolia (joshua tree), Pinus monophylla (single leaf pinon), and Juniperus utahensis (Utah Juniper).
Joshua tree (*Yucca brevifolia*), Spanish Bayonet (*Yucca baccata*), and Blackbrush (*Coleogyne ramosissima*) are transition species common to both elevation and soil zones. Relatively dense stands of Joshua tree and Spanish bayonet commonly occur high on alluvial fans and outwash plains. A chief variation in vegetation distribution is that Brigham tea (*Ephedra nevadensis*) predominates on the west slope of the Pahranagat and adjacent ranges whereas Shadscale (*Atriplex confertifolia*) predominates on east slopes. Table 5 lists common plants found in the Pahranagat District after (Hermansen, 1940).

The soils of the Pahranagat area are, like the climate, in a transition zone between Red Desert soils and Sierozem or Gray desert soils. They have been developed under conditions of light rainfall and high evaporation, but under conditions essentially less severe than those which tend to produce red desert soils.

A detailed soil conservation survey was made in the Pahranagat area by Taylor (1940). Twenty-one soil series, including 35 types, 5 special types, and one complex type were described and mapped. A review of Pahranagat Soil Geology will be presented in the subsequent Part V of this investigation (Economic Geology).
Woodland

Tree growth in the Pahranagat Range area consists mainly of pinon and juniper. Small isolated stands of yellow pine and white fir occur on some of the high peaks. The pinon-juniper stands run mainly to thrifty (nearly mature) to mature trees.

Since the average elevation of the area is relatively low, the woodland areas are largely confined to high, partially inaccessible mountains. Mountains bordering the valley are practically barren of timber. The woodland edition of the Caliente Quadrangle (pocket) indicates that less than 100 of the 600 square mile Pahranagat Map area (Plate I) is considered woodland. This is essentially confined to elevations above 6500 feet.

Wildlife

Deer are the only big game animals occurring to any extent in the Pahranagat area. Gambel quail, dove and several species of ducks abound in the moist Pahranagat valley. Ring neck pheasants and fish have been planted in the Pahranagat Lakes which are leased to the Buckhorn Gun Club of Las Vegas.

Jack rabbits and cottontail rabbits are very numerous in the area. Cottontails are considered a game animal and are protected during part of the year and kept fairly well under control by local hunters. Jack rabbits however, are much more numerous and
efforts are being made to reduce their numbers. Besides their
effects on forage and crops in Pahranagat Valley, especially alfalfa
seed, they are carriers of tularemia, a disease, which, if transmitted
to man may be fatal. It is believed that the artificial reduction in
the number of coyotes has probably had a marked effect on the in-
crease in the rabbit population.

Minor numbers of antelope ground squirrel, kangaroo rats,
pocket gophers, and hopi chipmunks also occur. Several species of
lizards are abundant.
### TABLE 5

**Common Plants found in the Pahranagat District**

Based on Field Observations and information from the United States Forest Service and Grazing Service compiled by R. D. Hermansen (1940)

* Poisonous Plants

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
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<td><strong>GRASSES</strong></td>
<td></td>
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<tr>
<td>Agropyron cristatum</td>
<td>Crested Wheatgrass</td>
</tr>
<tr>
<td>Agrostis alba</td>
<td>Redtop</td>
</tr>
<tr>
<td>Aristida fendleriana</td>
<td>Fendler three-awn</td>
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<tr>
<td>Bonteloria gracilis</td>
<td>Blue grama</td>
</tr>
<tr>
<td>Bromus carinatus</td>
<td>California brome</td>
</tr>
<tr>
<td>Bromus rubens</td>
<td>Red Broms (Foxtail chess)</td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>Bermuda grass</td>
</tr>
<tr>
<td>Distichlis stricta</td>
<td>Desert Saltgrass</td>
</tr>
<tr>
<td>Elymus condensatus</td>
<td>Giant-wild Rye</td>
</tr>
<tr>
<td>Festuca octoflora</td>
<td>Sixweeks fescue</td>
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<tr>
<td>Hilgria jamesii</td>
<td>Galleta grass</td>
</tr>
<tr>
<td>Hilaria rigida</td>
<td>Big galleta</td>
</tr>
<tr>
<td>Hordeum jubatum</td>
<td>Foxtail Barley</td>
</tr>
<tr>
<td>Hordeum nodosum</td>
<td>Meadow Barley</td>
</tr>
<tr>
<td>Muhlenbergia perteri</td>
<td>Bush Muhly</td>
</tr>
<tr>
<td>Munrea squarrosa</td>
<td>False Buffalo Grass</td>
</tr>
</tbody>
</table>
Oryzopsis hymenoides  Indian Rice Grass
Paspalum distichum  Knotgrass
Pea fendleriana  Mutton Grass
Pea nevadensis  Nevada Blue Grass
Polypogon monspeliensis  Rabbitfoot Grass
Sitania hystrix  Squirreltail
Sorghum halepense  Johnson Grass
Sporobolus airoides  Alkali Scaton
Sporobolus contractus  Spike Dropseed
Sporobolus cryptandrus  Sand Dropseed
Sporobolus flexuosus  Mesa Dropseed
Stipa comata  Needle and Thread Grass
Stipa speciosa  Desert Needle Grass
Triodia mutica  Slim triodia
Triodia pulchella  Fluff Grass

GRASS-LIKE

Carex sp.  Sedge
Juncus sp.  Rush
Scirpus peludosus acatus  Common Tule
Scirpus peludosus  Bulrush
WEEDS

Anemopsis californica
Annuals unidentified
Arenaria kingii
Argemone platyceras
Aster sp.
*Astragalus lentiginosus
  var. fremontii
*Astragalus sp.
Baileya multiradiata
Baileya pleniradiata
Brassicaceae sp.
Castilleja sp.
Chenopodium sp.
Cogswelia sp.
Collinsia sp.
*Datura metaloides
*Delphinium amabile
*Delphinium scaposum
Eriogonum inflatum
Eriogonum nichrothecum
Eriogonum vimeum
  ssp. nidularium
Erodium cicutarium
Yerba mansa
King Sandwort
Pricklepoppy
Aster
Loco
Loco
Baileya
Baileya
Mustard family
Indian Paint Brush
Lamb's quarter
Cogswelia
Collinsia
Jimson weed
Larkspur
Larkspur
Eriogonum
Eriogonum
Eriogonum
Alfileria
Franseria acanthicarpa  Ragweed
Franseria sp.  Ragweed
Geranium sp.  Geranium
Lappula occidentalis  Stickweed
Lepidium fremontii  Peppergrass
Leptodactylon nattallii  ---
* Lupinus sp.  Lupine
Marrubium vulgare  Hoarhound
Nicotiana attenuata  Wild tobacco
* Oxytropis sp.  Loca
Pectis papposa  Clinchweed
Penstemen sp.  Penstemen
Phacelia sp.  Phacelia
Rumex sp.  Dock
Salsola pestifer  Russian thistle
Solidago sp.  Golden rod
Sophia sp.  Tansymustard
Sphaeroica mumroana  Globemallow
Stanleya pinnata  Princes plume
Suaeda sp.  Sea blite
Typha latifolia  Cattail
Wyethia amplexicaulis  Mules ears
Xanthium sp.  Cocklebur
# TREES AND SHRUBS

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<td>Allenrollea occidentalis</td>
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<td>Arctostaphylos sp.</td>
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<td>Artemisia spinescens</td>
<td>Budsage</td>
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<td>Artemisia tridentata</td>
<td>Big sagebrush</td>
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<td>Atriplex canescens</td>
<td>Fourwing saltbrush</td>
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<td>Atriplex confertifolia</td>
<td>Shadscale</td>
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<td>Atriplex lentiformes</td>
<td>Quail bush</td>
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<td>Atriplex sp.</td>
<td>Salt bush</td>
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<td>Lanceleaf, Rabbitbush</td>
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<tr>
<td>Chrysothamnus nauseosus gnaphalodes</td>
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<tr>
<td>Chrysothamnus viscidiflorus pumilus</td>
<td>Rabbitbush</td>
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<td>Colcogyne ramosissima</td>
<td>Blackbrush</td>
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<tr>
<td>Covillea tridentata</td>
<td>Creosote bush</td>
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<td>Cowania stansburiana</td>
<td>Cliff rose</td>
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<tr>
<td>Encelia sp.</td>
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<td>Ephedra nevadensis</td>
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<td>Eriodictyon augustifolium</td>
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<td>Eriogonum Wrightii</td>
<td>Wright buckwheat</td>
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<tr>
<td>Eurotia lanata</td>
<td>Winterfat</td>
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<td>Fallugia paradoxaca</td>
<td>Apache plume</td>
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<td>White Bur-sage</td>
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<td>Bursage</td>
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<td>Hopsage</td>
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<td>Range ratany</td>
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<td>Lycium andersonii</td>
<td>Wolfberry</td>
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<td>Menodora spinescens</td>
<td>Greenfire or Twinberry</td>
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<td>Odostemon fremontii</td>
<td>Fremont hollygrape</td>
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<td>Opuntia sp.</td>
<td>Prickly pear</td>
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<tr>
<td>Parosela fremontii</td>
<td>Fremont dalea</td>
</tr>
<tr>
<td>Parosela johnsonii</td>
<td>Desert beauty</td>
</tr>
</tbody>
</table>
Parosela sp.  Peabush
Pinus monophylla  Single leaf Pinyon
Pinus ponderosa  Ponderosa pine
Pluchea sericea  Arrow-weed
Prunus sp.  Chokecherry
Purshia tridentata  Bitterbrush
Quercus dumosa  ---
Quercus gambelii  Gambel oak
Quercus sp.  Oak
Salazaria mexicana  Bushmint or Bladder sage
Salis sp.  Willow
Salvia cornosa  Desert sage
Sarcobatus vermiculatus  Greasewood
Symphoricarpos sp.  Snowberry
* Tetradyemia axillaris  Longspine horsebrush
* Tetradyemia glabrata  Littleleaf horsebrush
Yucca baccata  Spanish bayonet
Yucca brevifolia  Joshua tree
POLITICAL AND CULTURAL HISTORY
OF THE PAHRANAGAT RANGE AREA

There is little knowledge of the "prehistory" of the Pahranagat Area. No ruins or artifacts of a prehistoric civilization have been found within a radius of 75 miles. All that is available are the excellent Petroglyph localities, which will be places for reference on future editions of the base map, Plate I. Modern American Indians make no claim to these undeciphered hieroglyphics. Small tribes of Pahranagat, Piute, and Shoshone Indians inhabited the Pahranagat Valley and were present when the first white settlements were established. Arrowheads are also found occasionally in remote parts of the Pahranagat Range.

The early history of the Pahranagat Area is closely related to the general exploration of Eastern Nevada and to the development of Lincoln County as a result of mineral discoveries. It is not supposed that any Spanish explorers came near the Pahranagat Range. A composite map of all Spanish exploration routes (1535-1706) show none that enter present Nevada boundaries.
The first American Nevada explorer was Jedediah Smith, (1797-1827). In 1826 he left his trapping business in Salt Lake City to explore the great stretches of desert to the southwest hoping to find new trapping territory and also a new route to the Pacific Ocean from which furs could be shipped directly to the market in Canton, China. He passed through the Las Vegas-Lake Mead area the same year. A letter written to William Clark, (of Lewis and Clark), then Secretary of Indian Affairs for the Department of the Interior, tells of his entrance into Nevada just east of what is now the town of Panaca and of his Meadow Valley trip to the Muddy or Moapa River, (Squires, 1959). See Route Figure 3, p. 78.

The Fremont expedition passed through Glendale Junction, 64 miles south of Alamo, on their eastward journey along the Old Spanish Trail in 1844. The Death Valley Party passed through the Pahranagat Range across Hancock Summit in 1849 (Figure 3). Although the Panaca Spring area, about 60 miles east of Pahranagat Valley was first visited by Mormon missionaries in 1857, formal settlement was not effected until 1866. Mormon missionaries under the leadership of William Bringhurst first colonized the Las Vegas Valley in 1855 but were recalled by Brigham Young in 1857 (Maxey and Jameson, 1948, p. 4). There were probably transitory white settlements in the Pahranagat Valley between 1850-1860.
Figure 3.- County Outline Map of Nevada.
The Pahranagat Region attracted no significant interest until the discovery of Silver at Mount Irish in 1865. In March of that year six men prospected the country following reports they had heard in Panaca of a Silver Mountain near a lake. This first party appears to have camped near the springs at the north end of the Pahranagat Valley, and the site became known as Hiko the Indian expression for White Man's Camp. The "Ely and Sanderson" Lode was filed on the 17th of March and during the next three days a large number of localities were made. It was not until October, however, that a permanent settlement was made and during 1866 from 100-200 men were in the district (State Mineralogist, 1867, p. 64).

News of the new discovery spread to the towns of western and central Nevada by the end of 1865. The Reese River Reveille of Austin, the nearest Nevada newspaper, chronicled the developments as they were received via the rumor circuit and from there the word was spread by the chain reaction of other newspapers. The Reveille reported on January 2, 1866, that the Pahranagat inhabitants, estimated at 500, were clamouring for a county government; (this number considered an exaggeration by Hulse, 1958). The Reveille made a substantial report on the excellent Pahranagat mines January 17, 1866, in which it was noted that Henry Butterfield,
an Indian Agency interpreter, had made a trip directly from Fort Ruby to Pahranagat. Further promising reports followed quickly. There were stories of the extraordinarily rich and valuable mines on January 30 and February 1.

By this time the Pahranagat discovery had assumed a "boom" proportion and was of concern to State and Federal officials. On February 2, 1866 The Reveille reported that several parties were leaving for the new lode. One party was headed by Major Peoples, who took with him "a small party of artillery" to clear the unknown road if Indians were encountered. It is significant that the only known route between Austin and Pahranagat was eastward about 160 miles over the overland transcontinental stage and mail route to Egan Canyon, directly north of present day Ely, and then 150 miles south to Pahranagat over a little known road which Indian Agents and military officials had used. Such a trip required nearly a month for most parties. The Reveille regarded the possibility of a direct route from Austin to Pahranagat as remote: "No one, that is no paleface, has ever traveled over the desert region, and if men have ever gone between the embryo county of Stewart and the town of Ione, as has been related, we suppose it must have been by balloons" (Resse River Reveille, February 6, 1866). See Figure 3.
This report reflects the fact that the earliest residents of Pahranagat envisioned the creation of a county to be named for Senator William Stewart.

In the first weeks of the rush and shortly thereafter five small communities developed. Near the north end of the Valley were Hiko and Crystal Springs which took advantage of the plentiful waters of the Valley. Hiko at that time seemed likely to become the milling center of southeast Nevada, since its supply of water was nearest to the Pahranagat Mines, (location Figure 2, p. 46 and Plate I). To the northwest, in the vicinity of Mount Irish were the communities of Logan, Crescent, and Silver Canyon. Logan is located slightly southeast of Mount Irish in a wide pass through the mountain and Crescent is located on the west side of the Range about 2 miles west of Logan. Silver Canyon was located about 4 miles north, (northeast of Mount Irish); Figure 3 (State Mineralogist 1867-68, p. 30).

History says very little about the latter three towns. They have almost completely disappeared and there are no known photographs or plans to show what they were like. Several dozen stone foundations remain today at Logan while there are few remains at Crescent. The population at Logan probably never exceeded 100. Both these towns are on strike with the Gilbert fault which controls excellent spring water. Water had to be hauled to Silver Canyon
where miners had to pay 10 cents per gallon. Silver Canyon is pictured as nothing more than a couple of large boarding houses and a large number of small cabins scattered over the hills (Cotton, 1912, pp. 24-25).

The people at Pahranagat wanted to create Stewart County from a portion of Nye County, which at that time had jurisdiction over the entire region. It is not possible to say what specific efforts toward self-government were made prior to 1866. Reference is made to George Rogers "Sheriff of Lincoln County" whose body was found after he was murdered by Indians somewhere between the Pahranagat settlements and Meadow Valley (Territorial Enterprise April 25, 1866). A vigilante group that avenged Rogers death might be regarded as a type of law. The creation of a Mining District did impose a kind of squatters government and a county organization was probably maintained as far as the settlers could act without authority of legislation. Desire for county organization was understandable because Ione, the seat of Nye County, was more than 150 air miles from Hiko (Figure 3).

On January 22, 1866, a bill to give the people of the Pahranagat Valley their own government was introduced in the Nevada State legislature by assemblyman George Munckton of Ormsby County. The bill passed the assembly February 7 after the name had
been changed to Lincoln in the legislative in-fighting (Assembly Journal, 1866, pp. 100, 155, 173). The bill encountered formidable trouble in the Senate because the new county and county seat was considered to be in the Utah Territory, (Nevada Senate Journal, 1866, p. 186). A Federal law of May 5, 1866 moved the Nevada boundary one degree to the east which placed Pahranagat without question in Nevada and provided that the shifting of the boundary would have no effect on the titles to the mining claims, (Congressional Globe 39th Congress 1st Session Part 3, pp. 2368-70). The bill finally passed in substantially its original form and was approved by Governor Henry Blasdel on February 26. In essence it outlined the general boundary for Lincoln County, provided that three persons should be appointed County Commissioners and empowered to form a government, made Crystal Springs the County Seat, and provided that when 300 persons had entered a petition with the Nye County Clerk for a government Lincoln County would be in effect (Nevada Statutes 1866 Chapter III, pp. 131-132).

Nevada's first Statehood Governor, Henry G. Blasdel, became one of the first men to make a direct trip across "Death Barren" from western Nevada to Pahranagat Valley. He left Carson City in the spring of 1866 to organize the county which the legislature had created. Soldiers from Fort Churchill accompanied his party as far east as Silver Peak and then turned back. The Governor's
party ran short of supplies in the Armagosa Desert, and Blasdel and a companion (State Geologist White) went ahead to Logan for aid. When the supplies reached the party, which was struggling in the vicinity of Ash Meadows, one man had died and the others were subsisting on Lizards. (Reese River Reveille, April 21, 1866, Territorial Enterprise, June 26-29, 1866, Hulse 1957, Pioneer Nevada Vol. II, 1959, p. 66).

When Governor Blasdel was able to view the communities at Mount Irish and in the Pahranagat Valley he found that they did not have the required number of people to organize the county. Moreover, he found that although the district had been known for some time the regulations were extremely bad—some 5000 claims having been made without provision for effective development. There were no excavations more than 2 feet deep, pay streaks were small, and the district had been formed by men without Nevada or California mining experience.

Governor Blasdel left the region about May 21 and arrived in Carson City about June 10. On his return trip he passed through Austin and his views expressing disappointment in the Pahranagat Mining district were published by the Reese River Reveille June 9, 1866. There were, however, several reports about failures in the Pahranagat mines before Governor Blasdel's finding (Joseph Todd in
Reese River Reveille March 29, 1866 and Territorial Enterprise April 6, 1866).

In 1867 the Nevada legislature passed another act creating a government in the Pahranagat Region. This act eliminated the conditions and requirements which had caused the first act to fail. It designated the county commissioners by name and gave them power to form the county. Hiko was made the Lincoln County seat and boundaries were changed slightly. Bluff Springs, about 15 miles east of the Reveille district became the northwest corner of the new political unit (Nevada Statutes 1867, Chapter XC, pp. 129-130 and Browne 1868, p. 339).

Although Crystal Springs, about 4 miles south of Hiko, was an inviting site for a town and was officially designated as the first county seat when the 1866 legislature made the unsuccessful effort to create Lincoln County, there is no evidence to indicate the former existence of a significant town there nor is there any settlement there now. There were, however, farms in the vicinity. The new county seat, Hiko, was regularly laid out on a level plot of ground near the several large springs. In 1867 the population numbered less than 100. There was a court house, post office, and several stores. "A number of families were residing, but there was no public school or church," (Report of the State Mineralogist 1867-1868).
The three men who were named county commissioners, H. H. Day, Mortimer Fuller, and Charles Wilson held their first meeting at Logan on April 16, 1867, to take the oath of office. They next met in Hiko April 22 and appointed county officers. On October 29, 1867 they leased the building known as Butler and Pearson's Saloon to be occupied for county purposes. The commissioners used this building for about 6 months, and then they leased other property on which they planned to build a court house. The board identified the property in the official minutes by saying that it was opposite the brewery then owned and operated by Thomas Hartle (County Commissioners Records, Vol. I, pp. 1-2, 18, 27).

The county records reflect not only the proximity of the liquor establishments; they betray also other features of communities which were populated by transient wealth seeking miners. Such mining population was not stable, and the men who were elected to fill the county offices commonly left in the middle of their terms. At times the Commissioners would not meet for several weeks. In the election of 1868, the first in the County's history, the voters selected James Mee, Charles P. Ely, and J. Gilbert as commissioners. When time arrived for them to assume office, all had departed from the county and three other men were appointed by the governor to fill their places (County Commissioners Records, Vol. I, pp. 38, 42 and Pioche Record February 12, 1874).
A large number of the resignations and vacancies during this time coincides with the disillusionment concerning the Mount Irish mining prospects. Throughout 1866 investors who had staked claims began the long task of hauling milling equipment into Pahranagat Valley. William H. Raymond, who later became a millionaire from the rich mines at Pioche, completed the construction of two small furnaces at Hiko, June 11, 1866. About 100-150 men were said to be working for 8 companies (Reese River Reveille June 12, 1866).

During the summer of 1866 two basic problems faced the developers, and neither problem was adequately solved during the sixties. The miners and investors were unable to process the ores by simple means or with the equipment they had imported, and the isolation increased the problem of getting equipment, most of which arrived from Los Angeles and Salt Lake City. William Raymond was finally able to get his mill into operation in November. It ran for some time, operating five stamps, but was declared "defective" in February 1867 (Reese River Reveille February 28, 1867).

After this the activity in the district was uneven. Small amounts of bullion probably found their way to Salt Lake City in 1867, and there were several efforts to find a suitable milling or smelting process, but there were no important successes. Occasional reports of new strikes failed to stimulate new enthusiasm
outside the immediate area. The Federal report of 1868 estimated investments in the Pahranagat district at $933,323 and bullion extracted before July 1868 was about $20,000 (Raymond, 1869, pp. 114-115). It came to be accepted in Austin and in the Federal Reports that bad management and absence of both mining and milling skill were responsible for the Pahranagat failures (Reese River Reveille, November 30, 1867, Raymond 1869, p. 114).

Although Pahranagat did not overcome its technical problems relating to the production and processing of ore, it did conquer some of the communication and transportation problems. Indians carried the mail in July 1866. During 1867 the road from Austin to Egan Canyon to Pahranagat became well known. Late in 1867 a tri-weekly stage service was connecting Austin and Pahranagat via Belmont in northern Nye County (see Figure 3, p. 78).

The minutes of the County Commissioners of Lincoln County during these years suggests difficulties in government as well as mining. One troublesome problem was the boundary dispute with the Utah Territory which developed after 1866. The boundary change that year, which moved Nevada's eastern border one degree to the east, gave Lincoln County much new land, but little or no tax advantage resulted because the Mormon communities refused to acknowledge Lincoln County until after a survey was made in 1870.
This meant that the county was receiving taxes on only about one-half of the assessed valuation of taxable property. The county's unstable financial position is suggested by figures which were sent to the state controller during the late sixties:

<table>
<thead>
<tr>
<th>Year</th>
<th>Assessed Valuation</th>
<th>County tax due</th>
</tr>
</thead>
<tbody>
<tr>
<td>1867</td>
<td>$213,941</td>
<td>$3,209</td>
</tr>
<tr>
<td>1868</td>
<td>225,161</td>
<td>3,337</td>
</tr>
<tr>
<td>1869</td>
<td>253,474</td>
<td>4,182</td>
</tr>
<tr>
<td>1870</td>
<td>521,833</td>
<td>8,602</td>
</tr>
</tbody>
</table>

There were other evidences of the government's weakness. On more than one occasion local citizens took the law into their own hands and hanged an accused offender before the legal process could be applied. A notable case occurred in July 1867, when a man who was suspected of murder, L. B. Vail, was seized from the Hiko Jail by a crowd which gave him a "fair trial" and hanged him the same day. Legend says that the proceedings of the self-appointed court were interrupted time and again by the hammerings of construction of the gallows and coffin outside the window of the court room (Reese River Reveille, July 18, 1867, Pioneer Nevada, Vol. I, 1951, p. 111).

On April 6, 1868 the Commissioners approved a petition from the heads of ten families for the creation of a school district
at Hiko. Since no records were reported to the State School Superintendent before 1871 it is doubtful that Hiko had a school before that time.

Further evidence that the county government was born prematurely are shown in the election of 1868. There were 106 votes recorded but the names of more than 30 men were before the voters. Thus about a third of the voters were seeking office (County Commissioners Records 1867-68, pp. 37-38). There are also reports of county officials who failed to account for public funds.

Pahranagat experienced a brief period of success in 1869. James Wilson, General Agent for the Hiko Company, arrived in Austin that year with 22 bars of silver worth $25,000 (Reese River Reveille, November 19, 1869). This suggests a temporary victory over the technical problems. The Federal Report of 1870 cites only one important Pahranagat enterprise left in active operation, that of the Hiko Company operating on a vein of the same name. This report states that the "total amount of bullion produced in the district during 1869 was small, probably not exceeding $80,000." (R.W. Raymond, 1870, pp. 195, 201).

William Raymond moved his 5 stamp mill from Hiko to a site north of Panaca to treat the first Pioche ores in 1869. This mill and another 10 stamp plant at Crescent emerged as the only tangible asset from all the investments in Pahranagat during
this era. The Crescent mill is believed to have remained in operating condition through 1871 processing some ores from the newly discovered mines at Tempiute (Raymond, 1871, p. 174, Cotton, 1912, op. cit. 1. 224-228). The Tempiute district did not, however, become a significant producer until the 20th century.

A combination of new rich mining discoveries at Pioche and White Pine with the demise of the Pahranagat workings brought abandonment of Silver Canyon in the winter of 1869 and closing of the Hiko Silver Mining Company which had "finally become tired of paying out four dollars to get one back" (Cotton, 1912, pp. 28, 34-35).

The famous Pioche bonanza of 1870 spelled the doom for Hiko. On July 25 and November 9, 1870 the board received and rejected demands for the removal of the county seat to the new town. A legislative act, approved on February 21, 1871 required an election on the question of whether to move the County Seat (Nevada Statutes 1871, Chapter 19, p. 64). In the voting Pioche received 501 votes, Panaca 54, Las Vegas 1, and Meadow Valley 1. Not a single vote was counted from persons wishing to retain the county seat at Hiko (County Commissioners Records 1870-71, p. 119). Immediately after the change a Court House was built which stands today as a reminder of the frontier days of Pioche when the law of the gun settled many arguments.
The boom years in Pioche lasted from 1870 to 1877. Raymond and Ely, who had been involved in most phases of the Pahranagat mining problems, controlled 60% of the Pioche ores and grossed 15 million dollars. The Pahranagat Region was virtually ignored during these years. While Hiko survived, it attracted no attention because of the mines. The State Records for 1871 and 1872 showed that the former county seat did not increase in size and population for several years. "It is more especially noted now for its swarms of mosquitoes than for its activities and business prospects," (State Mineralogist 1871-1872, p. 34, Hulse 1958, p. 60). The 1873 Federal Mining Report listed no activity in the Pahranagat district (Raymond 1874, p. 233).

In 1875 the legislature added an area 45 miles wide and 50 miles long to the northern portion of Lincoln County (Nevada Statutes 1875, Chapter 36, pp. 80-82). The northern boundary of the county had originally passed only a few miles north of Pioche. This area was extensively prospected by Pioche miners and to this day produces a substantial amount of the county's mineral wealth.

Throughout the seventies Pahranagat Valley was sparsely settled. Votes cast in Hiko in the elections of 1872, 1874, and 1876 are as follows:
1872  33
1874  30
1876  44

(County Commissioners Records 1867-76, pp. 280-281).

The Pahranagat Indian tribe which numbered 105 in 1864
was reduced to only 40 in 1874 (Cotton 1912).

Pahranagat Valley, hemmed in by stark ranges to the east
and west, sparsely settled, and far removed from any major town
provided the maximum of protection for rustler bands. Here
throughout the seventies and early eighties horse thieves found a
haven for fattening stolen stock on the lush grass and fertile soil
of the Valley before driving them on to Utah, California, and
Arizona markets. So widespread were the activities of the horse
thieves that at one time settlers counted as many as 350 brands on
the grazing stock. Pahranagat Valley gained reputation as a rendez-
vous and headquarters for the worst outlaws of the time and there
were gun fights between outlaws and settlers and with posses that
entered the Valley upon occasion trailing after murderers (Pioneer

Pahranagat Valley murders are cited in the Pioche Record
October 1, 1881 and a cry for vengeance against the "Cowardly
curs in Pahranagat Valley" with request for a vigilance committee
are noted in the Pioche Record of January 17, 1885. Another incident
of bravery at that time was the murder of an insane man by Pahranagat Valley citizens in 1883 "just to get rid of him." (Scott 1958, p. 8.)

Although the population of Pioche, 1,141 in 1871, may have reached as high as 6,000 in the peak boom year of 1872, the county population numbered 2,753 in 1876 and 2,637 in 1880. The latter year the Pahranagat Valley population was 50.

By 1880 there was no operating mine at Pioche and mineral activity from 1880-1890 was limited to milling of tailings. There were only 144 registered voters at Pioche in 1888. 232 votes were cast there in the election of 1890.

When Pioche mining collapsed in 1880 Henry Raymond, the brother of William Raymond, opened a mine in the Pahranagat region and put a mill into working order in February 1881. The March 5 Pioche Record observed that 45 men were at work in the area. The traditional excitement was generated, but by mid May, the company was saddled in debt and the project came to an end.

In 1891 the famous Delamar mines were discovered by Pahranagat Valley prospectors John E. Ferguson and Joseph Sharp, (location 5, Figure 3). This area became known as the Ferguson district or Monkey Wrench. The mining district was formally created by 18 men February 20, 1892. Unlike previous booms the early settlement of the Ferguson district was accomplished almost
entirely by Pioche, Meadow Valley, and Pahranagat Valley residents rather than by outside interests.

Small quantities of Delamar ore were processed by a mill at Hiko in 1893. This practice became difficult due to the condition of the roads in the winter months (The Lode December 23, 1893, January 13 and 27, 1894). The milling at Hiko was resumed as the weather improved but proceeds were small. The Hiko mill burned in May 1894 after which a mill was built at Delamar.

The Delamar mines became the most active camp in Nevada for a 6 year period 1895-1900 and was nationally noted for the death of several hundred miners from silicosis. Maximum population at Delamar is estimated at 1500 in 1896-97. At that time the population at Pioche was 300. Only 26 votes were cast in Pioche in the election of 1898.

In 1900 Lincoln County, which then included Las Vegas and all of modern Clark County, was the largest county in the United States with 18,576 square miles. The 1900 census was 3824 with 157 in Pahranagat Valley.

Although the first Railroad Survey had been made in 1889 it was not until 1905 that the county got its first railroad artery to the outside world. Even Pioche, which was a well known habitable community compared to Pahranagat Valley at that time, was considered the "Timbuktu" of the west. The railroad ended a long
period of poverty and gave some market to the small ranching operations. The San Pedro line, first ran February 9, 1905 between Salt Lake City and Los Angeles through Caliente, the Meadow Valley, and Las Vegas. This same route is the main line of The Union Pacific and today is the nearest railroad to the Pahranagat Valley (see Caliente Quadrangle map-pocket).

The oldest living inhabitants of the Pahranagat Valley, Carl Foremaster, 64, and Meryl Scofield, 74, came to the area shortly after 1900. At that time there were 126 Indians in the Valley and some 50 white settlers. Between 15 and 20 of the Indians were Shoshone and the remainder Piutes. No Moapa Indians were known at Pahranagat even though they have a substantial reservation about 60 miles south (Meryl Scofield 1959, personal communication). The Pahranagat Range and Valley took its name from the Pahranagat Indians, who were so named by the Piutes, because they raised and ate a kind of squash. The word Pahranagat is said to be an Indian term for watermelon or squash, "pah" meaning water and "ranagat" a vegetable such as melon, squash or pumpkin growing on a vine. (Browne, 1868). By 1900 the Pahranagat Indians had disappeared and apparently had all died out between 1875 and 1900. The Pahranagats, a branch of the Digger Indians of California, were a very low poverty-stricken
set without horses, cattle or grain. They lived on pine nuts, rabbits, snakes, and lizards--besides the watermelon and squash. In 1864 the tribe numbered 105; in 1874 only 40, (Cotton 1912).

Present inhabitants of Pahranagat Valley have the idea that Pahranagat means Water Valley in Piute. Actually the connotation of water in the word Pahranagat refers only to watermelon eaten by the Pahranagat Indians and not to the plentiful water of the Valley, (Pahranagat Valley means Watermelon Valley, Scott 1958, p. 4). (Mount Irish was named for Mr. Irish, the U.S. Indian Agent for the territory of Utah, (Browne, 1868, p. 426).

Scofield and Foremaster remember the Piutes and Shoshone well, and relate riding, sports, and games between the Whites and Indians in the early 1900's. There were no Indian problems in Pahranagat Valley at that time, or since--and the Indians were considered "honest good workers" (Scofield and Foremaster 1959, personal communication). The last Indian "Doc" Pete died some 20 years ago.

In 1905 the new town of Alamo was founded, largely by Mormon settlers who purchased the land and moved from Utah and Arizona in a communal enterprise (Hulse, 1958, p. 118).

The rapid growth of Las Vegas after 1905 made the county division question the most significant single issue in local politics between 1905 and 1910. The County division bill was finally
passed by both houses of the legislature in 1909 creating Clark County south of the 3rd standard parallel south of the Diablo baseline. The boundaries have remained unchanged since that time (Figure 3).

The Pahranagat Valley remained almost as isolated from 1910-1935 as it had been in the 19th century. Alamo became the central community with school houses, general store, post office and church. The present modern Mormon church building was built in 1930. Hiko diminished to its present status of a farm. The population of the Valley remained rather constant. The 1930 census shows a population of 289 at Alamo and 81 at Hiko; the 1940 census 457 for Pahranagat Valley; the 1950 census 386.

Although some farmers had their own power plants it was not until after the completion of Hoover Dam that electrical power came to Pahranagat Valley. Many residents still used kerosene lamps as late as 1938. Highway 93 from Glendale Junction to Caliente was not paved until 1946 and Highway 25 westward across the Pahranagat Range was first paved in 1956 and this mainly for access to the Tepiute Mine (Figure 2, p. 46 and Plate 1).

It is interesting that the population of Lincoln County, 3824 in 1900, was 3837 in the 1950 census. Because of the current mining depression the county population probably does not exceed 2500 and with the closing of the Tepiute Mine in 1957 the Alamo and
Pahranagat Valley population is estimated at 250, (1957 Alamo-
Pahranagat Valley population 308--Resources Report Lincoln County
1958 - p. 72).

The major occupation of Pahranagat Valley inhabitants today
is farming, some aspects of which will be discussed in a separate
heading under Economic Geology Part V in so far as it affects soil
studies and ground water problems. Major produce is feed for
Stock and Dairy cattle in the Valley. Intermittent mining activities
at Mount Irish have had no economic effect on the Pahranagat Valley
community. Further elaboration on these mines will be covered
under Mineral Economics.

The Pahranagat Range and adjacent Valley have experienced
much that deserves consideration in determining what was typical
of frontier America. Modern theories applied to conquering of the
desert and exploitation of its resources have not changed this area
significantly in the past 100 years.
PREVIOUS WORK IN THE AREA

Introduction

There are no previous published geological reports that refer specifically to the Pahranagat Range by title, except by the writer as a consequence of this study. There is no topographic map available with a scale greater than 1 inch to 4 miles, (Caliente Quadrangle 1:250,000), and no geological map. No definitive geological investigation has ever been conducted in the area. There are, however, a number of brief remarks that concern various aspects of Pahranagat geology scattered throughout the literature.

References in Written Reports

The oldest reference known to the writer appears in The Mining and Scientific Press of San Francisco, California, December 1865. This gives the assays from five different samples of silver ore from the Pahranagat (Mt. Irish) mines. The ores were considered peculiar carbonates of lead, copper, and antimony, and yielded silver analyses valued from $263.00 to $1036.00 per ton.

The Pahranagat mining activity is reported by Stretch
(1867) in the Annual Report of the Nevada State Mineralogist for 1866. This reference describes Mt. Irish as "a mass of white porphyritic rock, the flanks consisting of a blackish limestone (abounding in fragments of crinoids and corals) overlying slates and capped with a heavy body of quartzite. On Silver hill and Sanderson Mountain the outcroppings of the lodes are in limestone. On the western slope of the range, crystalline eruptive rocks are abundant."

Browne (1868, pp. 215, 339-340, 402, 426-429) reporting on the Mineral Resources of the States and Territories West of the Rocky Mountains for 1867 gives a considerable amount of information on the description of the Pahranagat area, location and size of the major mineral claims and companies involved, ore processing problems, minerals, assays, and general geological surroundings. The deposits are reported to occur in a belt about 5 miles long and two wide, stretching across the foothills and spurs of Quartz mountain (Mt. Irish), in which "stratification of the country rock is greatly disturbed." The silver and copper ores come from "fissure veins in a metamorphosed limestone formation and in a quartzose veinstone." The surface ores showed by assay a percentage of silver varying from $50 to $2500 per ton. "The vein stone is quartz and calspar, carrying iron, zinc, and
manganese rendering the reduction troublesome." The major ore mineral was considered polybasite. Three mills, totaling 20 stamps and run by steam power, are listed in the Pahranagat District. The elevation of Mt. Irish is incorrectly given as 11,000 feet.

A more elaborate discussion of the Pahranagat Mining District is given by Raymond (1869, pp. 112-115). Considerable geological information on the sedimentary and volcanic lithologies, mineralogy of ores, classification of the mineral deposits including the attitude and extent of the veins, faulting, and academic as well as practical geological problems are covered along with economic considerations. The silver bearing minerals are given as galena and stetefeldtite (partzite) containing 2 to 13 per cent silver and not polybasite. It is in this report that Raymond (1868, p. 115) gives the sum expended in Pahranagat as $933,323 and the value of bullion extracted up to July 1868 as $20,000.

Raymond (1870, pp. 194-201) again reported on the Pahranagat Mining District to the U.S. Treasury for 1869. He quotes a very elaborate and careful report published in the Berggeist of Cologne in December 1869 by Herr Bergreferendar Carl Haber, who apparently was consulted on the complex Pahranagat ores. Also discussed is the preliminary report of a military reconnaissance through southern Nevada that included the Pahranagat area
by Lieutenants George M. Wheeler and D. W. Lockwood of the United States Engineers, January 21, 1870; the report of Mr. John H. Forster, State Engineer of Michigan, who examined the mines early in 1869; the report of A. F. White, Mineralogist for the State of Nevada, who examined the mines in August 1868, and the files of the Engineering and Mining Journal. The Raymond report of 1870 determines the principal, permanent, and most promising lode of the district--that of the Illinois-Indiana vein, discusses the mining operations in some detail, and makes suggestions for more profitable operation. The total amount of bullion produced in the district during 1869 was estimated at $80,000.

George M. Wheeler (1871, pp. 43-44) reported on exploration and surveys of Nevada and Arizona which included the Pahranagat Lake Mining District, Nevada. He noted that Great Quartz Mountain had a general dip to the west, that the quartzite was 500-600 feet thick and that its edges were exposed on both sides of the mountain, that the mines were on the east side of the mountain in a "much disturbed and faulted area," and he quoted Gilbert from written communication that these rocks, profusely fossiliferous, correlated with the Hudson River and Trenton Groups of the "Silurian" system. He reviewed some of the mining history and noted that a "bed of volcanic tufa at Logan Spring can furnish a
very superior building stone." This report includes a hachure map on a scale of 1 inch to 24 miles which locates the Pahranagat Range, Quartz Peak, Hiko, and Pahranagat Lake. This is the earliest map known to the writer to include the Pahranagat Range by name.

The Pahranagat mines are referred to by Browne and Taylor (1868, p. 33), Raymond (1871, p. 174, 1874, p. 233), White (1869, pp. 80-85), Hill (1912, p. 217), Schrader et al (1917, pp. 194-198), Lincoln (1923, p. 123) and Nolan (1936, p. 63). These references make little additional geological contribution. It is interesting to note that between 1915-1932 111 tons of silver, gold, copper, and lead ores were produced from Pahranagat with a value of $5,207 (Nolan, 1936, p. 63).

The first geological reconnaissance of the Pahranagat area with objectives other than mining exploration was made in 1871 by G. K. Gilbert in conjunction with the Wheeler Topographic Survey. He described a major structural feature and made some stratigraphic observations in the Pahranagat and adjacent ranges in the Wheeler Report--U.S. Geographical and Geological Survey West of the One Hundredth Meridian Volume III 1875, pp. 37-40, 112, 123, 168-169, 181). It was pointed out that a large mass of strata north of Logan Pass had a westerly dip with a number of
step faults invariably downthrown to the east. South of Logan the predominate dip is eastward with step faults downthrown to the west. Because Gilbert found no folds, and volcanic material was abundant between the areas of reversed dip, he concluded that there was a huge scissors fault transverse to the Pahranagat Range and extending eastward through the Hiko and westward through the Tempiute Ranges. A diagramatic cross section of the northern part of the Pahranagat Range and an idealized dip map was presented to show the relationships.

Gilbert measured 3350 feet of strata by barometer at Silver Canyon which included parts of the Pogonip, Eureka, and Lone Mountain formations. A columnar section is given with some faunal lists from field notes—the specimens being lost in transit (Gilbert, 1875, pp. 168-169, 181). Gilbert also made some remarks on the Pahranagat volcanic rocks and the water supply of Pahranagat Lake and Hiko Spring (Gilbert, 1875, pp. 112, 152).

Hague (1892, pp. 195-200) published Walcott's description of a large part of the Pahranagat Paleozoic section. Thicknesses and faunal lists were presented for the Pogonip, Eureka, Lone Mountain, Devonian, and Carboniferous sections at Fossil Mountain and from localities near Mount Irish. Walcott was not able to determine the thicknesses for the different systems with any degree
of precision noting especially that it was impossible to draw any line between the Silurian and Devonian but provisionally made the following divisions at Mt. Irish:

<table>
<thead>
<tr>
<th>Division</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lone Mountain Niagaran</td>
<td>535</td>
</tr>
<tr>
<td>Lone Mountain Trenton</td>
<td>515</td>
</tr>
<tr>
<td>Eureka</td>
<td>400</td>
</tr>
<tr>
<td>Pogonip</td>
<td>750</td>
</tr>
</tbody>
</table>

2,200 feet

South of Mount Irish Walcott made the following divisions on the basis of fauna:

<table>
<thead>
<tr>
<th>Division</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboniferous</td>
<td>2160</td>
</tr>
<tr>
<td>Devonian</td>
<td>5400</td>
</tr>
<tr>
<td>Silurian</td>
<td>1000</td>
</tr>
</tbody>
</table>

8,560 feet

Assuming that the Lone Mountain Niagaran is included in the Silurian section south of Mt. Irish, Walcott measured approximately 10,225 feet of Paleozoic strata and included some 80 invertebrate species in the faunal lists. At Fossil Mountain 2000-3000 feet of strata were measured.

The findings of Gilbert and Walcott were reviewed by Spurr (1903, pp. 153-154) in his Descriptive Geology of Nevada South of
the Fortieth Parallel. This report contains a Geological Reconnaissance Map (1 inch to 15 miles) that was compiled from all previous available information and covers a large area of southern Nevada and part of California.

Carpenter (1915) made a ground water study of a wide area in southeastern Nevada including the White River drainage basin. Discussion is given regarding the source, quality, and amount of water in the Pahranagat Valley including observations on the late Tertiary and Pleistocene history, (Carpenter, 1915, pp. 53-58, 65-69). A hachure map of the region on a scale of 1 inch to 8 miles (1:500,000) gives locations of flowing, non-flowing, and dry wells and springs and the approximate position of shore lines of ancient lakes. The significant topographic features of the Pahranagat Range area are shown.

Keyes (1923) made a general review of the stratigraphic geology of Nevada. He introduced the terms Pinyon series for rocks he regarded as late Ordovician, and Pahranagat formation for the uppermost Ordovician (Richmondian) in the Pahranagat area. The 5400 feet of Devonian strata of Hague (1892) after Walcott is referred to by Keyes (1923, pp. 53-55). A hachure sketch map includes the Pahranagat Range by name (Plate IV, p. 37). It is not likely that Keyes ever visited the area; his report
being compiled completely from the literature.

Kirk (1933, p. 37) quoted Hague’s thickness of 400 feet for the Eureka quartzite at Quartz Peak (Mount Irish) in the Pahranagat Range.

Merriam briefly reviewed the available information concerning Devonian strata in the Pahranagat area in the light of his knowledge in establishing the western Devonian type section and faunal zones from the Roberts Mountains Region, Nevada (Merriam, 1940, pp. 40-41). The details of this reference have been previously discussed.

A detailed soil conservation survey of the Pahranagat Valley was completed for the U.S. Department of Agriculture by W. D. Taylor in 1940. 41 soil types were described and mapped on air photos and recommendations made for more efficient use of the available farming and grazing areas in the valley proper and adjacent range land.

The 5400 feet of Devonian strata in the Pahranagat area is again referred to by Donovan (1951, p. 48) without additional information in an attempt to isopach Paleozoic systems in the Great Basin.

A chemical study of Pahranagat Valley spring waters and remarks concerning the relationship of the Pahranagat Range area to the Colorado River drainage system are contained in a report
on Irrigation Waters of Nevada by M. R. Miller, et al. (1953, pp. 18-20, 56).

Part of the Devonian section on the west side of the Pahranagat Range was measured by John C. Osmond in connection with his regional study of the Sevy and Simonson dolomites (1954). The Pahranagat Range is not discussed in the text but the thicknesses for the Sevy formation, its upper sandstone member, the Simonson formation, and each of its 4 members occur on the respective isopach maps. Statistical data on the Lower Alternating member of the Simonson formation from the Pahranagat Range are incorporated in Table III, p. 1943, Osmond (1954). This information represents the first new data published on Pahranagat Range Paleozoic stratigraphy since that of Hague (1892).

A columnar section of the Mississippian strata in the Pahranagat Range measured by R. L. Langenheim, Jr. is presented in a correlation chart by Dale Duley (1955, p. 26) in connection with his study of the Mississippian Stratigraphy of the Meadow Valley and Arrow Canyon Ranges, Southeastern Nevada. This report is an unpublished Masters Thesis at the University of California.

Two photos and a thickness for the Laketown dolomite in the Pahranagat Range appear in a regional study of Silurian strata in
the eastern Great Basin by McFarlane (1955). The Pahranagat Laketown section (711 feet) is located on the isopachus map and isometric fence diagram. There is no text discussion. The report is an unpublished Masters thesis at Brigham Young University.

Upper Silurian Brachiopoda were described from the Great Basin by R. H. White (1956). One of the collection localities is in the upper part of the Laketown dolomite in the Pahranagat Range. This report represents the only published systematic paleontological work done in the Pahranagat Range area.

A section of the Eureka Quartzite from the Pahranagat Range was measured by Gregory W. Webb (1958) in connection with his regional study of Middle Ordovician Stratigraphy. The total thickness of the formation and its members appear on the several isopach maps, but there is no discussion in the text and the Pahranagat section is not involved in the correlative cross-sections.

The Pogonip Group was measured by James D. Lowell (1959) from the central Pahranagat Range in connection with his study of the Lower and Middle Ordovician Stratigraphy in eastern and central Nevada. A columnar section appears in his correlation chart Figure 2, p. 20. Brief remarks concerning its significance in terms of regional correlation and some faunal lists appear in the text. This report is an unpublished doctorate dissertation at Columbia University.
A study of the Mississippian and lower Pennsylvanian biostratigraphy in the Pahranagat Range was made by Lawrence S. Griffith (1959). This report, an unpublished Masters Thesis at The Rice Institute, was conducted under partial supervision of the writer.

Two figures representing bedding characteristics of the Simonson and West Range formations in the Pahranagat Range appear in an unpublished doctorate dissertation at The Rice Institute by Alonzo D. Jacka (1959, pp. 28, 154). A discussion of the environmental significance of the stratification pattern in these formations and also in the Pilot and lower Joana formations is made on pages 106 and 152. These references are a small part of a much larger report. Dr. Jacka obtained the data while visiting the writer in the field in 1958.

The writer has published two titles, (Reso and Croneis, 1959, Reso, 1959), which are essentially preliminary reports on Devonian stratigraphy in the Pahranagat Range. The first confirms the great thickness of Devonian strata reported by Hague (1892, p. 200) and identifies all Devonian stages, with the possible exception of the Helderbergian, known throughout the Basin and Range from lower Devonian sediments to beds transitional to the Mississippian. The total composite Devonian section is given as
6048 feet. The second introduces the subject of the classic reef
development in the Pahranagat Devonian.

Brief references to the Pahranagat Range Area may be found
in annual reports of the Resources of Lincoln County from the Office
of George W. Malone, United States Senate, Nevada. These contain
the most recent mineral activity on the Mount Irish Mines or agri-
cultural activity in Pahranagat Valley.

Map References

A topographic map of the Pahranagat Valley was published
by the U. S. Geological Survey in 1939. The map, surveyed in
1934-1935 and titled "Plan of Pahranagat Valley, Nevada, Dam Site,"
was probably part of the regional studies of that time with respect
to the Hoover Dam project. The map includes established bench
marks, township lines, and 5 and 10 foot contours on a scale of
1:31, 680. This map is out of print and will not be reprinted
(U.S.G.S., 1959, written communication).

The Alamo Quadrangle map was published by the Corps of
Engineers, U.S. Army 1945. It includes Alamo and the southern
half of the Pahranagat Range on a scale of 1:125,000 with hachures
only. This map is highly inadequate, contains several cultural
errors, and will not be reprinted.

The Pahranagat Range appears on the Physiographic Diagrams
of North America by A. K. Lobeck (1932, p. 77, 1950), drawn by
Guy Harold Smith. The same diagram of the Great Basin appeared
earlier in Fennemen (1931, p. 327). The Pahranagat Range is
neither correctly drawn nor correctly located. The Landform Map
of the United States and that of California-Nevada of Raisz 1957
labels the Pahranagat Range by name. Although correctly located,
the northern half of the Range needs revision (see Figure 1, p. 40).

The Mt. Whitney Sectional Aeronautical Chart 1959 shows
the Pahranagat area on a scale of 1:500,000 with 1000 feet contours.

The most accurate available map that includes the Pahranagat
Area is the Caliente Quadrangle 1959 edition, 1:250,000 with a con-
tour interval of 200 feet. A woodland edition has also been pub-
lished (see pocket).

All of these maps are inadequate for geological mapping
purposes, thus necessitating the writer's construction of Plate I.

Nearby and Related Research in Progress

At the time of this report a study of the Tertiary Volcanic
Rocks of the Pahranagat Area is being conducted by Mr. Abraham
Dolgoff with the partial collaboration of the writer.

A geological map of Lincoln County, which will include the
Pahranagat Area, is being completed by Mr. Charles M. Tschanz
of the U.S. Geological Survey. This will be on a scale of 1:125,000
with 200 foot contours. The written report will eventually be published by the Nevada Bureau of Mines, (Charles M. Tschanz, 1959, personal communication).

The Geology of the Arrow Canyon Range, about 40 miles south of the Pahranagat Area, is under study by R. L. Langenheim, Jr. who is also conducting regional investigations of Mississippian strata in Eastern and Southern Nevada.

A Reconnaissance Geological map of Clark County, Nevada, was recently published by Bower et al. (1958) for the U.S.G.S. on a scale of 1:200,000 and a contour interval of 500 feet. This map is of considerable advantage in making "nearby" reconnaissance and comparative stratigraphic and structural studies.

Considerable stratigraphic and structural investigations have been made by oil companies in eastern Nevada since 1946. Virtually all information gathered is unpublished and unavailable. Shell, Gulf, Richfield, and Continental, the most active companies in Eastern Nevada between 1952-1957, have done reconnaissance geology in the Pahranagat Range.

Summary

Thirty four written references that allude to Pahranagat Range geology during the past 95 years have been found. Only the two references by the writer and one unpublished thesis (Griffith 1959)
mention the Pahranagat Range in title; the remaining 31 are brief remarks in other works. Fourteen concern early explorations and Mt. Irish mining. The earliest stratigraphic work of Hague (1892) is repeated by 5 authors between 1903-1951 without additional contribution. Four references remark only on soil, ground water, and agriculture. Six references are merely points on maps to locate a measured stratigraphic unit under regional study. There is only one paper that has described Pahranagat fauna (Waite 1956). Six of the references are unpublished theses.
FIELD METHODS

Private houses in Alamo and trailer cabins at Alko, 2 miles north of Alamo, were rented during the summers of 1958 and 1959. These served as field headquarters and temporary laboratories for evaluation of data, drafting and mapping, and disposition of collections. A minimum of camping on the Range was experienced. Time and energy that would have been dissipated on cooking and camping chores was equivalent to time spent in transportation to and from specific field localities. Meals were secured for the most part at the Alko Cafe. Rugged terrain and excessive summer heat, often in excess of 130°F in the sun, made it advisable to secure the quarters available for maximum mental and physical field efficiency.

Transportation was effected by 4 wheel drive vehicles, a Ford panel truck in 1958 and both a station wagon type and smaller conventional jeep in 1959. Despite the availability of these vehicles long rugged mountain climbing was necessary in order to explore
remote areas of the Range. Three to six hour hikes covering 5
to 8 miles one way and several thousand feet of elevation were not
uncommon in order to measure important stratigraphic sections.
No less than two, and as much as four quarts of water were taken
by each man on such trips.

Since no large scale topographic map is available for the
Pahranagat Range, field work was supported entirely by air photos.
Preliminary mapping has been done directly on the air photos or
upon acetate overlays for future transfer to the base map (Plate I).
Plane table work was limited to location of section corners and
accurate scaling of air photos in connection with construction of
the base map.

Measurement of stratigraphic sections was accomplished
entirely by the Jacob Staff method as described by Kummel (1943),
Broggi (1946), Bergstrom (1958) and Robinson (1959). A four foot
aluminum staff was used with an attachment for the Brunton Compass.
This method is as accurate as any other and affords direct measure-
ments without trigonometric conversions.
TERMINOLOGY

Descriptions of carbonate rocks follow the terminology of Grabau (1913) as extended by Kay (1951, pp. 5-6). The view is taken that calcitites are almost invariably detrital with the exception of oolitic limestones or such rock as travertine which has crystallized into a solid mass. Thus most limestones are called calcilutites, calcisiltites, calcarenites and calcirudites, which means that limestone particles were of lutaceous, siltaceous, or arenaceous texture at the time of deposition and have essentially remained so. Limestones that apparently have been subsequently recrystallized are termed crystalline limestones. It is pointed out, however, that many fine grained crystalline limestones may have been called calcilutites. The writer agrees with Sando et al. (1959, pp. 2744-46) that it is difficult to distinguish between granular and crystalline texture in calcitite sizes smaller than 1/8 mm. diameter with a hand lens.

The writer believes that dolomites are preponderantly metasomatic rocks and rarely of dolomite detritus. Texture is
described as aphanitic or phaneritic without implication of any original detrital texture (DeFord 1946; Folk 1959, p. 16). Carbonate rocks which would not readily effervesce in dilute hydrochloric acid were considered dolomitic.

Descriptions of rocks of the quartzite series follow Krynine (1948). Grain sizes are designated according to the grade scale of Wentworth (1922), and roundness classes after Pettijohn (1957, p. 59). The sand gauge folder of the Geological Speciality Company, Oklahoma City, Oklahoma was used in the field.

Colors were determined with the National Research Council Rock Color Chart, 1948. Particular care is given to describing the color of both the weathered and fresh surfaces in the detailed description of measured sections in this report including the appropriate numerical designation from the color chart. This is done because in the drilling of wells only the fresh-surface color is seen, but the weathered outcrop color of the rock may be helpful to others doing field work in the region.

Terms such as "thick" and "thin" applied to bedding are relative to one's stratigraphic training and experience. Recent literature that attempts to standardize the limits of thick, medium, and thin for bedding are in considerable disagreement (McKee and

In this report thickness of stratification and parting units less than 1/2 inch are termed laminated; those from 1/2 inch to 5 inches - thin bedded; 5 inches to 3 feet - medium bedded; and greater than 3 feet - thick bedded. In many cases the actual dimensions are given in the detailed description of the measured sections. The ambiguous and misused term massive is avoided but when used applies to thick beds that have no preferred direction of cleaving or breaking after Ingram (1953, p. 371). In the field one commonly finds massive parted ledges within which are thin beds. In such cases the situation is explained. In this report the use of bedding terms compares closely with that of McKee and Weir (1953, p. 383).

Weathering resistance is described in progressive classes of saddle-forming, bench-forming, slope-forming, resistant slope-forming, semi cliff-forming, and cliff-forming.

In all cases in this report the attitude of strata are described by amount of dip and direction of dip, i.e. 20° in the direction N 25° E. The strike is never given.
DISPOSITION OF COLLECTIONS

At the time of this report the majority of Cambrian, Ordovician, Mississippian, Pennsylvanian and Tertiary lithologic samples and faunal specimens are retained at the Geological Laboratory, The Rice Institute, Houston, Texas. The majority of Silurian and Devonian collections are catalogued at The Pratt Museum, Amherst College, Massachusetts. However, representative specimens of all Paleozoic and Tertiary faunas are available at both institutions.

Small collections referred to the Stratigraphic and Paleontological Branch of the U.S. Geological Survey for identification are retained at the U.S. National Museum, Washington, D.C.
PART II

STRATIGRAPHY

INTRODUCTION

Over 18,000 feet of Paleozoic strata ranging in age from early late Cambrian to late early Pennsylvanian, and up to 3000 feet of Tertiary rocks are exposed in the Pahranagat Range. There are no known Mesozoic rocks.

The Paleozoic section is primarily composed of dolomite, limestone and orthoquartzite with a minor amount (5%) of shale. Tertiary rocks are represented primarily by a sequence of welded tuffs (ignimbrites) of the flowing avalanche type, other pyroclastics, and minor amounts of water worked tuffs, lacustrine beds, basalt flows, and alluvium.

The Tertiary volcanic sequence is divisible into widespread mappable units which permits treatment along with Paleozoic strata under the general stratigraphic heading in this report. No intrusive rocks have been found in the subject area.
The Paleozoic and Tertiary sections are both typical of unique depositional tectonic frameworks. The Paleozoic is typical of miogeosynclinal deposition; and the Tertiary typical of a site of prolific acid eruptive accumulation. The origin, mode of transportation, and accumulation of such rocks in their respective depositional provinces remains a subject of debate and controversy.

In the following description of stratigraphic units the reader is referred to Plate II (pocket); Composite Columnar Section of Exposed Paleozoic and Cenozoic Rocks in the Pahranagat Range, Nevada.

PALEozoIC ROCKS

Introduction

The maximum composite thickness of exposed Paleozoic strata in the Pahranagat Range is 18,200 feet. Nineteen formations and 33 members belonging to 12 of the formations are recognized in this report. These units have been correlated where possible with lithologies and faunas described elsewhere in eastern Nevada and Utah. Visits to type areas and exchange of information on the most recent developments by other investigators in the Basin and Range province has resulted in the employment of considerable established terminology. Only two new terms of formation rank are introduced Members are referred to as lower, upper, or by alphabetical letters
as A, B, C, etc. in order to avoid giving them any official status in this report. However, additional new terms for significant members will be introduced in later reports. The thickness of virtually all Paleozoic formations exceeds that reported from other areas in eastern Nevada.

The areas to which the Pahranagat Range Paleozoic strata and faunules are correlated and referred to below are located on Figure 4, p. 126.

A magnificent, eastward dipping, continuous exposure of 14,250 feet of Paleozoic strata that includes rocks from lower upper Cambrian to lower Mississippian occurs on the west side of the Pahranagat Range (Plate VIII).

CAMBRIAN ROCKS

Introduction

About 4000 feet of upper Cambrian rocks are exposed in the Pahranagat Range and are referred to the Lizard Hill formation (new term), the Dunderberg formation, and the Desert Valley formation (new term), Plate II. A continuous sequence of Cambrian strata occurs in two north-south trending, eastward dipping bands on the west side and in the center of the Pahranagat Range. In the latter case the Cambrian section is continuous across the Cambrian-Ordovician boundary, but there is probably a Cambrian-Ordovician
hiatus on the west side of the range. Faunas are very rare.

Lizard Hill formation

The Lizard Hill formation includes the oldest rocks of the Pahranagat Range exposed at the base of the eastward tilted sequence on the west side of the Range. This includes several small outliers that protrude through alluvium separated by only a small distance from the main section (Plates VII and VIII). The Lizard Hill formation is named for the farthest west outlier (appropriately termed Lizard Hill). The total minimum thickness of the formation is 1614 feet. It is divided into three distinctive members; a lower dolomite member, a middle limestone member, and an upper dolomite member. Because the formation is incomplete these members are designated A, B, and C respectively.

Member A:

Member A of the Lizard Hill formation has a minimum thickness of 383 feet. It includes the entire section on Lizard Hill with base and top covered. The member consists of medium light gray to dark gray weathered and fresh surfaces of massive ledged, thin to medium bedded, fine phaneritic dolomite. In general the fresh surfaces are slightly darker than the weathered. The member is also characterized by some calcite and dolomite veining, disseminated fine quartz grains and some sand stringers, local brecciation, and slightly calcareous zones. No fossils have been found. One bed contains rocks which give off a hydrocarbon fetid odor.
EXPLANATION OF PLATE VII

Continuous eastward dipping exposure of 14,250 feet of Paleozoic strata on the west side of the Pahranagat Range.

Stratigraphic units included are:

Cambrian

| a-b | Lizard Hill formation |
| b-c | Dunderberg formation |
| c-d | Desert Valley formation |

| d | Cambrian-Ordovician boundary |

Ordovician

| d-e | Pogonip group |
| e-f | Eureka quartzite |
| f-g | Fish Haven dolomite |

| g | Ordovician-Silurian boundary |

Silurian

| g-h | Laketown formation |

| h | Silurian-Devonian boundary |

Devonian

| h-i | Sevy dolomite |
| i-j | Simonson dolomite |
| j-k | Guilmette formation |

For thicknesses of formations and members see Plate II
The top of member A is separated from the main section by alluvium. Approximately 144 feet of stratigraphic section has not been described (Plate II).

**Member B:**

The minimum thickness of member B is 420 feet. It consists of very characteristic alternations of resistant mottled and less resistant laminated calcilutite and fine crystalline limestone. Alternations may vary from 2 to 30 feet but attain a more numerous cyclic appearance in the upper half of the member.

The resistant alternations consist mainly of light olive gray weathered mottles in a field of dark gray to grayish black weathered, massive parted ledges of thin bedded (1/2 to 1 1/2 inches), continuously and discontinuously bedded, very fine crystalline limestone. Fresh surfaces are lighter than the weathered. Several zones have pale grayish red weathered mottles in a matrix of light to yellowish gray weathered limestone. If the mottles and matrix are about equal the rock attains an unusual "leopard spot" or "tiger stripe" pattern.

The less resistant alternates are composed of grayish orange pink weathered, slightly darker grayish orange fresh surface, laminated calcilutite to very fine crystalline limestone. Laminations are commonly finer than 1/32 inch. Variations include weathering surfaces that color medium light bluish gray to moderate orange to pink. Persistence of the latter lithology in excess of 10 feet produces eroded benches between the resistant slope-forming to semi cliff-forming mottled alternates.
In the lower half of the member the less resistant alternations are recognized as more massive 3 foot parted ledges with 1/4 to 1/2 inch banded laminations with some partial dolomitization. The resistant alternate is medium light gray weathered, massive 2-4 foot parted ledges of thin to medium bedded (5-6 inches), very fine calcisiltite to calcilutite and crystalline limestone. No organic remains have been found in member B.

Member C:

The thickness of one measured section of member C from the west side of the Pahranagat Range is 667 feet. The member is essentially homogeneous—consisting of light olive to medium gray weathered, light to dark gray fresh surfaces, massive 1 to 3 foot parted ledges of fine to medium phaneritic dolomite. Massive ledges thicken to 10-12 feet in the upper part of the member forming continuous rugged cliffs.

Member C contains minor amounts of light olive gray weathered aphanitic dolomite, some mottling, and pale reddish brown partings and jasperoid? speckles. "Ghost" laminations and thin beds (1/4-2 inches) are in some places discernible in the parted massive ledges. The lower 60 feet contains 4-8 foot lithic alternations, that except for complete dolomitization, resemble member B. No fossils have been found in member C.
Age, fauna, and correlation

No fossils have been found in the Lizard Hill formation.

The age is determined by correlation of distinctive lithic features with similar units elsewhere in the Basin and Range occurring at the same stratigraphic position below the Dunderberg formation, whose age is known to be early late Cambrian (Dresbachian to earliest Franconian).

The Lizard Hill formation resembles parts of units B and C and may also include unit D of the Yucca Flat formation in the Nevada Proving Grounds (Johnson and Hibbard 1957, pp. 341-342). It correlates with parts of the upper Highland Peak formation and possibly part of the Mendha limestone in the Pioche District (Wheeler and Lemmon 1939, Wheeler 1940); and with the uppermost part of the Highland Peak formation as used by Humphrey (1945, pp. 21-22) in the Groom District, Nevada. See locations Figure 4. Sequences of alternating cream colored laminated dolomite and dark limestone creating a diagnostic "cyclic" or banded effect are described from this stratigraphic position at the latter three localities. These lithologies are strikingly similar to member B of the Lizard Hill formation which apparently can be used as a general regional marker. However, there is considerable variation in the proportions of dolomite to limestone among these sections making precise correlation difficult. The Lizard Hill formation has a greater amount of dolomite
than its time equivalents elsewhere.

The Yucca Flat formation is at least 2,815 feet thick, (Johnson and Hibbard 1957, p. 341). Only the uppermost unit D contains fossils which have been identified as Late Dresbachian. Johnson and Hibbard assigned a middle Cambrian to early late Cambrian age to the formation. In the Groom District the total thickness of the Highland Peak formation exceeds 4000 feet. Faunas from the base are considered to be high in the middle Cambrian, and the upper part of the formation is considered to cross into the lower upper Cambrian, Humphrey (1945, pp. 21-22). At Ploche, Nevada the Highland Peak formation is considered latest middle and earliest late Cambrian with the Mendha limestone entirely upper Cambrian (Wheeler, 1940, pp. 33-34).

The Lizard Hill formation correlates with members B and C of the Emigrant Springs limestone in the Southern Egan Range. A. R. Palmer in Kellogg (1959, p. 24) has identified faunas from the upper 400 feet of member B that correlate with the upper part of the Crepicephalus zone of the Standard Upper Cambrian (Howell et al, 1944). Palmer also reports the presence of Glaphyraspis sp. from a collection 10 feet above the base of member C of the Emigrant Springs limestone. These are considered basal beds of the Standard Upper Cambrian Aphelaspis zone. Collections from the middle and uppermost part of member C also contain faunas that fall within the Aphelaspis zone (Aphelaspis and Dunderbergia zones
of Lochman-Balk and Wilson, 1958, p. 334) which are very late Dresbachian (early-late Cambrian).

The Lizard Hill formation is a close correlative of the Hamburg dolomite in the Eureka District. Nolan, Merriam and Williams (1956, pp. 16-18) describe the Hamburg as essentially light to medium gray, porous and vuggy, coarsely crystalline dolomite containing some limestone and banded, mottled, speckled, brecciated textural variations. Thus members B and C of the Lizard Hill formation are certainly involved. A.R. Palmer (in Nolan, Merriam and Williams, 1956, p. 18) considers the lower Hamburg dolomite youngest medial Cambrian on faunal evidence and the upper part early late Cambrian on stratigraphic position below the Dunderberg shale (Dresbachian).

The Lizard Hill formation correlates with the upper part of the Lincoln Peak formation in the Southern Snake Ranges (Drewes and Palmer, 1957, pp. 113-114) and with part of the Weeks formation in the House Range, Utah (Wheeler and Steele, 1951). Fossils from many levels in the Lincoln Peak formation range in age from at least late middle Cambrian through most of the early late Cambrian.

The Lizard Hill formation correlates with a number of formations in the Basin and Range whose ages are late medial Cambrian through early upper Cambrian. Because the Lizard Hill correlates only with the upper parts of these formations its age is considered entirely early late Cambrian.
Origin

The Lizard Hill formation was probably deposited under shallow to moderately deep water shelf conditions and has subsequently been recrystallized and profoundly dolomitized. Thus all possible organic remains which are known to occur elsewhere in less altered limestone facies have been obliterated. Nolan, Merriam, and Williams (1956, p. 17) likewise consider the Hamburg dolomite essentially a product of alteration. These views differ from those of Humphrey (1945, p. 21) who states that the Highland Peak formation in the Groom District, Nevada, is a primary carbonate precipitate in shallow waters. He considers the dolomite to have been precipitated in stagnant waters and laminated limestones precipitated during seasonal or periodic inundations by the sea at which time waters would have been less stagnant.

Four "cycles" each consisting of massive cliff-forming calcisiltite to calcilutite capped by oolitic calcarenites which in turn grade upward into thinly bedded argillaceous quartz-silty calcisiltites, are recognized in the Emigrant Springs limestone in the Southern Egan Range by Kellogg (1959, p. 23). Cycles of this nature suggest to the writer a progressive shallowing, then deepening of water level. One such megacycle is visualized to occur in the upper part of member C of the Lizard Hill formation although the correlative massive cliff is entirely phaneritic dolomite in the
Pahranagat Range. This is followed by oolitic limestone in the lowest beds of the overlying Dunderberg formation which grade upward into thin-discontinuously bedded silty calcsilite. It is possible that Kellogg's fourth cycle may be stratigraphically younger in the Pahranagat Range or that the lowest parts of the Pahranagat Dunderberg may correlate with the upper part of member C of the Emigrant Springs limestone in the Southern Egan Range. These problems demand further detailed stratigraphic and faunal studies.

A detailed study of the rapid horizontal and vertical limestone and dolomite changes, which are well displayed and widespread at the general stratigraphic level of member B of the Lizard Hill formation in eastern Nevada, might lead to further enlightenment on the dolomite problem.

The presence of some hydrocarbon residue and locally vuggy zones suggests consideration of parts of members A and C the Lizard Hill formation as potential petroleum reservoirs.

**Dunderberg formation**

The Dunderberg shale was originally named the Hamburg shale by Hague (1883, pp. 255-256; 1892, p. 41) from exposures near the Hamburg and Dunderberg mines in the Eureka District, Nevada (Figure 4). It was later redefined as the Dunderberg shale by Walcott (1908, p. 184) in order to avoid use of Hamburg for two
formations in the same area. The Dunderberg shale includes interbedded limestones at Eureka which become more abundant in the Southern Egan Range. For this reason Kellogg (1958, p. 27) preferred the use Dunderberg formation rather than simply "shale." The usage is adopted in this report.

The Dunderberg is a relatively thin, easily recognized, widespread Basin and Range stratigraphic unit which contains a distinctive fauna. Regardless of lithologic variations in comparison to the type section the name Dunderberg has fortunately been retained by most eastern Nevada and western Utah investigators (Bentley, 1958, p. 21-22, Robison and Bentley, 1958, p. 1702).

The Dunderberg has a distribution that is similar to that of the Lizard Hill formation. Two north-south trending, eastward dipping, bands occur along the west side and in the center of the Pahranagat Range south of Highway 25. It forms a brownish colored saddle between the more resistant subjacent Lizard Hill and superjacent Desert Valley formations (Plate VII, Plate VIII, Figure A). Two measurements of the Dunderberg on the west side of the Pahranagat Range give thicknesses of 391 and 402 feet.

Description

The base of the Dunderberg formation is defined by the abrupt change from resistant massive dolomite of Member C of the Lizard Hill formation to less resistant limestone. The lower 30-100
EXPLANATION OF PLATE VIII

Figure A

Outcrop of the Dunderberg formation (391-402 feet) on the west side of the Pahranggat Range. The Dunderberg forms a saddle between the resistant dolomite of subjacent member C of the Lizard Hill formation (€1h) and superjacent Desert Valley formation (€dv).

Resistant ledges (a) are brownish gray cross-bedded siltstones and oolitic calcarenites of the lower Dunderberg. The typical light olive gray shale is interbedded with trilobite bearing yellowish brown calcarenite stratigraphically above (a) and thin easily eroded discontinuously bedded calcitites stratigraphically below. View is looking north.

Figure B

Interbedded light olive gray shale and thin beds of yellowish brown calcarenite typical of the upper Dunderberg formation. This type of bedding is thought by Jacka (1959) to be representative of a tidal flat.
feet of the Dunderberg consists of medium light gray weathered (medium gray fresh surfaces), thin-discontinuously bedded, pale grayish orange shale parted, recrystallized calcarenite to calcilutite. Also included are some oolitic limestone and lime pebble conglomerate (calcirudite). Fossil hash, including arthropod fragments, and algae (1/4 inch diameter) are abundant. This is followed by about 100 feet of more resistant medium olive gray to medium greenish gray weathered thin (1/2 to 1 inch) continuous and discontinuously wavy bedded, shale parted, silty calcilutite to calcisiltite. Fresh surfaces are medium light gray. Oolitic limestones with some included brown mud pebbles occur locally. Distinctive of this zone are ledges of brownish gray to brownish black (desert varnish) laminated to thin bedded, cross-bedded siltstone.

The upper half of the Dunderberg is composed of easily eroded, partly covered, benches of light to medium olive gray flaky shale interbedded with thin silty limestone beds and resistant 1 to 3 foot ledges of thin-wavy bedded, silty calcarenite to calcisiltite, (Plate VIII, Fig. B). Fresh surfaces of the limestones are medium gray. The limestones contain a prolific hash of trilobite fragments and inarticulate brachiopods. The shale fraction diminishes in the upper part of the formation giving way to more massive ledges of medium bedded, brownish gray,
weathered silty limestone. Near the top of the Dunderberg the limestones weather light bluish gray, become finer grained, more massive and less silty; and they contain very thin argillaceous partings.

The upper boundary of the Dunderberg is placed at an abrupt increase in slope essentially coincident with departure of shale partings and appearance of abundant chert nodules and stringers in massive limestone of the overlying Desert Valley formation.

Age, fauna and correlation

The base of the Dunderberg formation in the Pahranagat Range is placed at the abrupt lithologic change from resistant massive dolomite to thin discontinuously bedded limestone. This is an arbitrary but also a "natural" division that may reflect a fundamental change in the sedimentary cycle or depositional environment. This division does not match lithically with described sections in the Southern Egan Range (Kellogg, 1959) and Nevada Proving Grounds (Johnson and Hibbard 1957). The problem is simply that at the latter two locations beds subjacent to the Dunderberg are fossiliferous limestone whereas the sections below the Dunderberg in the Pahranagat Range and at the Eureka type section are barren dolomite. However, it is known that
beds below the Dunderberg in the Proving Grounds and in the Southern Egan Range both contain characteristic trilobites that fall within the *Aphelaspis* zone of the American Standard Cambrian and are late Dresbachian (early late Cambrian).

The fauna from the Dunderberg formation is a large one and has been studied by a number of paleontologists in recent years (Palmer, 1955). The calcarenite interbeds in the upper Dunderberg contain prolific trilobite assemblages. A collection from this zone in the central Pahranagat Range was examined by A.R. Palmer, (C.M. Tschanz, 1959, personal communication) who identified the following species:

*Dunderbergia nitida* Hall and Whitfield

*Homagnostus tumidosus* Hall and Whitfield

*Linnarsonella* sp.

These forms are characteristic of the upper part of the Dunderberg shale at the Eureka type section where they occur with many other trilobite species including *Elvinia roemerii* (Shumard) considered a guide to the *Elvinia* zone of the standard American Cambrian faunal succession. These trilobites indicate that the upper Dunderberg is lower Franconian (Palmer, in Nolan et al., 1956, p. 19).

Nearly identical assemblages have also been identified by Palmer from the upper Dunderberg in the Southern Egan Range
(Kellogg, 1959, p. 28) and in the Nevada Proving Grounds
(Johnson and Hibbard, 1957, p. 343).

The Dunderberg formation in the Pahranagat Range is
therefore considered to embrace a time interval from the upper-
most Aphelaspis zone to the Elvinia zone; uppermost Dresbachian
to early Franconian; or late early to middle upper Cambrian.

The lower Dunderberg calcarenites correlate with the
Johns Wash limestone whereas the upper Dunderberg is a cor-
relative of the Corset Spring shale of the Southern Snake Range
(Figure 4) described by Drewes and Palmer (1957, pp. 115-116).
The Johns Wash limestone lies between beds containing fossils of
the post Aphelaspis zone and the Elvinia zone and is therefore
early to middle late Cambrian. The Corset Spring shale contains
trilobites which are characteristic of the Elvinia zone. The writer
suggests reducing the rank of the Johns Wash limestone and Corset
Spring shale formations to lower and upper members of the Dun-
derberg formation respectively.

The Dunderberg formation is a correlative of a limestone
and shale unit in the lower Mencha limestone at Pioche (Wheeler
and Lemmon, 1939, p. 44; Wheeler, 1940). The Dunderberg litho-
tope is recognized in the House Range, western Utah (Hintze, et al.
1958, p. 1689). It is also present in the Stansbury Range and Tintic
District, Utah (Bentley, 1958, p. 29).
**Origin**

The lower Dunderberg interval reflects a shallowing condition with extensive inner shelf development. Fossiliferous, thin wave-agitated calcilutite to calcarenite and oolitic limestone suggests a shallow water inner neritic bank environment of deposition after Newell and Rigby (1957). Cross bedded siltstones and thin-discontinuously bedded calcitites and oolitic limestones in the middle Dunderberg suggests a decrease in shelf gradient and close proximity to source under littoral conditions. Interbedded shale and thin calcarenites containing prolific trilobite assemblages of the upper Dunderberg (Plate VIII, Figure B) suggests a tidal flat environment (Jacka, 1959). The loss of clastics and shelly facies fauna with increase of fine textured, massive, continuously bedded limestone indicates a deepening of water on the inner neritic shelf in latest Dunderberg time.

**Desert Valley formation**

The Desert Valley formation is here named for the sequence of cherty limestones and dolomites that overlie the Dunderberg formation and underlie the Lower Limestone formation of the Pogonip Group. The formation is completely exposed on the lower slopes of the west face of the Pahranagat Range overlooking Desert Valley (Figure 2). Here it occurs as a north-south trending, eastward dipping, band that runs for several miles until terminated by east-
west faulting on both the north and south ends of the outcrop. It is well exposed in the central Pahranagat Range south of Highway 25, and it makes up the north wall at the west end of Crescent Canyon on the upthrown side of the Gilbert fault in the northwestern part of the Range.

The Desert Valley formation has a thickness of 2110-2123 feet and is divided into four members (Plate II).

**Member A**

Member A is essentially a transition unit between limestones of the uppermost part of the Dunderberg formation and pure dolomites of member B of the Desert Valley formation. It consists of medium light gray to light bluish gray weathered massive ledges of calcilutite to fine crystalline limestone, with partially dolomitized zones. Coarse calcarenites, coarse crystalline limestones, and dolomitic calcarenites are locally present. Chert stringers and nodules increase to 1-2 inches wide in the upper half of the member. The thickness of member A is 82-84 feet. No fossils have been found in member A.

**Member B**

Member B consists of light to medium dark olive and brownish gray weathered, invariably darker fresh surfaces of semi cliff-forming, massive ledged, fine phaneritic dolomite. Thin-wavy 1/2-2 inch discontinuous bedding is recognized within massive 2 to
4 foot parted ledges in the lower half of the member. Thin beds and massive ledges contain moderate reddish brown to orange weathered shaly partings. White and pink dolomite veining and slightly calcareous zones occur locally. Most distinctive are abundant chert nodules and stringers 1/2 to 3 inches wide. In the upper parts of member B the chert forms semi-continuous 1 inch bands 6 inches to 1 foot apart. The thickness of member B of the Desert Valley formation is 680 feet. Well preserved brachiopods are found in the lower 300 feet.

**Member C**

The boundary between members B and C is placed at the base of a distinctive 17 foot zone of very light gray weathered, massive, slightly calcareous fine phaneritic dolomite. The fresh surface is very light to yellowish gray. This dolomite and a number of similar 5 to 10 foot zones in the lower 250 feet of the member C make a series of white bands above the darker colored dolomites of member B. These bands can be traced for miles across the entire outcrop and are easily seen at great distances when the sun is in a favorable position. These bands serve to distinguish the formation as well as the member throughout the region and are particularly valuable for correlating faulted sections (Plate IX, Figure A).
Aside from the light bands, member C is primarily composed of light to medium dark olive gray weathered, semi cliff-forming to cliff-forming, massive, sugary phaneritic dolomite. Some light to medium dark gray weathered surfaces are present and in general fresh surfaces are equal to, or slightly lighter than, weathered surfaces. Slightly calcareous zones, scattered chert, and pink and white dolomite veining in brecciated zones occurs locally. The upper half of the member is distinguished by speckles and mottles. The thickness of member C is 884-918 feet. A coral-gastropod faunule occurs 189-199 feet from the base of the member (951-961 feet from the base of the formation) at Anchor Point Ridge on the west side of the Pahranagat Range.

**Member D**

Member D of the Desert Valley formation consists of light to medium olive gray weathered, bench to resistant slope-forming, thin-wavy discontinuously bedded (1-6 inches) fine phaneritic dolomite. It is readily distinguished from subjacent member C in being less resistant, thin bedded, and containing abundant chert. Some bluish gray and brownish gray weathered surfaces are also present and calcite veining is locally abundant. The thickness of the member is 477-500 feet.

The lower 175-200 feet is fine phaneritic dolomite with disseminated quartz sand and brown weathered sand stringers. This is followed
EXPLANATION OF PLATE IX

Figure A

Type locality for the Desert Valley formation on the west side of the Pahranagat Range. White dolomite bands of member C distinguish the formation throughout the region. Dark ledges at the lower part of the mountain are cross-bedded siltstones and calcarenites of the Dunderberg formation.

Figure B

Contact between the Desert Valley formation (cherty dolomite member D) and the Lower Limestone formation of the Pogonip Group in the central Pahranagat Range (a-a). The contact is also the Cambrian-Ordovician boundary in the region. Paleozoic strata dip 55 degrees eastward and are overlain by the gently dipping Tertiary Hells Bells Canyon formation (b). View looks northward toward Mt. Irish in the background.
by 250 feet of coarser phaneritic vuggy dolomite containing prolific
distinctive medium bluish gray 1 to 3 inch wide chert stringers,
bands and knobs. The upper 50 feet of the member is again very
fine phaneritic dolomite without chert. The top of the member and
formation occurs at the boundary between dolomite and overlying
limestones of the Pogonip group (Plate IX, Figure B).

Age, Fauna and Correlation

Only two faunules have been found in the Pahranagat Range
Desert Valley formation. At Anchor Point Ridge on the west side
of the Range thin-wavy (1/2-2 inch) discontinuously bedded,
reddish brown shaly parted, fine phaneritic dolomite 164-176 feet
from the base of member B (246-258 feet from the base of the
formation) yielded a prolific collection of silicified brachiopods.
These were examined by W. C. Bell who identified the following
species:

**Angulotreta sp.** cf. **A. tetonensis** Walcott

**Billingsella sp.** cf. **B. perfecta** Ulrich and Cooper

"I'll predict with considerable certainty that this faunule
comes from the *Conaspis* zone, Franconian Stage, of
the Standard Upper Cambrian classification." (Bell,
1959, written communication)

The same faunule occurs 144-148 feet from the base of
member B (228-232 from the base of the formation) two miles on
strike southward. At Anchor Point Ridge the brachiopods are found intermittently throughout 140 feet of section above the main collecting site or totally from 164-316 feet from the base of member B. Undescribed species of associated small linguloid brachiopods are found in the higher zones.

A coral-gastropod faunule occurs 189-199 feet from the base of member C (951-961 feet from the base of the formation) at Anchor Point Ridge. The corals were examined by Vladimir J. Okulitch, who identified a species identical or very similar to "Holophragma."

"....."This genus is known from the Stony Mountain formation of Manitoba, and I have seen it in the Sarbach formation of the Canadian Rockies. The age is probably high lower Ordovician." (V.J. Okulitch, 1959, written communication.)

The gastropods from the same faunule were examined by Roger Batten who states:

".....they cannot be identified. They are in real sad shape in that they do not have growth lines or complete apertures. Just as a triple question mark wild guess I would say that they could be high in the Cambrian. I would prefer to call them Ordovician." (Batten, 1959, written communication.)

The Conapsis zone brachiopod faunule in member B of the Desert Valley formation has recently been found at the same general stratigraphic level at two other localities in southeastern Nevada. It is therefore considered a very reliable time marker. The age of
the coral-gastropod faunule in member C is doubtful, because the suggested age is inconsistent with regional correlations. The gastropods could not be identified, and the Holophragma is apparently a new occurrence of the form from strata older than ever previously reported.

The Desert Valley formation correlates with the post Dunderberg, pre-Pogonip Group interval described as the Whipple Cave formation by Kellogg (1959) in the Southern Egan Range. In this area a lower cherty limestone member (566-906 feet) is overlain by an upper dolomite member (1058-1260 feet) whose base is defined by a 100 foot white dolomite band. The Whipple Cave has yielded Ceratreta, Billingsella, acrotretid, and linguloid brachiopod species 144 feet above the base of the formation. A.R. Palmer identified the forms (Kellogg, 1959, p. 32), as belonging to the Conopsis zone of the middle upper Cambrian and this is almost certainly the same faunule that occurs in member B of the Desert Valley formation. Two collections from 1286 and 1303 feet above the base of the Whipple Cave formation (approximately 336 feet below the top) contained species of trilobites distinctive of the latest Cambrian (Kellogg, 1959, p. 32). Hintze (1952, pp. 65-66) collected the trilobites from limestones 180 feet above the top of the Whipple Cave formation which included Symphysurina, considered
by him a guide to the basal Ordovician of Nevada (Hintze 1951, p. 11; 1952, p. 5).

The Desert Valley formation occupies the same time interval as the Windfall formation of the Eureka district (Nolan, Merriam and Williams, 1956, pp. 20-22). The Windfall formation is 650 feet thick and is essentially all silty-shaly limestone. It contains faunas that are Franconian and Trempeleauan although no representatives of the Conapsis zone of the Franconian have been found in the Eureka district. Faunules that immediately overlie the Windfall formation contain *Symphysurina eurekensis* (Walcott) and *Symphysurina spicata* Ulrich, considered to be guides to the basal Ordovician.

The Desert Valley formation correlates with the unnamed limestone formation that overlies the Corset Spring shale in the Southern Snake Range (Drewes and Palmer, 1957, pp. 116-117). Conapsis zone faunas occur 230 feet from the base of this formation.

The Desert Valley is a correlative of part or all of units A-D of Upper Cambrian rocks in the Atomic Proving Grounds, Nevada (Johnson and Hibbard, 1957, pp. 343-345). In this area post Dunderberg, pre-Pogonip strata have a thickness of about 2600 feet, and consist of cherty limestone and dolomite. These beds, in their lower parts, contain faunas from the *Elvinia* and *Ptychaspis* zone of the middle and upper Franconian.
The Desert Valley formation is correlated with upper portions of the Mendha limestone in the Pioche district (Wheeler and Lemmon, 1939), with the Notch Peak limestone in the House Range of western Utah (Bentley, 1958, pp. 24-25; Hintze et al, 1958, p. 1689) and with the Ajax limestone in the Tintic district, and Standbury Mountains Utah (Lindgren and Loughlin, 1919, pp. 31-32; Morris, 1957, pp. 5 and 9; Bentley, 1958, pp. 25-26, and Rigby, 1958, pp. 25-28). All of these units are massive cherty limestones and dolomites that span the time interval between the Dunderberg equivalents and the lowermost Ordovician.

The Desert Valley formation is considered medial upper Franconian (middle-upper Cambrian) in the lower parts to Trempealeauan (late upper Cambrian) in its upper part.

**Origin**

The Desert Valley formation was probably deposited as fine clastic limestone under shallow to moderately deep water shelf or bank conditions. The source was probably from an eastern area of low relief. Member A (82-84 feet) is partly recrystallized and partly dolomitized fine lime mud (calciutite) that was deposited in a deepening (transgressive) sea phase that followed the clearly littoral depositional environment of the subjacent Dunderberg interval. The remainder of the formation was secondarily (peneccontemporaneously or diagenetically) profoundly altered into a monotonous 2000 foot sequence of massive dolomite.
Introduction of silt and shale in thin wave-agitated beds (above wave base) reflects a regressive shallowing in the lower part of member B. Prolific amounts of chert nodules and banding in members A and B implies considerable addition of silica to the sea following maximum regional uplift during Dunderberg time. A western volcanic source is possible. There is also evidence to suggest introduction of silica by erosion of newly exposed acid rocks on the craton to the east.

Little or no chert, and continuous massive parted ledges of light phaneritic dolomite, suggests a slight deepening transgressive condition during deposition of member C. This is again followed by shallowing regressive conditions with closer proximity to source in the lower 175-200 feet of member D. This interval is characterized by thin-discontinuous bedding with introduction of disseminated quartz sand and stringers. Chert knobs, bands, and stringers (1-3 inches wide) become prolific in the middle and upper parts of member D. The upper 50 feet of the Desert Valley formation once again contains little or no chert which might possibly reflect a deeper water transgressive phase and farther distance from silica source.

Equivalents of the Desert Valley formation in western Utah are considered to have been subject to disturbance by current activity in shallow seas probably less than 50 feet deep (Bentley, 1958).
Upper parts of the Whipple Cave formation in the Southern Egan Range contain oolitic calcarenites. The latter sediments suggest deposition in a widespread bank environment according to Newell and Rigby (1957).

Interpretation of the Desert Valley formation is extremely difficult because primary structures, textures, and fauna have been largely obliterated by dolomitization. The few fossils found are all silicified. Regional lithofacies studies should provide answers to problems concerning upper Cambrian depositional history and paleogeography as well as to the dolomite problem in the Basin and Range area.

The middle and upper parts of member D of the Desert Valley formation contain suggy zones which suggest that they be considered as possible petroleum reservoirs. The formation, however, is not a source rock for petroleum.
CAMBRIAN-ORDOVICIAN BOUNDARY

The contact between dolomite of the Desert Valley formation and limestone of the Pogonip Group defines the Cambrian-Ordovician boundary in the Pahranagat Range (Plate II and Figure 6). The _Holophragma_ coral from the middle of the Desert Valley formation is known from lower Ordovician strata in Canada (Okulitch, 1959, written communication). Because upper Cambrian faunas are found at stratigraphic levels above _Holophragma_ in southeastern Nevada, the coral is not considered diagnostic of the Ordovician.

The fact that in southeastern Nevada upper Cambrian rocks are mainly dolomite and lowermost Ordovician rocks are limestone has been noted in the Southern Egan Range by Lowell (1958, p. 15; Kellogg, 1959) and in the Atomic Proving Grounds by Johnson and Hibbard (1957). Faunules previously cited restrict the Cambrian-Ordovician boundary to between 336 feet below and 180 feet above the Whipple Cave formation in the Southern Egan Range (Kellogg, 1959, p. 33). Moreover, Ordovician trilobites are found 185 feet above the base of Pogonip limestone unit A superjacent to upper Cambrian dolomite in the Proving Grounds (Johnson and Hibbard,
1957, pp. 347-348). The Pahrangat Range is located between these areas (Figure 4) and contains almost identical lithologic relationships and consistent thicknesses. For example, the Desert Valley formation has an intermediate thickness (2123 feet) between the Whipple Cave formation (1883 feet) in the Southern Egan Range to the north and upper Cambrian rocks (2660 feet) in the Proving Grounds to the southwest. This indicates that the dolomite to limestone contact is interformational and not an expression of degrees of dolomitization within these formations.

In the central Pahrangat Range the uppermost 50 feet of the Desert Valley formation contains units of thin bedded limestone followed by cherty dolomite before the final change to Pogonip limestone. The writer has placed the boundary at the second and final dolomite-limestone contact (Plate IX, Figure B). On the west side of the Pahrangat Range interbedded limestone in the uppermost Desert Valley was not observed (Figure 6).

The limestones and dolomites across the Cambrian-Ordovician boundary represent a conformable sequence in the central part of the Pahrangat Range, but a paraconformity probably exists on the western side. Modern schools of thought de-emphasize world wide diastrophic episodes between systems (the problem is briefly reviewed in Weller, 1960, pp. 384-390). Nevertheless, the fact that a lithologic and regional faunal break exists, as well as a hiatus, and a "natural"
systematic boundary can be determined in the conformable Pahranagat section (with no indication of mixed or intermediate faunas in the region) is proof that something significant happened at this specific time. The situation is too perfect to be coincidental and the validity of the world-wide accepted time division is at least partially confirmed.

However, faunal and lithologic evidence indicates that there is a gradational contact between Cambrian and Ordovician strata in the northern part of eastern Nevada. This suggests that deposition continued without interruption from one system to another. Uppermost Cambrian and lowermost Ordovician rocks in this area are limestones. Where lithologies are constant the systematic boundary must be determined faunally. This is the case in the Southern Ruby Mountains (Sharp, 1942, p. 659), and in the Southern Snake Range where Drewes and Palmer (1957, p. 116) state that cliff-forming limestone of Cambrian age is lithologically like, and conformable with, limestone of the lower Ordovician correlative with the Pogonip group. For the purposes of mapping, Drewes (1953, p. 227) included 550 feet of upper Cambrian rocks with the similar lithologies of the Ordovician Pogonip group. The same situation has been observed at this contact in the Northern Panamint Range, Southern California (McAllister, 1952, pp. 11-12).
It is believed that careful stratigraphic work can determine the precise system boundary at each of the above localities. It is significant that in the Eureka district where uppermost Cambrian and lowermost Ordovician strata are likewise conformable limestones Nolan, Merriam, and Williams (1956, p. 24) had no trouble establishing a readily mappable sharp boundary between thin bedded platy limestones of the Windfall formation below and massive, gray, cherty Pogonip limestones above. It is also significant that a Cambrian-Ordovician unconformity indicating a withdrawal of the seas exists to the east in northern Utah (Richardson, 1913, p. 408) in the Stockton and Fairfield Quadrangles, Utah (Gilluly, 1932, pp. 18-20), in the Tintic district, Utah (Loughlin, 1919, p. 80) and in the Gold Hill district, Utah (Nolan, 1935, pp. 14-15). The presence of an unconformity in the Roberts Mountains region, Nevada (approximately 25 miles northwest of location 1, Figure 4) upon which lower Ordovician rocks are absent has been noted by Nolan, et al (1956, p. 23).
ORDOVICIAN ROCKS

Introduction

The maximum composite thickness of exposed Ordovician rocks in the Pahranagat Range is 4220 feet. This sequence is divisible into 4 formations of the Pogonip group (Canadian and Chazyan), the Eureka quartzite (Black River? and Trentonian) and the Fish Haven dolomite (Cincinnatian). These formations represent a near maximum thickness of all known Ordovician time stratigraphic units in the eastern Basin and Range except that part of the Black River assigned to the Copenhagen formation in east central Nevada (Webb, 1958).

Completely exposed Ordovician sections are found along the west side of the Pahranagat Range and in the center of the Range. Extensive outcrops of parts of the Ordovician section occur in many other areas.
POGONIP GROUP

Introduction

The name Pogonip was originally defined by Clarence King (1878, p. 188) from Pogonip Ridge some 30 miles southeast of Eureka. Originally defined as a formation it included all sediments between the "Cambrian Quartzite" (Prospect Mountain quartzite) and the "Ogden Quartzite" (later named the Eureka quartzite of middle Ordovician age). Hague (1883, p. 260; 1892, pp. 48-49) redefined the Pogonip as including only the strata between the Dunderberg shale and the Eureka quartzite.

In recent years the Pogonip has been elevated to group rank to include strata only of Ordovician age (Hintze, 1949; 1951; Easton et al, 1953; Nolan et al, 1956). As applied to the Pahranagat Range the Pogonip group embraces several mappable units overlying the Cambrian Desert Valley formation and underlying the Eureka quartzite (Plate II).

The Pogonip group has been the object of considerable study in the Basin and Range in recent years. Hintze, (1951, 1952) zoned the Pogonip on trilobites and distinguished six formations in western Utah which he traced as far west as the White Pine Range (about 35 miles southwest of Ely). These formations are in ascending
order: House formation, Fillmore limestone, Wahwah limestone, Juab limestone, Kanosh shale, and the Lehman formation. These units are of very similar lithology and difficult to distinguish in eastern Nevada. Nolan, Merriam, and Williams (1956, p. 24) were unable to use them in the Eureka district where they introduced three new formations for the Pogonip group.

Although Hintze (1952, pp. 60-67) recognized his six Pogonip formations in the Southern Egan Range (Figure 4), Lowell (1958) was only able to distinguish the Kanosh and Lehman formations. He subdivided the remaining lower Pogonip into three unnamed limestone formations. Kellogg (1959) utilized Lowell's five formation classification in the Southern Egan Range recognizing the oldest as Hintze's House limestone.

The writer has tentatively divided the Pahranagat Range Pogonip sequence into 4 formations. These are in ascending order: Lower Limestone, Upper Limestone, Kanosh, and Lehman formations (Plate II and Figure 6). Because of the gradational nature of the formation boundaries the group is mapped as undifferentiated. Faunas are very scarce in pre-Kanosh rocks where further work is necessary on the problem of group subdivision. It is significant that in correlating the Pogonip group in eastern Nevada Lowell (1958, p. 16) stated that the Pahranagat Range section possibly should not be considered in his
classification and that there may be a separate, more natural division for the Pogonip group in southern Nevada just as there is in central Nevada. This is apparently the case. It is also interesting that if the Kanosh and Lehman formations were combined in the Pahrnanagat Range the Pogonip would assume a 3 formation classification that resembles that described in the Eureka district (Nolan et al. 1956) and in the Antelope Range, Nevada (Merriam, 1956).

A maximum thickness of 3141 feet of Pogonip group strata is exposed in the central Pahrnanagat Range whereas only 2568-2710 feet is found on the western side of the Range. This difference in thickness essentially results from the increase in thickness from 183 to 772 feet in the Lower Limestone formation between the two locations. The relationships are illustrated in Figure 6 and the significance will be discussed later. There are 3150 feet of Pogonip group strata exposed in the Atomic Proving Grounds (Johnson and Hibbard, 1957, p. 347). Lowell (1958) and Kellogg (1959) report an excess of 3500 feet of Pogohip in the Southern Egan Range. Nolan et al (1956) and Merriam (1956) have determined a total of 3000 feet in the Eureka district and Antelope Valley areas respectively. Sharp (1942, p. 650) reported 3,650 feet of Pogonip from the Ruby Range, Nevada.

The lower contact of the Pogonip group with the Desert Valley
formation is conformable and coincident with the Cambrian-Ordovician boundary in the central part of the Pahranagat Range as previously discussed. However, the upper contact with the Eureka quartzite is paraconformable in all areas of the Range. (Plate II; Figure 6; and Plate X, Figure B, p. 172).

The Pogonip group is widely exposed throughout the Pahranagat Range with complete sections extending in north-south bands in the central and western areas south of highway 25. Numerous large Pogonip fault blocks constitute most of the southwestern extension of the Range. The Lehman formation makes up an extensive area north of the Gilbert Fault and west of Irish fault in the vicinity of Mount Irish (Plate I).

**Lower Limestone formation**

The lower limestone formation consists of medium light to medium gray and light olive gray weathered, bench to resistant slope-forming, thin to medium bedded calcisiltite to calcarenite. Fresh surfaces are medium light to medium dark gray. Massive 1-5 foot parted ledges occur throughout with the interbedded thin to medium bedded zones that display some wavy and knobbly, discontinuous as well as continuous bedding. Distinctive of the formation is the abundance of light brownish gray chert nodules and bands up to 4 inches wide. Also abundant are intraformational lime pebble conglomerates and some sandy zones with quartz sand
Figure 5.- Index map showing the Pahranagat Range and surrounding area, Lincoln County, Nevada, with location of measured sections of the Pogonip group (Figure 6).
POGONIP SECTIONS IN THE PAHRANAGAT RANGE
LINCOLN COUNTY, NEVADA

Location A
Central
Pahranagat Range
Sec 27, T 6 S, R 59 E

EUREKA QUARTZITE

Leopardito Zone

Location B
West Side
Pahranagat Range
Sec 17-18, T 7 S, R 59 E

LEHMAN FORMATION

Patinsara sp
Receptaculites Zone
"girvanella"

KANOSH FORMATION

Cephalopods

UPPER LIMESTONE FORMATION

MACURITES sp
Receptaculites Zone

LOWER LIMESTONE FORMATION

Proto-
plomerops

Trilobite fragments

Desert Valley Formation

Vertical Scale

LEGEND

Sandstone or Quartzite

Dolomite

Limestone

Cherty Limestone or Dolomite

Shaly Limestone

Arenaceous Limestone

Dolomitic Limestone or Limy Dolomite

1 INCH = 400 FEET

A RESO 1960
stringers. Bluish gray fresh and weathered surfaces occur locally. Brown shale partings increase in the upper part of the formation with a slight decrease in the amount of chert. Trilobite fragments, gastropod casts, and organic hashes are common but organisms are so badly preserved as to defy identification.

As previously stated the formation is 772 feet thick in the central Pahranagat Range but only the upper 183 feet is present on the western side of the Range. Three interpretations for the difference in thickness can be considered. First, it is possible that a high angle reverse fault or thrust has omitted the difference in section. Preliminary mapping has not revealed such a fault. Secondly, it is possible for up to 600 feet of section to have been eroded or not to have been deposited on the western side of the range (location B, Figure 6). The localities, however, are only a little over 3 miles apart. Thirdly, the difference may suggest that the Pogonip section in the center of the range (location A, Figure 6) may be part of klippe of an allochthone derived from the west. If such were the case the Pogonip section at location B would be the autochthonous Pahranagat sequence. Regional stratigraphic and structural considerations indicate that the latter hypothesis is quite possible. The approximate 2600 foot Pogonip thickness at location B is situated between a 3150 foot thickness to the southwest in the Proving Grounds (Johnson and Hibbard, 1957).
and a thickness of less than 1800 feet in the western end of the Delamar Range some 30 miles south and east of Alamo. Pogonip strata is being lost from the bottom. The 3141 foot section in the center of the Pahranagat Range is quite anomalous and contains a Lower Limestone formation thickness comparable to its correlative unit A in the Proving Grounds to the west. Should further work prove conclusively that the allochthonous theory is correct then both conformable and paraconformable Cambrian-Ordovician boundaries are present in the Pahranagat Range at locations A and B respectively (not shown symbolically in location B, Figure 6). Furthermore, Plate II would then illustrate the maximum, but allochthonous, Pahranagat Pogonip sequence rather than that in situ.

**Age, Fauna and Correlation**

The Lower Limestone formation contains abundant trilobite fragments, gastropod impressions and organic hashes. No fossils have been definitely identified by the writer. The trilobite _Protopliomerops sp._ is the only form identified by Lowell (1958, p. 20).

The Lower Limestone formation correlates with a Lower Limestone formation defined in the Southern Egan Range by Lowell (1958, p. 17) and later referred to the House Limestone by Kellogg (1959). The presence of early Canadian fossils including _Protopliomerops sp._ is recorded from the upper part of the latter unit by Hintze (1952, p. 66) and Lowell (1958).
The Lower Limestone formation correlates with the House limestone of Utah as used by Hintze (1951, 1952, 1958); with unit A of the Pogonip Group in the Atomic Proving Grounds (Johnson and Hibbard, 1957, p. 348); with the lower part of the Goodwin limestone of the Eureka district (Nolan, Merriam, and Williams, 1956, pp. 25-27) and in the Antelope Valley, Nevada (Merriam, 1956). All faunas known from the above stratigraphic units are definitely early Canadian. The Lower Limestone formation of the Pogonip group in the Pahranagat Range is entirely early Canadian.

The contact with the overlying Upper Limestone formation is gradational and approximates a line of transition from relatively resistant cherty calcisiltite to calcarenite to easily eroded shale parted calcilutite and fine crystalline limestone.

**Origin**

The Lower Limestone formation was deposited under shallow water neritic to sublittoral shelf conditions. It was subject to intermittent wave agitation as demonstrated by intraformational lime pebble conglomerates, wavy discontinuous bedding, and shelly facies fauna (trilobites; gastropods; and organic hashes). Shale partings and sandy zones also suggest close proximity to a clastic source area which may have likewise supplied an unusual amount of silica to the sea as demonstrated by the prolific chert bandings and nodules.
Upper Limestone formation

A non-resistant zone constitutes the lower part of the Upper Limestone formation in both the central and western Pahranagat Range sections.

In the central area (location A, Figure 6) there are 342 feet of medium light to medium dark gray weathered easily eroded bench to saddle-forming, thin, knobbly-discontinuously bedded calcilutite and aphanitic limestone. Yellow shale partings are common as are poorly preserved fragments of shelly facies fauna (brachiopods, gastropods, trilobites, and cephalopods). Brown, crystal-faceted limonite pseudomorph nodules are locally abundant.

In the western area (location B, Figure 6) the non-resistant zone consists of 388 feet of light gray and medium bluish gray weathered and fresh surface of massive, resistant 1-2 foot cherty calcarenite and crystalline limestone ledges interbedded with 2-3 foot zones of brownish gray to light olive gray fissile shale and thin bedded shaly, sandy, calcisiltite. Trilobite fragments are common throughout. Penicentenporaneous lime pebble conglomerates occur in some of the resistant ledges.

Although the non-resistant zone is of comparable thickness at both locations - the "western," (but presumably the eastern authchthonous section) is coarser grained, contains more clastic quartz sand, much more chert, and apparently more shale. A somewhat different lithotope is suggested.
EXPLANATION OF PLATE X

Figure A

Upper Limestone, Kanosh (a-b) and Lehman formation (b-c) equivalents of the Pogonip group totally exposed below the Eureka quartzite on the west side of the Pahranagat Range.

Figure B

Contact (hammer) between the Lehman formation of the Pogonip group and the superjacent Eureka quartzite on the west side of the Pahranagat Range. Exposures of this contact are rare in the region due to Eureka talus generally covering the less resistant underlying Lehman calcitites.

The contact is considered paraconformable due to absence of that part of the Black River assigned to the Copenhagen formation in east central Nevada (Webb, 1958).
The middle portion of the Upper Limestone formation consists of medium light gray weathered and fresh surfaces of resistant slope-forming thin to medium (1/2-6 inches), continuous and discontinuously bedded, grayish orange to yellowish gray shale parted, cherty calcisiltite to calcarenite. The central and western Pahranagat sections are almost identical except for a greater calcilutite fraction in the central area in which brown clay balls are commonly found in the calcarenites. Gastropod-trilobite-brachiopod hashes are common.

The upper part of the Upper Limestone formation is light to medium gray and bluish gray weathered, resistant slope to semi cliff-forming, massive-medium to thick bedded (6 inches to 3 feet) calcisiltite to calcarenite with some calcilutite. Thin brown chert stringers decrease upward. Orthoceroid cephalopods are common at the central range location but large arthropod fragments, horn corals and shelly fauna hash occur in both sections. This massive zone is roughly 572 feet thick in the western locality (Plate X, Figure A) and 540 feet thick in the central Pahranagat Range. The contact with the overlying Kanosh formation is gradational and not precisely established.

Age, Fauna and Correlation

The Upper Limestone formation is fossiliferous but almost all of the collected fauna is fragmental. Specific identifications will require concentrated study.
The Upper Limestone formation correlates with both the Middle and Upper Limestone formations recognized by Lowell (1958) in the Southern Egan Range. The latter units were defined as the Parker Spring and Shingle limestone formations respectively by Kellogg (1959). No fossils were found by Kellogg in the Parker Spring, but Hintze (1952, p. 66) collected lower Ordovician (Canadian) fossils from this interval.

Hintze (1952, pp. 66-67), Lowell (1958, p. 18) and Kellogg (1959, p. 39) have collected from the Upper Limestone equivalents in the Southern Egan Range. The faunas include *Trigonocerca typica*, characteristic of the upper Fillmore, *Lachnostoma latucelsum* Ross of the Wahwah, and *Orthambonis subalatus* Ulrich and Cooper of the Juab. On the basis of these and other fossils a late Canadian age has been assigned to the Wahwah and a Chazyan age to the Juab.

The Upper Limestone formation correlates with the upper-most part of the Goodwin limestone, the Ninemile formation, and the lowermost Antelope Valley formation of central Nevada (Nolan, Merriam, and Williams, 1956, pp. 25-29; Lowell, 1958). The Ninemile formation with various species of *Kirkella, Hesperonomia antelopensis* Ulrich and Cooper, and *Archaenorthis elongata* Ulrich and Cooper is entirely late Canadian (Beekmantown). Since a Chazyan age has been assigned to the Juab limestone and to the lowest zone of the Antelope Valley formation, the Upper Limestone formation
in the Pahranagat Range includes the Canadian-Chazyan boundary (Plate II).

The Upper Limestone formation is a correlative of units B-G, and probably the lowest part of unit H, of the Pogonip group in the Atomic Proving Grounds described by Johnson and Hibbard (1957, pp. 348-349).

The Upper Limestone formation has approximate thicknesses of 1227 feet in the central Pahranagat Range and 1422 feet on the western side of the range. Lowell (1958) obtained a thickness of 1468 feet for the combined Middle and Upper Limestone formations in the Pahranagat Range.

**Origin**

The Upper Limestone formation was deposited under sub-littoral (neritic) shallow water shelf conditions.

The lower non-resistant part of the autochthonous section was deposited near shore as shown by wave agitation that produced penecontemporaneous lime-pebble breccias, thin-knobly and discontinuous bedding. Also indicative are the clastics: sandy zones, shale, calcarenites and fossil hashes. The equivalent in the allochthonous section (presumably deposited farther west), although also having thin-discontinuous bedding, contains less shale and sand with finer textures. This suggests deposition in somewhat deeper water at a greater distance from source.
Thicker and more continuous bedding in the middle portion of the Upper Limestone formation reflects a deeper water environment and lower energy conditions. This continues through the upper part of the formation as shown by medium to thick-massive and continuous bedding with fine textures. Fossils are numerous and well preserved in the upper half of the Shingle limestone of the Southern Egan Range (Kellogg, 1959). This suggests a deeper water, lower energy condition, that resulted in less reworking of the shelly faunas.

The Upper Limestone formation is a transgressive deposit that illustrates progressive deeper water conditions. It is for this reason that the formation is difficult to subdivide although members could be assigned to the three described phases.

The formation may have been highly organic at time of deposition but constant reworking probably destroyed materials that might have made the unit a petroleum source rock. It may be significant that unit F of the Pogonip group in the Proving Grounds, a correlative of the upper part of the Upper Limestone formation characterized by straight-coned cephalopods, commonly emits a fetid odor when struck by a hammer (Johnson and Hibbard, 1957, p. 347).

**Kanosh formation**

The Kanosh formation was named by Hintze (1951, p. 18) for an interval of fissile shales with limestone interbeds exposed
above the Juab limestone and below the Lehman formation in western Utah. The type Kanosh contains only a small amount of thin interbedded limestone but in the Pahranagat Range the sediments are primarily thin to medium bedded calcisiltite to calcarenite with shale partings. This increase in limestone content at the expense of shale in the Kanosh of eastern Nevada has been noted in the Southern Egan Range by Hintze (1951, p. 18), Lowell (1958, p. 21) and Kellogg (1959, p. 40). Lowell also remarked on this situation in the Pahranagat Range.

The term Kanosh is used provisionally by the writer for a non-resistant argillaceous limestone that forms long dip-slopes and a saddle between the subjacent resistant limestones of the Upper Limestone formation and the superjacent slope-forming Lehman formation (Plate X, Figure A). Although an equivalent of the Kanosh formation, as defined in this report, it is relatively thin and has gradational boundaries. It does not make a practical unit for mapping. Even though containing "Kanoshian" faunas the fact that it is not a shale is also justification for combining it with the overlying Lehman formation under a new term. This procedure will be followed in future reports.

Description

The Kanosh formation is composed of light to medium gray and bluish gray weathered, non-resistant bench to slope-forming,
thin to medium knobbly bedded (1-8 inches), orange shale parted calcsiltite to calcarenite. Fresh surfaces are medium light to medium dark gray. The formation contains local chert, some calcilutite, local massive 1-3 foot parted ledges of calcarenite and evidence of recrystallization.

The Kanosh formation has a thickness of roughly 171? - 290 feet on the western side of the Pahranagat Range and 272-380? feet in the center of the range. Lowell (1958) obtained 287 feet for the Kanoshian interval in the latter area.

Age, Fauna and Correlation:

The Kanosh formation is abundantly fossiliferous. The following fossils have been collected by the writer:

Receptaculites elongatus Walcott
Receptaculite mammilaris Newberry (2" diameter)
Maclurites sp.
Palisseria sp.
"Girvanella" sp.
small gastropods
corals
orthid brachiopods
bryozoans
trinoid columnals
trilobite fragments

The presence of Receptaculites, Maclurites and Palliseria suggests correlation of the Pahranagat Kanosh with the middle part of the Antelope Valley limestone of central Nevada (Nolan, Merriam, and Williams, 1956, p. 29, Lowell, 1958). The Kanosh correlates with Receptaculites beds of the lower Tank Hill limestone of the
Pioche district described by Westgate and Knopf (1932, pp. 14-15) and with \textit{Receptaculites-Mitrospira} bearing beds of the lower part of unit H of the Pogonip group in the Atomic Proving Grounds. It is significant that in the latter area Kanoshian faunas are found in massive resistant limestone. (Johnson and Hibbard, 1957, Plate 33).

The Kanosh formation is Chazyan.

\section*{Origin}

The Knosh formation was deposited as clastic limestone under relatively shallow water neritic shelf conditions. An uplift or regression is reflected to the north and east by the influx of shale. This is only of minor consequence in the Pahranagat area but the reestablishment of intermediate energy conditions by thin to medium knobby bedding, increase in grain size and shale partings likewise indicates a regressive sedimentary phase. This is in contrast to an apparent maximum transgression which took place during the deposition of the upper part of the underlying formation. Relative shelf instability had practically no effect on the equivalent time unit in the Nevada Proving Grounds to the southwest.

\section*{Lehman formation}

The Lehman formation was named by Hintze (1951, p. 19) for bluish gray calcilutites overlying the Kanosh shale in the Snake Range near Lehman Caves, Nevada. In the Pahranagat Range the
bottom contact with the Kanosh is conformable but the contact with the superjacent Eureka quartzite is paraconformable. The Lehman is widely exposed throughout all areas of the Pahranagat Range and is readily identified and accessible in resistant slopes below the Eureka quartzite (Plate X, Figure A).

**Description**

In the Pahranagat Range the Lehman formation is medium bluish gray and medium light gray weathered, resistant slope-forming, thin, knobby-wavy, and discontinuously bedded, shale parted calcisiltite to calcilutite. Fresh surfaces are medium dark gray. Also characteristic are occasional interbeds of more resistant, massive, 2 foot calcilutite ledges, local chert and lime pebble conglomerate. Thin units (up to 12 feet thick) of pale grayish orange platy, laminated, silty, limy, shale occur in the upper half of the formation. The section in the central Pahranagat Range (location A, Figure 6) contains more chert nodules than normal, and a greater calcisiltite fraction at the expense of calcilutite.

The uppermost few feet of the Lehman formation is dolomite in the central Pahranagat Range. Variable thicknesses of brown weathered fine phaneritic to aphanitic dolomite replace upper parts of the Lehman on the western side of the Range. The upper part of the formation is usually covered by talus from the overlying Eureka quartzite but where the contact is well exposed (Plate X, Figure B)
dolomitization of the upper Lehman varies from nothing to 32 feet.
At Anchor Ridge South irregular and interbedded brown dolomitization occurs throughout the upper 112 feet of the Lehman. Uppermost Lehman secondary or penecontemporaneous dolomitization has been noted over a widespread area in eastern Nevada. Hintze (1952, p.60) described a discrete dolomite "member" between the calcilutites of the typical Lehman and the quartzites of the Eureka in the Southern Egan Range. The validity of the member was discredited by Lowell (1958, p. 23) and Kellogg (1959, p. 42) as the 65 foot dolomite zone was traced along strike into typical Lehman limestone. A 53 foot dolomite interval is present at the top of the Lehman formation in the Grant Range (location 17, Figure 4) and Hintze (1952, p. 68) reported a 27 foot dolomite interval at the top of the Lehman formation in the White Pine Range. A thickness of 35 feet of dolomite containing silicified mollusca is reported from the uppermost Pogonip in the Arrow Canyon Range (Langenheim, 1960, written communication). Upper Lehman dolomitization is of importance since it might be confused with the Crystal Peak dolomite, a separate unit of Chazyan age in western Utah. Upper Lehman dolomitization probably has some bearing on the pre-Eureka paraconformity.

The Lehman formation is 666-673 feet thick on the western side of the Pahranagat Range and 762 feet was measured in the central area. Lowell (1958) obtained 573 feet in the Pahranagat
Range. A precise Lehman thickness has little meaning due to the gradational nature of the lower contact with the Kanosh. The writer has used the change in slope from the last non-resistant saddle to define the base of the formation (Plate X, Figure A).

**Age, Fauna and Correlation**

The Lehman formation is abundantly fossiliferous containing brachiopods, corals, gastropods, bryozoa, sponges, ostracodes, and trilobite fragments throughout. Thin bedded, *Leperditia* coquinas are abundant in the upper part of the formation at all localities. This is a widespread zone in eastern Nevada.

Hintze (1951, pp. 19-20) considers the Lehman formation younger Chazyan than the Kanosh in eastern Nevada. Lowell (1958) collected from the Pahranagat Range Lehman and correlated it with zone N of Hintze. Hintze (1952), Webb (1958), Lowell (1958), and Kellogg (1959) have studied Lehman faunules in the Southern Egan Range (location 8, Figure 4) and elsewhere in eastern Nevada. They all agree that the Lehman formation is Chazyan. Duncan (1956, pp. 215-216) considers the Lehman coral fauna (*Lichenaria* and *Eoflectoria*) older than the Chazyan fauna of eastern North America. Webb (1958, pp. 2352, 2366-67) considers the strata below the Eureka in Eastern Nevada Chazyan and possibly Black Riverian.
The Lehman formation of the Pahranagat Range correlates in part with the Watson Ranch tongue of the Swan Peak quartzite and the Crystal Peak dolomite of western Utah (Webb, 1958, p. 2366; Hintze, 1959, p. 1688). The Lehman is also a correlative of the upper part of the Tank Hill limestone in the Pioche district (Westgate and Knopf, 1932); the upper part of the Antelope Valley limestone (Nolan, Merriam and Williams, 1956); the upper part of unit H of the Pogonip group in the Nevada Proving Grounds (Johnson and Hibbard, 1957, pp. 348-349); and the upper 219 feet of unit F of the Pogonip group in the Arrow Canyon Range (Langenheim, 1960, manuscript in preparation).

Origin

The Lehman formation was deposited in a shallow water, sublittoral (inner neritic), mildly unstable shelf environment. Thin, wavy, knobbly, shale parted, discontinuous bedding predominates throughout indicating continuous wave agitation and intermediate to high energy conditions. Facies of the upper Lehman are sandstone tongues in western Utah. The Lehman is part of a regressive cycle of sedimentation that attains a zenith in the widespread lower Eureka orthoquartzites.

Lehman–Eureka Unconformity

The contact between the Eureka quartzite and the limestones of the underlying Lehman is sharp and paraconformable in the
Pahranagat Range (Plate X, Figure B; Figure 6; and Plate II). There is no evidence of angular discordance or a channeling erosion surface on the upper Lehman. Nevertheless some of the upper part of the Lehman known elsewhere in Nevada is probably absent as is the Copenhagen formation. The Copenhagen formation was named by Merriam (1956, manuscript) for about 350 feet of silty limestones and argillaceous beds that occupy the interval between the Antelope Valley limestone and the Eureka quartzite at Copenhagen Canyon on the west side of the Monitor Range in central Nevada. The total thickness may exceed 600 feet.

A prolific fauna indicates that the lower part of the Copenhagen formation is late Chazyan and early Black Riverian and the upper part of the formation is medial Trentonian. Thus, an unconformity exists between the upper and lower parts of the formation (Cooper, 1956, in Twenhofel et al., 1954; Lowell, 1958, p. 56). Webb (1958, p. 2367) considered the Copenhagen medial Black Riverian to medial Trentonian. He correlated the lowest part of the Eureka quartzite (probably present in the Pahranagat Range) as a facies of the Black Riverian part of the Copenhagen formation.

The Copenhagen formation has received considerable study in recent years and additional discussions may be found in Hintze and Webb (1950, p. 1524), Webb (1953), Cooper (1956) and Merriam (1960, in press).
The fact that a pre-Eureka paleogeology exists throughout central and eastern Nevada has been documented by many authors (see Webb, 1958, Figure 7; Nolan et al, pp. 30-31). It has been demonstrated that the quartzite lies on eroded Pogonip surfaces. The Receptaculites zone of the Pahranagat Kanoshian Pogonip occurs 720-800 feet below the Eureka in autochthonous sections. In the allochthonous central Pahranagat section the Receptaculites zone is 906-946 feet below the Eureka (Figure 6). In the Southern Egan Range Receptaculites is found 756 feet below the Eureka (Webb, 1958, p. 2362). Langenheim (1960, written communication) reports the Receptaculites zone only 219 feet below the Eureka in the Arrow Canyon Range (Figure 4) and the Leperditia zone was not found. This indicates both a thinning of the Pogonip and erosion or non-deposition of more than 500 feet of the upper part. Thus the Lehman-Eureka hiatus increases rapidly south of the Pahranagat Range.

Eureka quartzite

The Eureka quartzite was originally defined by Hague (1883, p. 262; 1892, pp. 54-57) for a prominent white quartzite in the vicinity of Eureka, Nevada. Because of inadequate exposures and structural complications, which do not allow determination of the thickness of the formation at Eureka, Kirk (1933, p. 34) proposed that the well exposed section at Lone Mountain, Nevada, 16 air-miles
northwest of Eureka be chosen as a new type locality (Figure 4). This redesignation has been accepted by the U.S. Geological Survey (Nolan et al., 1956, p. 29).

Kirk divided the formation into 3 parts (1) a basal 75 feet of quartz sandy dolomites and brownish crossbedded quartz sandstones (2) the main mass of 150 feet of dense vitreous white quartzite (3) the uppermost 0-3 feet of dolomitie sandstones which are overlain by upper Ordovician dolomite. The upper few feet of dolomitie sandstones were thought by Kirk to be a basal deposit of the overlying transgressive dolomites and possibly should not be included within the Eureka.

Webb (1956; 1958) excluded 40 feet of quartz sandy dolomites at the base of the Lone Mountain section and placed them as a facies of the Copenhagen formation. He recognized 3 members in the restricted 178 feet of Eureka: a) 35 feet of yellowish brown and dark reddish brown weathered quartzite ("lower discolored member"); b) 35 feet of massive white quartzite ("white quartzite member"); and c) 43 feet of light gray cross laminated quartz sandstone ("upper gray quartzite member") which grades into the 3 feet of dark bluish gray quartz sandy dolomite. Because of a sharp contact above the sandy dolomite rather than below, Webb (1958, p. 2342), included it within the Eureka rather than in the overlying formation
differing from Kirk (1933) and Nolan, Merriam, and Williams (1956, p. 30). However, Webb did not formally designate these upper beds as a separate 4th member. The Eureka quartzite, as restricted, is believed by Webb to transgress the erosion surface in much of central Nevada previously discussed.

In the Pahranagat Range the writer recognizes the 3 original members defined by Kirk. Division of the lower member into a lower Copenhagen facies and "discolored quartzite member" demands further field analysis. Kellogg (1959) was able to distinguish 27-50 feet of shaly quartzite above the Lehman formation in the Southern Egan Range as Webb's restricted Copenhagen facies.

The middle member of the Eureka quartzite in the Pahranagat Range includes both the white quartzite and upper quartzite members of Webb. The Upper member of the Pahranagat Eureka involves 0-20 feet of dolomite and sandstone. This is placed in the Eureka formation after Webb (1958) and not in the overlying formation after Kirk (1933) and Nolan and others (1956). See Plate II - pocket.

The Eureka quartzite is well exposed and is a conspicuous marker in all areas of the Pahranagat Range (Plates V, VII, X, XI, XII, and others). The thickness of seven measured sections varies from 385-552 feet. These sections are located on Figure 7 and correlated on Figure 3, p. 203.
Lower Member

The lower member consists of pale reddish brown to grayish pink and brownish red weathered hues of resistant slope to semi cliff-forming, massive 1-4 foot ledges of well sorted, subrounded to subangular, very fine to medium grained quartz sandstone and quartzite. Fresh surfaces are pink to light gray and light yellowish gray. The member contains both dense, silica bonded quartzite and calcareous, friable sandstones with local cross-bedding. Abundant "worm" burrows ("scolithus tubes") occur locally. Rare brachiopod molds were found at the Waite Hill section. The member has a remarkably uniform thickness of 160-174 feet. (Plate XI, Figure A; Plate XII, Figure A).

Middle Member

The middle member constitutes the typical Eureka quartzite. It exhibits very light gray to gleaming vitreous white weathered and fresh surfaces with some pinkish gray surfaces. It is remarkably homogeneous with few impurities. The member is virtually all massive cliff-forming, well sorted, subrounded, fine grained orthoquartzite. Occasional friable zones are restricted to the upper half. "Worm" tubes are rare. The middle member stands out as a more resistant cliff over the subjacent member (Plates XI and XII). The thickness varies from 205-378 feet.
Upper Member

The upper member consists of a 3-5 foot massive ledge of medium gray to medium brownish gray weathered, sandy, limy phaneritic dolomite. Fresh surfaces are light to medium gray. The unit contains some crinoid columnals. The dolomite is overlain by 8-15 feet of very light gray to white, massive, subrounded to subangular dolomitic quartz sandstone. This uppermost sand varies from typical vitreous quartzite of the middle member to light brownish gray weathered limy sandstone containing 10% foreign minerals.

The upper member is 0-20 feet thick, (Plate XI, Figure B; Figure 8). It is not present, however, in the thick Eureka sections (in excess of 500 feet) such as in the northwest and central Pahranagat Range (locations 2 and 6, Figures 7 and 8; Plate XII).

Thickness

The Eureka quartzite thins progressively southward over a 20 mile exposure along the western side of the Pahranagat Range. It is 552 feet in the northwestern part of the Range, 415 feet at Waite Hill, and 386 feet at Devonian Ridge (Figures 7 and 8). The lower and middle members each thin progressively. The lower member from 174 to 172 and 160 feet; and the middle member from 373 to 232 and 205 feet respectively at the 3 locations. Since the 512 foot section (location 6, Figure 8) is in juxtaposition with the thin Devonian Ridge section (location 5), this furnishes additional evidence in support of the central section being a northwesterly derived klippe.
EXPLANATION OF PLATE XI

Figure A

The Eureka quartzite (a-b) on the western side of the Pahranagat Range (approximately 390 feet thick at this locality). The pale reddish brown lower member is easily distinguished from the white vitreous middle member. Below are the limestones of the Lehman formation of the Pogonip group and above are dolomites of the Cincinnatian Fish Haven formation.

Figure B

The upper member of the Eureka quartzite and the contact with the overlying Fish Haven dolomite exposed on the west side of the Pahranagat Range. The upper member consists here of a 3 foot dolomite ledge overlain by 8 feet of dolomitic quartzite. The vitreous white middle member of the Eureka is exposed below the upper member. The lower part of the Fish Haven is bench and slope-forming calcareous dolomites and dolomitic limestones which change to dark gray massive cliff-forming cherty dolomite above.
The complete Eureka quartzite section is only about 200 feet thick in the western part of the Delamar Range (Figure 7) and 132 feet is reported from the Arrow Canyon Range by Webb (1958, p. 2350, Figure 5) Johnson and Hibbard (1957) found 285 feet of Eureka in the Nevada Proving Grounds and Kellogg (1959) obtained 465-621 feet from 5 measurements in the Southern Egan Range. See locations Figure 4. An isopach map of the Eureka and each of its members appears in Webb (1958). The Pahranagat thicknesses extend a Eureka negative area farther south.

**Age, Fauna and Correlation**

Worm burrows ("scolithus tubes") are locally abundant in the lower member and rare in the middle member. Some indeterminate brachiopod molds were collected in the lower member at Waite Hill, and some crinoid columnals were found in the dolomite ledge of the upper member.

Although the Eureka quartzite has yielded few fossils, its age has been fairly well established throughout the region by the underlying fossiliferous limestone of late Chazyan and early Black Riverian age and by the overlying fossiliferous dolomite of Cincinnati age.

The precise dating of the Eureka quartzite and its relationships to other Ordovician formations has received considerable study in recent years because of its importance in deciphering the paleogeography and structural history of the Basin and Range during
Ordovician time. Elaborate discussions are available in Nolan and others, 1956, pp. 32-33 and in Webb (1958, pp. 2366-76). It is sufficient to remark here that in the Pahranagat Range the Eureka quartzite is probably Black Riverian in the lower part and medial to late Trentonian and possibly early Cincinnatian in the upper part.

Although it is generally believed that an erosion surface exists on the top of the Eureka in eastern Nevada there is no clear cut evidence for post Eureka stripping in the form of an erosion surface in the Pahranagat Range. Furthermore, it has been shown that variations in thickness are progressive within Eureka members.

**Origin**

The origin of the Eureka quartzite is related to the general St. Peter blanket sand problem. A discussion of this subject is beyond the scope of this report. The Eureka quartzite was deposited over an immense area probably under shallow water unstable shelf conditions. Worm burrows, brachiopods and crinoid columnals preclude consideration of the formation as a non marine deposit at least in the Pahranagat area. The lower Eureka is a regressive deposit indicating widespread emergence in middle Ordovician time which restricted marine limestone lithotopes to local areas in central Nevada and eastern California. The upper Eureka is considered a transgressive deposit.

The lower member of the Eureka has friable porous zones which would serve as ideal petroleum reservoirs especially with the
impermeable vitreous quartzites of the middle member as a cap. The writer, however, knows of no contemporaneous source beds. The only possibility would be fault controlled migration of later rather than earlier oil in regions beyond the Pahranagat area.

**Fish Haven dolomite**

The Fish Haven dolomite was described and named by Richardson (1913, pp. 409-410) for 500 feet of dark gray to blue black locally cherty dolomite that overlies the Swan Peak quartzite in the Bear River Range of northern Utah. This is one of the most persistent stratigraphic units in the Basin and Range (Bissell, 1955, p. 1643). Since 1913 the use of the term Fish Haven has been extended throughout western Utah and eastern Nevada, (Nolan, 1935, pp. 16-17; Hintze, 1951, p. 23; Rush, 1956, pp. 19-20; Drewes, 1958, p. 227; Kellogg, 1959, p. 46). The name has priority over other terms such as Ely Springs and Blue Bell for upper Ordovician and is, therefore, used here.

The Fish Haven is exposed in all areas of the Pahranagat Range superjacent to the Eureka quartzite. Above the quartzite there is easily distinguished a thick dark unit (about 650 feet thick), a thinner light unit (about 350 feet thick) and a thin dark unit (about 200 feet thick). See Plates V, Figure A; Plate VII; and Plate XII, Figures A and B. The Fish Haven comprises approximately the lower half of the thick dark unit. The thickness of 7 measured sections varies from 260 to 527 feet.
Description

The Fish Haven dolomite in the Pahranagat Range can be divided into three general members. These are defined with average thicknesses (excluding the central Pahranagat section) on Plate II. They are not distinguished in Figure 8, p. 203.

The lowest part of the Fish Haven consists of 16-28 feet of medium to dark gray and light olive gray weathered, non-resistant bench-forming, medium bedded (4-8 inches) arenaceous, slightly calcareous, fine phaneritic to aphanitic dolomite. Fresh surfaces are medium dark gray. At several localities this unit may be entirely calcisiltite to fine calcarenite or partly dolomitized calcitite. Chert is rare. The unit contains some small brachiopods, relict fossil fragments, and unusual beaded crinoid columnals.

The lower "member" is followed by approximately 220 feet of medium to dark gray and olive to brownish gray weathered, semi cliff-forming, massive-medium to thick bedded (4 inches to 5 feet) cherty, fine sugary phaneritic dolomite. Fresh surfaces are medium gray to grayish black and invariably darker than fresh surfaces. Chert is prolific in the lower part of the unit forming both continuous and discontinuous bands and lenses from 1/4 to 6 inches wide. Chert stringers and knobs up to 3 inches in diameter continue upward through most of the unit. The upper part of the unit contains penecontemporaneous dolomite breccias. Beds may
EXPLANATION OF PLATE XII

Figure A

Exposure of the Eureka quartzite, Fish Haven dolomite, Laketown formation, and Sevy dolomite in the northwest Pahranagat Range (location 2, Figures 7 and 3). The section is dipping to the east, away from the observer at about 13 degrees. The thick-dark, thinner-light, and thin-dark units are easily distinguished above the quartzite. The Eureka is 552 feet thick at this locality in which 378 feet of the vitreous white middle member forms a massive cliff above the somewhat less resistant lower member of 174 feet. The upper member is not present. Above the Eureka: a-b Fish Haven dolomite (336 feet); b-e Laketown formation (309 feet); b-c lower member; c-d middle member; d-e upper member.

Above e is the Devonian Sevy dolomite. b and e are the Ordovician-Silurian and Silurian-Devonian boundaries respectively.

Figure B

Similar exposure as Figure A on the west side of the Pahranagat Range south of Highway 25 (Figure 7). The section is essentially that of locations 4 and 5. a-b Fish Haven dolomite; b Ordovician-Silurian boundary; b-e Laketown formation - lower dark b-c, middle light c-d, and upper dark d-e members; e contact of Laketown formation and Sevy dolomite (Silurian-Devonian boundary).
PLATE XII

Figure A

Figure B
contain up to 40% 1-2 inch darker gray angular dolomite fragments. The unit has locally abundant dolomite and calcite veining. The massive cherty cliff that constitutes the lowest part of the member superjacent to the bench-forming lower member (Plate XII, Figure B) has been found as bluish gray, massive ledged calcarenite demonstrating beyond question secondary or diagenetic-pene-contemporaneous dolomitization. The member displays a progressive change from thick 3-5 foot bedding in the lower part to medium bedding, 8 inches to 2 feet in the middle part, and finally to thin 2-4 inch bedding in the upper part. Because sedimentary breccias are limited to the upper part, the member illustrates a regressive or shallowing condition from bottom to top where wave agitation affects deposition.

The upper member of the Fish Haven dolomite consists essentially of about 150 feet of light olive to yellowish gray and medium light gray weathered, non-resistant bench to slope-forming, thin to medium bedded (1 to 4 inches), very fine phaneritic to aphanitic slightly limy dolomite. Fresh surfaces are medium light to medium dark gray. The upper 50 feet of the unit weathers light brownish gray, has grayish pink fresh surfaces and displays thin 1-3 inch discontinuous bedding with shale partings. A silicified brachiopod faunule is present in this zone at virtually all locations (Figure 7 and 8; Table 6). Some chert,
penecomparaneous dolomite breccias, and calcite veining also occur in this member. The uppermost 2 feet is a distinctive bed containing irregular medium gray to dark gray dolomite mottles in a matrix of light pinkish to olive gray dolomite. This bed, which is found at most localities defines the top of the Fish Haven dolomite and lies directly below the Ordovician-Silurian boundary. It is overlain by dark gray cliff-forming cherty phaneritic dolomites of the lower member of the Laketown formation.

At Buckhorn fault (location 7, Figures 7 and 8) the upper member of the Fish Haven is light bluish gray, thin bedded to laminated, discontinuously bedded, shale parted calcisiltite to calcilutite which grades laterally along strike into yellowish gray dolomite. The calcitites are abundantly fossiliferous. Some thin beds contain "rain drop" impressions. The upper member continues to display every aspect of shallowing water from above wave base to tidal flat conditions. These facts shed important light in considering an Ordovician-Silurian unconformity.

The Fish Haven dolomite thins from a maximum of 527 feet at Fossil Mountain to 412 feet at the Buckhorn Fault (Locations 1 and 7, Figures 7 and 8) over a distance of 32 miles on the eastern side of the Pahranagat Range. Four measured sections on the west side of the range vary from 321-352 feet. The anomalous section is again location 6 where the Fish Haven is only 260 feet. This is
in the allochthonous section (a westerly derived klippe). The Fish Haven thicknesses support the latter hypothesis.

Otooni (1959, personal communication) obtained thicknesses for the Fish Haven dolomite of 514-532 feet in the Southern Egan Range. Kellogg (1959, p. 47) measured 549 feet in the Southern Egan Range. There are 337-388 feet of the correlative Ely Springs dolomite in the Arrow Canyon Range (Langenheim, 1960, written communication). Rush (1956) reports the Fish Haven is 505-590 feet thick throughout western Millard County, Utah (Figure 4). Rigby (1958) obtained 250-270 feet in the Stansbury Mountains, Toole County, Utah (Figure 4). Merriam measured 560 feet at the type section of the equivalent Hanson Creek formation in central Nevada which thins to 300 feet east and south, (Nolan and others, 1958, p. 33).

Age, Fauna and Correlation

Abundant fossils have been collected from the Fish Haven dolomite in the Pahranagat Range. Locations are placed geographically on Figure 7 and stratigraphically on Figure 8. Faunas are listed on Table 6.

At Fossil Mountain, Buckhorn Fault, and in the central Pahranagat Range a prolific, silicified brachiopod-coral faunule occurs in the upper few feet of the formation. Streptelasma sp.,
Catenipora sp. cf. C. gracilis (Hall) and Bighornia sp. were identified by William A. Oliver, Jr. who states that these forms are characteristic of the upper Ordovician (Oliver, 1959, written communication). Furthermore, Duncan (1957, p. 611) states that Bighornia is an index of the upper Ordovician. Species of Rhynchotrema, Zygospira, Platystaphia, Sowerbyella, Paucicrura and large strophomenoid brachiopods resembling Strophomena and Rafinesquina are also abundant in the Fish Haven and are indicative of upper Ordovician.

The Fish Haven dolomite is a time equivalent of the Hanson Creek formation of central Nevada (Merriam, 1940; Nolan and others, 1956). The Fish Haven correlates with the Ely Springs dolomite in the Pioche district (Westgate and Knopf, 1932) and with units A and B (225 feet) of undifferentiated middle Paleozoic strata in the Atomic Proving Grounds described by Johnson and Hibbard (1957, p. 350). The Fish Haven is a time correlative of the Saturday Mountain formation of central Idaho (Ross, 1953) the Montoya formation of Texas, and the Maquoketa shale of Iowa and Minnesota. Duncan (1956, pp. 219-220) correlates the coral fauna of the Fish Haven with that of the Bighorn dolomite and believes it suggests a "Late-probably early late-Ordovician age."

The fauna of the Fish Haven dolomite and its equivalents in the western United States has been generally considered late
Figure 1. - Index map showing the Pahranagat Range and surrounding area, Lincoln County, Nevada, with location of measured sections of the Eureka, Fish Haven, and Laketown formations (Figure 8).
TABLE 6

Faunules in the Fish Haven and Laketown Formations

LOCATION 1 FOSSIL MOUNTAIN

Section 6, T. 3 S., R 61 E Lincoln County, Nevada

FISH HAVEN DOLOMITE

FD-2 small brachiopods (not abundant)

FD-7 *Rhynchotrema*? sp.

FD-9 *Platystropheia* sp.
   *Zygospira* sp.
   *Glyptorthsis* sp.
   *Plaesiomys* sp.
   *Diceromyonia*? sp.
   *Thaerodonta*? sp.
   *Sowerbyella*? sp.
   *Strophomena* sp.
   *Rafinesquina* sp.

   *Bighornia* sp.

LAKETOWN FORMATION

LM-12 brachiopod and coral section coquina (abundant)

LM-13 *Favosites* sp.
   *Large brachiopods*

LM-17 colonial corals (abundant)
   horn corals (abundant)
   stromatoporoid structures
   syringoporoid coral
   *Favosites* sp.
   *Breviphyllum*? sp.
   *Cyathophyllum thoroldense* Lambe 1901
SEVY FORMATION

S-1 silicified small corals and brachiopods (poorly preserved)

LOCATION 2 NORTHWEST PAHRANAGAT RANGE

Sections 21-22, T. 5 S., R 58 E., Lincoln County, Nevada

FISH HAVEN DOLOMITE

FD-13 Platystrophia sp.
Bighornia sp.

LAKETOWN FORMATION

LM-17 brachiopod and coral section coquina
Favosites sp.
LM-24 Halysites sp.
LM-25 horn corals
Amphipora sp.
LM-26 Camarotoechia pahranagatensis Waite
colonial corals
horn corals

LOCATION 3 W A I T E H I L L

Sections 31-32, T. 6 S., R 59 E., Lincoln County, Nevada

FISH HAVEN DOLOMITE

FD-14 beaded crinoid columnals

LAKETOWN FORMATION

LM-21 brachiopod and coral section coquina (abundant)
recrystallized-poorly preserved
LM-22  brachiopod relict structures
        favositid corals
        halysitid corals

LM-26  silicified small brachiopods (abundant)
        lower part of Waite zone

LM-27  Camarotoechia pahranagatensis Waite (zone)

LOCATION 4  MIDDLE MOUNTAIN

Section 17, T. 7 S., R 59 E., Lincoln County, Nevada

FISH HAVEN DOLOMITE

LM-7    coral and brachiopod relict structures

LAKE TOWN FORMATION

LM-12   small silicified brachiopods (lower Waite zone)

LM-13   Camarotoechia pahranagatensis Waite (zone)

LOCATION 5  DEVONIAN RIDGE

Section 20, T. 7 S., R. 59 E., Lincoln County, Nevada

FISH HAVEN DOLOMITE

FD-6    small silicified brachiopods
        beaded crinoid columnals

FD-9    Catenipora sp.  cf.  C. gracilis
        Streptelasma sp.
        Thaerodonta? sp.
        Sowerbyella ? sp.
        brachiopods

LAKE TOWN FORMATION

LM-12   Halysites sp.
LM-13 brachiopods and coral sections (poorly preserved)

LM-16 silicified small brachiopods (abundant)
Protathyris sp.
Howellella sp.

LM-17 Camarotoechia pahranagatensis Waite (zone)

LOCATION 6 CENTRAL PAHRANAGAT RANGE

Sections 35-36, T. 6 S., R. 59 E., Lincoln County, Nevada

FISH HAVEN DOLOMITE

FD-3 Rhynchotrema sp. cf. R. capex
Reserella sp. A
Reserella sp.? B
Sowerbyella sp.
Streptelasma sp.
Hebertella sp.

FD-4 silicified brachiopods (similar to FD-9 at location 1)

LAKETOWN FORMATION

LM-6 Halysites sp.
pentameroid brachiopods
Petraia? sp.
Synaptophyllum sp.

LM-7 brachiopod and coral sections (poorly preserved)
Halysites sp.

LM-9 pentamerid brachiopod coquina (silicified fragments up to 1 inch wide)

LM-15 Halysites sp.
Breviphyllum? sp.
Disphyllum? sp.
Favosites sp.
Clavidictyon sp.
"Cladopora"
SEVY FORMATION

S-1

Howellella pauciplicata Waite
Howellella smithi Waite
Howellella sp.
Atrypa ? sp.
Athyris ? sp.
Camarotoechia acutiplicata Amsden
Camarotoechia sp.
Meristella sp. (large - 1 1/2 inches length)

LOCATION 7  BUCKHORN FAULT

Sections 17-18, T. 8 S., R. 61 E., Lincoln County, Nevada

FISH HAVEN DOLOMITES

FD-5

small horn corals

FD-7

gastropods
brachiopods
crinoid stems
trilobite fragments
small horn corals

FD-8

horn corals (several species)
Bighornia sp.
brachiopods (several species)
Strophomena sp.
Rafinesquina? sp.
Strophomenoid brachiopods large (3/4-1 inch diameter)

LAKE TOWN FORMATION

LM-10

brachiopod and coral castes (abundant)

LM-11

large brachiopods (relict structures)
Halysites sp.

LM-12

Favosites sp.
stromatoporoida?
fossil fragments

LM-14

horn corals
colonial corals
poorly preserved cherty organic fragments
Ordovician (Richmondian). Hintze (1951, p. 51) summarized the prevailing views on this subject. No typical Eden or Maysville faunas have been identified from western North America. Webb (1958, p. 2368) reports a Richmondian faunule in the dolomites just above the Eureka quartzite north of Ely, Nevada. This led Webb to consider a post-Eureka quartzite-pre Fish Haven disconformity because lower and middle Cincinnatian faunas were unrepresented in the area. However, recently Gutstadt (1958, pp. 542-544) has suggested that the Eden and Maysville of the Cincinnatian type section are facies of the Richmondian Maquoketa shale of Iowa. This would clearly explain why no early Cincinnatian faunas are represented in the west, that none could be expected, and that no post-Eureka unconformity is necessary under these circumstances in the Basin and Range.

Origin

The Fish Haven was deposited in shallow water sublittoral to littoral shelf conditions. It is clearly demonstrated that it was originally deposited as clastic limestone and secondarily dolomitized. In the Pahrangagat Range continuous regressive shallowing conditions can be demonstrated from the lower part of the middle member to the top of the formation. This situation is in agreement with a suggested Ordovician-Silurian paraconformity.
ORDOVICIAN-SILURIAN BOUNDARY

In the Pahranagat Range the Ordovician-Silurian boundary is drawn at the contact between the light olive to yellowish gray, bench-forming, thin-bedded fine phaneritic to aphanitic dolomite of the uppermost Fish Haven and the medium dark gray, cliff-forming, massive ledged, cherty phaneritic dolomite of the lower member of the Laketown formation (Plates II, VII, XI, XII). A Richmondian faunule occurs within a few feet of the contact (Figure 8). No fossils have been found in the lowest part of the Laketown but the earliest succeeding fauna occurring 100-200 feet above the contact contains Halysites sp., Favosites sp., and pentameroid brachiopods of Silurian age. The Ordovician-Silurian boundary is quite similar in the Southern Egan Range where Otooni (1958, personal communication) collected Halysites and pentameroid brachiopods resembling Conchidium 17-35 feet above the contact.

This distinctive lithologic break at the Ordovician-Silurian boundary has been reported over a wide area in the Basin and Range. Merriam (1940) defined the base of the dark colored Silurian Roberts Mountains formation at the bottom of a massive belt of black chert
below which occurs the Ordovician Hanson Creek formation. What appears to be the same basal chert is also found on the west side of Antelope Valley and at Lone Mountain, Nevada, where it is 85-100 feet thick. This chert member is thought to occur as a siliceous bed in approximately the same stratigraphic position as far away as the Inyo Mountains in California (Nolan and others, 1956, p. 37).

McFarlane (1955, pp. 12-14) summarized the Ordovician-Silurian boundary problem and concluded that in most areas of eastern Nevada and western Utah a distinct color break occurs between Ordovician and Silurian strata which makes an easily mappable contact. Furthermore, even in gradational zones a systematic break may be determined by means of any combination of color, resistivity, bedding, chert, and fauna to a zone not exceeding 50 feet in vertical stratigraphic extent. It will be demonstrated below that the lower member of the Silurian Laketown dolomite in the Pahranagat Range is correlative with the Roberts Mountains formation in central Nevada. The writer feels certain that the cherty zone at the base of the Laketown corresponds to the chert beds that defines the base of the Roberts Mountains formation and its equivalents throughout the Basin and Range Province.

An Ordovician-Silurian unconformity is reported in the Ruby Mountains of north-central Nevada (Sharp, 1942, pp. 659-660). In this area the Lone Mountain formation is said to lie on the Pogonip
with upper Pogonip, Eureka, and Hanson Creek formations absent. However, the writer agrees with Nolan and others (1956, p. 34) that detailed future work may show that the Hanson Creek (Fish Haven) equivalent is actually present. An Ordovician-Silurian hiatus is suggested in the June Canyon region, Toquima Range, central Nevada where a Silurian shale formation rests on the Ordovician Pogonip with Eureka, Hanson Creek, and Lone Mountain formations absent (Reso, 1955).

Basin and Range Silurian faunas are exceedingly meager. Until the past few years they have been assigned exclusively to the Middle Silurian (Niagaran) and particularly to the Lockport. Thus, an unconformity was arbitrarily placed at both the bottom and top of western Silurian strata on almost all correlation charts (Swartz, et al 1942). Upper Silurian faunas have now been documented from the Basin and Range area (Nolan, Merriam and Williams, 1956, p. 39; Waite, 1956), and it is possible that lower Silurian faunas may yet be found, McFarlane (1955, p. 12). Nolan (1943, p. 17) did not recognize lower Silurian in the Great Basin and in regard to this he states:

The absence of basal Silurian rocks and the occurrence of beds at different horizons in the Ordovician beneath the contact indicate a fairly long interval of erosion preceding the deposition of Silurian formations.

Winterer and Murphy (1960) have made a detailed study of Silurian strata in central Nevada and in regard to the Ordovician-Silurian boundary they remark, p. 132:
Throughout its known extent in the Great Basin, the Silurian carbonate sequence rests unconformably on Ordovician or older rocks. The unconformity is generally not an angular discordance, but the lithologic break is generally clear cut, being marked in many places by an abundance of chert in the rocks just above the contact. Although evidence of erosion along this contact is on a minor scale, the fact that no lower Silurian strata have been recognized in the Great Basin indicates that this is a major hiatus. The lack of evidence for much differential erosion of the Ordovician, however, is a good measure of the relative tectonic stability of the region.

An Ordovician-Silurian unconformity based primarily on the absence of lower Silurian faunas in northern Utah has been suggested by Mansfield (1927, p. 173) and Richardson (1941, p. 18); and in the Gold Hill district by Nolan (1935, p. 17).

Whether or not lower Silurian faunas are one day recognized in the Basin and Range there is evidence for a regression in the late Ordovician strata of the Pahranagat Range. An abrupt contact is followed by Silurian beds of wholly different character suggesting a transgressive phase of a new sedimentary cycle. The fact that the Ordovician-Silurian boundary can be determined with such precision indicates to the writer that an important diastrophic event occurred over a wide area at that time and that a paraconformity exists.
SILURIAN ROCKS

Introduction

A thickness of 736-938 feet of Silurian strata is exposed in the Pahranagat Range. These beds are referred to a single formation, the Laketown dolomite, which has 3 distinctive members; a lower dark member, a middle light member, and an upper dark member (Plates II, VII, XII).

The Laketown is completely exposed along the western side of the Pahranagat Range and in the center of the range. Complete sections are available at Fossil Mountain in the northeast (Plate V), and at Buckhorn fault in the southeastern part of the range. Laketown measured sections are located on Figure 7 and correlated on Figure 8.

Laketown dolomite

The Laketown dolomite was defined by Richardson (1913, p. 410) for "massive light gray to whitish dolomite, containing lenses of calcareous sandstone, having a thickness of approximately 1000 feet" that overlies the Fish Haven in Laketown Canyon, Rich County, northern Utah. Nolan (1935) extended the term Laketown
to the 800-1200 feet of Silurian dolomites in the Gold Hill district, Utah (Figure 4). Since that time the term Laketown has been widely used for Silurian rocks in western Utah (Campbell, 1951; Easton, 1953; Bissell, 1955, p. 1643; McFarlane, 1955, pp. 18-19; Rigby, 1958, Figure 4) and in eastern Nevada (Osmond, 1954; Waite, 1956; Kellogg, 1959, p. 48; Reso and Croneis, 1959, Figure 2; Winterer and Murphy, 1960, Figure 6; Langenheim, 1960).

Lower Member

The lower member of the Laketown dolomite consists of medium light to dark gray and light to medium olive gray weathered, resistant slope to semi cliff-forming, massive ledged, medium to thick bedded (6 inches to 4 feet), cherty, fine phaneritic dolomite. Fresh surfaces are medium dark gray. Chert is prolific in the lower part of the member in both continuous and discontinuous bands averaging 1-2 inches in width. Chert is less abundant in the upper part but stringers up to 1 inch wide are found locally. Some thin sandy beds occur throughout. Minor characteristics include some mottled and aphanitic dolomite and rare thin bedding (1-6 inches). The member has thicknesses of 228 to 341 feet. The most distinctive feature of the upper part is a zone of coral sections and brachiopod casts that appear as "ghosts" in the rock. This is seen at every Laketown locality in the Pahranagat area and
represents a coquina in which the organisms have been almost completely obliterated by dolomitization. Fossils are rare in the lower member and invariably silicified. Pentameroid brachiopods and colonial corals *Halysites*, *Favosites* and *Synaptophyllum* have been collected.

**Middle Member**

The middle member consists of 324-460 feet of yellowish gray and very light to medium olive gray weathered, semi cliff-forming, massive medium and continuously bedded (6 inches to 2 feet), fine to coarse sugary phaneritic dolomite. Fresh surfaces are very light gray to medium dark gray. Intermittent brown chert occurs locally but otherwise the dolomites are relatively pure and most of the Middle member forms a homogeneous and monotonous sequence. The upper parts become extremely vuggy with some zones having vugs up to 1/4 inch in diameter. Algal or stromatoporoid structures occur in the lower part of the member in coarsely crystalline dolomite. Only one poorly preserved silicified favositoid coral and some dolomitized crinoid columnals have been recovered.

**Upper Member**

The upper member is light to dark olive gray to pale yellowish brown weathered, massive ledged (3-4 feet), medium
bedded (6 inches to 1 foot), resistant slope to semi cliff-forming, cherty, very fine phaneritic to aphanitic dolomite. Fresh surfaces are medium to dark gray. Chert increases upward in the member eventually forming stringers and nodules up to 3/4 inch in diameter. The upper 60 feet is distinguished at many localities by 2-10 inch wavy continuous bedding and 1-2 inch chert stringers. Abundant silicified colonial corals, stromatoporoid and algal structures, and well preserved brachiopods occur within 150 feet of the top of the member. In the uppermost 50 feet small 1/4 to 1/2 inch chert balls are found which can be traced down section into well preserved silicified brachiopods. The upper member is 39-222 feet thick.

Age, Fauna and Correlation

The lower member of the Laketown contains poorly preserved solitary and colonial corals including Balysites, Favosites, Petraia?, Synaptophyllum and pentameroid brachiopods. These forms have been considered middle Silurian (Niagaran). The middle member is essentially barren except for a rare Favosites sp. and crinoid columnals. The upper member contains abundant well preserved silicified horn corals, chain corals, tabulate corals, stromatoporoidea, algae?, and brachiopods. Faunules are located geographically and stratigraphically on Figures 7 and 8 respectively and are listed on Table 6 and Plate II.
Upper Silurian brachiopods have been described from the upper member of the Laketown dolomite in the Pahranagat Range (Waite, 1956). These commonly occur 50-136 feet below the top of the formation and may be utilized as an important marker on the west flank of the range. They are invariably found in two zones; a lower 28 foot zone characterized by Howellella and Protathyris overlain directly by a 12 foot zone almost exclusively of Camarotoechia pahranagatensis Waite. The latter zone varies from 50 to 96 feet below the top of the formation.

As previously described, however, chert balls of altered Camarotoechia occur somewhat higher in the section.

In the central Pahranagat section (location 6, Figure 8), at Fossil Mountain, and in the Northwest Pahranagat location the uppermost 20 feet of the Laketown contains a prolific coralline faunule characterized by the large horn coral Breviphyllum sp., but also containing Disphyllum? sp., Favosites sp., Halysites sp., and the stromatoporoid Clavidictyon? sp. William A. Oliver, Jr. who identified these specimens states:

Breviphyllum has been described only from Devonian rocks but numerous species of "Cyathophyllum" which have been described from the Silurian of North America are close to, and perhaps congeneric with Breviphyllum. The species in the collections is similar in internal structure to Cyathophyllum thoroldense Lambe, 1901, from the "Niagara formation" at Thorold, Ontario.
**Clavidictyon** is known from Silurian rocks, but has not been previously so reported in North America. This stromatoporoid is composed of small twig-like branches. In spite of poor preservation it is fairly certain that the axial canal characteristic of **Amphipora** is lacking. Such stromatoporoids are sometimes referred to **Amphipora** but should probably be called **Clavidictyon**. Whatever the name, this type of stromatoporoid is known from rocks possibly as old as middle Silurian of Asia, and from Devonian rocks in Europe. In North America they are known to occur in the Devonian but according to Helen Duncan and Jean Berdan they have yet to be recognized in the Silurian. The stromatoporoid then suggests but does not prove Devonian rather than Silurian age.

The Silurian age is indicated by the presence of **Halysites**. This genus has been reported or listed from the lower Devonian by various workers, but no such occurrence has been verified and all of the reports are suspect.

In conclusion, the two lines of evidence which seemed to suggest Devonian are outweighed by the occurrence of **Halysites** and the collections are apparently all Silurian. (Oliver, 1959, 1960, written communications.)

In support of the above conclusion the writer has collected several brachiopod specimens resembling species found in Waite's upper Silurian faunule mixed with the coral zone in both the northwest Pahranagat Range and in the central range section. Furthermore, as will be pointed out later, elements of upper Silurian brachiopods from Waite's zones occur in lower beds of the overlying Sevy formation in the central Pahranagat Range. The Laketown dolomite is therefore considered middle and upper Silurian. It should be kept in mind, however, that regardless of the presence or absence
of a paraconformity at the base of the Laketown only detailed paleo-
ontological work will prove or disprove the presence of lower Silurian
beds. The faunal succession of Basin and Range Silurian is relatively
unknown and it is apparent that Niagara faunules of eastern North
America do not correspond exactly with the "Niagara" of the
western United States.

A silicified coral faunule occurs at the top of the Laketown
dolomite in the Southern Egan Range. Kellogg (1959, p. 50) identified
Catenipora gracilis (Hall), Halysites sp. cf. H. agglomerata Hall,
Favosites favosus (Goldfuss), Heliolites megastoma McCoy,
Syringopora sp., and Clathrodictyon sp. cf. C. striatellum Orbigny,
indeterminate rugose corals and gastropods. He concluded that in
the Southern Egan Range the Laketown fauna is not conclusively
Niagaran. He did not find evidence for an unconformity at the base
of the formation and only slight evidence for one at its top.

A coral faunule in the upper 10 feet of the Laketown dolomite
is known from several other widely separated localities in western
Utah and east-central Nevada. (Osmond, 1954, p. 1929). It occurs
at Kings Canyon in western Millard County, Utah (Figure 4), in the
North Egan Range (north of Ely), and at Blackrock Canyon in the
White Pine Range (southwest of Ely). Halysites and favoritids are
reported from each location but the fauna also includes stropheodontids,
Muchisonia and a low-spike gastropod (Ectomaria?), zaphrentids, streptelasmoids, heliolitids, Synaptophyllum and fragments of Syringopora. Osmond states that these forms indicate a Silurian age for the dolomite beneath the Sevy formation.

In the Sulfur Springs and Pinyon Ranges, Nevada Carlisle, Murphy, Nelson, and Winterer (1957, p. 2180) report that...
"uppermost beds of the Lone Mountain dolomite commonly contain a fragmentary coral fauna consisting of Favorsites and zaphrentid types and at some places crinoid and doubtful brachiopod fragments. At some places a crude "spaghetti" texture suggestive of Cladopora is found." It is further reported that at some localities, as in the Mineral Hill quadrangle, Nevada, upper beds of the Lone Mountain dolomite contain a poorly preserved coral fauna which has not been dated (Winterer and Murphy, 1960, p.133).

It is probable that the faunule described at the top of the Laketown in the Pahranagat Range should be correlated with the above faunules.

In central Nevada rocks of Silurian age consist of a lower Roberts Mountains formation and an upper Lone Mountain dolomite (Merriam, 1940, pp. 11-14). The Roberts Mountains formation attains thicknesses up to 1900 feet and is essentially limestone at the type section about 30 miles northwest of Eureka, but reported to be only 650-741 feet and essentially dolomitic to the east
The overlying Lone Mountain dolomite is 1500-2000 feet thick in
central Nevada. Spiriferoids of the Howellella type occur within
the upper 500 feet of the Lone Mountain and these forms are con-
considered upper Silurian (Nolan and others, 1956, p. 39). It has been
shown that the Lone Mountain dolomite and Roberts Mountains
formation are largely lateral equivalents in the Roberts Mountains
(Winterer and Murphy, 1958, p. 1711, 1960, Figure 6). The Lone
Mountain is considered to be a reef-and-bank complex whose
original features were largely obliterated by dolomitization, and
the Roberts Mountains formation is a deep-water reef flank,
off-reef, and basin deposit. Thus the Roberts Mountains formation
is equivalent to lower parts of the Lone Mountain formation and
the Laketown dolomite in eastern Nevada and western Utah.

McFarlane (1955, p. 22) recognized that Conchidium and
smaller pentamerid brachiopods suggestive of Platymerella?,
known in the Roberts Mountains formation at the type locality
(Merriam, 1940, p. 12) are present at several localities in the
lower part of the Laketown dolomite in eastern Nevada including
the Pahranagat and Southern Egan Ranges. He stated furthermore
that the dark colored Roberts Mountains formation correlated with
the dark colored lower part of the Laketown and that in his opinion
"little doubt exists as to the correctness of this correlation; it is
supported by both lithologic and faunal evidence." (McFarlane, 1955, p. 20). The writer concurs with McFarlane and points out also that the lithology of the middle member of the Laketown dolomite in the Pahranagat Range and that of the Lone Mountain dolomite are identical. Thus the lower member of the Laketown dolomite in the Pahranagat Range is a correlative of the Roberts Mountains formation and the middle and upper members of the Laketown are equivalents of the Lone Mountain formation in central Nevada.

The Pahranagat Laketown correlates with the Roberts Mountains, Jack Valley and Decathlon formations of western Millard County, Utah (Rush, 1956, pp. 20-26), and with unnamed strata of Silurian age in the Pioche district, Nevada (Westgate and Knopf, 1932, p. 16). The Laketown is a correlative of the lower part of the Hidden Valley dolomite in the Panamint Range, California (McAllister, 1952, p. 15), and probably with parts or all of units C-E of undifferentiated middle Paleozoic strata in the Atomic Proving Grounds, Nevada (Johnson and Hibbard, 1957, p. 351).

Seven measured sections of the Laketown dolomite in the Pahranagat Range vary from 736-933 feet (Figure 8). A complete section in the Southern Egan Range is 1013 feet; the lower member 457 feet (Killogg, 1959, p. 49). The Laketown is reported to thin southward from 403-257 feet because of pre-Devonian erosion in the Arrow Canyon Range, Figure 4, (Langenheim, 1960, written communication). The Laketown is 1000 feet thick over a wide area
in western Utah (Rush, 1956). Teichert (1958, pp. 27-28) reports 614 feet in the Stansbury Mountains Utah and Rigby (1958, p. 33) found 664 feet of Laketown in the same area. The Laketown probably exceeds 750 feet in the Atomic Proving Grounds, Nevada.

Origin

The Laketown dolomite was deposited on a stable shelf in a shallow temperate sea. The coral-brachiopod fauna of the Laketown suggests epineritic to shallow infraneritic environment with water depth probably not exceeding 150 feet for any extended period of time. The prolific coralline beds at the top of the Laketown in the Pahranagat Range, favositid bioherms producing several feet of relief at the top of the Laketown in the Southern Egan Range (Kellogg, 1959, p. 49), and the Silurian reef complex in central Nevada (Winterer and Murphy, 1960) support this view.

The Laketown was originally deposited as fine clastic limestone and secondarily (penecomtemporaneously or syngenetically) dolomitized. Lateral gradation between dolomite and limestone has been described in the Laketown, notably at the type section, which indicates that dolomitization is secondary. Such gradations are not seen, however, in the Pahranagat Laketown. The widespread uniform nature of the Laketown dolomite precludes the possibility of dolomitization due to ground water circulation.

It is believed by a number of authors (e.g. McFarlane, 1955; Nolan et al, 1956) that slow subsidence and slow deposition provides
a long period of contact between magnesium-bearing sea water and
the newly deposited sediments. Logically the longer period of con-
tact between the two, the greater the possibility for dolomitization.
Slow deposition and subsidence with possible reworking of sediments
would also result in loss of organic matter. Such conditions would
result in coarser textured lighter colored dolomites while more
rapid deposition and subsidence might result in darker colored,
organically richer, somewhat finer textured dolomites. The best
preserved and most abundant faunas would be located in the later
deposits.

The writer believes that the Pahranagat Laketown dolomite
represents a complete systematic sedimentary-tectonic cycle. The
lower member (equivalent to the Roberts Mountains formation) was
deposited under mildly unstable shallow water shelf conditions in
which deposition and subsidence was relatively rapid. Dark color,
medium bedding, preservation of organisms, and a high clastic
quartz-silica ratio (chert and sands)—probably derived from distant
raised lands at the end of the Ordovician, represents a transgressive
phase.

The middle member (equivalent to the lower part of the Lone
Mountain formation) was deposited under very stable, moderately
shallow water shelf conditions. This is supported by light color,
massive, medium to thick continuous bedding, coarse texture, and
absence of organic materials. A very low clastic quartz ratio points
to absence of nearby tectonic lands, a provenance of cratonic carbonate rocks of extremely low relief, and thus a maximum marine transgression.

The upper member of the Laketown (equivalent to the upper part of the Lone Mountain formation) is dark colored, medium bedded, fine textured, contains abundant well preserved organisms and a high clastic quartz ratio. The uppermost part displays 2-10 inch wavy bedding. This indicates a return of mildly unstable shallow water shelf conditions, more rapid deposition and subsidence and represents a regressive phase that terminates with an unconformity.

Although the dark colored members of the Laketown dolomite contain a notable amount of bitumen they cannot be considered petroliferous. They are not source rocks in the Pahranagat area. Intercrystalline porosity is well developed in the vuggy zones of the upper part of the middle member, but it is doubtful that permeability is very high. The conditions are possible however for a locally petroliferous upper member to act as a source to fill a reservoir in the vuggy middle member under compaction. Under favorable structural conditions a permeable reservoir could be developed by tectonic fracturing.
SILURIAN-DEVONIAN BOUNDARY

The Silurian-Devonian boundary is generally unconformable in the Pahranagat Range. The contact is marked by the distinct lithologic change from dark olive to brownish gray fine phaneritic dolomite of the Laketown to very light gray and yellowish gray fine phaneritic to aphanitic dolomite of the superjacent Sevy formation. At several localities on the west side of the Pahranagat Range this boundary is irregular and disconformable, although the relief does not exceed a few feet. At the northwest Pahranagat section and at Buckhorn Fault (locations 2 and 7, Figure 8) the contact is gradational through 32-44 feet of vertical stratigraphic section. This transitional zone is very sandy and cherty as are the lowest beds of typical Sevy lithology. At other localities the contact is abrupt and paraconformable.

The upper member of the Laketown is 188 feet thick at Fossil Mountain and is the same thickness about 32 miles south at Buckhorn Fault on the east side of the Pahranagat Range (Figure 7). The upper member has thicknesses of 220 and 222 feet in the north, and 164 to 208 feet in the south on the west side of the Range. The upper member is only 89 feet thick in the central Pahranagat Range section (location 6, Figure 7). It is pointed out again that
this section is probably in a westerly derived allochthonous sequence
and the anomalous thickness as well as other lithic-faunal differences
is further proof of this.

The statement by Reso and Cronelis (1959, p. 1249) that...
"The Laketown thins eastward with loss of a major portion of its
upper member including Waite's upper Silurian brachiopod zone"...
is still essentially correct except that the writers were comparing
the Laketown on the west side of the Range with the central section.
With the additional data here presented from the sections at Fossil
Mountain and Buckhorn fault (Figure 7) it is apparent that even as-
suming pre-Devonian erosion of 30 feet of the upper member this
would not be sufficient to erode below the stratigraphic position of
the brachiopod faunule. Other factors--ecological or stratigraphic
must be responsible for the absence of the fauna. The statement by
Reso and Cronelis should now read..."The Laketown thins southeast-
ward. Waite's upper Silurian brachiopod zone is not present on the
east side of the Pahranagat Range. A klippe containing sections of
westerly derived Laketown and Sevy formations indicates that the
Laketown also thins southwestward with major loss of its upper
part including Waite's upper Silurian brachiopod faunule."

These facts are in harmony with the regional stratigraphy.
The Laketown is known to thin from 403 to 257 feet southward be-
cause of pre-Devonian erosion in the Arrow Canyon Range some 40
miles south of the Pahranagat Range (Langenheim, 1960). In the
northern Virgin Mountains of eastern Clark County, Nevada and northwestern Arizona the Laketown is completely absent and the upper Devonian Muddy Peak limestone rests unconformably on lower Ordovician Pogonip (McNair, 1951). In the Atomic Proving Grounds the lower Devonian Sevy formation is relatively thin but its very distinctive upper member is present. This suggests absence of the lower Sevy coincident with a Silurian-Devonian hiatus (Johnson and Hibbard, 1957). In the Southern Egan Range the Laketown is 1013 feet thick and the upper member as defined in this report is only 100 feet thick. Kellogg (1959, p. 50) states that there is only slight evidence for an unconformity at the top. However, Osmond (1954, p. 1916) believes that the Laketown-Sevy contact is unconformable and that diagenesis has caused a zone of apparent transition along the contact.

Throughout most of the Basin and Range Province a Silurian-Devonian unconformity is clearly demonstrated. The contact between the Laketown and the Sevy is unconformable at Gold Hill, Utah. Nolan (1935, p. 18) states:

"The truncation of beds at the top of the Laketown dolomite, as shown by the disappearance northward of the upper light-gray, coarsely crystalline member, and the local presence, in the basal Devonian formation, of conglomerate containing pebbles of the underlying Silurian formation, leave little doubt that there is a pronounced unconformity between the Laketown dolomite and the Sevy dolomite."

At Kings Canyon, western Utah, the top of the Laketown exhibits a few feet of relief with beds having been removed by pre-Sevy erosion.
(Osmond, 1954, p. 1915). In the vicinity of Eureka, central Nevada, (Nolan and others, 1956, p. 38) recognize a persistent, sharp, irregular contact..."probably an unconformity"...between the typical sugary light gray dolomites of the Lone Mountain formation below and lithologically distinctive white weathering dolomites of the Devonian Nevada formation above. They state that:

"There appears to be several feet of relief along the contact, and the uppermost Lone Mountain strata commonly are sedimentary breccias with fragments several inches across. The basal Devonian in contrast is not conglomeratic, but may be composed in places of as much as 6 inches of dolomite sand."

At another locality on the west flank of the Diamond Mountains Nolan et al report that the dense light gray dolomite of earliest Devonian age has 50-75 feet of sandstone or quartzite at its base, that the contact with the subjacent Lone Mountain dolomite is sharp, and that a sedimentary breccia occurs locally at the top of the Silurian strata.

West of Eureka in the Roberts Mountains region Winterer and Murphy (1960, p. 133) state that

"Wherever we have examined a good exposure of the contact between the Lone Mountain dolomite and the overlying Nevada formation, it is generally easy to place at one bedding plane....That this contact is an unconformity is indicated not only by the abrupt change in lithology but also by the slight convergence between the contact and the strata of the Lone Mountain dolomite, as near Willow Creek, where the Nevada formation rests on progressively older beds as the contact is traced southward."
Absence of Helderbergian rocks where the Lone Mountain
dolomite is overlain by the Nevada formation (Oriskany and younger
Devonian) is further cited in favor of a Silurian-Devonian hiatus,
although Helderbergian faunas are believed to occur between Silurian
rocks and the Nevada formation locally (Merriam, 1954, pp. 1234-
85; Nolan and others, 1956, p. 39; Winterer and Murphy, 1960,
p. 133).

An extension of the unconformity beneath the Devonian has
been reported in the Nopah and Resting Springs Ranges in California
(Hazzard, 1937, p. 327). Throughout eastern Utah, western Colorado
and northern Arizona, upper Devonian strata lie on Cambrian (Osmond,
1954, p. 1916, Figure 3).

In the Grand Canyon Region upper Devonian rests on upper
Cambrian (McKee, 1945, plate 1), and at Goodsprings Nevada
(Figure 4) middle Devonian is on middle Cambrian (Hazzard and
Mason, 1953, p. 649). Devonian rocks rest unconformably on
Cambrian to Silurian strata in the eastern Rocky Mountains of
Canada (Harker, Hutchinson and McLaren, 1954).
DEVONIAN ROCKS

Introduction

The maximum composite thickness of Devonian strata in the Pahranagat Range is 6062 feet. This sequence is divided into five formations, employing established terminology in eastern Nevada and western Utah. These formations are: The Sevy formation (lower and probably middle Devonian) 1386-1634 feet; the Simonson formation (middle Devonian) 1003-1168 feet; the Guilmette formation (partly middle? mostly upper Devonian) 2206-2410 feet; the West Range limestone (upper Devonian) 0-390 feet; and the Pilot formation (upper Devonian and possibly lower Mississippian) 176-460 feet. See Plate II.

The Devonian sections in the Pahranagat Range are possibly the most spectacular and complete exposures of Devonian strata thus far measured in western North American (Plate XIII). They occur in all areas of the range and exceed the thickness of the type section in central Nevada (Merriam, 1940) by approximately 1000 feet. They include all stages, with the possible exception of the Helderbergian, known throughout the Basin and Range from lower Devonian sediments to beds transitional to the Mississippian and
DEVONIAN SYSTEM IN THE PAHRANAGAT RANGE, SOUTHEASTERN NEVADA

Mile-thick Devonian section on west side of Pahranagat Range, Lincoln County, southeastern Nevada, as seen looking north from a spot on the somewhat thicker, but otherwise similar, section referred to in Figure 2 as Location A. The latter section is approximately 2 miles south of the ridge illustrated. Section shown is about 4 miles south of Highway 25 which can be seen trending northwestward across the Desert Valley just above the letter a in left of photograph.

The section illustrated dips slightly north of east, from more than 45° to less than 30° from west to east as a major fault is approached.

a. Contact of Laketown dolomite (Silurian) and Sevy dolomite (Lower and Middle Devonian)
   a-b. Sevy formation, approximately 1500 feet thick in this section
   b-c. Simonson formation (Middle Devonian)
   c. Approximate location of *Stringocephalus* zone
   c-d. Guinette formation (Middle and Upper Devonian)
   d-e. Pilot shale (Upper Devonian)
   e. Contact of Pilot shale and Joana limestone (Mississippian)
contain significant faunal zones which facilitate regional correlations and contribute to the knowledge of Devonian paleogeography.

**Sevy formation**

The Sevy dolomite was named by Nolan (1935, p. 18) from exposures in Sevy Canyon in the Deep Creek Mountains south of Gold Hill, Utah (Figure 4). The Sevy has been traced throughout an area of 100,000 square miles in Nevada, Utah, California and Idaho and is easily recognized by its distinctive homogeneous white to yellowish gray color (Plate XIII). It is conveniently divided into a lower dolomite member and an upper cherty dolomite-siltstone-sandstone member. For this reason the term Sevy formation rather than simply "dolomite" is preferred here. The thickness is 1386-1634 feet.

**Lower Member**

The lower member consists of light gray to almost white and light olive gray weathered, resistant slope to semi cliff-forming, massive 2-6 foot ledges of thin bedded to laminated, fine phaneritic to aphanitic dolomite. Fresh surfaces are very light to medium olive gray and generally slightly darker than weathered surfaces. However, light yellowish gray and light brownish gray fresh surface hues are also seen. The lower 100 feet of the formation contains up to 20% disseminated quartz grains. Sandy zones, discontinuous sand stringers, and cherty zones occur locally throughout the member.
Vuggy zones are seen only rarely. Most distinctive are intraformational breccias. Some breccia zones attain thicknesses of 40 feet on the west side of the Pahranagat Range. Although the entire member displays consistent massive thick parted ledges that range from 2 to 10 feet thick the majority of these ledges average 18 inches to 3 feet. The ledges commonly show distinctive deep differential weathering grooves indicating a fundamental laminated to thin bedding (Plate XIV, Figure A). The laminae commonly display primary deformation and contortions that evince the plastic nature of the original mud.

Five complete sections of the lower dolomite member of the Sevy formation in the Pahranagat Range vary from 1206-1440 feet in thickness. Stylolites are abundant in the upper part and have not been seen by the writer below 750 feet from the base. The stylolites are formed of light brownish red sandy zones that stand out in relief from the dolomite. These are locally prolific occurring about 6 inches apart through 100 feet of vertical extent. (Plate XIV, Figure B).

At Fossil Mountain there are 5-20 foot alternations of typical very light gray weathered, light olive gray fresh surface, 2-6 foot massive ledges of thin bedded (2") fine phaneritic to aphanitic dolomite with atypical light olive gray weathered, light brownish to dark gray fresh surfaces of thick 2-10 foot ledges of thin bedded to laminated medium to coarse phaneritic dolomite containing abundant chert stringers.
EXPLANATION OF PLATE XIV

Figure A

Typical Sevy dolomite showing rather constant 8-14 inch massive parted ledges. Distinctive deep differential weathering grooves indicate fundamental very thin beds to laminations.

Figure B

Prolific stylolites in the upper Sevy dolomite. The stylolites are formed of light brownish red sandy zones that stand out in relief from the dolomite. In this view they are seen to be regularly spaced from 4-6 inches.
Silicified, poorly preserved, small corals and brachiopods have been collected in the lower 80 feet of the Sevy dolomite at Fossil Mountain and a prolific well preserved silicified brachiopod faunule occurs at one location 90 feet from the base of the member in the central Pahranagat Range. One specimen of Amphipora sp. was found in the upper part. The member is otherwise completely barren.

Upper Member

The upper member of the Sevy formation is divided into three distinctive units.

The lowest unit consists of 52-88 feet of pale grayish orange to grayish yellow weathered and fresh surfaces of partly covered bench-forming, thin bedded (1/2-3 inches) calcareous siltstone. Occasional sandy shaly calcisiltite and very fine grained quartz sandstone beds also occur. The middle unit is 54-112 feet of grayish orange to pale yellowish orange and dusky yellow weathered, olive gray fresh surfaces, of non-resistant saddle-forming, thin bedded to laminated aphanitic dolomite with distinctive brownish gray chert. Lithic variations include dolomitic siltstone and some shale. The upper unit is 45-84 feet of grayish brown to light yellowish brown weathered, very light gray to light yellowish gray fresh surfaces, massive cliff-forming, cross-bedded and medium bedded (6 inches to 2 feet), subrounded to subangular, well sorted, medium to fine
EXPLANATION OF PLATE XV

Figure A

The upper member of the Sevy formation in the vicinity of Mount Irish. The shaly slope is the lower part of the upper member composed of limy siltstones and cherty aphanitic dolomite. This is overlain by the upper Sevy sandstone. On top of the sand are the light colored sandy dolomites of the lower Simonson formation. The section is dipping $13^\circ$ in the direction N $68^\circ$ W.

Figure B

Typical cross-bedding in the upper Sevy sand member.
PLATE XV

Figure A

Figure B
grained quartz sandstone. Cement is generally calcite but also includes dolomite and silica.

The lower two units of the upper member form a characteristic yellowish-orange colored saddle between the light Sevy dolomite and the sandstone unit. This can be distinguished at great distances throughout the Pahranagat Range and surrounding areas (Plates II, VII, XIII, XIV, XV). The thickness of the upper member is 84-212 feet. The thickest section was found in the central Pahranagat Range. Only one poorly preserved specimen of Amphipora was collected from the middle unit of the upper member.

**Age, Fauna and Correlation**

A well preserved silicified brachiopod faunule occurs at one location 90' from the base of the Sevy formation in the central section (location 6, Figures 7 and 8). Part of this collection was examined by Harold E. Kellogg who identified *Howellella smithi* Waite, *H. pauciplicata* Waite, *H. sp.*, *Camarotoechia acutiplicata* Amsden, *C. sp.*, *Atrypa sp.*, and *Athyris* sp. (Table 6; Plate II) Kellogg considers this fauna upper Silurian:

This fauna has elements of Waite's: "Upper Silurian" faunas (Waite, 1956) and is similar to the fauna of the Brownsport formation (Amsden, 1949). Although not exactly identical to Waite's fauna it is most probably Silurian. (Kellogg, 1959, written communication).

Poorly preserved silicified small corals and brachiopods are also present in the lower 30 feet of the Sevy at Fossil Mountain but
except for a specimen of *Amphipora*? in the middle unit of the upper member the formation is barren.

Fossils are extremely rare elsewhere in the Sevy; and, where present, they are poorly preserved. At Ninemile Canyon in the Southern Egan Range, Osmond (1954, p. 1928) reports *Syringopora* sp. cf. *S. perelegens* Billings and *Halysites* sp. cf. *H. catenularia* in the lower part of the formation. Kellogg (1959, p. 57) found small specimens of *Nudirostra*? sp. and indeterminate favositid corals in the pale yellowish brown aphanitic dolomite 30 feet below the top of the formation. At Big Spring Ranch in the Southern Snake Range Osmond found a *phaceloid disphillid*? 50 feet below the top of the Sevy.

The lower Sevy faunule in the Pahranagat Range and the occurrence of *Halysites* in the Southern Snake Range indicate a late Silurian age for the lowermost Sevy. It has been discussed that a regional unconformity occurs at the base of the Sevy but the extent of the hiatus in the Pahranagat Range may not be great. Several hundred feet of strata occur above a *Howellella* zone in the upper Lone Mountain formation in central Nevada and Helderbergian faunas are reported to occur locally. The relationships are still in doubt (Nolan and others, 1956, p. 39).

The writer interprets the upper Silurian fauna in the lower 100 feet of sandy Sevy beds as being a remnant fauna in a new transgressive cycle. It is pointed out that the upper Silurian
brachiopod faunule occurs in the westerly derived allochthonous sequence. It is suggested that if a transgressive nature is accepted for the Sevy it would be older in the west than in the east. It is also significant that with the exception of Halysites the uppermost beds of the Laketown dolomite contain a fauna of Devonian aspect. The writer believes that these "reversals" in fauna support, rather than refute the Silurian - Devonian boundary as determined in this report.

The type Devonian section in central Nevada consists of the Nevada formation and the overlying Devils Gate limestone which are locally divided into a number of members (Nolan and others, 1956, pp. 40-52; Carlisle and others, 1957). Merriam (1940, pp. 10-17) recognized 7 faunal zones and 2 subzones in this sequence which were reviewed and extended by Nolan, Merriam, and Williams, 1956). As previously discussed the Nevada formation rests both unconformably and conformably (where Helderbergian faunas are reported) on the Silurian Lone Mountain formation. The two lowest members of the Nevada formation are the Beacon Peak dolomite member and the Oyoke Canyon sandstone member. Merriam's oldest Devonian faunal zone at the type section in the Roberts Mountains (regarded at least as old as Oriskany) is believed equivalent to the Beacon Peak dolomite member of the Nevada formation (Nolan and others, 1956, p. 46; Reso and Croneis, 1959, p. 1251). The Sevy dolomite is lithologically identical to, and occupies the
exact stratigraphic position as, the Beacon Peak dolomite member of the Nevada formation. The Sevy dolomite is therefore considered to be early Devonian; and its upper sandstone member, which is equivalent to part of the Oxyoke Canyon sandstone; member of the Nevada formation includes strata transitional between lower and middle Devonian (Nolan and others, 1956, p. 47; Reso and Croneis, 1959, p. 1251). These correlations have been further substantiated by correlation of the Newark Mountain-Alhambra Hills section of Nolan and others (1956) with the more fossiliferous Sulfur Springs Range sections by Carlisle and others (1957). The problem is reviewed in Kellogg (1959, Figure 2; pp. 57-58). Osmond (1957) considers the Sevy lower Devonian, and Kellogg (1959) believes the Sevy to be lower Devonian with the uppermost part probably middle Devonian. This is further substantiated by the occurrence of an early middle Devonian fauna and from limestone beds about 120 feet below the upper member of the Sevy equivalent in the Nevada Proving Grounds (Johnson and Hibbard, 1957, pp. 350-352).

The Sevy formation correlates with unit G of undifferentiated "Ordovician to Devonian" strata and with unit A of the overlying Nevada formation in the Proving Grounds. The Sevy is a correlative of the McColley Canyon member and the lower part of the superjacent Union Mountain member of the Nevada formation described from the Pinyon and Sulfur Springs Ranges, central Nevada, by Carlisle and others (1957).
Five complete sections of the Sevy formation in the Pahranagat Range vary in thickness from 1386-1634 feet. Three sections along the west side of the range south of Highway 25 indicate a progressive southward thickening from 1386 to 1494 and finally to 1634 feet. The Sevy is 1524 feet thick at Fossil Mountain and 1580 feet in the center of the Pahranagat Range. Osmond (1954, p. 1912) recorded a Pahranagat Sevy thickness of 1375 feet which is probably at the location where the writer measured 1386 feet.

The Sevy is 1293-1323 feet thick in the Southern Egan Range (Kellogg, 1959, p. 57). It is 450-600 feet in the type section at Gold Hill, Utah (Nolan, 1935, p. 18). The 1634 feet obtained by the writer exceeds the greatest thickness previously reported of 1600 feet at Kings Canyon in the Confusion Range, western Utah (Osmond, 1954, p. 1927). South of the Pahranagat Range the Sevy is known to thin rapidly (Tschanz, 1959, personal communication). In the Arrow Canyon Range the Sevy is not recognized, although a time equivalent may be present in 200 feet of strata that bears Acrospirifer (Langenheim, 1960, written communication). The Sevy is absent in southern Nevada at Frenchman Mountain (McNair, 1952, p. 46) in the Muddy Mountains (Longwell, 1952) and at Goodsprings, Nevada (Figure 4).

The uppermost sandstone unit (in the upper member) of the Sevy is 45-84 feet thick on the west side of the Pahranagat Range and 60 feet thick in the center of the range. This sand thins northward
and is only 23 feet thick at Fossil Mountain. Here a second 10 foot sandstone is separated from the main unit by 36 feet of very sandy fine phaneritic dolomite. The development of two sands is seen at intervening localities as at Mount Irish (Plate XV, Figure A). Two sand units are conspicuous along the west face of the Hiko Range on the east side of Pahranagat Valley south of Caliente Pass. The upper Sevy sand unit thins progressively from 21 feet to 0 over a distance of 15 miles from south to north in the Southern Egan Range (Kellogg, 1959, p. 56).

The lower two units of the upper member of the Sevy (grayish orange siltstone and cherty aphanitic dolomite) also thin northward in the Pahranagat Range. They are not reported per se from the Southern Egan Range but Kellogg’s statement that he collected fauna in a pale-yellowish brown, aphanitic dolomite bed 30 feet below the top of the formation is suggestive. (Kellogg, 1959, p. 57). Osmond (1954, p. 1918) made a regional study of the Sevy and states that these lithologies underlying the sand are different from all other sections seen by him and that they occurred only in his two southernmost sections in the Worthington and Pahranagat Ranges.

Origin

The Sevy dolomite member was deposited as fine carbonate muds. The purity of the rock, dearth of organic material (bitumens or fossils), and intraformational breccias indicate very slow deposition and occasional reworking under very shallow water stable
shelf conditions. The Sevy is a transgressive deposit onto areas of very low relief. Contorted laminae and soft sediment deformations suggest a plastic nature for the original mud. The provenance of this mud is thought by Osmond to be eastern areas of low relief underlain by carbonate rocks of Silurian age and older. The deposit might have been an extensive tidal mud flat (Osmond, 1954, p. 1930; 1957, p. 1869). Disseminated quartz sand in the dolomite is thought to have been derived in large part from erosion of middle Ordovician quartzites along the eastern margin of the miogeosyncline. Streams carried the sands to the edge of the flats and sand grains were then blown periodically across the flats. Quartz sand could also have been incorporated indigenously in the carbonate muds and carried by current suspension far from shore.

It is known that disseminated quartz sand in Sevy dolomite increases southeastward in eastern Nevada and that they are better sorted northwestward. This is interpreted by Osmond to mean that the direction of source was from the southeast. He supports this contention in the Pahranagat Range by the fact that foreset beds of cross laminations in the upper Sevy sandstone unit show that major current movement was from the southeast. Moreover the upper sand unit thins northward (as previously discussed). Since upper Devonian strata rest on Cambrian and lower Ordovician in southern Nevada and northwestern Arizona, it is thought that the source of the sand
was from upwarps that first removed the Silurian and upper Ordovician dolomites and progressively exposed and reworked the middle Ordovician Eureka quartzite. The Sevy sequence is the inverse of the sequence in the source area (Osmond, 1954, p. 1930).

However, there remain some interesting problems. The Silurian and upper Ordovician deposits are almost entirely dolomite. Thus erosion of this sequence on positive areas peripheral to the shelf would provide only dolomite sediment and solute. The absence of clay minerals in the Sevy agrees with the absence of shale in the upper Ordovician and Silurian. Hence, it is concluded by Osmond (1957) that the Sevy originated as a primary evaporitic dolomite with redeposited dolomite. This was subsequently recrystallized. A second problem concerns the extent of Eureka, Fish Haven, and Laketown deposition in Southern Nevada and northeastern Arizona. That is, were these units deposited and subsequently eroded or never originally deposited? Further stratigraphic work is needed to solve this problem.

Osmond does not believe that the upper sand member of the Sevy possesses regressive characteristics similar to those of the Eureka. Instead he believes that the distribution of sorting values and thicknesses indicates slow southeastward and eastward transgression of the sand depositing environment. It is the writer's opinion, however, that a complete regressive sequence may be
present within the upper member of the Sevy formation in the Pah-ranagat Range and southern Nevada. This suggestion is strengthened by the presence of the lower siltstone and middle cherty aphanitic dolomite units which underlie the sandstone. Regional studies of these units, which are not present to the north, may shed further light on early Devonian paleogeography and tectonics in southern Nevada. It is curious that foreset bed cross-laminations in the upper sand unit in the Southern Egan Range are all directed southeast thus indicating a northwest source (Kellogg, 1959, p. 56). Although Osmond (1954, p. 1924, Figure 9) shows a northwestward current direction as indicated by cross laminations in the upper Sevy sand unit in the Pahranagat Range, the writer has seen similar cross laminations indicating a southeast directed current in the northern part of the Range. A statistical analysis of current directions in the upper Sevy sand should be made on a regional basis.

The Sevy cannot be considered either a source or reservoir rock for petroleum. Fracture porosity developed in the base of the Sevy might provide a reservoir for petroleum derived from underlying petrolierous? dolomites of the upper Laketown.

Simonson formation

The Simonson formation was named by Nolan (1935, p. 19) for a sequence of light to dark gray phaneritic dolomites that overlie the Sevy dolomite in Simonson Canyon, Deep Creek Mountains,
northern Utah. When first describing the Simonson Nolan wrote that
the most striking feature is the general presence of fine laminations.

Complete sections of the Simonson are exposed along the
west side of the Pahranagat Range (Plate XIII) and in the vicinity of
Mount Irish on the east side of the range. Extensive outcrops of
badly faulted sections occur between Fossil Mountain and the Hiko
Narrows in the northeastern part, and south of the Buckhorn Fault
in the southeastern area. A complete section of the Simonson occurs
in the center of the Pahranagat Range south of Highway 25 but a
large part of it is covered by Tertiary volcanics.

Osmond (1954, pp. 1931-1954) divided the Simonson into four
members, all of which are easily recognized in the Pahranagat Range.

**Coarse Member**

The contact between the upper Sevy sand unit and basal beds
of the Coarse Member of the Simonson formation is clear and sharp
at localities where the sand is thick. At other areas, particularly
where two sand units are developed, the contact is somewhat grada-
tional. Interbedded sands and 1-3 foot interbeds of aphanitic dolo-
mite, resembling the main body of the Sevy, occur in the basal 80
feet of the Simonson, the contact with the latter formation is con-
sidered conformable (Plate XV, Figure A).

The lower part of the Coarse Member consists of resistant
slope to semi cliff-forming massive 2-3 foot ledges of sandy aphan-
tic to fine phaneritic dolomite. Weathered and fresh surfaces are
light to medium gray and light olive gray. Interbedded thin sand beds, sand stringers, and disseminated quartz sand decrease upward throughout the lower 80 feet of the Coarse Member.

The main part of the Coarse Member is very light yellowish brown to light brownish and pinkish gray, cliff-forming, massive ledged very coarse sugary phaneritic dolomite. Slightly calcareous dolomite and vuggy zones occur locally. Fresh surfaces are light yellowish gray and very light gray to almost white. This unit is extremely homogeneous and forms a prominent cliff in the lower Simonson overlying the saddle of the upper Sevy and slope of the lowermost Simonson (Plate XIII). The Coarse Member is 229-284 feet thick. Recrystallization has destroyed most primary structures. No fossils have been found in the Coarse Member, but some 1-2 foot brownish gray weathered ledges of fine phaneritic dolomite in the lowest 30 feet of the member emit a hydrocarbon odor when struck with a hammer.

**Lower Alternating Member**

The name of this member is derived from the alternations between brown and gray dolomite beds. The contrasting colors of these beds create an outstanding striped appearance (Plate XVI, Figure A).

The brown beds consist of light to dark brownish gray and yellowish brown weathered, massive ledges of laminated to thin
bedded fine phaneritic dolomite. Fresh surfaces are dark gray to grayish black and always darker than weathered surfaces. The most important characteristics of the brown beds is the strong hydrocarbon odor, distinct laminations, occasional mottling, and relict organic structures. Thicknesses range between 1-14 feet, but beds 2-8 feet thick are the most common.

The gray beds are light to medium gray and light olive gray on weathered surfaces but medium to dark gray on fresh surfaces. The strata are massive-ledged, laminated to thin bedded, in some cases vuggy, very fine phaneritic to aphanitic dolomite. Fresh surfaces are invariably darker than the weathered. Thicknesses of the gray beds range from 2-22 feet with 2-8 feet most common. However, the gray bed fraction of the member is somewhat greater than the brown beds in the Pahranagat Range with many 12-18 foot zones alternating with only 2-3 foot brown beds in the upper part of the member. The hydrocarbon fetid odor is less prominent in the brown beds of the upper part.

There are as many as 50 alternations between the brown and gray beds in the member which has a thickness of 306-368 feet. Amphiporids and relict algal-stromatoporoid structures occur in the upper part. The Lower Alternating member forms a resistant slope between the cliff of the subjacent Coarse member and superjacent Brown Cliff member (Plate XIII).
EXPLANATION OF PLATE XVI

Figure A

Typical outcrop of the Lower Alternating member of the Simonson formation which clearly shows one cycle of the alternation between brown laminated fine phaneritic hydrocarbon dolomite and light gray laminated aphanitic dolomite. As many as 50 such alternations are contained in the member.

Figure B

Section of *Stringocephalus* in the uppermost beds of the Simonson formation. The diagnostic brachiopod (to the left of the Brunton Compass) is characterized by large size, overturned beak, smooth shell, unique cardinal process and medium septum on the pedicle valve.
PLATE XVI

Figure A

Figure B
The cyclic nature of the brown-gray alternations has been discussed in detail by Osmond (1954).

Brown Cliff member

The Brown Cliff member consists of dark yellowish to grayish brown and olive gray weathered, massive cliff-forming phaneritic dolomite with distinct mottling. Fresh surfaces are medium dark gray. The brown cliff is apparently a biostrome within which are small bioherms. The member is replete with dolomitized relict organic structures including amphiporids, stromatoporoids, algae, corals, gastropods, and brachiopods. A strong fetid hydrocarbon odor is emitted from the freshly broken rock.

The upper and lower contacts of the member are somewhat gradational. The thickness increases southward along the west side of the Pahranagat Range from 94 to 176 feet. At the location of the maximum thickness there occurs a lower 52 foot biostromal mass and an upper 92 foot mass separated by 32 feet of medium dark gray bench-forming, thin bedded dolomite.

Upper Alternating Member

The Upper Alternating member of the Simonson is essentially another sequence of alternating light and dark dolomites. It differs from the Lower Alternating member in that the cyclic nature of the alternations is less clearly defined. The alternating units have greater variations in thicknesses, thin bedding becomes as prevalent as laminations, and sedimentary breccias are more abundant.
Typical 2-6 foot brownish gray to dark yellowish brown weathered, laminated, fine phaneritic hydrocarbon dolomite ledges occur in the lower part of the member alternating with medium light gray 2-12 foot massive ledges of thin, continuously bedded (2-4") fine phaneritic to aphanitic dolomite. The brown beds contain an abundance of relict organic structures and branching colonial corals. Gray beds contain 3-10 foot zones of penecontemporaneous breccias. Higher in the member the gray dolomite ledges dominate, attaining continuous cliff-forming thicknesses of 36-76 feet with only intermittent brown beds. The latter become progressively medium dark gray and lose their hydrocarbon odor. In the upper part of the member alternations are between light gray and medium gray beds.

The uppermost 75 feet of the Simonson is characterized by medium light gray, thin, continuously bedded fine crystalline limestone interbedded with light olive gray sugary phaneritic dolomite. Abrupt lateral as well as vertical changes between dolomite and limestone are distinctive. Calcite veining and "zebra-striped" thin (crystal heaved) dolomite veins occur at widely separated localities in the uppermost part of the Simonson.

Within a 75 foot zone of transition from Simonson dolomites to limestones of the overlying Guilmette formation there occurs a
4-25 foot zone containing *Stringocephalus*. This diagnostic brachiopod (Plate XVI, Figure B) has been found at this stratigraphic level in all areas of the Pahranagat Range and is used to define the top of the Simonson formation. Only a few well preserved specimens of *Stringocephalus* have been collected. The brachiopod occurs silicified in either dolomite or limestone but the zone is primarily a coquina of fragments. Occurring with *Stringocephalus* at a few localities, but usually found in a separate 4-10 foot zone directly below *Stringocephalus*, is *Emanuela subumbona* Hall with some high spired gastropods and algal biscuits.

Five measured sections of the Upper Alternating member of the Simonson formation vary from 309-430 feet. The four thicker measurements all occur on the west side of the Pahranagat Range; the thinnest section occurs at the northernmost locality near Mount Irish. **Thickness**

Despite variations in its individual members the total thickness of the Simonson is remarkably constant. Four complete sections from the Pahranagat Range fall within 1003-1168 feet and indicate a progressive southward thickening over a distance of 20 miles. It is also remarkable that seven measured sections in the Southern Egan Range (5 by Osmond, 1954; 2 by Kellogg, 1959) fall within 1061-1168 feet (Figure 4). In the Southern Egan Range the Simonson-
Guilmette contact is placed at the top of the last dolomite in a zone of limestone-dolomite displaying both lateral and vertical gradations which occurs below a 200-400 foot cliff-forming limestone. This contact is almost certainly the same as that in the Pahranagat Range.

A 10 inch zone of *Stringocephalus* sp. was found at only one locality in the Southern Egan Range in a calcilutite bed 81 feet below the top of the formation (Kellogg, 1959, p. 61).

**Age, Fauna and Correlation**

There are few fossils that can be identified in the Simonson formation even though there was certainly an abundance of organic remains deposited with the original sediment. Dolomitization has oblitered all fauna and most primary structures in the lower two members. The Brown Cliff biostrome and the Upper Alternating member contain locally abundant *Amphipora* sp. These branching stromatoporoids were widely distributed in the seas of Devonian time. They are mostly small tubular forms 2-5 millimeters in diameter. Profound recrystallization has invariably destroyed their original structure. They stand out in relief from the weathered dolomites and produce a distinctive "spaghetti"-like mottling. Many of these forms have been incorrectly referred to bryozoa and, or to branching corals such as *Cladopora* sp. The Brown Cliff member also contains other stromatoporoidea or algae that form concentric masses several inches in diameter,
branching corals, gastropods and brachiopods. The fauna that serves to date the formation, however, is *Stringocephalus* sp. and *Emanuella subumbona* Hall. These brachiopods are guides to the upper middle Devonian of the world. The Simonson formation is entirely middle Devonian.

The Simonson formation readily correlates with the upper members of the Nevada formation in central Nevada. The lowest Coarse member is a correlative of the upper part of the Oxyoke Canyon sandstone member of the Nevada formation. The Lower Alternating member is a time equivalent of the Sentinel Mountain dolomite member of the Nevada, and the Upper Alternating member correlates with the Bay State dolomite member of the Nevada formation. The intervening Brown Cliff member is probably a time equivalent of the Woodpecker limestone member of the Nevada. It is suggested that the Woodpecker limestone is in part a western facies of the Brown Cliff dolomite biostrome of the Simonson. *Stringocephalus* extends nearly throughout the Bay State dolomite member of the Nevada formation (Nolan and others, 1956, p. 47).

The Simonson is correlated with the upper part of the Union Mountain member and with the Telegraph Canyon member (containing *Stringocephalus*) of the Nevada formation in the Sulfur Springs Range (Carlisle and others, 1957, pp. 2182-2184).
The Upper Alternating member of the Simonson correlates with the lower 250-300 feet of strata exposed at the base of the Devonian section at Dutch John Mountain (Figure 4). This is apparently the interval in which Kirk found a specimen of Stringocephalus (Westgate and Knopf, 1932, p. 19; Merriam, 1940, p. 39; Kellogg, 1959, p. 62).

The Simonson correlates with unit B and probably with unit C of the Nevada formation in the Atomic Proving Grounds (Johnson and Hibbard, 1957, p. 354). In the Arrow Canyon Range south of the Pahranagat Range (Figure 4) the Simonson is represented in the upper part of a 320 foot dolomite formation that contains Acrospirifer at the base and a Stringocephalus biostrime at the top (Langenheim, 1960).

Origin

The Simonson formation was deposited in moderately shallow water under mildly unstable shelf conditions. Dolomitized calcium carbonate organic remains, particularly in the Brown Cliff member, and limestone-dolomite lateral and vertical gradations indicate that dolomitization was secondary (penecomparaneous or diagenetic).

The brown-gray dolomite alternations in the Simonson are of particular interest. It is thought by Osmond (1954) that the brown beds represent more rapid lithification in poorly circulated water
in which bitumens and organisms were retained; the gray beds representing slower deposition and reworking of sediments with resulting removal of bitumens. Because lower surfaces of the gray beds rest on uneven eroded top of the brown beds in many areas, and upper surfaces are undulating but not erosion surfaces, Osmond believes deposition took place very near sea level, and that the gray beds represent interruptions in the rate of burial caused by eustatic changes. Thus each cycle begins with a gray bed and terminates with a brown bed.

Bioherms in the Lower Alternating member (Osmond, 1954, p. 1939) and in the Brown Cliff member indicate deposition in relatively shallow water.

Brown beds of the Simonson contain 3-5% (by volume) bituminous residues indicative of indigenous petroleum. Inter-
crystalline porosity is well developed in the Coarse member. The biohermal nature of the Brown Cliff member with bituminous residues indicates possibilities for reef trap petroleum reservoirs. Both source and reservoir conditions prevail in the Simonson formation.

A detailed account of the petrology and regional stratigraphy of the Simonson formation is given in papers by Osmond (1954; 1956).
Guilmette formation

The Guilmette formation was named by Nolan (1935, p. 20-21) for a 900-1400 foot sequence of interbedded dolomites, limestones and sandstones that lie above the Simonson formation in the Deep Creek Mountains, Gold Hill district, Utah. In the latter area the Guilmette is unconformably overlain by the Mississippian Madison limestone with upper parts of the Guilmette, the West Range limestone, and the Pilot formation absent (see Plate II).

The Guilmette formation is 2296-2410 feet thick in the Pahranagat Range. Spectacular complete exposures of the Guilmette are present on the west side of the Range (Plate XIII) and east of Mount Irish. Although the Guilmette is widely exposed in other areas of the Pahranagat Range complete sections are difficult to measure because of faulting and the heterogeneous nature of the formation. A complete section is present in the center of the Range but is partly covered by Tertiary volcanics.

The Guilmette is divided into two members.

Guilmette-Simonson Contact

Above the Stringocephalus zone there continues 57-193 feet of medium light to medium dark gray and bluish gray weathered, resistant slope-forming, thin to medium bedded calcilutite to calcarenite and crystalline limestone. Fresh surfaces are medium gray. Interbedding and gradations between partially dolomitized
calcitute and calcareous aphanitic dolomite is common. At many localities along the west side of the range the strata immediately above *Stringocephalus* are mostly light yellowish to olive gray, thin bedded, limy fine phaneritic dolomite. Above this dolomite there occurs a distinctive and persistent non-resistant "yellow-bed" zone 28-93 feet thick. This consists of moderate grayish yellow to pale yellowish orange weathered, bench to saddle-forming, laminated to medium bedded (1/2 to 6"), platy, silty, aphanitic dolomite with some limy dolomitic siltstone. Fresh surfaces are light olive gray. This yellow unit thickens progressively southward throughout the Pahranagat area, (Plate XVII, Figure A).

At the type locality of the Simonson and Guilmette formations at Gold Hill, Utah, (Nolan, 1935, p. 19) placed the top of the Simonson at the base of a persistent dolomite conglomerate bed 100 feet below a 4 foot zone of *Stringocephalus*. The overlying Guilmette formation is predominantly dark dolomite and thick limestones. The Simonson-Guilmette contact at the type section is not a striking one and must be related to either the *Stringocephalus* zone or to the appearance of limestone. Merriam (1940, pp. 24-25) drew the upper boundary of the Nevada formation at the upper limit of *Stringocephalus* which appeared to range through only a few feet of strata at the "Western Devonian" type section at Lone Mountain, Nevada (Figure 4). Merriam did recognize, however, that *Stringocephalus* ranges
through 75 feet of strata at nearby localities.

Since 1940 objections have been raised regarding the use of *Stringocephalus* to mark the top of the Simonson and Nevada formations. Sharp (1942, pp. 562-563) noted that *Stringocephalus* was distributed through several hundred feet of strata in the Southern Ruby Mountains. The same is true in the vicinity of Eureka (Nolan and others, 1956) and in the Sulfur Springs Range, Nevada (Carlisle and others, 1957). In other areas it may be rare or not recognized.

Osmond (1954, p. 1946) suggested that if the Simonson is to conform to the definition of a formation its upper contact should be marked by a lithologic change. He regarded the most easily recognized contact to be the one where the dolomite section changes upward into predominantly limestone.

Because of the interfacies nature of this contact, however, the fact that dolomites predominate for as much as 200 feet (stratigraphically) above the appearance of limestones and since *Stringocephalus* is restricted to a few feet of strata within the zone of dolomite-limestone transition, Reso and Croneis (1959, p. 1252) again used the key brachiopod to define the top of the Simonson formation in the Pahranagat Range.

It is apparent that the *Stringocephalus* zone is a valid, widespread, ubiquitous, and stratigraphically restricted marker in southern Nevada and, in conjunction with or without the dolomite-
limestone transition, it serves to separate the Simonson and Guilmette formations.

Another procedure adopted by the U.S. Geological Survey, however, is to use the base of the "yellow bed" zone to define the Simonson-Guilmette contact in southern Nevada (Tschanz, 1959, personal communication). The "yellow bed" zone thickens progressively southward throughout the Pahranagat area from 28-93 feet (Figure 10). It attains a thickness of 300 feet 40 miles farther south in the Arrow Canyon Range (Figure 4) where its base lies superjacent to a Stringocephalus biostrome. In this latter area the "yellow beds" are being mapped as a new Devonian formation (Langenheim, 1960, written communication).

The "yellow bed" zone is a distinctive marker (Plate XVII, Figure A) and its use in the manner described is perfectly reasonable. It is easily distinguished on air photographs. It must be kept in mind, however, that this zone is apparently restricted to southern Nevada and may not be carried to the type sections.

**Lower Member**

The description of the two lowest units of the Guilmette has been discussed. Above the "yellow beds" there occurs a sequence of medium dark to bluish gray resistant slope to semi cliff-forming, massive ledges of thin bedded calcisiltite to calcilutite and fine crystalline limestone. These beds alternate with medium olive to
brownish gray fine phaneritic to aphanitic dolomite. In general limestones predominate over the dolomites. Alternating units range between 1-15 feet but 1-2 foot ledges or 4-8 foot zones are most common. Thin discontinuous bedding and laminations are displayed by the limestones, and penecontemporaneous brecciation occurs locally in the dolomites.

Up section the dolomite ledges disappear and the limestones become medium bedded (3'-2') producing a step and bench effect between resistant and non-resistant ledges (Plate XVII, Figures A and B). Many of the resistant ledges are algal biostromes commonly containing more than 50% rounded algal biscuits. Although there are only a few varieties of algae one particular type is almost round and is rarely greater than 1 1/2 inches in diameter.

This form has been found in a thin zone about 130 to 150 feet above the "yellow beds" at localities many miles apart on the west side of the Pahranagat Range (Plate XVIII, Figure B). These units coalesce to form thick limestones and subdivide again into thin units laterally, They coalesce progressively vertically, however, and form a massive cliff-forming algal biostrome 120 to 340 feet thick (Figure 10; Plate XVII, Figures A and B; Plate XVIII, Figure A).

The cliff is medium light to medium dark and bluish gray calcisiltite to calcilutite and crystalline limestone. Bedding alternates between massive, thick to thin ledges and laminated beds. The cliff contains locally prolific amounts of algal structures up to
EXPLANATION OF PLATE XVII

Figure A

Lower Guilmette section on the east slope of Mt. Irish. The non-resistant grayish orange aphanitic dolomite ("yellow bed") zone is easily distinguished on the lower slopes. The Stringocephalus zone occurs 104 feet below the base of the "yellow beds" at this locality. Resistant and non-resistant ledges of algal limestones and dolomites produce a step and bench effect grading upward into a massive cliff-forming algal biostrome. Upon the latter foundation local bioherms developed. The bioherm seen is 172 feet thick in the center and lenses out in all directions. The section pictured is illustrated diagrammatically in location 2, Figure 10.

Figure B

Lower Guilmette section at Downdrop Mountain (location 3, Figure 10). Ledges of algal limestones and interbedded dolomites form a step and bench effect between resistant and non-resistant units. The lower member of the Guilmette terminates in a massive algal biostrome 120 feet thick at this location. Above the biostrome are thick (50 to 150 feet) quartz sandstone units, siltstones, thin argillaceous limestones, and local coralline biostromes.
EXPLANATION OF PLATE XVIII

Figure A

Massive cliff 328 feet thick (stratigraphically) that terminates the lower Member of the Guilmette formation at Devonian Ridge on the west side of the Pahranagat Range (location 5, Figure 10). Locally prolific algae up to 8 inches in diameter commonly constitute more than 50% of the rock. The section is dipping about 25 degrees in the direction north 75-88 degrees east to the left of the Photograph. Above the cliff are light olive to yellowish gray thin bedded platy argillaceous limestones containing abundant brachiopods and corals.

Figure B

Distinctive round algal structures up to 1 1/2 inches in diameter that occur in a zone 130 to 150 feet above the "yellow bed" zone in the lower member of the Guilmette formation.
EXPLANATION OF PLATE XIX

Figure A

Algal biscuits from the cliff-forming biostrome in the lower member of the Guilmette formation. The algae have been almost obliterated by dolomitization in the upper (white) part of the rock, whereas algal structures are easily distinguished in the limestone below. The dolomite-limestone contact ordinarily is remarkably abrupt; rarely is it gradational.

Figure B

Typical sedimentary breccia in the cliff-forming algal biostrome in the lower member of the Guilmette formation.
8 inches in diameter commonly constituting 50% of the rock, organic structures including gastropods, brachiopods, amphiporids, and other stromatoporoida. Also distinctive are dolomitic zones up to 20 feet thick, dolomitized algal biostromes, and local sedimentary breccias (Plate XVIX).

The cliff-forming biostrome appears to thicken progressively southward along the west side of the Pahranagat Range. The cliff is about 120 feet thick at Downdrop Mountain just south of Highway 25 (location 3, Figures 9 and 10; Plate XVII, Figure B), but at Devonian Ridge five miles south it is 328 feet thick (location 5, Figures 9 and 10; Plate XVIII, Figure A). However, this "thickening" has proved to be primarily a function of individual thin to medium bedded units coalescing into massive ledges down section.

The thickness of the lower member is 598-696 feet on the west side of the range. At Mount Irish, on the east side of the Range, which is almost directly north on strike with the "western section," the lower member is 833 feet thick (location 2, Figures 9 and 10; Plate XVII, Figure A). The top of the lower member is placed at the abrupt break in slope and termination of the cliff.

**Upper Member**

The cliff-forming biostrome served as a foundation upon which slightly to completely dolomitized coralline and calcareous organic local bioherms developed. The most spectacular bioherm
occurs at Mt. Iris (location 2, Figures 9 and 10; Plate XVII, Figure A). This reef is 172 feet thick in the center and consists of very light yellowish gray weathered semi cliff-forming recrystallized calcarenite to calcisiltite. It is extremely massive with practically no discernible bedding. It contains abundant corals, brachiopods, gastropods, and crinoid debris. The lower 30 feet is dolomitic.

The section immediately above the lower biostromal foundation is different at every locality studied. At Downdrop Mountain there are only a few feet of medium olive gray bench-forming platy calcisiltites containing abundant brachiopods and thin coralline biostromes on the foundation. This is followed by a sequence of light yellowish brown massive cliff-forming, cross bedded, well sorted, subrounded to subangular, fine to medium grained quartz sandstone units up to 150 feet thick. These contain interbedded light olive gray thin bedded (1-2") calcareous siltstones (location 3, Figure 10; Plate XVII, Figure B). Five miles south at Devonian Ridge the section above the foundation consists of light olive to yellowish gray bench-forming, platy, powdery, silty, shaly, calcisiltite to calcilutite and fine crystalline limestone. Interbedded gray, massive, mottled, coralline patch reefs up to 20 feet thick occur locally (location 5, Figure 10; Plate XVIII, Figure A). The section at Hiko Narrows is also completely different being virtually all "reef." Locations and correlations of suggested
Figure 9.- Index map showing the Pahranagat Range and surrounding area, Lincoln County, Nevada, with location of measured sections of the lower part of the Guilmette formation (Figure 10).
Correlation of the Lower Guilmette Sections
Lincoln County, Nevada.

Vertical Scale
1" = 200' (individual beds not to scale)
### TABLE 7

**Faunules in the lower Guilmette formation**

#### LOCATION 1  HIKO NARROWS

Sections 6-7 T. 3 S., R. 59 E., Lincoln County, Nevada

**GUILMETTE FORMATION (Upper Member)**

| G-16 | Syringopora sp.  
|      | colonial branching corals  
|      | large horn corals  
|      | Algae (up to 6" in diameter)  
|      | Stromatoporoidea?  
|      |  
| G-17 | Pachyphyllum sp.  
|      | Alveolites sp.  
|      | "Cladopora" sp.  
|      | small and large horn corals (abundant)  
|      | syringoporoid corals  
|      | *Cyrtospirifer* sp.  
|      | brachiopods

#### LOCATION 2  MOUNT IRISH

Section 3, T. 4 S., R. 59 E., Lincoln County, Nevada

**GUILMETTE FORMATION (lower member)**

| G-97 | poorly preserved and recrystallized:  
|      | gastropod castes  
|      | algal structures  
|      | relict brachiopods  
|      | fossil hash  
|      |  
| G-102 | spiriferoid brachiopods  
|       | abundant poorly preserved:
G-104 branching colonial corals
solitary corals
Atrypa sp.
brachiopods

GUILMETTE FORMATION (Upper Member)

G-105 abundant poorly preserved recrystallized
and dolomitized:
corals
brachiopods
gastropods
crinoid columns

LOCATION 3 LOWER DOWNDROP MOUNTAIN

Section 19 T. 6 S., R 59 E. Lincoln County, Nevada

GUILMETTE FORMATION (Upper Member)

G-52 Meristella sp. (abundant)

LOCATION 4 DOWNDROP MOUNTAIN REPEAT

Section 20 T. 6 S., R. 59 E. Lincoln County, Nevada

GUILMETTE FORMATION (Lower Member)

G-74 Emanuellia subumbona (Upper member)

G-93 Atrypa sp.

G-96 Martinia sp.

G-97 Meristella sp.
Pseudodouvinella sp.

G-112 Macgeea sp.
large horn corals

G-113 branching corals (abundant)
Atrypa sp.
brachiopods (abundant)
small crinoid columnals
LOCATION 5  DEVONIAN RIDGE

Section 16  T 7 S, R 59 E, Lincoln County, Nevada

GUILMETTE FORMATION (Upper member)

G-104  
Pseudodouvinella sp.  
Atrypa sp.

G-105  
Pseudodouvinella sp.  
Meristella sp.  
Atrypa sp.

G-106  
large gastropods  
small brachiopods  
Meristella sp. (abundant)

G-108  
branching corals  
brachiopods  
gastropods

G-109  
Macgeea sp.  
Tabulophyllum sp. cf. T. mcconnelli Whiteaves  
T. sp.  
Papilophyllum ? sp.  
cyathophyllloid horn coral  
Thamnopora ? sp.
facies relationships are given in figures 9 and 10. Faunules are recorded stratigraphically in Figure 10 and listed in Table 7. A zone of *Meristella sp.* is persistent immediately above the lower foundation member.

The remaining part of the upper Guilmette consists of a heterogeneous sequence of irregularly interbedded and intergrading limestones, dolomites, and sandstones. The limestones range in thickness from 1 to 75 feet but are generally in the order of 2 to 20 feet thick. They consist of medium light to medium dark, and bluish gray weathered bench to cliff-forming, thin to thick bedded calcilutite and very fine crystalline limestone. Dolomitic and sandy zones are common. Shelly facies faunas (brachiopods, gastropods, colonial and solitary corals) are locally abundant being best represented in thin, wavy, discontinuously bedded, shaly zones. There are also amphiporids and other stromatoporoids (Plate XXI, Figure B). Of importance stratigraphically is a zone of robust molluscan? bivalve structures occurring 400 to 650 feet below the top of the Guilmette (Plate XXII). These are commonly found as coquinas and invariably recrystallized with the limestone so that individual specimens do not weather out. A few scattered valve structures are found from 318 to 961 feet from the top of the Guilmette but are primarily concentrated in the zone mentioned. They have not been found on the east side of the range.
Dolomites display a broad range of colors from light to medium dark gray; light to dark brownish gray; and yellowish to olive gray. They are resistant slope-forming, massive, thin to medium bedded, and fine phaneritic to aphanitic. Sandy stringers and lenses are common and sedimentary breccias occur locally. Spectacular amphiporid biostromes are abundant and most diagnostic of the upper Guilmette in the field. They usually emit a strong hydrocarbon fetid odor when struck with a hammer (Plate XX; XXI, Figure A). Dolomites range in thickness from 1 to 35 feet but zones 4-12 feet thick are most common.

Sandstones weather yellowish brown and consist of well sorted, subrounded to subangular, medium grained (1/4 to 1/2 mm) quartz. Cement may be calcite, dolomite or silica. Cross bedding is common. The sandstones of the Upper Guilmette resemble the Eureka and the upper unit of the Sevy formation. Sands increase in the upper part of the Guilmette (Plate II). The formation is everywhere terminated by a sand unit and this is usually a characteristic pale reddish brown weathered vitreous unit 12 to 35 feet thick. The interbedded lithologies of the upper Guilmette are spectacular and diagnostic in the field (Plate XXIII, Figure B).

The Upper Member of the Guilmette formation is 1572 to 1639 feet thick.
EXPLANATION OF PLATE XX

Figure A

Spectacular amphiporid biostromes of this type occur throughout the upper member of the Guilmette formation.

Figure B

Close view of Figure A that shows prolific amounts of amphiporids standing out in relief from the weathered dolomite.
EXPLANATION OF PLATE XXI

Figure A

Mottling in phaneritic dolomite produced by profound alteration of an amphiporid? biostrome. Ledges several feet thick emit a hydrocarbon fetid odor when struck with a hammer.

Figure B

Typical stromatoporoid or algal? structures from biostromes in the upper part of the Guilmette formation.
EXPLANATION OF PLATE XXII

Figures A and B

Cross sections of indeterminate valve structures from the upper member of the Guilmette formation. These forms, which are probably molluscan bivalves, are found as coquinas in very fine crystalline limestone and calcilutite throughout a zone 400 to 650 feet below the top of the Guilmette. Single valves attain sizes up to 3 1/2 inches long and 7/8 inch wide.
PLATE XXII

Figure A

Figure B
EXPLANATION OF PLATE XXIII

Figure A

View of Bactrian Mountain on the east side of the Pahranagat Range. The section dips about 15 degrees in the direction S 50-60° west. The first hump contains 1081 feet of the upper part of the Guilmette formation and 223 feet of West Range limestone down the dip slope and saddle.

The second hump contains a section of the Pilot formation 368 feet thick overlain by the cliff-forming Joana limestone. Through the saddle of Bactrian Mountain is seen part of the Tertiary volcanic sequence dipping eastward.

Figure B

The Upper Guilmette section at Bactrian Mountain consisting of interbedded yellowish brown orthoquartzites, light to medium and bluish gray limestones, and olive gray dolomites.
Age, Fauna and Correlation

The Guilmette formation is locally very fossiliferous. Faunas from the lower part are listed in Table 7 and all fossils identified at the time of this report are listed on Plate II. A large part of the collections require further study.

A few silicified *Emanuella* sp., cf. *E. subumbona* (Hall) have been collected in the lowest Guilmette above the *Stringocephalus* zone. The lower member contains abundant fossils in the algal biostromes but these are severely recrystallized and poorly preserved. They have not proved diagnostic of epochs within the Devonian.

A coral fauna from a patch reef above the cliff-forming biostrome at Devonian Ridge was examined by William A. Oliver, Jr. He identified among other forms *Macgeea* sp., *Tabulophyllum* cf. *T. mcconnelli* (Whiteaves), and *Papilophyllum?* sp. Regarding this collection he states:

"*Macgeea* is known from rocks of both Middle and Upper Devonian age but is yet unreported from the Middle Devonian of North America and is rare in rocks of this age elsewhere. It is a common and widespread form in the Upper Devonian. *Tabulophyllum* is supposed to be limited to the early late Devonian (Frasnian) but similar middle Devonian forms are known. One specimen, however, is very close if not identical to *T. mcconnelli* from the lower Upper Devonian of the Mackenzie River region. *Papilophyllum* is also Upper Devonian but the present identification is questionable. The collection is almost certainly from the lower Upper Devonian." (Oliver, 1959, written communication.)
Brachiopods from the platy argillaceous limestones below the patch reef, and from several localities in the lowest beds of the upper member above the biostromal cliff, include *Martinia* sp., *Meristella* sp., *Atrypa* sp., and *Pseudouvillina* sp. cf. *P. euglyphaea* Stainbrook, and coral *Macgeea* sp. These forms were identified by Harold E. Kellogg who states:

"With the exception of *Macgeea* and *Atrypa*, these fossils were not found in the Southern Egan Range sections. The stratigraphic position of the faunas and the presence of *Macgeea* and *Atrypa* suggest correlation with the *Macgeea*-Disphyllum faunas of Nolan, Merriam, and Williams (1956, p. 50). The other forms apparently have no counterpart in described Nevada sections, but *Pseudouvillina* is found in the Swisshelm formation of Arizona (Epley, Gilbert, and Langenheim, 1957, A.A.P.P. Bull., p. 2254) and in the Independence shale (Stainbrook, 1945, G.S.A. Mem. 14); it is lower Upper Devonian (probably Fingerlakesian, depending on the species). *Meristella* and *Martinia* are long-ranging genera in the Devonian, but determination of the species of the former may be of some help. The stratigraphic position of the faunas indicates correlation with the upper part of the lower member of the Guilmette formation in the Southern Egan Range and with the upper part of the Meister member of the Devils Gate Limestone at Eureka. These were previously thought to be Middle Devonian, and not on very good evidence."
(Kellogg, 1959, written communication.)

Other fossils including *Tenticospirifer utahensis* (Meek) and abundant *Atrypa* sp. in the upper part of the Guilmette indicate an early late Devonian age. The Guilmette is probably all early late Devonian except for the possibility of the lowermost part being uppermost middle Devonian. The middle-upper Devonian boundary is tentatively placed at the base of the "yellow bed" zone (late R.).
The Guilmette formation correlates with the Devils Gate limestone below the *Cyrtospirifer* zone in central Nevada (Nolan and others, 1956). It is a time equivalent of the Silverhorn dolomite above the *Stringocephalus* zone and below zone D at Dutch John Mountain, Nevada (Figure 4) and the Silverhorn dolomite in the Pioche district (Westgate and Knopf, 1932, p. 18; Merriam, 1940, pp. 39-40). The Guilmette is represented in the Nevada Proving Grounds by 1380 feet of Devils Gate? limestone (Johnson and Hibbard, 1957, pp. 355-356), and by 1370 feet of Upper Devonian strata in the Arrow Canyon Range (Langenheim, 1960).

**Origin**

The Guilmette formation was deposited in shallow warm-water shoals. The widespread biostromal beds suggest lateral reef migration under changing eustatic levels and slightly unstable shelf conditions. The heterogeneous sequence of the upper Guilmette reflect progressive accumulation of interfingering organic shoals and inter reef channels (Reso, 1959).

These conditions were apparently widespread in western North America in late medial and early late Devonian time. The Pahranagat Guilmette sequence is almost identical to that described by Andrichuk (1958) from central Alberta, Canada. In the latter area the Cooking Lake formation is a widespread biostromal shoal carbonate unit containing abundant stromatoporoids, algae and shelly
facies fauna that provided a foundation for subsequent relatively more vertical reef growth. It was on this "platform" that the famous Leduc reef developed. The Cooking Lake is the basal formation of the Woodbend group. It is correlated with the post Stringocephalus Maligne formation of earliest upper Devonian age (Taylor, 1957). It is suggested that the bioherms that developed on the cliff-forming unit of the lower Guilmette are time synchronous with the Leduc reef (Plate XVII, Figure A).

Off-reef argillaceous facies of the Leduc reef (Duvernay formation) are bituminous. Although the off-reef facies of the Pahranagat reefs are thin bedded, platy argillaceous calcilutites they are not characteristically bituminous. However, they may be so elsewhere. Virtually all source and reservoir possibilities are represented in the Guilmette reef complex including petroliferous amphiporid biostromes higher in the formation.

Integrated lithofacies and biofacies analysis of the completely exposed Guilmette sections in the Pahranagat Range and surrounding areas may demonstrate reef zonation and will increase knowledge of Basin and Range Devonian reef paleoecology.

**West Range limestone**

The West Range limestone was named by Westgate and Knopf (1932, pp. 16-19) for strata between the uppermost quartz sandstone unit of the Silverhorn dolomite (Guilmette formation) and the base of the
Mississippian Bristol Pass limestone (Joana limestone) in the Pioche district, Nevada. In the Pahranagat Range it constitutes the interval between the Guilmette and Pilot formations (Plate II).

**Description**

The *West Range* limestone consists of medium to light gray weathered resistant 1-2 foot ledges of shaly calcisiltite to calcilutite interbedded with non-resistant benches of pale grayish orange to moderate yellowish brown powdery, shaly calcisiltite to calcareous shale. Fresh surfaces are light to dark gray and yellowish to olive gray. Distinctive of most of the formation is thin (1 to 2 inches), wavy, knobly, discontinuous bedding. Medium continuous bedding occurs in some of the resistant ledges (Plate XXIV, Figure A).

The formation is 0 to 390 feet thick. It thickens southward on the east side of the Pahranagat Range from 140 to 390 feet over a distance of about 20 miles (Figures 11 and 12). An upper Devonian unconformity is believed responsible for the absence of the *West Range* limestone and the lower part of the superjacent Pilot formation on the west side of the Range (Plate XIII). The relationships are suggested in Figure 12.

**Age, Fauna and Correlation**

The *West Range* limestone contains a prolific well preserved brachiopod fauna. It also contains gastropods, pelecypods, and cephalopods. Fossils from locations given in Figure 12 are listed in Table 8.
Figure II.- Index map showing the Pahranagat Range and surrounding area, Lincoln County, Nevada, with location of measured sections of the Pilot and West Range Formations (Figure 12).
Correlation of the Pilot and West Range Formations in the Pahranagat Range
Lincoln County, Nevada.
**TABLE 8**

Faunules of the West Range and Pilot Formations

**LOCATION 1**  
MOUNT IRISH EAST

Section 34, T. 3 S., R. 59 E., Lincoln County, Nevada

**WEST RANGE FORMATION**

<table>
<thead>
<tr>
<th>WR-34</th>
<th>poorly preserved: cephalopods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gastropods</td>
</tr>
<tr>
<td></td>
<td>brachiopods</td>
</tr>
</tbody>
</table>

**LOCATION 3**  
BACTRIAN MOUNTAIN

Section 11, T. 5 S., R. 59 E., Lincoln County, Nevada

**WEST RANGE FORMATION**

<table>
<thead>
<tr>
<th>WR-37a</th>
<th>orthoceroid cephalopods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>breviconic cephalopods: aff. Eleusoceras sp.</td>
</tr>
<tr>
<td></td>
<td>Tenticospirifer sp. cf. T. keleticus Crickmay</td>
</tr>
<tr>
<td></td>
<td>Cleiothyridina? sp.</td>
</tr>
<tr>
<td></td>
<td>Productella sp.</td>
</tr>
<tr>
<td></td>
<td>Cyrtospirifer sp. cf. C. breviposticus Stainbrook</td>
</tr>
<tr>
<td></td>
<td>Athyris angelica</td>
</tr>
<tr>
<td></td>
<td>Schizophroria sp.</td>
</tr>
<tr>
<td></td>
<td>gastropods</td>
</tr>
<tr>
<td></td>
<td>pelecypods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WR-37b</th>
<th>Cyrtospirifer portae Merriam</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cyrtospirifer sp. cf. C. whitneyi Hall</td>
</tr>
<tr>
<td></td>
<td>Cyrtospirifer animasensis (Girty)</td>
</tr>
<tr>
<td></td>
<td>Cyrtospirifer sp.</td>
</tr>
<tr>
<td></td>
<td>Schizophroria simpsoni Merriam</td>
</tr>
<tr>
<td></td>
<td>Ambocoelia sp. cf. A. parva Weller</td>
</tr>
<tr>
<td></td>
<td>Athyris angelica Hall</td>
</tr>
<tr>
<td></td>
<td>Nudirostra Walcotti (Merriam)</td>
</tr>
<tr>
<td></td>
<td>Pustula sp.</td>
</tr>
<tr>
<td></td>
<td>productellid brachiopods small</td>
</tr>
<tr>
<td></td>
<td>Camarotoechia sp.</td>
</tr>
</tbody>
</table>
PILOT FORMATION

P-39  Neozaphrentis sp.
      Camarotoechia sp.
      Shellwienella sp.
gastropods
      crinoid stems

LOCATION 4 CURTIS CANYON

Section 28, T. 6 S., R. 60 E., Lincoln County, Nevada

WEST RANGE FORMATION

WR-33  Tenticospirifer sp. cf. T. keleticus Crickmay
       Athyris angelica
       Schizophroria sp. cf. S. simpsoni Merriam
       Cyrtospirifer sp. cf. C. whitneyi Hall
       Cyrtospirifer portae Merriam
       Cyrtospirifer sp.
       Cleiothyridina sp.
       Camarotoechia sp.
       Ambocoelia sp. cf. A. parva
       Nudirostra walcotti (Merriam)
       cephalopods
       gastropods

LOCATION 3 DOWNDROP MOUNTAIN REPEAT

Section 21, T. 6 S., R. 59 E. Lincoln County, Nevada

PILOT FORMATION

P-198  small brachiopods
       pelecypods
       trilobites
       crinoid columnals
EXPLANATION OF PLATE XXIV

Figure A

Typical outcrop of the West Range formation showing
the thin, wavy, knobly, continuous and discontinuously
bedded, shaly calcisiltites and calcilutites.

Figure B

Typical outcrop of the Pilot formation showing the
laminated to thin bedded platy, silty calcisiltites and cal-
careous shales.

The change from massive limestones, dolomites and sandstones of the upper Guilmette to the shaly limestones of the West Range formation is accompanied by a distinct faunal change. Corals, algae, stromatoporoids are absent in the West Range. *Atrypa*, a brachiopod typical of the upper Guilmette, is also absent. Instead, the West Range is characterized by species of *Cyrtospirifer*, *Athyris angelica* and *rhynchonellid* brachiopods.

The same faunal change has been noted over a wide area in western North America. It occurs in central Nevada between the *Martinia nevadensis* and *Cyrtospirifer* zones of the uppermost Devils Gate limestone (Merriam, 1940, pp. 59-61; Nolan, Merriam, and Williams, 1956, p. 51); in New Mexico and Arizona between the
coral and *Athyris* bearing Martin limestone and Swisshelm formation and the *Cyrtospirifer*-bearing Percha shale (Stainbrook, 1947; Epis, Gilbert, and Langenheim, 1957); and in Idaho and southwestern Montana between the Jefferson limestone and the Cyrtospirifer-bearing Three Forks shale (Baldwin, 1943; Berry, 1943). In western Canada the faunal break occurs at the base of the *Cyrtiopsis* faunas of Crickmay (1952), the *Nudirostra gibbosa walcotti* fauna of McLaren (1954) and the *Nudirostra walcotti* fauna of Warren and Stelk (1956).

In the Catskill "delta" of New York the expansion of *Cyrtospirifer* at the expense of *Athyris* is accompanied by the first occurrence of *Athyris angelica* and marks the base of the Canadaway stage (Greiner, 1957, p. 53). This event is equivalent to the initiation of the *Cyrtospirifer* and *Tenticospirifer keleticus* faunas of Nevada, and establishes their age as late upper Devonian (Kellogg, 1959, pp. 74-75; 1959, written communication).

The West Range formation is considered Chautauquan (Cassadaga and possibly Conewango) or late upper Devonian.

The West Range limestone in the Pahranagat Range correlates with the lower member and most of the middle member of the West Range formation as defined by Kellogg (1959) in the Southern Egan Range. The West Range limestone is a time equivalent of the upper 215 to 240 feet of the Devils Gate limestone at its type locality near Eureka, Nevada (Merriam, 1940, pp. 16-17, 61).
It correlates with the *Cyrtospirifer*-bearing faunules that include *Manticoceras* in the upper part of the Pilot shale in the Confusion Range of western Utah (Donovan, 1951, p. 49; Kellogg, 1959, p. 76).

The West Range limestone may correlate as a facies of the lower Pilot shale east of Eureka that bears a conodont fauna dated as pre-Cassadagan by Hass (Nolan and others, 1956, p. 53), and it may be a time equivalent of part of the Crystal Pass limestone in the Arrow Canyon Range (Langenheim, 1960).

**Origin**

The West Range limestone was deposited under shallow water shelf conditions. Wavy, knobby, discontinuous bedding with shale partings indicate that deposition was generally above wave base.

The West Range is a silty, clastic limestone. It represents a profound change in both source of sediments and environment of deposition in contrast to the underlying massive calcilutites and quartz sandstones of the upper Guilmette. It marks the termination of dolomitization that accompanied deposition of early and medial Paleozoic sediments. In relation to subjacent and superjacent sediments in the Pahranagat Range area, the West Range is considered a transgressive deposit.

**Pilot formation**

The Pilot shale was named by Spencer (1917, p. 26) for a 100 to 400 foot interval of carbonaceous shales overlying the Devils Gate
limestone (Devonian) and underlying the Joana limestone (Mississippian) in the Ely district, Nevada (Figure 4). In the Pahranagat Range the term Pilot is applied to the interval between the West Range limestone (Upper Devils Gate limestone) and the Joana limestone (Plate II). Because this interval includes argillaceous limestones, sandy zones, chert beds, as well as shale, the term Pilot formation is employed here.

The Pilot formation thickens progressively southward from 176 to 460 feet along the east side of the Pahranagat Range over a distance of about 20 miles (Figure 12). Only the upper 234 to 250 feet is present on the west side of the Range due to an unconformity. Here the upper Pilot rests on the terminating sand unit of the Guilmette with the West Range limestone also absent (Plate XIII). The hiatus on the west side of the Range involves over 600 feet of strata that are present on the east side. These relationships are illustrated in Figures 11 and 12. The Pilot formation in the central section (location 6) was estimated at 200 feet with the West Range absent. This section is in the sequence previously discussed as a klippe of a western derived allochthone.

The Pilot formation forms a very distinctive yellow slope below the massive cliff-forming Joana limestone and may thus be distinguished at great distances (Plate XIII; XXIII, Figure A; Plate XXV).
Description

The lower part of the Pilot formation consists of pale yellowish orange to yellowish brown weathered, non-resistant, laminated to thin bedded, platy, silty calcisiltite to calcareous shale (Plate XXIV, Figure B). Fresh surfaces are generally medium dark gray but also pale to dark yellowish brown. Platy calcareous siltstones, grayish orange medium grained poorly sorted quartz sandstones, and thin wavy discontinuously bedded shaly fossiliferous calcisiltites also occur locally in the lower part.

The middle and upper parts of the formation are characterized by medium dark gray to grayish black 1 to 4 foot resistant ledges of thin bedded to finely laminated dense chert. The chert ledges commonly have a dusky yellow to pale grayish orange weathered crust. Unless they are broken with a hammer they are not everywhere easily distinguished from the interbedded platy calcisiltites of the same weathered color. However, dark chert fragments are commonly seen in the float, and where massive they protrude as resistant ledges from the shale slope.

The upper part of the Pilot is a medium to dark gray powdery to fissile calcareous shale with occasional 4 to 6 inch dense calcilutite interbeds. The upper 16 to 60 feet is a dark gray ("black") shale containing rounded limestone concretions. Thus the upper part of the Pilot formation, both in lithology and stratigraphic
position, is strikingly similar to other ubiquitous North American black shales at or near the Devonian-Mississippian boundary. The contact with the superjacent lower member of the Joana limestone is gradational (Plate XXV, Figure B; XXVI).

Age, Fauna and Correlation

Fossils are scarce in the Pilot formation. A zone containing small corals *Neozaphrentis* sp., brachiopods including *Shellweinella* sp. and *Camarotoechia* sp., crinoid stems and well preserved small gastropods occurs 92 to 122 feet above the base of the formation at Bactrian Mountain (location 3, Figure 12; Plate XXIII, Figure A; Plate XXV, Figure A). *Shellweinella* is not very diagnostic. It could be uppermost Devonian or lowest Mississippian,*Neozaphrentis* sp. was identified by William A. Oliver, Jr. Regarding this collection he wrote:

"The following 3 points were brought to my attention by Helen Duncan: 1) The specimens in this collection (Pilot shale) are remarkably similar to specimens illustrated by Williams (U.S.G.S. Prof. Paper 203, Pl. 6 figs. 31-37) from the Louisiana limestone as *Neozaphrentis* sp. 2) A fauna resembling that of the Louisiana limestone with corals similar to those collected has been found elsewhere in the Pilot shale (Confusion Range, Utah). 3) The age of the Louisiana limestone is in doubt--it is either highest Devonian or lower Mississippian.

It must be noted that while the similarity between these corals and Williams' specimens is remarkable, our knowledge of either type is too limited to establish identity. Further, the age of Williams' material is uncertain. Therefore the collection may be either Upper Devonian or Lower Mississippian (Oliver, 1959, written communication)."
This faunule contains forms similar to those listed from 30 feet below the top of the upper member of the West Range formation as used by Kellogg (1959, p. 73) in the Southern Egan Range (Pilot formation of this report). The latter faunule includes, however, Leioprotodontus cf. L. coloradoensis (Kindle). Leioprotodontus is common in the Percha and Three Forks shales, which are considered Upper Devonian by some (Cooper and others, 1942, p. 1776, 1785) but an early Mississippian (Kinderhookian) age cannot be ruled out.

A prolific Kinderhookian fauna occurs in the lowest (28 foot) member of the Joana limestone (Griffith, 1959). Thus the Pilot shale in the Pahranagat Range spans the interval from the uppermost Devonian to the earliest Mississippian. It is considered entirely upper Devonian in this report because correlatives have been considered so elsewhere; the fauna does not prove a Mississippian age; and on the basis of stratigraphic relations the Pilot belongs with the late Devonian sedimentary cycle.

The Pilot formation in the Pahranagat Range correlates with the upper part of the middle member and the lower part of the upper member of the West Range formation in the Southern Egan Range (Kellogg, 1959). It is a time equivalent of the Narrow Canyon limestone in the Nevada Proving Grounds area (Johnson and Hibbard, 1957, p. 356). It is represented by strata described as zone E at
Dutch John Mountain, Nevada (Figure 4) by Merriam (1940, pp. 39-40) and Chilingar and Bissell (1957, p. 2264). It is a probable correlative of part or all of the Pinyon Peak limestone of north-central Utah (Morris, 1957, pp. 13-14; Rigby, 1958, pp. 36-40, 83-88); the Ouray limestone in Colorado (Knight and Baars, 1957); the Percha shale in New Mexico and Arizona (Stainbrook, 1947); the Three Forks shale in western Montana and Idaho (Baldwin, 1943; Berry, 1943); and the Exshaw shale in western Canada. The Exshaw fauna is considered Devonian although faunal evidence of age is inconclusive. Some Exshaw fossils resemble specimens from the Louisiana limestone of Missouri (Harker and McLaren, 1958).

**Origin**

The Pilot formation was deposited as fine clastic silty calcareous muds under shallow to moderately deep water unstable shelf conditions. A large part of the formation was probably deposited under low energy conditions below wave base. It reflects a continuation of a deeper water transgressive phase that began with the subjacent West Range limestone. The increase in clastic muds is associated with the raising of tectonic wedges to the west (Manhattan Geanticline) and is considered to represent sediments derived from the first pulsation of the Antler orogeny (Roberts and others, 1958, p. 2850).

The upper "black" shales of the Pilot formation deserve regional consideration as a possible petroleum source.
DEVONIAN-MISSISSIPPIAN BOUNDARY

The boundary between the Pilot formation and the Joana limestone is conformable and gradational (Plate XXVI). As previously discussed, however, a paraconformity occurs within the Pilot sequence (Figure 12). It is not known for certain that the part of the Pilot shale above the paraconformity is Devonian or Mississippian. The Pilot fauna below the paraconformity is believed to be Devonian with reservations. The Devonian-Mississippian boundary in the Pahranagat Range could be placed at the paraconformity and the boundary may be represented in complete sections at the base of the chert beds (Figure 12). Sandy zones are intercalated with the chert beds and the strata of the upper Pilot grades into a "black" shale, above which a Kinderhookian fauna occurs.

The hiatus between the Guilmette and upper Pilot that occurs on the west side of the Pahranagat Range is also present in the Nevada Proving Grounds farther west. In the Southern Egan Range a hiatus involving 300 feet of West Range-Pilot strata is believed due to erosion (Kellogg, 1959, p. 77). Westward, in the Grant Range (Figure 4), the upper part of the Guilmette is commonly
absent and the basal Joana rests on dolomite and limestone bearing a *Tenticospirifer utahensis* fauna. It is believed by Kellogg that a positive area formed west of the Southern Egan Range in late Devonian time. In the central part of the uplift upper Guilmette was eroded and eastward successively younger West Range-Pilot strata were exposed. The same positive area apparently existed west of the Pahranagat Range.

Elsewhere in the Basin and Range basal Joana commonly contains 1 to 2 feet of quartzite suggesting local areas of erosion or non-deposition (Langenheim, 1959; written communication). Twenty miles south of Ely, near Lund, the Joana limestone rests unconformably on Simonson dolomite (Duley, 1955, p. 24; Langenheim, 1956, p. 1714).

A Devonian-Mississippian unconformity occurs in the Golli Hill district, Utah (Nolan, 1935, pp. 21-22), and a similar pre-Mississippian unconformity has been reported over a wide area in western Utah (Loughlin, 1919) and in northern Utah by Rigby (1959). A pre-Mississippian unconformity occurs in southwestern Montana where the Sappington sandstone is the basal Mississippian subjacent to the Madison limestone and superjacent to the upper Devonian Three Forks shale. In Southwestern Montana a disconformity is also believed present between the Three Forks shale and the underlying Jefferson limestone (Holland, 1952, pp. 1699, 1705). In western Canada the Exshaw shale
rests disconformably on the upper Devonian Palliser formation. Harker and McLaren, (1958) placed the Devonian-Mississippian boundary at the disconformity even though the Exshaw shale may be upper Devonian.

A tectonic movement of some magnitude occurred over a wide area in western North America approximately at or coincident with, the time represented by the Devonian-Mississippian boundary. This diastrophism is clearly reflected in the Pahranagat Range, Nevada.
MISSISSIPPIAN ROCKS

Introduction

About 2000 feet of Mississippian strata are exposed in the Pahranagat Range area. They are referred to three formations: the Joana limestone (Kinderhookian and Osagian-lower Mississippian) 972-1014 feet; the Chainman formation (Meramecian and Chesterian)-Upper Mississippian) approximately 800 feet; and the Scotty Wash formation (Chesterian) 163-263 feet (Plate II).

Magnificent complete exposures of the Joana limestone occur along the east side of the Pahranagat Range south of Highway 25 (Plate III; XXV). The Chainman and Scotty Wash are also best displayed on the eastern side of the Range. Because of structural complications only the lowest part of the Joana is present on the western side and central parts of the Range. Part of the Chainman is also exposed in the central area.

Joana limestone

The Joana limestone was named by Spencer (1917, p. 26) for "a series of rugged knobs and prominent cliffs" above the Pilot shale and below the Chainman shale in the Ely district, Nevada (Figure 4).
In the Pahranagat Range the Joana is subdivided into three members.

**Lower Member**

The Lower Member consists of medium light to yellowish gray weathered, resistant slope-forming, thin (1/2 to 3") wavy, knobby, discontinuously bedded, shale parting calcisiltite to calcarenite (Plate XXVI). Fresh surfaces are medium light gray to light olive gray. Shale partings weather moderate pink to pale yellowish orange. Chert lenses up to 3 inches wide occur in local thin beds. The Lower member is a distinctive unit occurring throughout the Pahranagat area above the Pilot formation and below the massive cliff member of the Joana. It is 25 to 28 feet thick and abundantly fossiliferous.

**Middle Member**

The lower part of the middle member consists of light gray weathered, massive, cliff-forming, medium to thick continuously bedded (6" to 6') crinoidal calcarenite to calcisiltite and crystalline limestone. Fresh surfaces are medium gray. A distinctive 30 foot zone containing discontinuous chert lenses from 1 to 4 inches thick occurs in the middle of the member about 110 feet from the base. The upper part of the member is less massive, resistant slope to semi-cliff forming and contains rather uniform 6" to 3' medium bedding. The member is about 260 feet thick comprising the spectacular cliff (Plate XXV). It is moderately fossiliferous containing poorly preserved solitary corals and locally abundant crinoid stems.
EXPLANATION OF PLATE XXV

Figure A

View of the Joana limestone at Bactrian Mountain (see Plate XXIII, Figure A). The cliff comprises over 300 feet of lower Mississippian strata overlying the non-resistant calcareous shales and calcisiltites of the upper Devonian Pilot formation.

Figure B

Similar view of the Joana limestone and underlying Pilot formation at Curtis Canyon on the east side of the Pahranagat Range. At the base of the cliff there is a 28 foot bioclastic limestone containing a Kinderhookian fauna (Plate XXVI). Note truck in foreground for scale.
EXPLANATION OF PLATE XXVI

Figure A

The lower member of the Joana limestone exposed at the base of the cliff at Curtis Canyon (just to the right of Figure B, Plate XXV). The lower member is 23 feet thick at this locality.

Figure B

A close-up view of Figure A showing the gradational contact between the uppermost black shales of the Pilot formation and limestones of the lower Joana. These consist of thin, wavy, knobly, discontinuously bedded shale parted calcisiltite to calcarenite containing a prolific Kinderhookian fauna.
in the lower part. The upper 70 feet becomes increasingly fossiliferous containing solitary and colonial corals as well as abundant crinoid stems up to 3 inches in length and 1/2 inch in diameter.

**Upper Member**

The Upper Member of the Joana consists of medium light to medium gray weathered, resistant slope to semi cliff-forming, medium-continuously bedded (6" to 2') shale parted calcilutite to very fine crystalline limestone. Fresh surfaces are medium to dark gray, occasionally medium olive gray, but invariably darker than the weathered surfaces. Shale partings weather grayish orange. Chert bands up to 3 inches thick occur locally. The member is distinguished by remarkably uniform bedding, very fine texture, and dark fresh surfaces (Plate XXVII, Figure A). It is moderately fossiliferous containing well preserved lithostrotonoid and syringoporoid corals, large horn corals, brachiopods, bryozoa and crinoid debris.

The upper hundred feet of the member becomes progressively lighter colored on weathered surfaces but maintains its medium dark gray hues on fresh surfaces. Bedding up section becomes progressively thinner, and wavy. Occasional discontinuously bedded zones occur with local calcarenites and chert bands increase. The uppermost 30 feet of the Joana is a distinctive light gray weathered, dark gray fresh surface, bench-forming, thin bedded, shaly, cherty
calcilutite containing abundant crinoid and bryozoan fragments.

The total thickness of the Upper member is about 728 feet. The lower contact with the Middle member is gradational.

**Thickness**

The Joana limestone is 1014 feet thick at Bactrian Mountain (location 3, Figure 11). Eleven miles south at Curtis Canyon 972 feet were measured with the uppermost part incomplete. The Joana is 100 to 290 feet thick at the type section near Ely, Nevada (Spencer, 1917, p. 26; Chilingar and Bissell, 1957). The Joana is 0 to 135 feet thick in the vicinity of Eureka (Nolan and others, 1956, p. 55). Stensaas and Langenheim (1960, p. 181) report 380 feet at Ward Mountain, 12 miles south of Ely. In the Southern Egan Range Kellogg (1959, p. 80) measured 670-705 feet; and 1415-1467 feet of Joana is reported in the Arrow Canyon Range by Langenheim (1960). The Joana clearly thickens southward in eastern Nevada.

**Age, Fauna and Correlation**

Fossils from the Joana limestone are listed on Plate II. The lower member contains *Spirifer centronatus* Winchell, *Camarotoechia tuta* (Miller), *Leptaena analoga* Phillips, *Ambo- coelia aff. minuta* White, and *Dictyoclostus sp. cf. D. arcuatus* (Hall). These forms are considered lower to upper Kinderhookian by Kellogg (1959), and lower to middle Kinderhookian by Griffith
(1959). Coral faunules from the middle and upper Joana of the Pahranagat Range have been examined by Helen Duncan and William J. Sando. They identified *Homalo-phyllites* sp. considered a guide to early Mississippian strata of the western United States. This coral has not been reported in strata of Meramecian age (Duncan, 1959, written communication). An early Mississippian age is also indicated by locally abundant lithostrotonoid and syringoporoid corals, fenestellid bryozoa, productid brachiopods, and gastropods. The Joana limestone was considered Lower Mississippian (Kinderhookian to Osagian) with no part Meramecian by Kellogg (1959, p. 82). Chilingar and Bissell (1957, p. 2269) studied the Joana limestone in eastern Nevada and western Utah and considered its fauna upper Kinderhookian and lower Osagian.

Stensaas and Langenheim (1960, p. 186) however, have correlated the upper two thirds of the Joana limestone with the upper Banff and the Rundle limestones of the Canadian Rockies on the basis of *Kakwiphyllum dux* Sutherland and *Lithostrotonella jasperensis* Kelly. These forms are considered to span the time between the Osagian and Meramecian. Stensaas and Langenheim consider the lower cliff of the Joana as late Kinderhookian to Osagian, and the middle and upper parts and its equivalents late Osagian to Meramecian. Thus, some part of the upper Joana may involve Meramecian. Such possibilities have been previously suggested by Duley (1955) and Griffith (1959).
The Joana limestone correlates with the Madison limestone of Utah and Montana; the Bristol Pass limestone of the Pioche district (Westgate and Knopf, 1932, p. 20); the Mercury limestone of the Nevada Proving Grounds (Johnson and Hibbard, 1957, pp. 356-357); and with the Tin Mountain limestone in southeastern California (McAllister, 1952, pp. 20-22). The Joana has been correlated with the Dawn, Anchor, Bullion, Arrowhead, and Yellowpine members of the Monte Cristo formation in southern Nevada (Langenheim, 1956, p. 1714).

The Lower member of the Joana in the Pahranagat Range probably correlates with the uppermost faunal zone of the West Range formation (containing Spirifer sp. cf. S. marionensis) in the Southern Egan Range (Kellogg, 1959).

Origin

The Joana limestone was deposited under shallow to moderately deep water shelf conditions. The lower member was deposited in shallow water under intermediate energy conditions generally above wave base. It reflects a regression relative to the low energy deeper water depositional environment of the subjacent Pilot shales. The middle cliff member is a transgressive deposit indicating moderately deep water on a submerging platform. The upper member suggests slow emergence of the shelf relative to sea level with possible cyclic deposits that finally
terminate in the wavy thin, discontinuous bedding (wave agitated) limestones of the uppermost part. These strata are succeeded by siltstones and shales in the lower Chainman formation indicating further regressive shallowing and closer proximity to source.

Chainman formation

The Chainman shale was first described by Spencer (1917, pp. 26-27) for a sequence of very dark, soft, fissile carbonaceous shales in the Ely district, Nevada. In this area the shales grade locally into fine grained sandy shale.

In the Pahranagat Range the Chainman is represented by the siltstones and shales overlying the Joana limestone and underlying the Scotty Wash formation. Because the Chainman is divided into a lower siltstone member and an upper shale member the term Chainman "formation" is employed in this report.

The Chainman is poorly exposed in the Pahranagat area due to its nonresistant nature and structural position in the axes of synclinal structures. It underlies a long valley between east-west reversed dipping Joana backslopes on the east side of the Range. Limited exposures occur in the central part of the Pahranagat Range south of Highway 25. Lower and upper parts of the Chainman have been measured but a complete, continuous, section was not found. The total thickness of the formation is conservatively estimated at 800 feet, (Plate II). Because the Chainman is the only soft unit in the
middle and upper Paleozoic it has absorbed much diastrophic stress and is highly deformed (Plate XXVII, Figure A).

**Lower Member**

The Lower Member consists of very distinctive pale, yellowish brown to grayish orange weathered, resistant ledges of slightly calcareous siltstones and interbedded non-resistant gray shales. Siltstone fresh surfaces are medium dark gray ("black"). Yellowish brown weathered bench-forming, laminated (1/8-1/4 inch) calcareous siltstone and paper thin dark gray flaky shale occur throughout the member with local chert. The member is about 200 feet thick. The lower contact with the Joana limestone is abrupt. The upper contact is gradational with the Upper Member. No fossils have been found in the Lower Member.

**Upper Member**

The Upper Member consists of medium gray to dark gray, non-resistant, flaky, fissile shale with a few interbedded thin silty shale and siltstone units. The lower 100 feet of the member is distinguished by zones of brown weathered concretions up to 2 inches in diameter. Fresh surfaces of the concretions are a distinctive dark dusky red. Locally abundant, well preserved goniatites occur in the lower part of the member. Carbonized brachiopod impressions may be found in the shales and some of the concretions contain fish scales (?). The boundary between the Chainman and the superjacent
Scotty Wash formation is gradational. The contact is placed where the shale becomes interbedded with sandstone and calcarenite strata and turns from dark gray to olive gray. The thickness of the member is conservatively estimated at 600 feet. Only the lower 350 feet, and the upper 100 feet have been measured.

**Age, Fauna and Correlation**

The only fossils that have been collected from the Chainman formation in the Pahranagat Range come from the lower 100 feet of the Upper Member. Poorly preserved carbonized brachiopods and possible fish scales have not been specifically identified. Griffith (1959, pp. 42-43) referred the well preserved goniatites to *Cravenoceras nevadense* Miller and Furnish.

The geologic range of *Cravenoceras* in North America has been the subject of debate but it is generally considered to be represented throughout the Chesterian series and at least part, if not all, of the Meramecian series. Griffith assigned an upper Meramecian to Chesterian age to the Pahranagat Chainman on the basis of *Cravenoceras nevadense* and stated that relationships with European faunal equivalents (Youngquist, 1949) would suggest a middle and upper Visean age. Mackenzie Gordon states that *Cravenoceras* is confined to the lower and upper *Eumorphoceras* zones. He regards *Cravenoceras nevadense* as properly included in the genus and considers that the rocks which yield the species are in all probability
late Chesterian. In the Confusion Range of Utah, the unit called Chainman contains assemblages that Gordon reports range from late Meramec to late Chester (Duncan, 1959, written communication).

A study of Carboniferous strata and faunas was made by Dale Duley (1955) at Kane Springs Wash, about 40 air miles southeast of Alamo (southeast of location 14, Figure 4). A large fauna including Cravenoceras hesperium Miller and Furnish and Cravenoceras kingii Hall and Whitfield were collected from the lower Chainman shale (at approximately the same stratigraphic position as the occurrence of Cravenoceras in the Pahranagat Range). Cravenoceras merriami Youngquist was found in the upper part of the shale. Duley noted that although Cravenoceras is said to first appear in the basal portion of the Namurian series in Europe (approximately equivalent to the Chester), Miller and others, 1952, p. 151 suggested that it probably occurs in the upper Visean (approximately equivalent to the Meramecian series) in western Utah and Nevada.

Other fossils identified by Duley from the Chainman shale at Kane Springs Wash included:

Mooreoceras crebriliratum (Girty)
M. choctawense (Girty)
Rayonnoceras cadyi Croneis
Rayonnoceras fayettevillensis Croneis
Bembexia nevadensis
Nudirostra quadicostatum Vanuxem
Camarotoechia purduei Girty
Orbiculoidae newberri (Hall)
Dictyoclostus richardi (Girty)
In an elaborate discussion Duley (1955, pp. 33-38) concluded that all of these species are known from both Meramecian and Chesterian strata in North America.

The Chainman formation in the Pahrangat Range is considered Meramecian in the lower part and Chesterian in the upper part. It correlates with the Peers Spring formation in the Pioche district (Westgate and Knopf, 1932, pp. 20-21; Langenheim and Peck, 1957, p. 1833); the Perdido formation in California (McAllister, 1952, pp. 22-25; Langenheim and Tischler, 1959, p. 1635); and at least the lower part of the Eleana formation in the Nevada Proving Grounds (Johnson and Hibbard, 1957, pp. 357-360).

The Chainman is a correlative of the Barnett shale of Texas; the Heath formation of southwestern Montana; the Caney shale of Oklahoma; the Moorefield, Rudell, Batesville and lower Fayetteville formations of Arkansas; and the cephalopod-bearing portions of the Floyd shale of Georgia.

The thickness of the Chainman formation in the Pahrangat Range is estimated at 800 feet. The Chainman is 900 to 1000 feet thick in the Southern Egan Range (Kellogg, 1959, p. 83) and 933 feet is reported at Kane Springs Wash by Duley (1955, p. 19).

Origin

The lower siltstone member of the Chainman was deposited under littoral to very shallow water unstable shelf conditions. Fossil
wood (Stigmaria sp.) is reported from the lowermost Chainman and uppermost Joana at Kane Springs Wash (Duley, 1955). The lower member clearly indicates a continuation of regressive conditions that were displayed in the Upper Joana limestone. The upper shale member of the Chainman was deposited under deeper water transgressive conditions at a somewhat greater distance from clastic source than the lower member.

The Chainman sediments were derived from a major pulsation of the Antler orogeny in central Nevada (Roberts and others, 1958, pp. 2838-2839). The lower siltstones are the earliest clastics to be deposited in southern Nevada from this movement in the orogenic belt. As tectonic lands were rapidly worn down there was a marine transgression and subsidence of the foreland. This is represented by the Chainman shale interval. Another regression occurs in latest Mississippian time which is demonstrated by the deposition of coarse clastics in the overlying Scotty Wash formation. Chainman equivalents thicken and become coarser westward.

It is believed by Duley (1955, pp. 41-42) that the lower part of the Chainman is a facies of the upper Joana limestone. Griffith (1959, p. 49) thought that because of the relatively great distance between southern Nevada and the Antler orogenic belt, the effects of uplift and erosion were not reflected in the Pahranagat area sediments until late Mississippian time. Thus, while Chainman
clastics were being spread eastward Joana limestone deposition
would continue in southern Nevada. This view supports the facies
concept of Duley to which the writer subscribes.

The petrolierous nature of the Chainman shale and its
probable lateral as well as vertical gradation into calcareous and
arenaceous beds of some porosity suggests a fertile field for
petroleum exploration. Oil seeps from the "White Pine" (Chainman)
shale in central Nevada have been noted by Anderson (1909) and
Lavington (1927). Youngquist (1949, p. 277; 1951, pp. 54-56)
described a locality in the "White Pine" (Chainman) shale where
some of the numerous cephalopods contain dark petrolic liquid
which flows freely when the specimens are broken. The Chainman
should be considered a source rock for petroleum even though it has
been subject to intense deformation.

Scotty Wash formation

The Scotty Wash quartzite was named by Westgate and Knopf
(1932, p. 21) for a 700 foot sequence of quartzitic sandstones which
overlie the Peers Spring (Chainman) formation in the Pioche dis-
trict. In the Pahranagat Range the Scotty Wash is represented
primarily by silty calcarenites and shale with only a minor amount
of quartzite. For this reason the term Scotty Wash formation is
employed in this report. The Scotty Wash is 163 to 263 feet thick.
Exposures are limited to the eastern side of the Pahranagat Range.
EXPLANATION OF PLATE XXVII

Figure A

Uppermost part of the Joana limestone displaying uniform and continuous bedding (6 inches to 1 foot). The section is slightly overturned to the east with the lower part of the superjacent Chainman formation exposed to the right of the photograph.

Figure B

The upper part of the Scotty Wash formation exposed in Crystal Wash on the east side of the Pahranagat Range. The Scotty Wash consists of silty calcarenite ledges, interbedded olive gray shale, and dusky brown cross laminated siltstone (dark ledge at right of photograph).
PLATE XXVII

Figure A

Figure B
Description

The Scotty Wash formation consists primarily of light to medium yellowish brown, resistant slope-forming, thin bedded calcarenite interbedded with non-resistant light olive gray flaky shale. The formation is terminated by a distinctive 10 to 15 foot unit of medium to dusky brown, thin bedded, cross laminated very fine grained sandstone to siltstone (Plate XXVII, Figure B). A similar thinner unit occurs in the lower part of the formation. These siltstones are partly quartzitic. Thin beds are separated by light olive gray shale. Ripple marks are locally prominent. Also distinctive are some ledges of dark dusky red, resistant, silty calcirudite coquina and calcareous siltstone. The coquina is essentially composed of brachiopods and particularly the inarticulate Orbiculoidea. Red concretionary fragments occur locally in the shale interbeds.

Age, Fauna and Correlation

Calcarenite interbeds in the Scotty Wash formation contain abundant productids, spiriferoids, and other brachiopods, bryozoa, crinoid columnals, and fossil wood. Griffith (1959) identified Orbiculoidea sp. cf. O. missouriensis Schumard and Composita subtilita Hall from Scotty Wash beds in the Pahranagat Range. However, Griffith did not separate the Scotty Wash formation from the overlying Ely limestone, Griffith (1959, p. 44). A faunal collection that probably came from the Pahranagat Scotty Wash
(collected by Charles M. Tschanz) was examined by Mackenzie Gordon who identified the following:

"Buxtonia" aff "B" arkansana (Girty)
Rhipidomella nevadensis (Meek)
Reticuliina campestria (White)
Spirifer sp. cf. S. fayettevillensis Snider
Martinia? sp.
Cleiothyridina sp.
Cystodictya sp.
Fistuliporoid bryozoa
Stenoporoid bryozoa
Solitary coral
Crinoid columnals
Strophomenid brachiopod fragment

"This collection is likely of very late Mississippian age. Rhipidomella nevadensis Meek ranges generally through 500 feet of beds in this eastern Nevada region and brackets the Mississippian-Pennsylvanian boundary. This combination of species, however, is more characteristically Mississippian than Pennsylvanian."
(Gordon, 1957, written communication to C.M. Tschanz).

At Kane Springs Wash, about 40 air miles southeast of Alamo,
Duley (1955) identified the following species from the Scotty Wash formation.

Cleiothyridina obbicularis (McChesney)
Composita sp.
Reticularina spinosa (Norwood and Pratten)
Rhipidomella nevadense (Meek)
Spirifer rockymontanus Marcou
Dictyoclostus sp.

Duley considered this fauna upper Mississippian although also suggestive of the Pennsylvanian. He correlated the Scotty Wash with the Diamond Peak quartzite in east central Nevada which is also considered mostly upper Mississippian (Nolan and others, 1956, pp. 60-61),
and with the Indian Springs member of the Bird Spring formation at Goodsprings, Nevada which contains Mississippian fossils (Longwell and Dunbar, 1936, p. 1203).

In the Southern Egan Range Kellogg (1959, p. 85) identified the following species from the Scotty Wash:

- Productus sp. cf. P. altonensis Norwood and Pratten
- Diaphragmus? sp. cf. Avonia oklahomensis Snider
- Dictyoclostus sp.
- Composita sp. cf. C. subquadra (Hall)
- Cypricardina? sp.
- indeterminate pelecypod

Kellogg stated that these species are most comparable to upper Mississippian forms.

The Scotty Wash formation in the Pahranagat Range is considered upper Mississippian (Chesterian). The Mississippian-Pennsylvanian boundary is placed at the top of the terminating siltstone unit of the Scotty Wash.

The Scotty Wash formation correlates with the Diamond Peak formation in central and eastern Nevada which consists largely of sandstones and lies between the Chainman shale and the Ely limestone (Nolan and others, 1956, pp. 60-61). James (1954, p. 1268) however, states that "although the quartzites are believed to be nearly time stratigraphically equivalent to the Diamond Peak quartzite..., they are not interpreted as a direct eastern facies." Scotty Wash time equivalent strata are probably represented by the middle and upper
parts of the Eleana formation in the Nevada Proving Grounds
(Johnson and Hibbard, 1957, pp. 357-360).

The Scotty Wash formation is 116 feet thick at Kane Springs
Wash but only 30 feet is present in the Arrow Canyon Range to the
south (Duley 1955). In the Southern Egan Range the Scotty Wash is
350 to 385 feet thick (Kellogg, 1959, p. 84). These areas to the
south and north contain a larger amount of sandstone and quartzite
than does the Scotty Wash in the Pahranagat Range. The formation
thins progressively southward in eastern Nevada.

**Origin**

The Scotty Wash formation was deposited as clastic silt,
sand, limestone, and shale under shallow water to littoral-tidal
flat conditions. Cross bedding, ripple marks and fossil wood
(*Calamites* and *Stigmaria*) are suggestive of rapid deposition, under
high energy conditions above wave base. The Scotty Wash is a re-
gressive deposit in which strand line conditions were established
in the Pahranagat area relative to the deeper - water subjacent
Chainman shales and superjacent transgressive Pennsylvanian *Ely*
limestones representing a new sedimentary cycle. The Scotty Wash
reflects continued orogenic movement in the Basin and Range area
in which tectonic lands were established both west and north of the
Pahranagat area. James (1954) statistically analyzed the orientation
of cross laminae foreset beds in the Scotty Wash and concluded that the predominant current direction at the time of deposition was from the north-northeast.

The Scotty Wash formation may be considered a petroleum reservoir rock, but also a source rock locally. Highly organic strata above and below as well as lateral facies conditions (stratigraphic traps) should be considered in petroleum exploration.
MISSISSIPPIAN - PENNSYLVANIAN BOUNDARY

In the Pahranagat Range the Mississippian-Pennsylvanian boundary is placed at the top of the terminating siltstone unit of the Scotty Wash formation. The Scotty Wash contains a fauna that is predominantly upper Mississippian although some forms are suggestive of the Pennsylvanian. The situation presented here is somewhat more complicated because the position of the Mississippian-Pennsylvanian boundary elsewhere in the Basin and Range has been a subject of controversy.

James (in Foster, 1953) reported "productids, as Echinoconchus, indicating a Pennsylvanian age" from limestones within the Scotty Wash in the Southern Egan Range. Rhipidomella nevadense, which is found in the Scotty Wash was considered earliest Pennsylvanian (Springeran) by Dott (1955, p. 2243). Mackenzie Gordon, however, states that Rhipidomella nevadense ranges generally through about 500 feet of strata in eastern Nevada that brackets the Mississippian-Pennsylvanian boundary. Duley (1955, pp. 25, 27) considered the Scotty Wash upper Mississippian but suggested that the systematic boundary could be within the upper part of the Scotty Wash quartzite. He did not recognize a distinct
faunal change other than relative abundance between the Scotty Wash and the overlying Bird Spring formation of Pennsylvanian age at Kane Springs Wash. He believed, however, that the Scotty Wash fauna is more closely related to the Bird Spring than to the underlying Chainman.

The general similarity of many of the brachiopods that occur in the latest Mississippian and earliest Pennsylvanian rocks in the Basin and Range makes it difficult to place the systematic boundary. Spirifers of the increbescens-opimus group are particularly hard to tell apart, one species is ordinarily considered to be Upper Mississippian, the other Pennsylvanian. Neospirifer is believed characteristic of the Pennsylvanian. Diaphragmus is considered by Mackenzie Gordon to indicate Mississippian. However, in the Pioche district beds above the Scotty Wash contain Rhipidomella nevadense and Diaphragmus. Westgate and Knopf (1932, p. 21) considered the Scotty Wash entirely Mississippian and placed the boundary with the Pennsylvanian within the overlying Bailey Spring limestone (equivalent to the Bird Spring formation of southern Nevada and the Ely limestone). It has been noted that in the Confusion Range, Utah the Mississippian-Pennsylvanian boundary appears to fall in the lower part of the unit mapped as the Ely limestone. In the Las Vegas area, the Indian Springs member of the Bird Spring formation contains upper Mississippian (Chester) and lower Pennsyl-
vanian (pre-Atoka) equivalents.

In discussing the age of the Diamond Peak formation, which
is believed to be essentially an equivalent of the Scotty Wash formation,
Nolan and others (1956, p. 61) concluded:

"The local occurrence of some forms that are usually
found in Pennsylvanian rocks in association with upper
Mississippian ones suggests that there may be beds
that are really early Pennsylvanian in age in the upper-
most part of the Diamond Peak formation. We believe,
however, that such beds, if actually present, are of
small thickness and are confined to the uppermost part
of the formation in only a few localities."

It is evident that further detailed paleontological study is
needed on this specific boundary problem. At this time the writer
knows of no one so engaged.

In conclusion, it may be said that in the Pahranagat Range
marine regression is clearly expressed in the Scotty Wash formation
until strand line (littoral-tidal flat) conditions are attained. This is
followed by deposition of wholly different strata representing a
new sedimentary cycle. There is no evidence for a hiatus of any
consequence at the Mississippian-Pennsylvanian boundary although
a diastrophic (epeirogenic) movement apparently took place over a
wide area which had its greatest effect virtually coincident with the
systematic boundary. It is therefore not surprising that faunas are
mixed; and it is significant that the consensus favors a late Missis-
sippian age for the Scotty Wash interval.
PENN SYLVIAN ROCKS

Introduction

A total thickness of 764 feet of Pennsylvanian rocks is represented in the Pahranagat Range and are referred to the lower member of the Ely limestone (Plate II). The involved strata are considered early Pennsylvanian (Springeran to Morrowan, Plate II). The Ely limestone is exposed at only one location on the east side of the range immediately south of Highway 25 about 6 miles west of Crystal Springs. The section is in the axis of a synclinal structure and contains prolific faunal assemblages throughout.

Ely limestone

The Ely limestone was first described by Lawson (1906, p. 295) for limestone overlying the Chainman shale in the Robinson mining district (Ely quadrangle). The name was subsequently used by Spencer (1917, pp. 27-28) in his description of the Ely district where the type section is greater than 2000 feet thick. Kellogg (1959, p. 87) followed this terminology in describing 3000 feet of equivalent strata in the Southern Egan Range. In this area Kellogg divided the Ely limestone into two lithically and faunally distinct members. The lower member is 1355 feet thick. The 764 feet of Pennsylvanian strata in the Pahranagat Range is lithically and
faunally identical to the lower part of the lower member of the Ely limestone in the Southern Egan Range.

Description

The Ely limestone consists of light to dark gray and light olive to brownish gray weathered, resistant slope-forming, massive medium bedded (4" to 2') silty, sandy, shaly calcisiltite to calcarenite. Fresh surfaces are generally light yellowish gray. Chert occurs locally. Resistant ledges are cyclically interbedded with light yellowish gray to grayish orange less resistant, bench-forming, thin bedded to laminated platy, shaly calcisiltite to calcarenite, calcareous shale and siltstone. The cyclic aspect of the formation is enhanced by the fact that the resistant and non-resistant beds and zones are commonly of equal thickness producing a step and bench topography. Well preserved fossils are weathered out of the shaly non-resistant beds.

Age, Fauna and Correlation

A study of the fauna of the Pahranagat Ely limestone was made by Griffith (1959, pp. 44-46). A large part of his identifications are listed on Plate II. The most diagnostic fossils include:

- **Composita subtilita** Hall
- **C. elongata** Dunbar and Condra
- **Cleiothyridina orbiculoidea** (McChesney)
- **Punctospirifer kentuckiensis** (Shumard)
- **Neospirifer camaratus** Morton
- **Echinochonchus semireticularus** var. **hermonsanus** Girty
Rhipidomella sp. cf. R. nevadense
Schizophoria sp. resupinoides Cox
Dictyoclostus sp. cf. D. inflatus (McChesney)
Spirifer occidentalis Girty

Schizophoria, Rhipidomella, Neospirifer, and Punctospirifer are prolific in the lower 300 feet of the formation and extremely rare thereafter. Above 400 feet of the section the fauna is dominated by Dictyoclostus and other productid brachiopods. The age of the lower member of the Ely limestone in the Pahrangat Range was considered early to middle Pennsylvanian (Morrowan to Desmoinesian) by Griffith (1959). However, since no definite middle Pennsylvanian fossils have been identified and the total thickness of the Ely is somewhat limited, the strata probably do not actually involve any Desmoinesian time. The Ely, as defined here, should probably be assigned solely to the Springeran, Morrowan, and possibly earliest Atokan time.

The Ely limestone correlates with the lowest part of the Bird Spring formation at Kane Spring Wash (Duley, 1955, p. 33) and the lower part of the Bailey Springs limestone in the Pioche district (Easton and others, 1953, p. 147). Units A and B (875 feet) of the Tippipah limestone in the Nevada Provinces are lithologically similar and occupy the approximate stratigraphic position of the Pahrangat Ely limestone (Johnson and Hibbard, 1957, p. 360).

Origin

The Ely limestone was deposited under shallow water inner
neritic (epineritic) shelf conditions. It is a transgressive deposit marking a distinct change in depositional environment, paleogeography, and source of sediments in relation to the subjacent coarser clastics of the Scotty Wash formation. Cyclic deposition suggests eustatic changes on a submerging shelf.
PALEOZOIC-CENOZOIC UNCONFORMITY

There are no known late Paleozoic, Mesozoic, or early Tertiary rocks in the Pahranagat Range. Tertiary strata, as old as Oligocene, may rest on any Paleozoic formation. A profound angular unconformity is displayed throughout the Pahranagat area (Plate IX, Figure B, p. 148; Plate XXIX, Figure A; Plate XXVIII).

It is possible that late Paleozoic (upper Pennsylvanian-Permian) and Triassic rocks may have been deposited and subsequently eroded away. It has been demonstrated by Harris (1959, pp. 2639-2643) that a large positive area existed in southeastern Nevada and western Utah from late Jurassic to early late Cretaceous time. This area, termed the Sevier Arch, supplied sediments eastward into Utah and Arizona. The Pahranagat area is located on the axis of the arch.

Late Paleozoic faulting or folding can not be certainly identified in the Pahranagat Range. The Sevier Arch was thrust faulted in late Cretaceous time. Oligocene sediments and volcanic rocks were deposited on an eroded surface with considerable relief.
EXPLANATION OF PLATE XXVIII

Figure A

Oligocene-Miocene volcanic rocks are seen in the background dipping about 15 degrees eastward. They rest with angular unconformity on the upper Devonian Pilot formation and lower Mississippian Joana limestone (cliff) which dip about 15 degrees westward. View is looking south on the east side of the Pahranagat Range.

Figure B

The Paleozoic-Cenozoic angular unconformity. The Oligocene Hells Bells Canyon formation is resting on lower Mississippian Joana limestone at this locality. A thin chert bed commonly occurs at the contact.
CENOZOIC ROCKS

Introduction

About 3000 feet of Cenozoic volcanic rocks and sediments are exposed in the Pahranagat Range. These strata are divided into 6 mappable units. The 3 lowest units, the Hells Bells Canyon, Curtis Canyon, and Alamo Range formations (Oligocene-Miocene) consist primarily of welded tuffs (ignimbrites) of the flowing avalanche type, other pyroclastics and flows, and minor amounts of water worked tuffs and lacustrine beds (Plate II; XXIX, Figure B). The 3 upper Cenozoic units are the Badger Valley Basalt (Pliocene), the Hiko formation consisting of well indurated Pleistocene gravels and sands, and Quaternary alluvium.

The middle Tertiary volcanic sequence was spread over most of the Pahranagat area and may be found resting unconformably on any Paleozoic formation (Plates IX, Figure B; XXVIII; XXX). Since Miocene time, erosion has stripped off considerable volcanic material exposing the underlying Paleozoic rocks. Inliers of Paleozoic strata protrude through volcanic cover along the east side of the Range (Plates III, XXIX, Figure A). In many areas the volcanic sequence is faulted against Paleozoic strata as a result of large scale late Tertiary and Quaternary deformation.
Hells Bells Canyon formation

The Hells Bells Canyon formation was named by Dolgoff (1960; Dolgoff, Reso, Rogers and Croneis, 1960), for the earliest Tertiary volcanic formation best exposed at Hells Bells Canyon on the east side of the Pahranagat Range (Plate XXX). The maximum composite thickness of the formation is about 1000 feet. Thickness and facies vary greatly due to deposition on an erosion surface of moderate to locally considerable relief. The formation is thin or completely absent on former topographic highs. The Hells Bells Canyon formation is divided into 4 members.

Member A

Member A consists of local pre-volcanic boulder conglomerates overlain by lacustrine limestones. Well cemented boulders of Paleozoic rocks attain sizes 2 to 3 feet in diameter. The conglomerate resembles recent stream deposited alluvium accumulating in young valleys and gorges. Fresh water limestones are interbedded with conglomerates and some pink tuffaceous sandstones up section. The Member is best developed at Buckhorn fault in the southeastern part of the Range where it is 220 feet thick.

Member B

Member B consists of light brown to pink resistant slope to cliff-forming, massive, blocky jointed welded vitric crystal rhyo-dacite tuff. Fresh surfaces are light gray, hard, and pseudo-
granitic. Two to three mm euhedral biotite and quartz grains are seen in hand specimen. A crudely aligned pitted surface formed by weathered out pumice fragments is characteristic of the lower part of the member. A 32 foot zone of semi-consolidated soft, cavernous tuff occurs 153 feet below the top of the Member. Five to six foot hollows are controlled by bedding. The upper cliff-forming part of the Member is distinguished by moderately consolidated tuff with thin crude slabby bedding (1/4 to 5 inches) and 15 to 20 foot rectangular joints. Member B is 0 to 725 feet thick.

Member C

Member C consists of about 100 feet of vitric welded rhyolite tuffs and flows with interbedded water-worked semi-consolidated tuffs.

Member D

Member D is a heterogeneous unit consisting of water worked white pumiceous tuffs, tuffaceous sandstones and breccias, and fresh water limestones. At the type locality in Hells Bells Canyon (Plate XXX), where only Member D of the formation is present, the lower 200 feet is white semi-consolidated water worked pumice tuff breccias. Angular fragments and pebbles of rhyolite and chert range from 1 to 3 inches in diameter. The Member exhibits laterally discontinuous bedding 2 to 5 feet thick. The upper 200 feet is distinguished by water worked white pumice tuffs and pumice tuff
EXPLANATION OF PLATE XXIX

Figure A

An inlier of the upper Devonian Guilmette formation (Dg) is seen protruding through the cover of Tertiary Hells Bells Canyon formation near Curtis Canyon on the east side of the Pahranagat Range. Tertiary rocks dip eastward toward the observer and the Guilmette dips westward.

Figure B

A view of the three middle Tertiary volcanic formations looking northeastward from Badger Valley. The lower slope consists of the upper part of the Hells Bells Canyon formation; the middle dark unit is the Curtis Canyon ignimbrite; and the upper unit is the Alamo Range formation. The section dips about 12 degrees eastward away from the observer.
EXPLANATION OF PLATE XXX

The type section of the Hells Bells Canyon formation at Hells Bells Canyon. The white unit consists of water worked pumiceous tuffs and tuffaceous sandstones and breccias. Cross bedding, minor unconformities, differential compaction features, and small channel fillings characterize this facies of the formation. Only the upper 394 feet of the formation (Member D, Plate II) is present at the type locality.

Above the Hells Bells Canyon formation is the Lower Ash Member (grayish-white zone below cliff) and part of the Upper Member of the Curtis Canyon ignimbrite exhibiting characteristic palisade-like columnar jointing.

The section rests unconformably on the Mississippian Joana limestone (lower foreground).
breccias with fragments up to 1 inch in diameter exhibiting good cross-bedding, minor unconformities, differential compaction features, and small (measured in inches) channel fillings.

Limestone facies of Member D at Bactrian Mountain, about 12 miles north of Hells Bells Canyon, consist of very light gray to pinkish gray weathered, resistant slope to semi cliff-forming, thin bedded (1 to 4 inches) dense fine crystalline limestone. Crenulated tufa structures, wavy, discontinuous bedding, and chert occur in the upper part of the limestone facies which is 174 feet thick. The lower part contains interbedded gray water laid sands and gravels. Gastropod casts and molds and algal? structures occur locally.

Curtis Canyon formation

The Curtis Canyon ignimbrite was named by Dolgoff (1960; Dolgoff and others, 1960) for a widely distributed volcanic formation that is best exposed along the east side of the Pahranagat Range in the vicinity of Curtis Canyon. The formation has a remarkable pseudo-granitic appearance weathering into colossal exfoliated boulders up to 50 feet in diameter which are controlled by tectonic jointing. Palisade-like columnar jointing is also characteristic (Plates XXX; XXXI). The Curtis Canyon formation lies superjacent to the Hells Bells Canyon formation at most places, but rests on Paleozoic strata where the Hells Bells Canyon is absent such as at
Ash Springs and Caliente Pass. Because the Curtis Canyon ignimbrite is widely distributed and is believed to have been deposited in a relatively short time it serves as an ideal mapping and time datum.

The Curtis Canyon formation is 400 to 700 feet thick throughout most of the Pahranagat Range area and thickens eastward to over 1000 feet on the east side of Pahranagat Valley in the Alamo Range (Figure 4). The Curtis Canyon is divided into two members.

**Lower Member**

The Lower Member consists of light gray to pinkish gray, slope-forming, crude slabby bedded, exfoliated dacite crystal-vitric tuff. Fresh surfaces are pseudo-granitic and display a crude alignment of 3 to 4 mm quartz and feldspar grains, 1/2 mm biotite, and pumice inclusions up to 5 mm in diameter. The Member grades upward from soft incoherent tuff into the hard ignimbrite of the Upper Member without a break. The Lower Member, which is 10 to 100 feet thick, is believed by Dolgoff (1959, personal communication) to represent a basal ash cleaned out of a fissure vent in advance of the major eruption.

**Upper Member**

The Upper Member consists of light brownish gray to pinkish
EXPLANATION OF PLATE XXXI

Figure A

The Curtis Canyon ignimbrite exposed at the mouth of Box Canyon on the east side of the Pahranagat Range. The formation is characterized by its pseudo-granitic appearance weathering into colossal joint controlled boulders up to 50 feet in diameter. The crudely bedded section dips about 15 degrees eastward away from the observer.

Arrow points to man for scale.

Figure B

Typical exfoliated boulder of the Curtis Canyon ignimbrite.
EXPLANATION OF PLATE XXXII

Figure A

Outcrop of the Badger Valley basalt flows at the type section. In this view a series of thin flows cap the low rolling topography of older volcanic rocks. A typical talus of small angular basalt fragments is seen at the base of the section (center foreground).

Figure B

View of the volcanic sequence exposed in the farthest northwestern part of the Pahranagat Range in the vicinity of Murphy's Gap (arrow).

The dark band of crystal-vitric tuff is the lowest unit of the Alamo Range formation at this locality. The Curtis Canyon ignimbrite constitutes the subjacent light colored slope.

Spectacular normal faulting is clearly seen. The white hills in the valley (center of photo) are outliers of the Devonian Sevy dolomite.
gray, resistant slope to semi cliff-forming welded dacite crystal-vitric tuff. Fresh surfaces are light gray, hard, and pseudo-granitic. Characteristic of the Member are frequent alignments of pitting caused by weathered out pumice inclusions. In hand specimen 2 mm euhedral quartz and feldspar crystals and 1/2 mm biotite needles are easily distinguished from 40 to 50% aphanitic matrix. The lower part of the Member exhibits a pseudo-gneissic streaking and flattening of glass lenses. Up section the Member becomes less well indurated, less crystalline, less welded, and distortion of shards diminishes.

The Upper Member is about 450 to 1000 feet thick and is remarkably homogeneous. Locally, however, the stratigraphic interval is occupied by a facies that resembles a rhyolite in the field. It is believed by Dolgoff (1960, written communication) that the Curtis Canyon formation is almost entirely a flowing avalanche (or pyroclastic) deposit on a slope not exceeding 5 degrees. Subsequent deformation is thus responsible for present dips up to 25 degrees.

Alamo Range formation

The Alamo Range formation was named by Dolgoff (1960) for a sequence of volcanic rocks that conformably overlie the Curtis Canyon ignimbrite and constitute a large part of the Alamo Range on the east side of Pahranagat Valley. Members and facies of the
formation are remarkably distinctive and uniform over wide areas. Parts of the formation are distributed as remnants (mesas and buttes) or occur as cuestas and hogbacks on top of the Curtis Canyon formation (Plate IV, Figure A; Plate XXIX, Figure B). The Alamo Range formation is approximately 1000 feet thick and is divided into 3 members at the type section.

**Lower Member**

The Lower Member consists of about 300 feet of grayish pink, poorly consolidated pumiceous tuffs. Water worked tuffs occur in the upper part.

**Middle Member**

The Middle Member consists of 10 to 250 feet of non-resistant pumice and vitric tuff breccias in which pumice fragments and lithic inclusions become coarser and increase up section. Hard, pink, flattened rhyolitic inclusions are particularly distinctive.

**Upper Member**

The Upper Member consists of brown weathered massive cliff-forming, well indurated (hard) welded rhyolite vitric tuffs with good alignment of flattened pumice inclusions. The Member closely simulates a flow breccia and may include some flows. Fresh surfaces are white to yellowish gray in the lower part.
Northwest Facies

The lower part of the Alamo Range formation at Bactrian Mountain and in the northwestern part of the Pahranagat Range includes some very distinctive facies. These include two very dark gray to black, resistant slope to semi cliff-forming, hard-welded? dacite crystal-vitric rhyolitic tuffs. Fresh surfaces are dark gray, dense, vitreous, and well foliated. These units simulate flow rocks. A red colored unit of similar composition is also distinctive. The black units may be distinguished as the basal Alamo Range at great distances (Plate XXXII, Figure B).

Up section the Alamo Range consists of variegated pink, brown, and gray resistant cliff-forming welded, and non-welded, rhyo-dacite vitric tuffs. Distinctive are slightly to well aligned streaked pumice fragments, a few flow inclusions, obsidian fragments, and well indurated, joint controlled, 5 to 15 foot weathered blocks.

Age, Fauna, and Correlation of the Hells Bells Canyon, Curtis Canyon, and Alamo Range formations.

Gastropods collected from the Bactrian Lake limestone facies (Member D) of the Hells Bells Canyon formation were examined by Dr. Aurèle La Rocque who states:

"In my opinion, these specimens all belong to the same species which is too imperfectly preserved for specific identification. It does seem to belong to the group of Stagnicola palustris (Muller), a living species also known certainly from the Pleistocene, and with some doubt,
for the Pliocene of North America. Certain Miocene and Oligocene species probably belong to this group also. Therefore, to be entirely on the safe side, I would venture the opinion that the Bactrian Lake Member is Miocene or younger but I would emphasize that this diagnosis is far from certain as it is based on a single species." (La Rocque, 1960, written communication).

The limestones containing the gastropods were tested for pollen without result. Other organic structures suggestive of algae could not be identified.

The Hells Bells Canyon formation and superjacent volcanic units are very similar to the sequence described by Kellogg (1959) in the Southern Egan Range. The lowest fanglomerate member of the Hells Bells Canyon formation is a probable correlative of the Stinking Spring (pre-volcanic) conglomerate that rests on known Eocene lacustrine strata. Above the conglomerate in the Southern Egan Range there occurs a sequence of white tuffaceous sediments followed by "tuffaceous flows" and a welded tuff (ignimbrite) formation that is lithically similar to, and occupies the approximate stratigraphic position as, the Curtis Canyon ignimbrite. Because the Tertiary volcanic sequence is overlain by sediments containing middle to late Miocene vertebrates in the Southern Egan Range Kellogg (1959, pp. 117-118) concluded that the volcanics are Oligocene and early Miocene.

The Hells Bells Canyon, Curtis Canyon, and Alamo Range
formations are considered medial Oligocene to medial Miocene. The sequence correlates with at least part of the Oak Spring volcanic formation in the Nevada Proving Grounds which also contains lacustrine limestones that have yielded Miocene gastropods (Johnson and Hibbard, 1957, p. 369). The sequence correlates with the lower Volcanic group (Garrett Ranch group) described in eastern Nevada by Winfrey (1938, pp. 77-78), Harris (1938, p. 90; 1959, p. 2638); and Kellogg (1959, pp. 112-117). A Potassium Argon date of 34 million years (mid-Oligocene) is cited by the above authors from an ignimbrite sample from the Lower Volcanic group. A detailed investigation concerning the stratigraphy, petrology and origin of the middle Tertiary volcanic sequence in the Pahranagat Range has been made by Dolgoff (1960).

**Badger Valley basalt**

The Badger Valley formation was named by Dolgoff (1960) for a 200 foot sequence of basalt flows that are best exposed in two dome-like areas in the south-central part of the Pahranagat Range in Badger Valley (Plate XXXII, Figure A).

**Description and Age**

The Badger Valley formation consists of brownish black weathered (desert varnish) dense aphanitic basalt. Flows range from 10 to 50 feet thick. They possess good jointing and distinctive vesicular structures on the top of each flow. "Ropy" flow structures occur locally.
The flows cap low rolling topography in the type area and rest unconformably on all earlier volcanic formations as well as on Paleozoic strata. Talus piles of small angular basalt cobbles are commonly seen on hill slopes. The flows are locally tilted at angles up to 60 degrees clearly indicating subsequent late Tertiary or Quaternary deformation.

The Badger Valley basalts are considered late Pliocene.

The Hiko formation

The Hiko formation is here named for well indurated sands and gravels exposed in dissected terraces along the margins of Pahranagat Valley. The most continuous and complete exposures are found in the northern part of the valley between Hiko and the Hiko Narrows. A minimum thickness of 250 feet is exposed (Plate XXXIII, Figure A).

Description, Origin and Age

The Hiko formation consists of light gray calcareous cemented sands and pebble, cobble, and boulder conglomerates. Lithic fragments are subrounded to subangular, poorly sorted, and include debris from all exposed Tertiary and Paleozoic formations. Distinctive are thin to medium discontinuous bedding (2 inches to 1 foot), graded bedding, and cross bedding.

The formation is essentially an accumulation of interfingering alluvial fans and stream channels, (Plate XXXIII, Figure B).
EXPLANATION OF PLATE XXXIII

Figure A

Typical outcrop of the Hiko formation consisting of well indurated sands and gravels composed of all exposed Tertiary and Paleozoic rocks in the Pahranagat area.

Figure B

Ancient (Pleistocene) stream channel seen in the Hiko formation.
The Hiko formation is discontinuously exposed along the entire east and west margins of Pahranagat Valley. Sections between 40 to 50 feet thick occur along highway 93 in the southern part of the valley and equally thick exposures are accessible in the northern part of the Valley. The Hiko formation is considered Pleistocene to Recent.

**Recent Alluvium**

Recent alluvium consists of unconsolidated to partly indurated valley fill and eroded debris in stream channels and alluvial fans.

The total thickness of Quaternary deposits including both the Hiko formation and recent alluvium is not known. Water wells have been drilled several hundred feet in the northern part of Pahranagat Valley without reaching "bed rock."
APPENDIX I

INTRODUCTION TO PART III - STRUCTURAL GEOLOGY

Almost every type of primary and secondary structure can be seen in the Pahranagat Range. Several of the more spectacular Cretaceous thrusts and late Tertiary normal faults are pictured on the following Plates.
EXPLANATION OF PLATE XXXIV

Figure A

Normal fault with about 100 feet of stratigraphic throw in the Laketown formation on the west side of the Pahranagat Range.

Figure B

Thrust fault in the Joana limestone on the east side of the Range.
EXPLANATION OF PLATE XXXV

Figure A

A klippe of highly deformed, vertically dipping, Joana limestone (mountain in central foreground) rests on gently dipping Joana strata on the east side of the Pahranagat Range.

Figure B

A view of Mount Irish from the south. The white band across the top of the mountain is the Ordovician Eureka quartzite which is seen abruptly terminated with downward drag against a slice of Upper Devonian Guilmette strata which in turn is thrust against the Mississippian Joana limestone.

In the left foreground the Eureka quartzite is seen trending across the terrain dipping 60 degrees eastward.
EXPLANATION OF PLATE XXXVI

Figure A

Synclinal structure seen on the west side of the Pahranagat Range looking southward from Hancock Summit. Cliff a-a' is the basal Joana limestone resting on the Pilot shale slope. Faulted slices of Guilmette strata occur in the axis of the "syncline." The Hancock fault trends from the position of the observer to the left of the eastern shale slope (arrow) along with Cambrian strata rest against upper Devonian.

Figure B

Highly contorted (chevron folded) and overturned Joana limestone in Crystal Springs Wash on the east side of the Pahranagat Range.
EXPLANATION OF PLATE XXXVII

Figure A

Fault on a dip slope of interbedded sands and carbonate strata of the upper Guilmette. The right block is upthrown displacing strata toward the observer.

Figure B

Joana limestone a-a', Pilot shale b-b', and upper Guilmette c-c' is displaced by a major fault in the plane of the photograph. Block in background is upthrown.
APPENDIX II

INTRODUCTION TO GEOLOGICAL HISTORY

Summary of Paleozoic Depositional History

More than 18,200 feet of Paleozoic strata ranging in age from early late Cambrian to late early Pennsylvanian are exposed in the Pahranagat Range. This sequence is primarily composed of limestones, dolomites, and orthoquartzites with a relatively minor amount of shale. Included are near maximum thicknesses of virtually all known Paleozoic time-rock units in the eastern Basin and Range Province. The sequence is typical of a mio-geosynclinal sedimentary tectonic environment (Millard Belt of Kay, 1951; Foreland Facies of others). During a great part of Paleozoic time the Pahranagat Range area was located at the approximate axis of the miogeosyncline.

Even though the Pahranagat Paleozoic sequence represents relatively complete and continuous sedimentation for the time-rock units present, virtually all regional disastrophic episodes and local depositional environments are reflected in the sediments. The majority of Paleozoic sequence was deposited under shallow water (epinertic) inner neritic (sublittoral) slightly unstable (generally subsiding) shelf conditions. Source of the sediments was generally...
from the east and southeast. Tectonic welts raised in the Antler orogenic belt in central Nevada contributed clastic detritus from the west in late Devonian time and during upper Mississippian time. Unconformities occur at or near each system boundary except at the Mississippian-Pennsylvanian boundary. At the latter boundary, however, littoral (tidal flat) conditions were attained during a marine regression. Unconformities also occur at the top of Lehman formation (Chazyan) and probably within the Eureka quartzite (Black Riverian and Trentonian). Marine regressions that resulted in the attainment of strand line sedimentary environments occurred in the Pahranagat area during late Dresbachian, late Canadian, late early Devonian, and earliest Meramecian time.

Table 9 lists continuous marine oscillations resulting from diastrophic (epeirogenic) episodes of the miogeosyncline as reflected in the Pahranagat Range Paleozoic sediments.

The Pahranagat Paleozoic sequence reflects almost every major diastrophic episode in North America Paleozoic history. It supports the conventional theory of "world-wide" relative short diastrophic episodes between systems. It is by itself a remarkable "textbook" example of generally prescribed North American Paleozoic history.
### Table 9

**Summary of Paleozoic Depositional History in the Pahranagat Range, Nevada**

<table>
<thead>
<tr>
<th>Formation</th>
<th>Member</th>
<th>Relative Marine Movement</th>
<th>Basin Diastrophism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ely</td>
<td>lower</td>
<td>transgressive cyclic-eustatic</td>
<td>subsiding</td>
</tr>
<tr>
<td>Scotty Wash</td>
<td></td>
<td>regressive</td>
<td>infilling rising-emergent</td>
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<tr>
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<td>submerging; infilling static-rising</td>
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<tr>
<td></td>
<td>lower</td>
<td>regressive</td>
<td>rising</td>
</tr>
<tr>
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<td>Basin Diastrophism</td>
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<tr>
<td></td>
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<td>Formation</td>
<td>Member</td>
<td>Relative Marine Movement</td>
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<td></td>
<td>C</td>
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<td>rising</td>
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<td></td>
<td>B</td>
<td>eustatic-shallow</td>
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</tr>
<tr>
<td></td>
<td>A</td>
<td>transgressive</td>
<td>subsiding</td>
</tr>
<tr>
<td>Dunderberg</td>
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<td>transgressive</td>
<td>submerging</td>
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<td>maximum regressive</td>
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<td>C</td>
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<td>A</td>
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</table>

**Summary of Geologic History**

Late Pennsylvanian, Permian, Mesozoic, or early Tertiary rocks have not been found in the Pahranagat area. It is possible that late Paleozoic and early Mesozoic were deposited and subsequently eroded. During late Jurassic and Cretaceous time the Pahranagat Range was uplifted as part of the Sevier Arch. Profound thrust faulting deformed the Arch during latest Cretaceous to early Tertiary time (Longwell, 1949; 1950; Johnson and Hibbard, 1957; Harris, 1959, p. 2646).

The Pahranagat area remained positive and was eroded during early Tertiary. A relief surface was developed. During the middle Tertiary (Oligocene-Miocene) prolific fissure eruptions discharged several thousand feet of glowing avalanche deposits, pyroclastics and flows. These units were partially eroded prior to late Tertiary volcanism that produced the basalt flows. Intense block faulting and late Tertiary deformation resulted in development of the present Basin and Range features.
EXPLANATION OF PLATE XXXVIII

Figure A

A view of Ash Springs hamlet about 7 miles north of Alamo on Highway 93 (Figure 2). A trailer parking area and swimming pool formed by damming the warm spring is seen in foreground. The east face of the Pahranagat Range is seen in the background. The cliff running along the foothills of the Range is the Joana limestone.

Figure B

The westward cut-off of Highway 25 from 33 at Crystal Springs in the Pahranagat Valley. This road, paved in 1956 for access to the Tempiute Mine, cuts across the Pahranagat Range through Hancock summit. The next nearest hamlet is Warm Springs (100 miles west) and the next nearest town is Tonopah (150 road miles west).
APPENDIX III

DETAILED DESCRIPTION OF MEASURED SECTIONS

EXPLANATION

Terminology used in the descriptions follows that outlined in the Introduction. The descriptions are arranged essentially from oldest to youngest strata and each specific section is described in the classic manner of superposition. Units are arbitrary. The higher the unit number the younger the rock. Thicknesses are given to the nearest foot. The formations being described are listed in each title with the location given to the nearest quarter section where practical. In most cases the dip of the section is given.

Total thicknesses of formations are underlined for rapid reference. Cumulative thicknesses are not given but thicknesses of members are recorded within the detailed descriptions.

Unit descriptions are generally recorded in the order of color, (weathered and fresh surface), weathering resistance, bedding, texture, composition, fauna, and remarks. Lithologies are capitalized and all organic materials are underlined (whether identified as to species or not) for rapid reference.
Measured Section of the Lizard Hill and Dunderberg formations and the lower part of the Desert Valley formation on the West Side of the Pahranagat Range.

E 1/2 Section 24, T 7 S, R 58 E; W 1/2 Section 19 T 7 S, R 59 E,

Lincoln County, Nevada

Dip 40-50 Degrees in the direction N 75-90 Degrees East

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
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<tbody>
<tr>
<td></td>
<td>Section continuously exposed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Desert Valley formation</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Medium light gray weathered (N-6), medium gray fresh surface (N-5), semi cliff-forming, massive ledged, thin-wavy bedded, fine phaneritic DOLOMITE with moderate reddish brown to orange weathered shaly? partings (10 R 5/6). Upper 4 feet of unit contains an abundant silicified brachiopod zone including Billingsella sp. cf. B. perfecta Ulrich and Cooper and Angulotreta sp. cf. A. tetonensis Walcott that correlates with the Conopsis zone, Franconian stage, upper Cambrian.</td>
<td>28</td>
</tr>
<tr>
<td>47</td>
<td>Light gray (N-7) to very light gray (N-8) weathered, medium light gray fresh surface (N-6), semi cliff-forming, massive 2 to 4 foot</td>
<td></td>
</tr>
</tbody>
</table>
ledges of suggestive thin-discontinuous bedding
(1/2 to 1 inch), fine phaneritic slightly limy

DOLOMITE with abundant chert nodules and
stringers (1/2 to 3 inches wide. Unit becomes
progressively darker weathered in upper part...... 120

Light bluish gray weathered, cliff-forming

CALCILUTITE to CRYSTALLINE LIMESTONE

with chert stringers and nodules increasing to 1
to 2 inches wide in upper half of unit............... 34

Unit 46 lower member of the Desert Valley
formation: 84 feet.

Total measured Desert Valley formation.......... 232

Contact Conformable

Top of Dunderberg formation

Light bluish gray weathered, resistant slope to
semi cliff-forming, massive 4 to 8 foot ledges
of thin-discontinuously bedded, shaly parted

CALCILUTITE........................................ 60

Medium yellowish brown (10 YR 5/2) to dark
yellowish brown (10 YR 4/4) weathered, medium
gray fresh surface (N-5), resistant slope-forming,
1 to 3 foot ledges of thin-wavy bedded (1 to 2 inches)
silty CALCISILTITE to CALCARENITE containing abundant trilobite fragments and inarticulate brachiopods interbedded with non resistant light to medium olive-greenish gray (10 Y-G 5/1) fissile SHALE. Shale fraction diminishes in upper part of unit giving way to more massive ledges of medium bedded brownish gray weathered CALCARENITE and gray CALCILUTITE. Fauna identified by A. R. Palmer from this unit in the central Pahranagat Range (section not measured) are: Dunderbergia nitida Hall and Whitfield, Homagnostus tumidosus Hall and Whitfield and Linnarsonella sp. of late Dresbachian to early Franconian age, upper Cambrian.................. 155

Medium light gray (N-6) weathered, light gray fresh surface (N-7), bench to slope-forming CRYSTALLINE LIMESTONE with small silicified fossil fragments ......................... 26

Medium olive gray (5Y 5/1) to medium greenish gray (5GY 5/1) weathered, medium light gray fresh surface, slope to bench-forming, thin (1/2 - 1 inch) continuous and discontinuous wavy bedded, shale parted CALCISILTITE to CALCILUTITE and OOLITIC LIMESTONE with some
included brown mud pebbles and several ledges
of brownish gray (5R 4/1) to brownish black
(5YR 2/1) desert varnish, laminated to thin
bedded, cross-bedded, limy SILTSTONE in
lower 25 feet of unit.................. 80

41 Medium gray weathered (N-5), medium light gray
fresh surface (N-6), resistant slope-forming
RECRYSTALLIZED CALCARENITE. Upper 2
feet of unit a lime pebble CONGLOMERATE.... 33

40 Medium light gray (N-6), medium gray (N-5), to
pale grayish orange (10 YR 8/4) weathered,
saddle-forming, thin-discontinuously bedded,
shaly parted, partly recrystallized CALCARENITE
containing arthropod fragments and small (up to
1/4 inch diameter) algal structures ............... 36

39 Medium light gray weathered (N-6), medium gray
fresh surface (N-5), bench-forming, thin-
discontinuously bedded, shaly parted fine CALCIS-
SILTITE to CALCILUTITE and OOLITIC LIME-
STONE with fossil fragments ................. 12

Total thickness of the Dunderberg formation..... 402

Contact Conformable

Top of Lizard Hill formation
38 Light olive gray (5 Y 6/1) to medium brownish gray (5 YR 5/1) weathered, medium light gray fresh surface, semi cliff-forming, massive 10 to 12 foot sub-units of phaneritic DOLOMITE .......................... 64

37 Medium dark gray weathered (N-4), dark gray fresh surface (N-3), cliff-forming, massive 1 to 3 foot ledges of very fine phaneritic DOLOMITE including some mottled and laminated beds .................. 48

36 Light olive gray weathered (5Y 6/1), medium light gray fresh surface (N-6), semi cliff-forming, massive 3 foot ledges of thin bedded (1-2 inches) aphanitic DOLOMITE ........................................... 80

35 Fine phaneritic DOLOMITE: same as unit 33 but weathers dark gray (N-3) ............................................. 36

34 Medium to dark gray weathered and fresh surface, semi cliff-forming, massive 2 foot ledges of fine phaneritic DOLOMITE with some reddish speckles alternating with medium gray weathered 8 to 10 foot ledges of very fine phaneritic to aphanitic DOLOMITE ...................................................... 32

33 Light gray (N-7) to very light olive gray (5Y 6/1) weathered, very light gray fresh surface, resistant slope-forming, massive 3 foot ledges of medium
phaneritic DOLOMITE.......................... 68

32 Yellowish gray weathered (5Y 8/1), very light gray
(N-8) to light brownish gray fresh surface, slope-
forming, massive 2 to 3 foot ledges of laminated
to thin bedded (1/4-1 inch) aphanitic DOLOMITE
alternating with slightly darker weathered ledges
of fine to medium phaneritic DOLOMITE........... 24

31 Very light olive gray weathered (5Y 7/1), light
gray fresh surface (N-7 - N-8), saddle to bench-
forming, highly jointed, massive ledges of sugary
phaneritic DOLOMITE with some pale reddish
brown partings and speckles......................... 126

30 Medium dark gray weathered (N-4), medium gray
fresh surface (N-5), cliff-forming, sugary
phaneritic DOLOMITE................................. 64

29 Light olive gray weathered (5Y 6/1), light gray
fresh surface (N-7), cliff-forming, massive
ledged, medium to coarse phaneritic DOLOMITE... 32

28 Medium gray weathered (N-5), medium dark gray
fresh surface (N-4), cliff-forming, massive ledged
slightly cherty phaneritic DOLOMITE.............. 33

27 Medium gray weathered (N-5), medium to dark gray
fresh surface, very fine phaneritic to aphanitic
DOLOMITE interbedded and alternating with very light olive to pinkish gray weathered and fresh surface fine phaneritic DOLOMITE. Like unit 26 but dolomite instead of calcitite. Alternations average 4 to 8 feet. "Ghost" laminations to thin beds (1/4 to 1 inch). Unit is cliff-forming.

Units 28-38 proposed member C of Lizard Hill formation-dolomite, 607 feet. Unit 27 - dolomite: resembles subjacent calcitite units but may also be included in member to give maximum thickness of 667 feet.

Up to 50 alternations averaging 2 to 7 feet of resistant mottled and less resistant laminated CALCILUTITE and CRYSTALLINE LIMESTONE and other heterogeneous LIMESTONES:

a) Grayish orange pink weathered (5 YR 7/4), slightly darker grayish orange fresh surface, bench to slope-forming laminated CALCILUTITE.

b) Light olive gray (5Y 6/1) weathered mottles in field of dark gray (N-3) to grayish black (N-2) weathered, medium gray (N-5) to medium dark gray (N-4) fresh surface, resistant slope to semi cliff-forming, massive 3 to 5 foot ledges of thin
bedded (1/2 to 1 1/2 inches), continuously and discontinuously bedded CALCILUTITE.

c) Medium light bluish gray (5B 6/1), moderate reddish orange to pink (10 R 7/6) weathered, laminated (less than 1/32 inch), slope-forming CALCILUTITE and CRYSSTALLINE LIMESTONE.

d) Medium light gray (N-6), light olive to yellowish gray (5Y 7/1), laminated, resistant slope-forming CALCILUTITE to CRYSSTALLINE LIMESTONE.

e) Pale grayish red weathered mottled (5R 5/2) in matrix of light to yellowish gray weathered (5Y 7/1), resistant slope-forming CALCILUTITE to CRYSSTALLINE LIMESTONE.

Unit 26

25 Numerous interbeds of light yellowish gray weathered, bench to slope-forming, massive 3 foot ledges of distinctly laminated (1/4-1/2 inch) fine CRYSSTALLINE LIMESTONE with darker gray weathered more resistant mottled, partly dolomitized, fine CRYSSTALLINE LIMESTONE like heterogeneous lithologies in unit 25 but also containing interbeds of light gray weathered
(N-7), medium light gray fresh surface (N-6),
resistant slope-forming, massive 2-4 foot ledges
of thin to medium bedded (5-8 inches), very fine

CALCISILTITE to CALCILUTITE and fine

CRISTALLINE LIMESTONE ...................... 220

Units 25-26 member B Lizard Hill formation -
limestone, minimum thickness 420 feet. Contact
with subjacent member A covered.

24 Covered ........................................ 144
23 Dark gray weathered, fine phaneritic DOLOMITE.... 3
22 Medium gray weathered, fine phaneritic DOLOMITE. 4
21 Medium gray weathered (N-5) fine CRISTALLINE
LIMESTONE mottles in matrix of light brownish
gray weathered (5 YR 6/1), dark gray fresh surface
(N-3) fine phaneritic limy DOLOMITE .......... 12

20 Light olive to yellowish gray weathered (5 Y 7/1),
medium dark gray fresh surface (N-4), bench-
forming fine phaneritic DOLOMITE with some brown
and grayish orange sandy stringers ............... 3
19 Medium dark to dark gray weathered phaneritic
DOLOMITE ........................................ 48
18 Medium gray weathered fine phaneritic DOLOMITE. 4
17 Medium dark gray weathered, resistant slope to
semi cliff-forming, fine phaneritic DOLOMITE

with some 6 inch beds of sandy, limy, speckled

DOLOMITE .................................................. 54

16 Medium light gray (N-6) to light olive gray

(5Y 6/1) weathered, bench-forming phaneritic

DOLOMITE extensively veined by white and pink

partly dolomitized calcite .................................. 7

15 Fine phaneritic DOLOMITE: same as unit 14

without veining and more resistant .................................. 30

14 Medium dark, to dark gray weathered slope-

forming fine phaneritic DOLOMITE with extensive

light gray dolomite veining ................................... 40

13 Medium gray weathered, resistant slope to semi

cliff-forming, massive ledged phaneritic DOLO-

MITE with light gray dolomite banding ................... 16

12 Dark gray weathered phaneritic DOLOMITE .......... 20

11 Medium gray weathered sugary phaneritic

DOLOMITE ................................................. 12

10 Medium dark to dark gray weathered fine phaneritic

DOLOMITE with slight hydrocarbon fetid odor.

Lower 3 feet of unit brecciated .............................. 20

9 Medium light gray calcite veined phaneritic

DOLOMITE .................................................. 4
3. Dark gray weathered DOLOMITE

7. Medium dark gray weathered (N-4), dark gray fresh surface (N-3), resistant slope-forming massive, very fine phaneritic to aphanitic DOLOMITE

6. Medium gray weathered (N-5), medium dark gray fresh surface (N-4), massive, white speckled, fine phaneritic DOLOMITE

5. Light olive gray weathered (5Y 6/1), medium light gray fresh surface (N-6) phaneritic DOLOMITE

4. Medium dark gray weathered, resistant slope-forming phaneritic DOLOMITE

3. Light gray weathered (N-7), slightly lighter fresh surface, massive, coarse phaneritic DOLOMITE

2. Medium gray weathered (N-5), medium dark gray fresh surface (N-4), resistant slope-forming 2 to 6 inch beds of fine phaneritic DOLOMITE

1. Medium light gray weathered (N-6), slightly lighter fresh surface, partly covered, bench to slope-forming, calcite veined fine CRYSTALLINE LIMESTONE. Gradational into unit 2

Units 1-23 member A Lizard Hill formation - dolomite. Minimum thickness 333 feet. Contact with superjacent member B covered.
Total exposed thickness of the Lizard Hill formation ........................................ 1614

Ease of section covered
Measured Section of the Upper Lizard Hill, Dunderberg,

Desert Valley and Pogonip Group Formations at Anchor

Point Ridge, West Side Pahranagat Range

N 2/3 Section 18, N 1/2 Section 17, T 7 S, R 59 E,

Lincoln County, Nevada

Dip 40-55 Degrees in the direction N 70-85 Degrees E

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (In feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Section Continuously Exposed</td>
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</tr>
<tr>
<td></td>
<td>Eureka Quartzite</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Medium grayish brown to brownish red weathered, resistant slope to semi cliff-forming, fine grained limy quartz SANDSTONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contact Paraconformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Pogonip Group (Lehman Formation)</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Medium light bluish gray weathered (5E 6/1), medium gray fresh surface (N-5), resistant slope-forming, thin-discontinuously bedded CALCILUTITE with some silicified brachiopods</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>in lower part of unit</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Pale grayish orange (10 YR 8/4) weathered and fresh surface, bench-forming, platy, laminated, silly, limy SHALE</td>
<td>12</td>
</tr>
</tbody>
</table>
Medium light gray (N-6) to bluish gray weathered, medium dark gray fresh surface (N-4), resistant slope-forming, wavy bedded, shale parted, CALCILUTITE with abundant bryozoa, gastropods, brachiopods, ostracods and trilobite fragments....

Bluish gray weathered, bench-forming, knobbly bedded, shaly CALCILUTITE interbedded with more resistant 2 foot ledges of CALCILUTITE.

Upper 100 feet of unit more massive resistant slope-forming.

Bluish gray weathered, medium dark gray fresh surface, resistant slope-forming, thin-knobbly bedded (1 inch), massive cherty CALCILUTITE with brachiopods, corals, gastropods, bryozoa, and sponges?

Units 83-87 Lehman formation of the Pocohip Group: 673 feet, but boundary with subjacent Kanosh formation not definitely determined.

Medium light gray (N-6) to light olive gray (5Y 7/1) weathered, medium dark gray fresh surface (N-4), bench-forming, 6 inch beds of partly recrystallized CALCILUTITE with abundant
silicified brachiopods, corals, and small
gastropods ...................................................... 20

81 Gray weathered, resistant slope-forming, massive
1 to 1 1/2 foot ledges of CALCARENITE with
large gastropods aff. Maclurites? sp .................. 24

80 Bluish gray weathered, resistant slope-forming,
thin (1 inch) knobbly bedded, massive, cherty
CALCILUTITE with poorly preserved brachiopods
and gastropods .............................................. 40

79 Bluish gray weathered, bench to slope-forming,
6 inch beds of CALCISILTITE to CALCILUTITE...... 20

78 Medium light gray (N-6) weathered and fresh
surface, easily eroded saddle-forming, knobbly
bedded, orange shale parting recrystallized
CALCARENITE with abundant Receptaculites sp.
cf. R. mammilaris Newberry (up to 2 inches in
diameter), large (1 3/4 inch) gastropods, bryozoa,
brachiopods, trilobite fragments, crinoid columnals
and some corals ............................................. 32

77 Medium light to medium gray weathered and fresh
surface (N-6) to N-5), bench-forming, 4 to 6 inch
knobbly bedded, shale parted, partly recrystallized,
course CALCARENITE with brown mud balls and
abundant poorly preserved bryozoa, brachiopods and crinoid columnals .................................. 42

76 Bluish gray weathered, semi cliff to cliff-forming, massive 1 to 3 foot ledges of fine CALCARENITE with fossil fragments and some gastropod castes.... 112

Units 76-82 Kanosh formation: 290 feet, but upper and lower boundaries not definitely determined.

75 Bluish gray weathered, semi cliff-forming, dense massive 6 inch to 3 foot beds of recrystallized cherty fine CALCISILTITE to CALCILUTITE with brown silty laminations and fossil fragments.

Upper half of unit contains less chert................. 300

74 Gray weathered, resistant slope-forming, massive medium bedded (1-2 feet) CALCILUTITE to CALCCARENITE with some chert. Upper 100 feet of unit becomes more massive, resistant, and cherty.............................. 272

73 Light olive gray weathered (5Y 6/1), light gray fresh surface (N-7), slope-forming, thin-knobbly bedded (1-6 inches), shale parted cherty CRYSTAL-LINE LIMESTONE with some poorly preserved silicified fossil fragments ..................... 56
72 Bluish gray weathered (5B 6/1), medium dark gray fresh surface (N-4), bench to slope-forming, thin-knobbly bedded, partly recrystallized CALCILUTITE with yellowish gray (5Y 8/1) to grayish orange (10 YR 7/4) shale partings and abundant gastropod and trilobite fragments. .................................................. 88

71 Bluish gray weathered (5B 6/1), easily eroded, saddle-forming, thin to medium bedded CALCILUTITE interbedded with yellowish gray SHALE .......................................................... 164

70 Medium light gray (N-6) weathered, medium gray fresh surface (N-5), thin bedded (1/2 to 4 inches) cherty, recrystallized, grayish orange (10 YR 7/4) shale parted CALCISILTITE to CALCARENITE with abundant trilobite and gastropod fragments. Lower 80 feet of unit resistant slope-forming; upper 74 feet partly covered bench to saddle-forming. .................................................. 154

69 Light to medium bluish gray weathered, easily eroded bench-forming, massive, 2 foot ledges of cherty CALCARENITE with reworked LIME CONGLOMERATE (pencontemporaneous
deformation) interbedded with less resistant, thin bedded, olive to brownish gray, shaly, sandy, 

CALCISILTITE to CRYSTALLINE LIMESTONE

with trilobite fragments .................... 196

68 Light gray (N-7) to medium-light bluish gray (5B 7/1) weathered and fresh surface, resistant 1 foot ledges of cherty CRYSTALLINE LIMESTONE interbedded with light olive gray (5Y 6/1) 2-3 foot zones of saddle-forming fissile SHALE ......................... 192

67 Medium gray weathered (N-5), easily eroded bench-forming, thin to medium knobbly bedded, sandy, cherty CALCARENITE to CRYSTALLINE LIMESTONE like unit 63 with rare trilobite fragments .................... 56

66 Pale brown (5 YR 5/2) to medium grayish brown (5 YR 4/2) weathered and fresh surface, slope-forming sandy CALCARENITE with chert stringers.. 7

65 Gray to moderate pink weathered recrystallized CALCARENITE with trilobite fragments ............. 7

64 Phaneritic DOLOMITE .................. 11

63 Medium gray (N-5), moderate yellowish brown (10 YR 5/4) to dark yellowish orange weathered
(10 YR 6/6) medium gray fresh surface (N-5),
slope-forming, thin to medium knobly bedded
(2 inches to 2 feet), fine CRYSTALLINE LIME-
STONE with chert and sandstone stringers and
rare trilobite fragments ................................ 50

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>62</td>
<td>Medium light gray (N-5) to light olive gray</td>
</tr>
<tr>
<td></td>
<td>(5Y 6/1) weathered, light gray fresh surface</td>
</tr>
<tr>
<td></td>
<td>(N-7), slope-forming, fine to medium CRYSTAL-</td>
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<tr>
<td></td>
<td>LIMESTONE with light brown (5 YR 5/6)</td>
</tr>
<tr>
<td></td>
<td>to moderate brown (5 YR 4/4) weathered quartz</td>
</tr>
<tr>
<td></td>
<td>sand laminations. Lower 16 feet of unit partly</td>
</tr>
<tr>
<td></td>
<td>dolomitic .................................................................... 52</td>
</tr>
<tr>
<td></td>
<td>Total thickness of Pogonip Group .................................. 2568</td>
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<tr>
<td></td>
<td>Contact Conformable</td>
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<tr>
<td></td>
<td>Top of Desert Valley Formation</td>
</tr>
<tr>
<td>61</td>
<td>Medium olive gray to yellowish gray weathered</td>
</tr>
<tr>
<td></td>
<td>very fine phaneritic DOLOMITE ...................................... 48</td>
</tr>
<tr>
<td>60</td>
<td>Phaneritic DOLOMITE: same as unit 57, vuggy</td>
</tr>
<tr>
<td></td>
<td>with little chert ..................................................... 38</td>
</tr>
<tr>
<td>59</td>
<td>Light olive and bluish gray weathered, slope-</td>
</tr>
<tr>
<td></td>
<td>forming sugary phaneritic DOLOMITE with</td>
</tr>
<tr>
<td></td>
<td>abundant 2 inch wide light blue chert knobs .................... 40</td>
</tr>
</tbody>
</table>
DOLOMITE: same as unit 57, but less resistant
bench-forming with abundant chert and brown
weathered sandy beds......................... 44

Light olive (5Y 6/1) to yellowish gray (5Y 8/1)
weathered, slope-forming, coarse phaneritic
DOLOMITE with abundant very light bluish gray
chert bands up to 2 inches thick.................. 76

Light to medium bluish gray weathered, slope-
forming, phaneritic DOLOMITE with brown sand
stringers and some chert....................... 60

DOLOMITE: same as unit 54 but less resistant
slope-forming with abundant brown weathered
sand................................................. 28

Light bluish gray weathered, resistant slope-
forming, thin wavy bedded, fine phaneritic sugary
DOLOMITE........................................... 9

Brownish gray weathered, bench-forming fine
phaneritic sandy DOLOMITE..................... 6

Light olive gray weathered, resistant slope-
forming, thin-discontinuously bedded (4 to 6
inches) fine phaneritic DOLOMITE with super-
ficial sand stringers......................... 13
Medium light olive gray weathered, thin-wavy
bedded (4 to 6 inches) very fine phaneritic

DOLOMITE........................................ 16

Medium olive gray weathered, resistant, thin
bedded (1-2 inches), very fine phaneritic

DOLOMITE with chert............................ 44

Units 50-61 Upper Member C of Desert Valley
formation: 477 feet.

Medium dark gray weathered, semi cliff-forming,
massive ledged of speckled phaneritic DOLOMITE
becoming thinner bedded near top of unit........... 124

Interbedded medium dark olive gray weathered
speckled phaneritic DOLOMITE and medium olive
gray mottled phaneritic DOLOMITE............... 84

Light to medium olive gray weathered phaneritic

DOLOMITE........................................ 10

Medium dark olive gray weathered speckled phaneritic

DOLOMITE........................................ 36

Light olive gray weathered, resistant slope to semi
cliff-forming mottled and speckled phaneritic

DOLOMITE........................................ 47

Medium olive gray weathered, cliff-forming, massive
mottled and speckled phaneritic DOLOMITE........ 88
43 Light gray to medium olive gray weathered, semi cliff-forming, massive phaneritic DOLOMITE

42 Medium light gray weathered phaneritic DOLOMITE

41 Medium olive gray weathered mottled phaneritic DOLOMITE

40 Light olive gray weathered, semi cliff-forming, massive phaneritic DOLOMITE with a few darker weathered beds

39 Medium olive gray weathered, very fine phaneritic speckled DOLOMITE

38 Light to medium dark gray weathered mottled phaneritic DOLOMITE

37 Light gray weathered phaneritic DOLOMITE (distinctive light unit e)

36 Medium olive gray weathered, semi cliff-forming, massive, speckled, phaneritic DOLOMITE

35 Light gray weathered, sugary phaneritic DOLOMITE, (distinctive light unit d)

34 Medium olive gray weathered (5Y 5/1) weathered, medium dark gray fresh surface (N-4), massive, phaneritic DOLOMITE with some lighter gray weathered DOLOMITE beds. Upper 10 feet of unit contains some poorly preserved silicified corals (Holophragma? sp.)
and small gastropods. Faunal zone 951-961 feet from base of formation............................... 26

33 Medium olive gray weathered, semi cliff-forming, massive, mottled, phaneritic DOLOMITE with some less resistant zones of pink brecciated DOLOMITE............................................. 32

32 Light olive gray weathered, sugary phaneritic DOLOMITE (distinctive light unit c).................. 10

31 Medium olive gray weathered, laminated, speckled, cherty, slightly limy, phaneritic DOLOMITE..... 38

30 Light olive gray weathered (5Y 6/1), very light gray (N-8) to yellowish gray (5Y 8/1) fresh surface, sugary phaneritic DOLOMITE (distinctive light unit b)................................................................. 10

29 Medium olive to brownish gray weathered (5Y-R 5/1), medium gray fresh surface (N-5), massive, mottled, phaneritic DOLOMITE........................................... 34

28 Medium gray weathered phaneritic DOLOMITE with chert bands........................................... 4

27 Medium brownish gray weathered (5YR 5/1), medium gray fresh surface (N-5), semi cliff-forming, massive sugary phaneritic DOLOMITE with scattered chert......................................................... 28
26 Very light olive gray weathered (5Y 7/1), very
light gray fresh surface (N-8), cliff-forming,
massive, slightly limy, fine phaneritic to
aphanitic DOLOMITE (distinctive light unit a)....... 17

25 DOLOMITE: same as unit 24 but with very little
chert................................. 68

24 Medium to dark gray weathered, cliff-forming,
fine phaneritic DOLOMITE with abundant semi-
continuous 1 inch bands of chert spaced from 6
inches to 1 foot............................ 128

23 DOLOMITE: same as unit 21, but more massive
ledged................................. 168

22 Medium gray weathered, semi cliff-forming, fine
phaneritic to aphanitic DOLOMITE as unit 21, but
containing increasing amount of chert knobs and
stringers, some pink dolomite veining, and several
rare zones of silicified brachiopods--same as unit
21................................. 140

21 Medium brownish to olive gray weathered (5 Y-R
5/1), medium dark (N-4) to dark gray (N-3) fresh
surface, semi cliff-forming, thin-wavy bedded
(1/2 to 2 inches), fine phaneritic DOLOMITE with
moderate reddish brown shaly partings and containing a prolific silicified brachiopod fauna which includes: Billingsella sp. cf. B. perfecta Ulrich and Cooper, Angulotreta sp. cf. A. tetonensis Walcott and small linguloid brachiopods that correlate with the Conapsis zone, Franconian Stage, Upper Cambrian. Faunal zones occur 246-258 feet from base of formation.  

20 Medium light to medium olive gray weathered, darker gray fresh surface, resistant slope-forming, fine phaneritic DOLOMITE with dolomite veining and some chert.  

Units 20-49 Middle Member 6 Desert Valley formation: 1564 feet.  

19 Light bluish gray weathered, partly covered, bench-forming, partly dolomitized CALCARENITE to COARSE CRYSTALLINE LIMESTONE.  

18 Medium light gray weathered and fresh surface (N-6), resistant slope-forming, massive ledged, fine CRYSTALLINE LIMESTONE.  

17 Medium brownish gray weathered, partly covered, slope-forming coarse CALCARENITE.
Units 16b-19 lower Member A Desert Valley formation: 82 feet.

Total thickness of the Desert Valley formation...... 2123

Contact Covered but considered Conformable where exposed elsewhere.

Top of Dunderberg formation

16b Covered........................................ 10

16a Covered........................................ 90

15 Partly covered, resistant slope-forming CALCARENITE--same as unit 14 but weathered gray.... 20

14 Medium brownish gray (5 YR 5/1), light brownish gray fresh surface (5 YR 6/1) recrystallized CALCARENITE with interbedded olive green SHALE.

Lower 100 feet of unit partly covered saddle to bench-forming; upper 72 feet slope-forming........... 172

13 Gray weathered, resistant slope-forming, massive ledged CALCARENITE to CRYSTALLINE LIMESTONE. 28

12 Gray weathered, bench-forming, thin bedded (1/2 inch) CALCARENITE with 1/8 inch brown siltstone laminations........................................... 10

11 Brownish gray weathered, semi cliff-forming, massive ledged CALCARENITE..................... 9
10 Brown weathered, resistant slope-forming
SILTSTONE and CALCARENITE

9 CRYSTALLINE LIMESTONE like unit 8 but
thinner ledged, less resistant bench to slope-forming and containing more brown-ferruginous
siltstone laminations

8 Medium gray (N-5) to medium brownish-olive gray
(5 Y-R 5/1), medium gray with streaks of brown
fresh surface, semi cliff-forming, massive ledged,
CRYSTALLINE LIMESTONE with 1/3 inch brown
ferruginous silt laminations

7b Covered saddle

Total thickness of the Dunderberg formation

Contact Covered but considered conformable where
exposed elsewhere. Postion of contact within
covered unit 7 estimated.

Top of Lizard Hill formation

7a Covered saddle

6 Alternating medium and dark gray weathered,
resistant slope to semi cliff-forming fine phaneritic
DOLOMITE

5 Medium light gray weathered, resistant slope-forming sugary phaneritic DOLOMITE
4 Alternating medium and dark gray weathered, slope-forming, massive ledged, fine phaneritic DOLOMITE.................................................. 8
3 Medium light gray weathered coarse phaneritic DOLOMITE.................................................. 10
2 Medium dark gray weathered, slope-forming, fine phaneritic DOLOMITE.................................................. 8
1 Gray weathered, partly covered, bench-forming, fine phaneritic DOLOMITE................................ .................. 20
Total Measured Lizard Hill Formation............. 253
All considered within upper Member C or Lizard Hill formation
Base of Section Covered
Measured Section of the Upper Lizard Hill, Dunderberg

Desert Valley and Pogonip Group Formations at Anchor

Point Ridge, West Side Pahranagat Range

NOTE

Units 20-49 described as Middle Member B of the Desert Valley formation (1564 feet) comprises both members B and C of the formation.

Units 20-25 (680 feet) is member B and units 26-49 is member C (884 feet).

Units 50-61 described as upper member C is actually member D (477 feet).
**Measured Section of the Desert Valley Formation**

**and the Pogonip Group on Anchor Ridge South**

S 1/2 Section 18, S.W. 1/4 Section 17, T 7 S, R 59 E

West Side Pahrnagat Range, Lincoln County, Nevada

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Section Continuously Exposed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eureka Quartzite</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Light reddish brown weathered, semi cliff-forming, massive, well sorted, fine to medium grained quartz SANDSTONE.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contact Paraconformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Pogonip Group (Lehman formation)</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Dark gray fresh surface (N-5), fine phaneritic to aphanitic DOLOMITE</td>
<td>16</td>
</tr>
<tr>
<td>25</td>
<td>Brown, fine phaneritic DOLOMITE</td>
<td>6</td>
</tr>
<tr>
<td>24</td>
<td>Light gray weathered, dark gray fresh surface (N-3), thin-discontinuously bedded CALCILUTITE with abundant fossil fragments including ostracods, brachiopods, gastropods, and trilobites. Upper 90 feet of unit irregularly dolomitized to brown aphanitic DOLOMITE. Lower 116 feet of unit bench-forming; upper 300 feet semi cliff-forming.</td>
<td>416</td>
</tr>
</tbody>
</table>
Light olive gray weathered, medium gray fresh surface (N-5), resistant ledges of CALCILUTITE irregularly interbedded with bluish gray, bench forming CALCISILTITE to CALCILUTITE with abundant ostracods.............................. 72

Dark gray fresh surface (N-3), resistant slope-forming, thin-discontinuously bedded CALCILUTITE with abundant poorly preserved brachiopods and gastropods. Vertical and horizontal dolomitization to brown aphanitic DOLOMITE with 1 to 3 inch chert stringers 20 feet from base of unit. Zone of large gastropods 50 feet from base of unit.................................................. 156

Units 23-26 definite Lehman formation: 510 feet.

With unit 22: 666 feet. Contact with subjacent Kanosh formation not satisfactorily determined.

Olive gray weathered, medium gray fresh surface (N-5), resistant ledge forming, thick bedded CALCARENITE................................. 19

Medium gray fresh surface, easily eroded saddle-forming, partly covered, shaly CALCARENITE.... 52

Dark gray fresh surface (N-3), resistant, massive ledged, shale parting CALCISILTITE with abundant
1 to 1 1/2 inch discontinuous chert stringers. Upper
140 feet of unit CALCARENITE with abundant
poorly preserved fossils. Receptaculites sp. 420
feet from base of unit............................ 508
Upper 100 feet of unit 19 and units 20-21 part of
Kanosh formation: minimum thickness 171 feet.
Upper and lower contacts of formation not deter-
mined.

18 Medium gray fresh surface (N-5), thin to medium
bedded, shale parted cherty CALCILUTITE to
CALCARENITE with abundant relict structures of
gastropods, bryozoa, and trilobites. Lower 20
feet of unit contains 1 to 4 inch intermittent chert
bands. Upper 40 feet of unit medium to thick
bedded, with less shale......................... 272

17 Medium light gray weathered, medium gray fresh
surface, resistant slope-forming, thin-discontin-
uously bedded, shale parted CALCILUTITE with
abundant fossil fragments and relict structures..... 88

16 Olive gray weathered, dark gray fresh surface
(N-3), thin bedded, brown shale parted CALCAR-
ENITE. Unit forms partly covered slope with
some 6 inch to 1 foot discontinuous resistant ledges. 200
Medium gray weathered, medium dark gray fresh surface, thin-discontinuously bedded, brown shale parted, CALCILUTITE to CALCARENITE. Lower 300 feet of unit partly covered slope-forming with some 1 to 2 foot resistant ledges; upper part becomes more resistant slope-forming with 4 to 5 foot discontinuous ledges. Olive-brownish gray weathered, medium dark gray fresh surface, massive medium phaneritic DOLOMITE with irregular 1 to 4 inch light gray chert stringers.

Medium gray weathered, medium dark gray fresh surface (N-4), thin-discontinuously bedded CALCILUTITE to CALCARENITE with some lime pebble CONGLOMERATE. 1 to 3 inch irregular light gray chert bands present within the CALCILUTITE and CALCISILTITE fraction.

Medium gray weathered, medium dark gray fresh surface (N-4), bench to saddle-forming, massive 1 to 5 foot ledges of thin-discontinuously bedded CALCARENITE to CALCISILTITE interbedded with 2 to 50 foot sub-units of brown shale parted CALCITITE. Light gray 1 to 3 inch chert bands in the more resistant ledges.
Medium gray weathered, medium dark gray fresh surface (N-4), thin-discontinuously bedded, interbedded CALCARENITE and CALCISILTITE.

Abundant light gray 1 to 3 inch chert stringers.......

Grayish brown weathered (5 YR 3/2), medium gray fresh surface, thin-discontinuously bedded CALCISILTITE with abundant 1 to 4 inch gray chert bands interbedded with light brownish gray weathered, medium dark gray fresh surface (N-4) thin to medium discontinuously bedded CALCARENITE with some lime pebble CONGLOMERATE.............

Light olive gray (5Y 6/1) weathered, medium light gray fresh surface (N-6), thin to medium bedded, brown shale parting CALCISILTITE with 1/4 to 2 inch irregular chert bands and grayish orange (10 YR 7/4) clay balls in bottom part of unit......

Total thickness of the Pogonip Group................ 2710

Contact Conformable

Top of Desert Valley formation

Olive gray weathered (5Y 4/1), dark gray fresh surface (N-3), bench to resistant slope-forming, thin to massive bedded, medium phaneritic DOLOMITE with abundant 1 to 3 inch medium bluish gray
(5B 5/1) and dark yellowish orange (10 YR 6/6) chert bands and stringers increasing in upper 300 feet of unit. Calcite veining common throughout unit. Lower 70 feet of unit thin bedded and partly covered. ........................... 828

Upper 500 feet of Unit 3 member C of Desert Valley formation. Exact thickness and contact with subjacent member B not determined.

8 Olive gray weathered (5Y 4/1), dark gray fresh surface (N-3), massive ledged, medium phaneritic Dolomite with abundant calcite veining. ............ 72

7 Yellowish gray weathered (5Y 8/1), light bluish gray fresh surface (5B 7/1), saddle-forming, massive ledged, vuggy, limy, fine phaneritic Dolomite. ................................... 13

6 Light olive gray weathered (5Y 8/1), dark gray fresh surface (N-3), cliff-forming, medium bedded, fine to medium phaneritic Dolomite with some 1 to 2 inch light gray chert stringers. ............... 96

5 Light olive gray weathered (5Y 6/1), medium gray fresh surface, cliff-forming, medium bedded, medium phaneritic Dolomite. ........................................ 12
Olive gray (5Y 4/1) to olive black (5Y 2/1) weathered, dark gray fresh surface (N-3), cliff-forming, massive ledged, fine to medium phaneritic DOLOMITE with 1/2 to 1 inch irregular dark gray chert stringers becoming less abundant toward top of unit................................. 156

Light olive gray weathered (5Y 6/1), medium gray fresh surface (N-5), cliff-forming, massive ledged, vuggy, calcite veined, medium phaneritic DOLOMITE........................................ 401

Olive gray weathered (5Y 4/1), dark gray fresh surface (N-3), resistant slope to semi cliff-forming, massive bedded, calcite veined, aphanitic to medium phaneritic DOLOMITE with 1 to 3 inch light gray to light blue chert bands................................. 520

Units 2-8 and part of unit 9 Member B of Desert Valley formation--estimated thickness 1598 feet.
Contact with superjacent member C not determined.

Total measured thickness of Desert Valley formation........................................ 2098

Grayish orange weathered (10 YR 7/4), medium light gray fresh surface (N-6), bench to slope-
forming, thin to medium bedded CALCISILTITE with 1/4 to 2 inch medium gray irregular chert stringers. Common brown shale partings.

Parts of Units 1 and 2 belong to Member A of Desert Valley formation—not measured.

Base of Section covered.
Measured Section of the Desert Valley formation and the Pogonip Group on Anchor Ridge South

NOTE

Units 2-8 described as Member B of the Desert Valley formation (estimated thickness 1598 feet) comprise members B and C of that formation.

Unit 9 described as member C (500 feet) actually member D of the Desert Valley formation.
Measured Section of the Pogonip Group

in the Central Pahranagat Range

South 1/2 Section 27, T 6 S, R 59 E,

Lincoln County, Nevada

Section dips 48-66 Degrees in the direction N 70-80 Degrees E

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
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<tbody>
<tr>
<td>Eureka Quartzite</td>
<td></td>
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</tr>
<tr>
<td>20</td>
<td>Red to brown weathered, white fresh surface, semi cliff-forming, thin to medium bedded, fine to medium grained quartz SANDSTONE</td>
<td></td>
</tr>
<tr>
<td>Contact Paraconformable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top of Lehman formation of the Pogonip Group</td>
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<tr>
<td>19</td>
<td>Medium light gray weathered (N-6), medium dark gray fresh surface (N-4), resistant slope-forming, thin, discontinuously bedded CALCISILTITE containing abundant arthropod fragments, gastropods, brachiopods, and ostracods including Leperditia sp. Unit contains many 1 1/2 to 2 foot resistant ledges of thin bedded CALCISILTITE and darker gray weathered CALCILUTITE...</td>
<td></td>
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<td></td>
<td></td>
<td>588</td>
</tr>
<tr>
<td>18</td>
<td>Yellowish gray weathered (5Y 7/2), light olive gray fresh surface (5Y 5/2) laminated CALCILUTITE. Lower 2 feet massive; upper 2 feet flaggy.</td>
<td>4</td>
</tr>
</tbody>
</table>
Medium light gray weathered (N-6), medium dark gray fresh surface (N-4), resistant slope-forming, thin, discontinuously bedded CALCISILTITE with some 1 to 2 inch brown chert nodules and abundant arthropod fragments, gastropods, bryozoans, and some ostracods including Leperditia sp. Unit contains numerous 1 to 2 foot resistant ledges of medium to dark gray weathered CALCILUTITE interbedded with somewhat less resistant major lithology and a 2 foot lime-pebble conglomerate 35 feet from base of unit. Lowest 32 feet mostly covered.......................... 170

Units 17-19 considered Lehman formation of the Pogonip Group: 762 feet, but contact with subjacent Kanosh formation not definitely determined.

Light gray weathered (N-7), medium gray fresh surface (N-5), dip slope-forming, thin to medium bedded CALCARENITE with abundant Receptaculites sp. and "Girvanella"? sp. especially in lower 40 feet of unit. U per 30 feet of unit mostly covered... 184

Light gray weathered (N-7), medium gray fresh surface (N-5), bench forming, thin to medium bedded CALCARENITE with some interbedded
14 Light gray weathered (N-7), medium gray fresh surface (N-5), slope forming, medium to thick bedded CALCISILTITE to CALCILUTITE with abundant algal balls "Girvanella"? sp., large gastropods (2 to 3 inches in diameter) and a few Receptaculites sp. Algal balls especially abundant in lower 3 feet of unit. Some intermittent thin chert stringers.................................

Units 15-16 definite Kanosh formation - minimum thickness 272 feet. Part or all of unit 14 possibly in Kanosh formation for maximum thickness of 380 feet, but upper and lower contacts not definitely established.

13 Light gray weathered (N-7), medium gray fresh surface (N-5), slope-forming, medium to thick bedded fine CALCISILTITE with some small horn corals, fossil fragments, and some intermittent thin brown chert stringers.............................

12 Medium gray weathered and fresh surface (N-5), resistant slope-forming, medium to massive continuously bedded CALCISILTITE to CALCARENITE with some brown crystal faceted (limonite?)
pseudomorph) nodules, large arthropod fragments, and some orthocerid cephalopod remains in upper 240 feet of unit. .................................... 420

11 Medium light gray weathered and fresh surface (N-6), resistant slope-forming, thin, discontinuously bedded CALCILUTITE interbedded with massive, more resistant ledges of CALCARENITE. Fossils sparse but crinoid and arthropod fragments in CALCARENITE which becomes more abundant toward the top of the unit, the uppermost 5 feet of which is a very coarse CALCARENITE containing brown clay balls. ...................... 237

10 Medium light gray weathered and fresh surface (N-6), slope-forming, thin to medium continuous and discontinuously bedded CALCILUTITE with abundant 1/4 to 1/2 inch wide brown chert stringers and some brachiopod and arthropod fragments. ............. 100

9 Medium gray weathered (N-5), dark gray fresh surface (N-3), easily eroded, saddle-forming thin, knobbly, discontinuously bedded, yellow shale parted CALCILUTITE with abundant brachiopod and arthropod remains and rare endocerid cephalopods. 128
8 Medium dark gray weathered (N-4), medium gray
fresh surface (N-5), bench to saddle-forming, thin,
knobbly discontinuously bedded CALCILUTITE with
brown crystal faceted (limonite? pseudomorph)
nodules and abundant brachiopod and arthropod
fragments ..................................... 214
Units 8-13 possibly upper limestone formation of
Pogonip group: 1227 feet.

7 Light olive gray weathered (5Y 5/2), medium
dark gray fresh surface (N-4), dip slope-forming,
thin to medium, continuous and discontinuously
bedded fine to coarse CALCISILTITE with abundant
1 to 3 inch wide chert stringers, some lime-pebble
conglomerate and sparse gastropod castes, arthropod
fragments, and other organic fragments ............... 142

6 Medium gray weathered (N-5), medium dark gray
fresh surface (N-4), resistant slope-forming, thin
to medium discontinuously bedded lime pebble
CONGLOMERATE with abundant 1/8 inch to 2 inch
chert stringers........................................ 80

5 Light olive gray weathered (5Y 5/2), medium gray
fresh surface (N-5), resistant slope forming, thin
to medium bedded, coarse CALCARENITE containing
some local lime pebble conglomerate, light brownish
gray chert stringers that become common in the
upper 220 feet of unit, and fairly abundant arthropod
fragments and gastropods .......................... 280

4 Medium light gray weathered (N-6), light to medium
bluish gray fresh surface (5B 6/1), bench to slope-
forming CALCISILTITE to CALCARENITE with
abundant 1 to 3 inch gray chert nodules. Upper 56
feet of unit becomes partly covered blue gray weathered
CALCILUTITE ........................................... 204

3 Dark yellow brown weathered (10 YR 5/2), medium
light gray fresh surface (N-6), wavy bedded CAL-
CARENITE with abundant chert ....................... 3

2 Medium light gray weathered (N-6), light to medium
bluish gray fresh surface (5B 6/1), resistant slope
forming, massive 3 to 4 foot ledges CALCISILTITE
to CALCARENITE with abundant gray chert nodules. 63

Units 2-7 possibly Lower Limestone formation
of Pogonip group: 772 feet.

Total Thickness of the Pogonip Group ............... 3141

Contact Conformable and Transitional

Top of Desert Valley formation
1  Medium light gray weathered (N-7), light gray
fresh surface (N-6), easily eroded bench-forming,
medium to coarse phaneritic DOLOMITE with
1/4 inch chert stringers.................... 25

Total measured Desert Valley formation  25

Section continuously exposed
Measured section of the Maximum Pogonip Exposure

on the Southeast Face of Fossil Mountain

SW 1/4 of Section 6, Township 3 South, Range 61 East

Pahranagat Range, Lincoln County, Nevada

Section measured by Ira Cram and David Park June 26, 1959. Entire section tentatively considered in Lehman formation of the Pogonip Group. Contact between the Lehman and Kanosh formations if present? not determined.

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eureka Quartzite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Pale red weathered (5R 6/2), light red fresh surface (5R 6/6) fine grained quartz sandstone. Contact Paraconformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Lehman formation of Pogonip Group</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Pale yellowish brown weathered (10 YR 6/2) grayish red purple fresh surface (5 RP 4/2) thin bedded (2&quot; to 6&quot;) CALCISILTITE</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Grayish orange pink weathered (5 YR 7/2) medium gray fresh surface (N-5), medium bedded (6&quot; to 1 1/2&quot;) aphanitic to fine phaneritic DOLOMITE</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Medium bluish gray weathered (5B 6/1), medium dark gray fresh surface (N-4), thin, wavy discontinuously bedded (1/2&quot; to 2&quot;), fossiliferous CALCILUTITE to CALCISILTITE. Forms 1 to 20 foot resistant ledges separated by shaly slopes</td>
<td>312</td>
</tr>
</tbody>
</table>
2 Bluish gray weathered (5B 5/1), medium dark gray
fresh surface (N-4), thin bedded 1 to 2 inches, cliff-
forming, interbedded CALCILUTITE and CALCISIL-
TITE. ......................................................... 72

1 Medium bluish gray weathered (5B 5/1), medium dark
gray fresh surface (N-4), thin, wavy, discontinuously
bedded (1/2" to 3"), buff shale parting, resistant ledges
separated by shaly slopes, interbedded CALCILUTITE
and CALCISILTITE. Abundantly fossiliferous contain-
ing Receptaculites sp., brachiopods, gastropods, and
arthropods including Leperditia sp. .......................... 344

Total Pogonip section measured ........................... 748

Base of section faulted
NOTE

The term Laketown dolomite should be substituted for Lone Mountain formation in all following descriptions. The Lone Mountain formation refers only to the two upper members of the Laketown dolomite. See text.
Measured Section of the Upper Pogonip, Eureka, Fish Haven, 
Lone Mountain, and Sevy Formations at "Waite Hill."

S.E. 1/4 Section 31 - S 1/2 Section 32, T 6S, R 59 E

West side Pahranagat Range, Lincoln County, Nevada

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Simonson Dolomite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Light yellowish gray weathered (5Y 7/1), light olive gray fresh surface (5Y 6/1), very sandy phaneritic DOLOMITE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contact conformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Sevy formation</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Light brown weathered, very light gray (N-8) to white fresh surface, massiveledged, subrounded to subangular well sorted fine grained lime cemented quartz SANDSTONE</td>
<td>45</td>
</tr>
<tr>
<td>33</td>
<td>Grayish orange (10 YR 7/4) weathered, olive gray fresh surface (5Y 5/1), thin bedded, easily eroded saddle forming, cherty aphanitic DOLOMITE</td>
<td>63</td>
</tr>
<tr>
<td>32</td>
<td>Grayish yellow (5Y 7/4) weathered and fresh surface partly covered, easily eroded saddle-forming, thin-bedded limy quartz SILTSTONE</td>
<td>72</td>
</tr>
<tr>
<td>Units 32-34 Upper Member of the Sevy formation: 180'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Very light gray weathered, light olive to yellowish</td>
<td></td>
</tr>
</tbody>
</table>
gray fresh surface, massive ledged, resistant slope
forming very fine phaneritic to aphanitic DOLOMITE
with several sandy zones and some slightly darker
weathered and coarser grained sub-units............. 1176

30 Very light gray to light olive gray weathered and fresh
surface, massive ledged, resistant slope-forming,
very sandy (up to 20% quartz grains) very fine phaneritic
to aphanitic DOLOMITE.................................. 30

Total thickness of the Sevy formation ................. 1386

Dips vary from 38 to 43 degrees in the direction
N 85 E.

Contact Paraconformable

Top of Lone Mountain formation

29 DOLOMITE: same as Unit 27; very little chert....... 24

28 DOLOMITE: same as Unit 27 containing small (1/4 to
1/2 inch) chert balls possible completely replaced
brachiopods? and superficial chert bands............. 30

27 Light olive gray (5Y 7/1) weathered, dark gray fresh
surface (N-3), semi-cliff-forming, very fine phaneritic
to aphanitic DOLOMITE with abundant Camarotoechia
pahranagatensis Waite in lower 12 feet of Unit........ 26

26 Very light olive gray (5Y 7/1) weathered, medium dark
gray fresh surface (N-4), semi cliff-forming very fine
phaneritic to aphanitic DOLOMITE with abundant small silicified brachiopods in lower half of Unit......

25 Light olive to yellowish gray weathered (5Y 7/1) medium dark gray fresh surface (N-4) fine phaneritic DOLOMITE with chert and relict coralline structures in lower quarter of Unit

Units 25-29 Upper member of Lone Mountain formation: 222 feet.

24 Light yellowish gray weathered, semi-cliff-forming sugary phaneritic DOLOMITE

Unit 24 Middle Member of the Lone Mountain formation, 351 feet.

23 Light to medium gray weathered, massive ledged, sugary phaneritic DOLOMITE

22 Medium olive gray (5Y 5/1) to medium dark gray (N-4) weathered, medium dark gray fresh surface phaneritic DOLOMITE with poorly preserved favositoid and halysitid corals and a few brachiopod relict structures.

21 Medium olive gray (5Y 5/1) weathered, slightly darker brownish medium gray fresh surface, massive ledged, phaneritic DOLOMITE with abundant brachiopod and coral sections in upper 50 feet of unit

20 Medium gray weathered, slightly darker fresh surface massive ledged, medium to thick bedded (6 inches to
4 feet) cliff-forming. Very fine phaneritic to aphanitic DOLOMITE with some chert in lowest part of unit.

Units 20-23 Lower Member of Lone Mountain formation, 322 feet

Total thickness of the Lone Mountain formation.............. 895

Dips from 35 to 40 degrees in the direction due East

Contact Paraconformable

Top of Fish Haven Dolomite

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Footnotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Medium olive gray weathered, slightly darker fresh surface fine phaneritic DOLOMITE.</td>
<td>37</td>
</tr>
<tr>
<td>18</td>
<td>Medium light gray weathered, slightly darker fresh surface, easily eroded bench-forming fine phaneritic to aphanitic DOLOMITE with some chert.</td>
<td>152</td>
</tr>
<tr>
<td>17</td>
<td>Medium gray weathered, slightly darker fresh surface, resistant slope to semi cliff-forming phaneritic DOLOMITE with no chert except at top of Unit and calcite veining.</td>
<td>64</td>
</tr>
<tr>
<td>16</td>
<td>Medium dark gray weathered, massive ledged, cliff-forming, chert banded phaneritic DOLOMITE.</td>
<td>24</td>
</tr>
<tr>
<td>15</td>
<td>Medium gray weathered massive ledge of CALCISILTITE.</td>
<td>8</td>
</tr>
<tr>
<td>14</td>
<td>Medium gray weathered (N-5), sandy, limy, bench-forming, phaneritic DOLOMITE with some crinoid columnals and chert.</td>
<td>36</td>
</tr>
</tbody>
</table>

Total thickness of the Fish Haven Dolomite.............. 321
Dips average 35 degrees due East

Contact Paraconformable

Top of Eureka Quartzite

13 Light brownish gray weathered (5YR 6/1), very light gray fresh surface (N-8), subangular fine grained quartz SANDSTONE with silica and calcite cement and up to 10% other minerals ................. 8

12 Medium brownish gray (5YR 5/1) weathered, medium dark gray fresh surface (N-4) sandy, limy, phaneritic DOLOMITE with some crinoid columnals.............. 3

Units 12-13 Upper member of the Eureka formation; 11 feet.

11 Very light gray (N-8) to light brown (5YR 5/5) weathered, very light gray (N-8) to white (N-9) fresh surface, cliff-forming, sub-rounded to sub-angular fine grained vitreous quartz SANDSTONE with silica cement and "worm" tubes ...................................... 232

Unit 11 Middle Member of Eureka formation: 232 feet.

10 Moderate orange pink (10R 7/4) to pale red (10R 6/2) weathered, pink to light gray fresh surface, 1 to 4 foot thick ledges of locally cross bedded, resistant slope to semi cliff-forming, dense to friable, sub-rounded to sub-angular, well sorted, very fine grained (1/8 to 1/4 inch) quartz SANDSTONE with silica cement, "worm" tubes,
and brachiopod relict fragments................. 172

Unit 10 Lower Member of Eureka formation: 172 feet.

Total thickness of the Eureka formation.............. 415

Dips vary from 38 to 40 degrees in the direction due East.

Contact Paraconformable

Top of the Lehman Formation (Pogonip Group)

9 Gray weathered, thin bedded, CALCISILTITE to CALCILUTITE with abundant brachiopods, bryozoa and gastropods ............................................. 212

8 Dark gray weathered CALCILUTITE with some interbedded ledges of CALCARENITE.................. 148

7 CALCISILTITE: same as Unit 6; resistant slope-forming. 40

6 Light gray weathered, buff gray fresh surface, nonresistant bench-forming CALCISILTITE............. 88

5 CALCARENITE: same as Unit 1; easily eroded....... 48

4 CALCARENITE: same as Unit 1; contains few Receptaculites sp. and corals ......................... 180

Units 4-8 probable Lehman formation of Pogonip Group: 716 feet. Contact with underlying Kanosh formation not satisfactorily determined.

3 CALCARENITE: same as Unit 1; prolific zone of Receptaculites sp. cf. R. mammilaris .............. 20
2 CALCARENITE: same as Unit 1; somewhat more resistant slope-forming with large gastropods on dip slopes of resistant ledges ...................... 192

1 Dark gray weathered, buff gray fresh surface, interbedded resistant ledges with less resistant shaly subunits of CALCARENITE, with some coral, brachiopod, and gastropod fragments. Contains penecontemporaneous deformation features of up to 1 inch cemented limestone fragments in lower part of Unit ..................... 112

Units 1-3 considered in Kanosh formation of the Pogonip Group 324 feet but exact contact with overlying Lehman formation not satisfactorily determined.

Total thickness of exposed Pogonip formations....... 1040

Dips vary from 35 to 40 degrees in direction due East Base unexposed
Measured section of the Eureka Quartzite on the

East face of Fossil Mountain

Section 6, Township 3 South, Range 61 East

Pahranagat Range, Lincoln County, Nevada

Section measured by Ira Cram, David Park, and Donald Blair June 14, 1959. Subdivision into members according to accepted standard regional correlations not made.

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish Haven formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Brownish gray to rust tan weathered; dark gray fresh surface (N-3), thin to thick bedded (3 inches to 4 feet) cliff-forming, medium to fine phaneritic DOLOMITE with irregular chert stringers. Contact Paraconformable Top of Eureka Quartzite</td>
<td>55</td>
</tr>
<tr>
<td>7</td>
<td>Moderate brown weathered (5 YR 4/4), light gray fresh surface (N-7), massive 7' ledges of medium grained quartz SANDSTONE</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Dip 29 degrees in the direction N 7E</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Dark to reddish brown weathered, white fresh surface, massive 3 to 5 foot beds of somewhat fractured fine grained quartz SANDSTONE</td>
<td>48</td>
</tr>
<tr>
<td>5</td>
<td>Vitreous white to grayish pink (5R 8/2) thin bedded (1&quot; to 1') partly covered bench forming, fine to medium grained quartz SANDSTONE</td>
<td>48</td>
</tr>
</tbody>
</table>
4 Light brown weathered (5YR 5/6), white fresh surface medium bedded (3" to 2''), medium to fine grained, badly fractured, cliff-forming quartz SANDSTONE ....
Dip 25 degrees in the direction N 25 W

3 Vitreous pale red purple weathered (5RP 6/2) pale pink fresh surface (5RP 8/2), thin to medium bedded (2'' to 2''), badly fractured fine to medium grained quartz SANDSTONE ..................

2 Pale red weathered (10R 6/2), pale pink fresh surface (5RP 8/2), thin discontinuously bedded (1/2'' to 2'') fine to medium grained, bench forming, quartz SANDSTONE with silica and calcareous cement............
Total thickness of the Eureka formation .............

Contact Paraconformable

Top of Pogonip Group (Lehman formation)

Pogonip

1 Dull light brownish gray weathered (5YR 6/1) medium dark gray fresh surface (N-4), thin discontinuously bedded (1/2'' to 2'') medium phaneritic DOLOMITE with thin chert stringers (1/4'') and common red staining.
Addendum to Measured Section of Eureka Quartzite on the East Face of Fossil Mountain

Partial Section N.E. 1/4 Sec. 6- N.W. 1/4 Sec. 5, T 3 S
R 61 E, Pahranagat Range, Lincoln County, Nevada
Dip 30 degrees in the direction North 12 degrees West

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base of the Fish Haven Dolomite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contact Paraconformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of the Eureka Quartzite</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Light gray weathered fine grained quartz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SANDSTONE................................................</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Medium gray weathered phaneritic DOLOMITE.......</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Units 2-3 Upper Member of the Eureka Quartzite:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 feet.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Light gray to white weathered and fresh surface,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cliff-forming, vitreous, fine grained quartz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SANDSTONE cemented by silica.......................</td>
<td>340</td>
</tr>
<tr>
<td></td>
<td><strong>Total measured Eureka Quartzite</strong>..............</td>
<td><strong>354</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Section incomplete - faulted.</strong></td>
<td></td>
</tr>
</tbody>
</table>
Measured Section of the Eureka Quartzite on Anchor Point Ridge

S.E. 1/4 of N.W. 1/4 Section 17 T 7 S, R 59 E

West Side Pahranagat Range, Lincoln County, Nevada

Dip 42 degrees in the direction N 70 E

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base of the Fish Haven Dolomite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contact Paraconformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of the Eureka Quartzite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper Member not present</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Light gray to white weathered, cliff-forming,</td>
<td>168</td>
</tr>
<tr>
<td></td>
<td>vitreous, fine grained quartz SANDSTONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unit 2 Middle member Eureka quartzite (section</td>
<td></td>
</tr>
<tr>
<td></td>
<td>faulted?).</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Medium grayish brown to brownish red weathered,</td>
<td>136</td>
</tr>
<tr>
<td></td>
<td>light yellowish gray fresh surface, resistant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>slope to semi cliff-forming, fine grained, limy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>quartz SANDSTONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unit 1 lower member Eureka quartzite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total thickness Eureka Quartzite</td>
<td>304</td>
</tr>
<tr>
<td></td>
<td>Contact Paraconformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Lehman Formation (Pogonip Group)</td>
<td></td>
</tr>
</tbody>
</table>
Measured section of the Eureka, Fish Haven, Lone Mountain, and Sevy Formations in the N.W. Pahranagat Range

N E 1/4 Section 21 to N.W.1/4 Section 22 T 5 S, R 58 E

Lincoln County, Nevada

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Light olive gray weathered, phaneritic to aphanitic DOLOMITE</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>Dip 25-33 degrees in the direction S 50 E.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total measured Sevy Dolomite</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>Top of Transition Unit - Contact Conformable</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Medium light gray weathered, medium dark gray fresh surface, fine phaneritic DOLOMITE</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Total thickness of Transition Unit 28</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Contact Paraconformable?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Lone Mountain Formation</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Medium dark gray weathered, massive 2-3 foot ledged, very fine phaneritic to aphanitic DOLOMITE</td>
<td>48</td>
</tr>
<tr>
<td>26</td>
<td>DOLOMITE: same as Unit 25, but slightly darker weathered surface. Contains abundant chert, solitary and colonial corals, and the brachiopod Camarotoechia pahranagatensis Waite (Waite Zone)</td>
<td>16</td>
</tr>
</tbody>
</table>
Medium olive gray weathered (5Y 5/1), medium dark gray fresh surface (N-4), very fine phaneritic to aphanitic DOLOMITE with silicified Amphipora sp.
and solitary corals ........................................ 72

Medium olive gray weathered (5Y 7/1), medium dark gray fresh surface (N-4), massive ledged very fine phaneritic DOLOMITE with local chert and corals including Halysites sp. ................................. 84

Dips 17°-23° in the direction S 55° E.

Units 24-27 constitute Upper Member of the Lone Mountain formation, 220'

Yellowish to light olive gray weathered (5Y 7/1) fine phaneritic DOLOMITE with 1" chert bands ........ 18

Light to medium gray weathered, bench forming,
fine phaneritic DOLOMITE; ................................. 8

Light gray weathered, cliff-forming, sugary phaneritic DOLOMITE ........................................ 248

Units 21-23 typical of middle member of Lone Mountain formation. Exact thickness and contact with lower member not satisfactorily determined.

Dark olive gray weathered, massive ledged, cliff-forming, coarse phaneritic DOLOMITE with some small (up to 4mm in diameter) algal structures .... 112
19 Dark gray weathered fine phaneritic mottled
DOLOMITE with some chert .......................... 20

18 Dark gray weathered, massive ledged, cliff-forming, very fine phaneritic DOLOMITE with some continuous 1" chert stringers and some superficial chert ...... 40

17 Medium to dark gray weathered phaneritic DOLOMITE with abundant poorly preserved brachiopod and coral sections including Favorites sp. 80' up from base of Unit .......................................................... 110

16 Dark gray weathered, massive ledged, very fine phaneritic DOLOMITE with continuous 1-2 inch wide chert bands ................................. 9

15 Medium gray weathered, medium dark gray fresh surface, massive ledged, cliff-forming, locally cherty fine phaneritic DOLOMITE ................. 116

14 DOLOMITE: same as unit 14 but containing abundant chert ......................................... 8

Units 14-19 typical of lower member of Lone Mountain formation but total thickness of member and contact with middle member not determined.

Total thickness of Lone Mountain formation .......... 909

Contact Paraconformable

Top of Fish Haven Dolomite
13 Light olive gray (5Y 6/1) to yellowish gray (5Y 7/2) weathered, medium dark gray fresh surface (N-4) very fine phaneritic to aphanitic DOLOMITE with silicified brachiopods including cf. Platystrophia sp. and coral, Bighornia sp. ................................................. 34

12 Medium gray weathered phaneritic DOLOMITE with about 40% 1–2 inch darker gray angular dolomite fragments: sedimentary breccia; penecontemporaneous deformation ................................. 20

11 Medium to dark gray weathered, massive ledged fine phaneritic DOLOMITE ............................................. 48

10 Medium light gray weathered, medium gray fresh surface, massive ledged phaneritic DOLOMITE containing darker angular dolomite fragments: penecontemporaneous deformation. Gradational contact with Unit 11 ................... 16

9 Medium dark gray weathered, massive ledged fine phaneritic DOLOMITE with dolomite veining. Gradational contact with Unit 10 ......................... 108

8 Dark gray weathered, semi-cliff-forming fine phaneritic DOLOMITE with irregularly dispersed chert knobs ................................................................. 36

7 Medium dark gray weathered, massive ledged, sugary phaneritic DOLOMITE with relict fossil fragments and no chert ......................................................... 32
Medium to dark gray weathered, massive ledged semi-cliff-forming chert banded, fine phaneritic DOLOMITE... 26

Medium to dark gray weathered, arenaceous, bench forming, fine phaneritic slightly calcareous DOLOMITE with some relict fossil fragments. ...................... 16

Total Thickness of the Fish Haven Dolomite .................. 336

Contact Paraconformable

Top of Eureka Quartzite

White weathered, cliff-forming, vitreous quartz

SANDSTONE ....................................................... 378

Pale reddish brown (10 R 5/4) to grayish pink (5R 3/2) weathered, subrounded to subangular, fine to medium grained, well sorted, massive ledged, locally cross bedded quartz SANDSTONE ....................... 174

Unit 3: lower member of Eureka formation

Total thickness of the Eureka Quartzite .................. 552

Contact Paraconformable

Top of Lehman formation of the Pogonip Group

Olive gray weathered, silty, very fine phaneritic to aphanitic DOLOMITE with some chert ............... 6

Blue-gray weathered, thin wavy bedded, non resistant CALCILUTITE .............................................. 20

Total measured Lehman formation .................. 26

Base covered.
Dips in Units 1-23, 13-15 degrees in the direction S 45-65 E.
Measured Section of the Eureka, Fish Haven, Lone Mountain, and
Sevy Formations in the Central Pahranagat Range.

N 1/2 Section 35 to N.W. 1/4 Section 36 T 6 S, R 59 E

Lincoln County, Nevada.

Entire section dips 45-55 degrees in the direction

N 50-60 degrees E.

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Section covered with angular unconformity by</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tertiary Volcanic Rocks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basal Simonson Dolomite exposed</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Contact Conformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Sevy Formation</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Moderate light yellowish brown weathered (10 YR 6/4), very light gray fresh</td>
<td></td>
</tr>
<tr>
<td></td>
<td>surface (N-8), subrounded to subangular, medium to fine grained, resistant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>quartz SANDSTONE cemented by silica and calcite.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dark yellow orange and grayish brown lichens</td>
<td>60</td>
</tr>
<tr>
<td>20</td>
<td>Pale yellowish orange weathered (10 YR 8/6), moderate yellowish brown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>fresh surface, thin bedded, saddle forming, SHALE containing brownish gray</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5 YR 4/1) chert near the top</td>
<td>112</td>
</tr>
<tr>
<td>19</td>
<td>Yellowish brown weathered, mostly covered, saddle-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>forming, aphanitic DOLOMITE and SILTSTONE</td>
<td>80</td>
</tr>
</tbody>
</table>
Units 20 and 21 definitely upper member of Sevy Formation. Part and possibly all of Unit 19 may also be within the upper Sevy member but contact is covered.

18  Covered ............................................. 8

17  Very light olive gray weathered, fine phaneritic resistant slope forming typical Sevy DOLOMITE with stylolites throughout upper 250' of unit .............. 1228

16  Very light olive gray weathered (5Y 7/1), light gray fresh surface (N-7) aphanitic to very fine phaneritic DOLOMITE with abundant silicified brachiopods throughout. These include: Howellella pauciplicata Waite Howellella smithi Waite, Howellella sp. cf H. pauciplicata, Atrypa? sp. Athyris? sp. Camarotoechia acutiplicata Amsden, Camarotoechia sp. and very large (up to 1 1/2" in length) Meristella? sp. .................. 92

Total thickness of Sevy formation ....................... 1580

Contact disconformable

Top of Lone Mountain formation

15  Medium to dark olive gray weathered (5Y 5/1)
medium to dark gray fresh surface (N-4), aphanitic to very fine phaneritic DOLOMITE containing silicified Halyrites sp. Upper 10 feet of unit on strike approximately 3/4 mile south in SW 1/4 Section 36 T 6 S, R 59 E contains prolific silicified coelenterate
faunule which include: *Breviphyllum*? sp., *Disphyllum*?

sp. *Favositessp.* and *Clavidictyon sp.*................. 89

Unit 15 is upper member of Lone Mountain formation.

14 Light gray weathered sugary phaneritic DOLOMITE.. 240

13 Medium to dark gray weathered fine phaneritic DOLOMITE .................. 16

12 Medium light gray weathered fine phaneritic to aphan-

itic DOLOMITE .......................................... 60

11 Light to medium gray weathered laminated phaneritic DOLOMITE .................. 44

Units 11-14 middle member of Lone Mountain forma-
tion - 360'

10 Dark gray weathered phaneritic DOLOMITE .......... 12

9 Massive ledge of medium gray weathered (N-5) medium
dark gray fresh surface (N-4) sugary phaneritic

DOLOMITE essentially a coquina of large (1" wide)
dolomitized, silicified poorly preserved *pentamerid*?
brachiopod fragments.................................... 5

8 Dark gray weathered, massive ledged, phaneritic

DOLOMITE with chert at top of unit ................. 40

7 Olive gray weathered (5Y 5/1), medium light gray

fresh surface (N-6) phaneritic DOLOMITE with poorly

preserved brachiopod profiles and coral sections in-

cluding *Halysites sp.*................................. 124
6 Light to medium gray weathered, resistant slope
forming aphanitic DOLOMITE .................. 80

5 Dark gray weathered fine phaneritic DOLOMITE with
abundant chert in upper part of unit. Units 5 - 10
lower member of Lone Mountain formation, 321'..... 60

Total thickness of Lone Mountain formation .......... 770

Contact Paraconformable

Top of Fish Haven Dolomite

4 Dark to medium gray weathered, partly covered
saddle forming, fine phaneritic to aphanitic DOLOMITE
with silicified brachiopods. Unit terminated by a two
foot distinctive bed of dark dolomite mottles in a field
of light gray DOLOMITE.......................... 88

3 Olive gray weathered (5Y 5/1) medium dark gray fresh
surface fine phaneritic to aphanitic DOLOMITE...... 172

Total thickness of the Fish Haven Dolomite......... 260

Contact Paraconformable

Top of the Eureka Quartzite

2 Pinkish Gray (5YR 8/1) to white (N-9) weathered, very
resistant, vitreous quartz SANDSTONE (silica cement).. 344

1 Moderate reddish to pink weathered, moderately re-
sistant, medium to fine grained quartz SANDSTONE
cemented by silica and some calcite. Distinctive worm

burrows.
Unit 1 lower member of Eureka formation .......... 168

Total thickness of the Eureka quartzite .......... 512

Contact Paraconformable

Top of Lehman formation of the Pogonip Group.
**Measured Section of the Eureka, Fish Haven, Lone Mountain and Sevy Formations at Devonian Mountain**

North 1/2 Section 20, T 7 S, R 59 E

West Side of the Pahranagat Range, Lincoln County, Nevada

Dips vary from 40-48 degrees in the direction N 70-80 degrees East

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>Very light olive gray weathered surface (5Y 7/1), slightly darker fresh surface, massive ledged, resistant slope-forming, sandy (greater than 20% subangular quartz grains) slightly calcareous very fine phaneritic to aphanitic DOLOMITE with sand stringers</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td><strong>Total measured Simonson Dolomite</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contact conformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Sevy Formation</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Grayish brown weathered (5YR 3/2), very light gray fresh surface (N-3), semi cliff-forming, subangular, fine grained quartz SANDSTONE cemented by calcite</td>
<td>56</td>
</tr>
<tr>
<td>28</td>
<td>Grayish orange weathered (10YR 7/4), medium dark gray (N-4) fresh surface, thin bedded, non resistant,</td>
<td></td>
</tr>
</tbody>
</table>
saddle-forming, cherty, silty, aphanitic DOLOMITE

with some Amphipora? sp............................. 58

27 Light olive gray (5Y 6/1) weathered and fresh surface,
thin bedded (1/2 to 3 inches) partly covered bench
forming, very fine grained quartz SANDSTONE to
SILTSTONE .............................................. 88

Units 27-23 Upper Member of Sevy formation: 202'

26 Light gray weathered, resistant slope-forming very
fine phaneritic to aphanitic DOLOMITE with dis-
tinctive stylolites from the base of unit................. 312

25 Light gray weathered, resistant slope-forming
aphanitic DOLOMITE.................................. 140

24 Light gray weathered, bench forming, aphanitic
DOLOMITE intraformational breccia cemented by
calcite .................................................. 40

23 Light gray weathered, resistant slope-forming
aphanitic DOLOMITE with disseminated chert in
lower 50 feet of unit and less resistant bench-forming
zone 100-130 feet from base of unit....................... 160

22 Light gray weathered, resistant slope to semi cliff-
forming, very fine phaneritic to aphanitic DOLOMITE
with occasional disseminated chert and vuggy zones
in the middle of the unit.............................. 580
21 Medium light gray weathered (N-6), medium olive gray fresh surface (5Y 5/1) aphanitic DOLOMITE

20 Very light gray (N-8) to almost white weathered (N-9), light yellowish gray fresh surface (5Y 9/1) aphanitic DOLOMITE containing up to 15% very fine grained quartz sand

19 Light gray weathered (N-7), very light olive gray fresh surface (5Y 7/1), massive ledged, resistant slope to semi cliff-forming, sandy, aphanitic, DOLOMITE with discontinuous sand stringers in lower half of unit

18 Medium olive gray weathered (5Y 5/1), medium dark gray fresh surface (N-4) semi cliff-forming very fine phaneritic to aphanitic DOLOMITE with some disseminated chert knobs (up to 3/4" in diameter) in lower part of unit probably representing completely replaced brachiopods and other fossil fragments

17 Medium olive gray weathered (5Y 5/1), dark gray fresh surface (N-3), semi cliff-forming, very fine phaneritic to aphanitic DOLOMITE with abundant
large (up to 13mm wide x 15mm long) Camarotoechia pahranagatensis Waite

Medium olive gray weathered (5Y 6/1), dark gray fresh surface (N-3), semi cliff-forming, very fine phaneritic to aphanitic DOLOMITE containing abundant silicified small brachiopods including Protathyris? sp. and Howellella sp.

Light olive gray weathered (5Y 4/1) medium dark gray fresh surface (N-4), massive ledged, medium bedded (3 inches to 1 foot), semi cliff-forming very fine phaneritic to aphanitic DOLOMITE with some disseminated chert increasing to chert bands in upper 20 feet of unit. Distinct weathering laminae.

Units 15-18 Upper Member of the Lone Mountain formation: 203 feet.

Very light gray (N-3) to light yellowish gray (5Y 3/1) weathered, light gray fresh surface (N-7), massive ledged, semi cliff-forming, locally vuggy fine to coarse phaneritic DOLOMITE.

Unit 14 is middle member of the Lone Mountain formation.

Medium olive gray weathered (5Y 5/1) medium gray (N-5) to medium dark gray (N-4) fresh surface, massive ledged, resistant slope to semi cliff-forming sugary
phaneritic DOLomite with zones of poorly preserved recrystallized brachiopod and coral sections in lower part of unit. Occasional distinct light and dark gray 1/16 inch color laminae and occasional cross lamina-
tions.

12 Medium gray (N-5) to medium olive gray (5Y 5/1) weathered, medium dark gray fresh surface (N-4), massive ledged, sugary phaneritic DOLomite with local chert and rare Halysites ? sp.

11 Light olive gray weathered (5Y 6/1), medium dark gray fresh surface (N-4), very fine phaneritic DOL-
MITE with chert.

Units 11-13 lower member of the Lone Mountain formation: 341 feet

Total thickness of the Lone Mountain formation......

Contact Paraconformable

Top of Fish Haven Dolomite

10 DOLomite: same as unit 8. Lower part bench-
forming; upper part resistant slope-forming. Contains fragments of dolomite (penecontemporaneous deforma-
tion) and abundant calcite veining.

9 Very light olive gray (5Y 7/1) to light gray (N-7) weathered, medium gray fresh surface (N-5), easily
eroded, bench forming, fine phaneritic DOLOMITE with abundant silicified corals including Catenipora sp. cf. C. gracilis and Streptelasma sp., and several species of brachiopods including Thaerodonta? sp. or Sowerbyella? sp. 

| 8 | Medium to medium light gray (N-5 - N 6), medium dark gray fresh surface (N-4), massive ledged, phaneritic DOLOMITE with local chert. Lower half of unit resistant slope to semi cliff-forming; upper half more easily eroded slope to bench-forming. | 227 |
| 7 | Medium dark gray (N-4) to medium brownish gray (5YR 5/1) weathered, dark gray fresh surface (N-3), semi cliff-forming phaneritic cherty DOLOMITE | 54 |
| 6 | Medium light gray weathered (N-6), medium dark gray fresh surface (N-4) massive 1-2 foot ledges of resistant slope-forming CALCILUTITE to CALCISILTITE with locally abundant chert bands and abundant small silicified brachiopods and unique beaded crinoid columnals | 15 |
| 5 | Medium gray, sandy, bench-forming, fine phaneritic limy DOLOMITE to CALCISILTITE | 28 |

Total thickness of the Fish Haven formation | 352 |

Contact Paraconformable

Top of the Eureka Quartzite
4  SANDSTONE: same as unit 2 ...................... 15

3  Medium gray (N-5) to medium brownish gray (5YR 5/1) weathered, medium gray fresh surface (N-5) sandy phaneritic DOLOMITE .................... 5

Units 3 and 4 upper member Eureka quartzite: 20'

2  Very light gray (N-8) to white (N-9) weathered and fresh surface, vitreous, massive, cliff-forming, (more resistant than unit 1 below), subrounded to subangular, well sorted, very fine grained quartz SANDSTONE with silica cement. Some friable zones in upper half of unit. 205

Unit 2 middle member of Eureka formation

1  reddish brown weathered, massive (compact), sub- rounded, well sorted, quartz SANDSTONE ............ 160

Unit 1 lower member of Eureka formation

Total thickness of the Eureka formation ............... 385

Contact paraconformable?

Top of Lehman formation (Pogonip Group)

Section continuously exposed
Measured Section of the Fish Haven and Lone Mountain Formations at the Buckhorn Fault

N.W. 1/4 Section 17 to S.E. 1/4 Section 18 T. 8 S. R. 61 E.

Pahranagat Range, Lincoln County, Nevada

Dips from 18-25 degrees in the direction S 30-40 W.

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Typical Sevy Dolomite. Light yellowish gray (5Y 9/1) weathered surface, light olive gray fresh surface (5Y 7/1), resistant slope forming, fine phaneritic to aphanitic DOLOMITE. No chert</td>
<td>4</td>
</tr>
</tbody>
</table>

Total measured Sevy Dolomite ....................... 4

Gradational Conformable Contact

Top of Transition Unit

15 Light gray weathered and fresh surface, sandy, cherty fine phaneritic DOLOMITE that grades upward into a yellowish gray (5Y 8/1) weathered and grayish yellow fresh surface (5Y 8/4) cherty phaneritic DOLOMITE, which then grades into Unit 16. Unit forms poorly resistant saddle. Considered a transition unit between the Lone Mountain and Sevy formations ............... 32

Total thickness of Transition Unit 15 ............... 32

Contact Paraconformable?

Top of Lone Mountain Formation
14 Light olive gray weathered (5Y 6/1), medium to dark gray fresh surface (N-4), massive ledged, medium bedded (8 inches to 2 feet), semi cliff-forming, fine phaneritic to aphanitic DOLOMITE containing brown weathered cherty organic fragments including colonial corals. Upper 100 feet of unit has abundant chert and meager solitary coral assemblage. Unit 14 is upper member of Lone Mountain formation.

13 Light yellowish gray (5GY 9/1) weathered and fresh surface, resistant slope forming, 3 to 4 foot ledges, of coarse phaneritic DOLOMITE becoming vuggy in upper half of unit (up to 1/4 inch vugs). Contains some crinoid columnals.

12 Light olive gray (5Y 6/1) weathered, light gray fresh surface, massive cliff forming, sugary phaneritic cherty DOLOMITE. Contains silicified Favosites sp. and other fossil fragments. Stromatoporoid? Units 12 and 13 comprise middle member of Lone Mountain formation, 460'.

11 Medium light gray weathered (N-6) to medium gray (N-5) massive ledged phaneritic DOLOMITE containing abundant large brachiopod relict structures and rare specimens of Halysites sp.
10 Medium gray weathered, massive semi-cliff-forming fine phaneritic DOLOMITE with intermittent brown weathered thin sandy beds and fairly abundant brachio-
pods and coral castes ..................................... 116

9b Medium to light gray weathered, medium to dark gray fresh surface, medium bedded (6 inches to 1 foot), resistant slope forming, fine phaneritic to aphanitic sugary DOLOMITE. Gradational contact into unit 10..... 94

9a Medium dark gray weathered (N-4), dark gray fresh surface (N-3) massive, resistant, aphanitic DOLOMITE with abundant chert. Unit grades into 9b............. 6

Units 9-11 comprise lower member of Lone Mountain formation, 230'.

Total thickness of Lone Mountain formation............. 928

Contact irregular-Disconformable

Top of Fish Haven Dolomite

8 Light olive to yellowish gray weathered (5Y 7/1), darker fresh surface, moderately resistant slope forming, medium bedded (4 inches to 2 feet), very fine phaneritic to aphanitic slightly limy DOLOMITE. Faint pinkish mottling. Contains large 3/4 to 1 inch diameter strophomenoid brachiopods aff. Strophomena sp. and Rafinisquina sp. as well as several other brachiopod genera and several species of solitary corals including Bighornia sp. Abundant light brown (5YR 5/5) chert blobs
in upper part of unit. Terminates with a distinctive 2 foot bed of mottles of medium gray slightly limy dolomite in a field of light olive gray DOLOMITE.

Light bluish gray weathered (5B 7/1), light olive gray fresh surface (5Y 5/2), thin to very thin wavy and discontinuously bedded, (above wave base), shaly parted resistant slope forming CALCISILTITE to CALCILUTITE. Becomes Buff-gray and partly dolomitized along strike, partly conglomeritic and containing abundant gastropods, brachiopods, crinoid stems, trilobite segments and appendages, and small solitary corals. Possible raindrop impressions? Becomes thicker bedded (3-4 inches) and more continuously bedded in upper part of unit.

Medium light gray weathered (N-6), dark gray fresh surface (N-3) thin discontinuously bedded (1 to 3 inches), shaly parted, poorly resistant, saddle forming, aphanitic DOLOMITE.

Medium dark gray weathered (N-4), dark gray fresh surface (N-3), highly fractured, medium bedded (4 inches to 2 feet) resistant fine phaneritic to aphanitic DOLOMITE containing abundant chert lenses up to 2 inches thick and a silicified small cup coral faunule 160 feet up from bottom of unit. Specimens not abundant.
Medium light gray weathering (N-6) slightly lighter fresh surface, fractured and calcite veined, sandy, massive cliff-forming fine phaneritic limy DOLomite ........................................... 2

Moderate to light brown weathered (5YR 5/4), light to medium gray fresh surface, massive ledged, medium to thick bedded, resistant slope forming, medium to coarse (1/4 to 1 mm) quartz SANDSTONE cemented by limy dolomite and silica.

Occasional black lichens .................................. 12

Gray (N-5) weathered, partly dolomitized, sandy, cherty, medium bedded, bench forming, fine CALCARENITE. Grades into unit 3b ......................... 16

Total thickness of Fish Haven Dolomite ............... 412

Contact Paraconformable.

Top of Eureka Quartzite

Yellowish brown weathered, light gray fresh surface, rounded, fine to medium grained quartz sandstone.

Calcareaous and silica cement, friable weathered surface. Less well sorted and less resistant than unit 1... 4

White (N-9) vitreous, massive cliff forming, fine to medium grained, subrounded to subangular, quartz SANDSTONE with slight ferruginous stain.............. 30

Total measured Eureka Quartzite ....................... 34
Base of Section faulted. Complete Eureka section not exposed.
Measured Section of the Fish Haven, Lone Mountain, and Sevy formations at Middle Mountain

N 1/2 Section 8, T 7 S, R 59 E

West Side Pahranagat Range, Lincoln County, Nevada

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simonson Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact Conformable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top of Sevy Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Moderate brown weathered, light yellowish gray fresh surface, semi cliff-forming quartz SANDSTONE</td>
<td>84</td>
</tr>
<tr>
<td>17</td>
<td>Dusky yellow to grayish orange weathered, easily eroded saddle to bench-forming partly covered</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>SILTSTONE and aphanitic DOLOMITE</td>
<td></td>
</tr>
</tbody>
</table>

Units 17-18 Upper Member of the Sevy Formation:

194'

16 | Light olive gray weathered, light gray fresh surface, resistant slope to semi cliff-forming, fine phaneritic to aphanitic DOLOMITE with stylolites in upper 420 feet of Unit and amphiporid? structures in upper 100 feet of Unit | 1300 |

Total thickness of Sevy formation | 1494 |
Contact Paraconformable

Top of Lone Mountain formation

15 DOLOMITE: same as Unit 11

14 DOLOMITE: same as Unit 11 containing distinctive small 1/4 inch chert balls possibly completely re-
placed brachiopods?

13 DOLOMITE: same as Unit 11 containing abundant silicified Camarotoechia pahranagatensis Waite in lower part of Unit.

12 DOLOMITE: same as Unit 11 containing abundant silicified brachiopods (Waite Zone)

11 Medium olive gray weathered, medium dark gray fresh surface fine phaneritic to aphanitic DOLOMITE
units 11-15 Upper Member of Lone Mountain formation; 164 feet.

10 Light gray weathered, resistant slope to semi cliff-
forming phaneritic DOLOMITE

Unit 10—Middle Member of Lone Mountain formation.

9 Medium dark gray weathered, semi cliff-forming fine phaneritic to aphanitic DOLOMITE

8 Medium dark gray weathered DOLOMITE

Units 8-9 definite Lower Member of Lone Mountain formation; minimum thickness 284 feet. Contact with underlying Fish Haven Dolomite not determined but Lone
Mountain may include at least half of Unit 7 or up to 330 feet?

7  DOLOMITE: same as Unit 5 containing poorly preserved brachiopod and coral sections in upper part of Unit.  .......................................................... 92

6  Medium to dark gray weathered, resistant slope to semi cliff-forming DOLOMITE.  ...................... 68

5  Brownish gray weathered, easily eroded bench-forming DOLOMITE.  ............................................. 104

Units 1-5 definite Fish Haven Dolomite; minimum thickness 200 feet. Contact with overlying Lone Mountain formation not determined but probably not higher than mid-unit 7 or approximately 300 feet.

4  Medium dark gray weathered, semi cliff-forming phaneritic DOLOMITE.  ............................................. 24

3  Gray weathered massive ledged cliff-forming CALCARENITE.  .......................................................... 24

2  Blue-gray weathered, heavy ledged, resistant slope-forming CALCARENITE with abundant chert bands. 24

1  Medium gray weathered (N-5), medium dark gray fresh surface (N-4), partly covered bench-forming sandy CALCISILTITE.  .......................................................... 24

Total combined thickness of Fish Haven formation and lower Member of the Lone Mountain formation.  644
Contact Paraconformable

Top of Eureka Quartzite

Grayish red (5 R 4/2) to pale red (5 R 6/2)

weathered and fresh surface, thin bedded, very fine

grained limy SANDSTONE to SILTSTONE .............. 3

Total measured Eureka Quartzite ..................... 3

Section continuously exposed
Measured Section of the Fish Haven, Lone Mountain
and Sevy formations at Fossil Mountain

Section 6, Township 3 South, Range 61 East
Pahranagat Range, Lincoln County, Nevada

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Very light gray weathered (N-8), olive gray fresh surface (5Y 4/1), thin to medium bedded, cliff-forming, aphanitic DOLOMITE with light brown chert stringers</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td><strong>Total measured Simonson Dolomite</strong></td>
<td><strong>10</strong></td>
</tr>
<tr>
<td></td>
<td>Contact Conformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Sevy formation</td>
<td></td>
</tr>
</tbody>
</table>

| 9d      | Grayish orange (10 YR 7/4) to dark yellowish brown (10 YR 4/2) light olive gray fresh surface (5Y 6/1), silica cemented, cross-bedded, fine grained quartz SANDSTONE | 9                   |
| 9c      | Pale yellowish-orange weathered (10 YR 7/4), medium gray fresh surface (N-5) thin bedded (2 to 6 inches) aphanitic to fine phaneritic DOLOMITE | 8                   |
| 9b      | Very pale yellow weathered, yellowish gray fresh surface, two foot ledges of cross bedded, resistant, arenaceous, (40% quartz grains) fine phaneritic DOLOMITE | 28                  |
Units 9b-d are here placed in Sevy formation but may possibly represent lowest Simonson above major terminating sand member of the Sevy.

9a Yellowish gray (5Y 3/1) to very dusky red (10R 2/2) weathered, very light gray (N-8) to yellowish gray, (5Y 8/1) fresh surface, fine to medium grained, well sorted, rounded to subrounded, massive, resistant cliff forming continuously bedded ledges (3 inches to 4 feet) cross-bedded quartz SANDSTONE cemented by slightly calcareous dolomite......................... 23

8 Grayish yellow weathered (5Y 8/4), medium gray fresh surface (N-5), partly covered non-resistant, saddle forming, aphanitic to very fine phaneritic DOLOMITE.

Unit has a 1 foot of brown quartz sandstone at the base.. 16

Units 8 and 9a are upper member of Sevy formation, 39', with 9b-d, 34'.

7 Yellowish gray weathered (5Y 7/1), slightly lighter fresh surface (5Y 8/1) very arenaceous, cross-bedded, medium phaneritic DOLOMITE. 40% subrounded to subangular quartz grains. Fore-set bed dips: 43 degrees N 80 W: 32 degrees N 42 E; 25 degrees N 85 W: 55 degrees N 45 E ............................................. 16
From 1 to 20 foot irregular alternations of the following lithologies: 
a) Very light gray weathering (N-8) light olive gray fresh surface (5YR 6/1), thick 2 to 6 foot massive ledges of thin bedded (2 inches), aphanitic to fine phaneritic DOLOMITE containing some light brownish red 1/8" to 1" chert stringers and common stylolites. 
b) Light gray (N-7) to moderate brown weathered (5YR 4/4) light brownish gray fresh surface (5YR 6/1), 2 to 4 foot ledges of thin to medium bedded, medium to coarse phaneritic DOLOMITE with common chert stringers. 

Light olive gray weathered (5Y 6/1) dark gray fresh surface (N-3) thin to medium bedded, fine phaneritic DOLOMITE. A distinctive darker unit. 

DOLomite: Same as Unit 6. 

From 5 to 20 foot irregular alternations of DOLOMITE same as a in Unit 6 with light olive gray weathering (5Y 6/1), dark gray fresh surface (N-3), thick (2 to 10 foot ledges of laminated fine phaneritic DOLOMITE. Distinctive deep differential weathered grooves indicating fundamental thin beds within thick parted ledges. First stylolites occur 335 feet from base of unit or 749 feet from base of formation.
From 5 to 20 foot irregular alternations of DOLOMITE
same as a in Unit 6 with light olive gray (5Y 6/1) to
light brownish gray (5YR 6/1) weathered, olive gray fresh
surface (5Y 4/1), thick, 2 to 10 foot ledges of thin bedded,
medium to coarse phaneritic DOLOMITE ............... 169

Very light gray weathered (N-3), light olive gray fresh
surface (5Y 6/1), massive 2 to 6 foot ledges of indistinct
thin bedded, semi-cliff forming, aphanitic to very fine
phaneritic DOLOMITE. Lower 30' of unit contains brown
weathered disseminated chert and poorly preserved sili-
cified small corals and brachiopods .................... 245

Total thickness of Sevy formation ....................... 1524

Dip 41-43° in the direction N 33-36 W

Contact Paraconformable

Top of Lone Mountain formation

Pale yellowish brown (10 YR 6/2) to light olive gray
weathered (5Y 5/1), medium dark gray fresh surface
(N-4), massive ledged, cliff-forming, aphanitic to fine
phaneritic DOLOMITE. Top 60' of unit distinguished by
wavy 2 to 10 inch continuous bedding, 1 to 2 inch chert
stringers and nodules, and locally abundant silicified
colonial and solitary corals, brachiopods and stromtoporoid
structures ....................................................... 188

Unit 17 represents Upper member of the Lone Mountain
formation.
16 Yellowish gray weathered (5Y 8/1), very light gray fresh surface (N-8), semi cliff-forming vuggy medium phaneritic DOLOMITE. Upper part coarse phaneritic and vuggy. 160

15 Olive gray weathered (5Y 4/1), medium dark gray fresh surface (N-4), medium bedded (6") semi-cliff forming fine phaneritic DOLOMITE ........................................ 64

14 Light gray weathered (N-7), medium gray fresh surface (N-5), medium continuously bedded (6" to 2") cliff-forming aphanitic DOLOMITE. Contains intermittent brown weathered chert. Upper 16 feet of unit is coarse phaneritic DOLOMITE ........................................ 100

Units 14-16: middle member of Lone Mountain formation - 324'

13 Medium light gray (N-7) to light olive gray weathered surface (5Y 6/1), medium light gray fresh surface (N-7), massive ledged, cliff-forming, phaneritic DOLOMITE. Contains superficial chert and abundant sections of brachiopod and coral fragments. Upper part of unit contains Favosites sp. larger brachiopods and an increase of chert. ......................................................... 104

12 Light brownish gray weathered (5YR 5/1), medium gray fresh surface (N-5), fine phaneritic DOLOMITE with some chert. ................................................................. 40
11 Light gray weathered and fresh surface (N-7), thin bedded
(1-6 inches), semi cliff-forming aphanitic DOLOMITE .... 40

10 Light olive gray weathered (5Y 6/1), dark gray fresh
surface (N-3) fine phaneritic DOLOMITE with abundant
chert. First 16 feet cliff-forming, 8 foot bench, followed
by 20 feet cliff-forming ...................................... 44

Units 10-13: lower member of the Lone Mountain
formation - 223'

Total thickness of the Lone Mountain formation ........ 740

Contact Paraconformable

Top of Fish Haven Dolomite

9b Light brownish gray weathered (5YR 7/1), grayish pink
fresh surface (5R 8/2), thin bedded (1-2 inches) bench
forming, very fine phaneritic DOLOMITE with abundant
silicified brachiopods which include: Platyostrophia sp.,
Zygospira sp., Glyptothecia sp., Plagiomys sp.,
Diceromyonia ? sp., Thaerodonta ? sp., or Sowerbyella ?
sp., Strophomema sp. and Rafinisquina sp., and corals
including Bighornia sp. Unit is terminated by a barren 2
foot distinctive bed of irregular medium gray DOLOMITE
mottles in a field of light pinkish gray DOLOMITE ....... 16

9a Light olive gray weathered (5Y 6/1) medium light gray
fresh surface (N-6), massive ledged, bench forming,
medium phaneritic sugary DOLOMITE ..................... 140
8 Olive gray weathered (5Y 4/1), medium dark gray fresh surface (N-4), cliff-forming, thin bedded (2" - 4") fine phaneritic DOLOMITE with intermittent cherty knobs up to 3" in diameter. .......................... 100

7 Olive gray weathered (5Y 4/1), dark gray (N-3) to grayish black (N-2) fresh surface, medium bedded (2-3 feet), highly fractured and calcite veined, cliff-forming fine phaneritic DOLOMITE. Weathers lighter than Unit 6 with relatively no chert. Contains brachiopod zone 6B feet above base of unit aff. Rhynchotrema sp. .............. 92

6 Same lithology as Unit 5 - DOLOMITE, but distinguished by chert increasing from 1/4 to 1/2 inch knobs to 2 to 6 inch lenses and knobs in upper half of unit. Cliff-forming. ........................................ 30

5 Medium dark gray weathered (N-4), dark gray fresh surface (N-3), medium bedded (8" to 2'), bench forming, abundant calcite veined fine phaneritic DOLOMITE..... 39

4 Light olive gray weathered (5Y 6/1), dark gray fresh surface (N-3), medium bedded (4" to 2'), cliff-forming, fine phaneritic DOLOMITE with 1" to 4" chert nodules. 63

3 Olive gray to brownish gray weathered (5Y(R)4/1), medium dark gray fresh surface (N-4), massive cliff-forming, thick bedded (3 to 5 feet) fine phaneritic DOLOMITE with discontinuous chert stringers at base of unit. 28
2 Light olive gray weathered (5Y 5/1), dark gray fresh surface (N-3), medium bedded (4 to 8 inches) partly covered, bench forming, fine phaneritic to aphanitic slightly calcareous DOLOMITE. Rare small brachiopods. 28

Total thickness of the Fish Haven dolomite ............... 527

Dip increases from 30-40° upward in Fish Haven and Lone Mountain section in direction N 10-15 degrees W.

Contact sharp: Paraconformable

Top of Eureka Quartzite

1 Moderate reddish brown (10R 4/6) to dark reddish brown weathered (10R 3/4), very light gray fresh surface (N-8) fine to medium grained (1/8-1/2mm), medium bedded 1-3 feet) well sorted, sub-rounded resistant quartz SANDSTONE - (Orthoquartzite) with friable weathered surface................................................................. 10

Total measured Eureka quartzite ....................... 10
Measured Section of the Sevy and Simonson Formations

and part of the Guilmette formation at Downdrop Mountain - South Ridge

South 1/2 Section 30, T 6 S, R 59 E, Lincoln County, Nevada

Dip from 42-50 Degrees in the direction S 80-90 Degrees E

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Section continuously exposed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guilmette formation</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>Light olive to yellowish gray weathered (5Y 7/1), resistant slope-forming, thin bedded to laminated, aphanitic DOLOMITE with medium gray weathered, phaneritic DOLOMITE and intermittent SILTSTONE</td>
<td>62</td>
</tr>
<tr>
<td>60</td>
<td>Medium dark gray weathered, slope-forming, massive ledged, laminated DOLOMITE</td>
<td>22</td>
</tr>
<tr>
<td>59</td>
<td>Pale grayish orange weathered DOLOMITE: same as unit 57</td>
<td>12</td>
</tr>
<tr>
<td>58</td>
<td>Medium dark gray weathered, thinly laminated, partly penecontemporaneously brecciated DOLOMITE</td>
<td>15</td>
</tr>
<tr>
<td>57</td>
<td>Pale grayish orange weathered (10 YR 8/4), light olive gray fresh surface (5Y 6/1), easily eroded,</td>
<td></td>
</tr>
</tbody>
</table>
bench-forming, thin bedded to laminated,
aphanitic DOLOMITE ("yellow beds")

56 Medium dark gray weathered, slope-forming, thin bedded (2-4 inches) aphanitic DOLOMITE with differential weathering laminations

55 DOLOMITE: same as unit 54

Total measured thickness of Guilmette formation

(All lower member Guilmette formation)
Contact conformable
Top of Simonson formation

54 Medium gray weathered, resistant slope-forming, aphanitic to phaneritic DOLOMITE, with brachiopod and coral fragments at top of unit. (Stringocephalus? zone)

53 Undifferentiated alternating brown and gray DOLOMITES as unit 51 with small silicified Emanuella subumbona at top of unit

52 Medium light gray phaneritic DOLOMITE

51 Undifferentiated alternating 2-6 foot units of medium light gray weathered and olive to brownish gray weathered fine phaneritic DOLOMITES. Some hydrocarbon odor in brown lithology

50 DOLOMITE: same as unit 48
49 Intraformational DOLOMITE BRECCIA............. 10

48 Medium light gray weathered, resistant slope to
semi cliff-forming, vuggy phaneritic DOLOMITE... 37

Units 48-54 definite Upper Alternating member
Simonson formation-minimum thickness 300 feet
but member also includes up to 100 feet of unit 47.
Precise contact not determined.

47 Medium light gray weathered, semi cliff-to-cliff-
forming, massive ledged fine phaneritic DOLO-
MITE with some darker weathered sugary
phaneritic DOLOMITE................................. 165

46 Light olive gray (5Y 6/1) to olive gray (5Y 4/1)
weathered, medium to dark gray fresh surface
(N-5 to N-4), semi cliff-forming, massive, very
fine phaneritic to aphanitic mottled DOLOMITE.... 78

Unit 46 and part of unit 47 Cliff Member Simonson
formation 78-133? feet. Contact between members
not definitely determined.

45 Medium gray weathered with both lighter and darker
fresh surfaces, resistant slope-forming, limy
fine phaneritic DOLOMITE with relict organic
structures and amphiporids......................... 16
<table>
<thead>
<tr>
<th>Page</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>Undifferentiated alternating gray and brown</td>
<td>40</td>
</tr>
<tr>
<td>43</td>
<td>Medium light gray weathered, resistant slope-forming phaneritic DOLOMITE</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>with brown bands</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Brown DOLOMITE: same as unit 15</td>
<td>6</td>
</tr>
<tr>
<td>41</td>
<td>Gray DOLOMITE: same as unit 32</td>
<td>15</td>
</tr>
<tr>
<td>40</td>
<td>Brown DOLOMITE: same as unit 15</td>
<td>6</td>
</tr>
<tr>
<td>39</td>
<td>Gray DOLOMITE: same as unit 32</td>
<td>8</td>
</tr>
<tr>
<td>38</td>
<td>Brown DOLOMITE: same as unit 15</td>
<td>7</td>
</tr>
<tr>
<td>37</td>
<td>Medium light gray weathered, slope-forming, laminated (1/4 inch), platy</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>limy DOLOMITE</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Gray DOLOMITE: same as unit 32</td>
<td>8</td>
</tr>
<tr>
<td>35</td>
<td>Brown DOLOMITE: same as unit 15</td>
<td>6</td>
</tr>
<tr>
<td>34</td>
<td>Gray DOLOMITE: same as unit 32</td>
<td>12</td>
</tr>
<tr>
<td>33</td>
<td>Brown DOLOMITE: same as unit 15</td>
<td>4</td>
</tr>
<tr>
<td>32</td>
<td>Medium light gray, fine phaneritic to aphanitic DOLOMITE</td>
<td>9</td>
</tr>
<tr>
<td>31</td>
<td>Brown DOLOMITE: same as unit 15</td>
<td>4</td>
</tr>
<tr>
<td>30</td>
<td>Gray DOLOMITE: same as unit 20</td>
<td>12</td>
</tr>
<tr>
<td>29</td>
<td>Brown DOLOMITE: same as unit 15</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>Medium light gray weathered, fine phaneritic DOLOMITE</td>
<td>6</td>
</tr>
<tr>
<td>27</td>
<td>Medium gray weathered, fine phaneritic DOLOMITE</td>
<td>9</td>
</tr>
</tbody>
</table>
26 Gray DOLOMITE: same as unit 20.......................... 3
25 Brown DOLOMITE: same as unit 15......................... 6
24 Gray DOLOMITE: same as unit 20.......................... 3
23 Brown DOLOMITE: same as unit 15......................... 3
22 Gray DOLOMITE: same as unit 20.......................... 6
21 Brown DOLOMITE: same as unit 15......................... 7
20 Medium light gray weathered, fine phaneritic

DOLOMITE.................................................. 8
19 Brown aphanitic hydrocarbon DOLOMITE: same
as unit 15..................................................... 4
18 Medium light gray weathered, aphanitic to fine
phaneritic DOLOMITE........................................ 6
17 Brown hydrocarbon DOLOMITE: same as unit 15.... 2
16 Light gray weathered, darker gray fresh surface,
resistant slope-forming, fine phaneritic DOLOMITE. 50
15 Medium brownish gray (5 YR 5/1) to medium olive
gray (5Y 4/1) weathered, medium dark gray (N-4)
to brownish gray (5Y 4/1) fresh surface, resistant
slope-forming, thin bedded to laminated, fine
phaneritic DOLOMITE with strong hydrocarbon
fetid odor ................................................... 2

Units 15-45 Lower Alternating member Simonson
formation: 306 feet. Member may also include part
or all of unit 14?
<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Medium light gray weathered, fine phaneritic DOLOMITE with some slightly darker weathered limy DOLOMITE</td>
</tr>
<tr>
<td>13</td>
<td>Very light yellowish brown (10 YR 7/2) to light gray (N-7) weathered and fresh surfaces, semi cliff-forming, massive, very coarse phaneritic DOLOMITE</td>
</tr>
<tr>
<td>12</td>
<td>Light gray weathered aphanitic DOLOMITE and medium dark gray phaneritic DOLOMITE</td>
</tr>
<tr>
<td>11</td>
<td>Light olive gray weathered, sandy (up to 20%) quartz, phaneritic DOLOMITE</td>
</tr>
<tr>
<td>10</td>
<td>Very pale orange (10 YR 8/2) to very light olive gray (5Y 7/1) weathered, very light gray to white fresh surface, resistant slope to semi cliff-forming coarse phaneritic DOLOMITE</td>
</tr>
<tr>
<td>9</td>
<td>DOLOMITE: same as unit 8 with less sand</td>
</tr>
<tr>
<td>8</td>
<td>Medium yellowish brown (10 YR 5/2) to light gray weathered (N-7), medium light gray (N-6) to light olive gray (5Y 6/1) fresh surface, resistant slope to semi cliff-forming, massive ledged (2-3 feet), very sandy, aphanitic to fine phaneritic DOLOMITE with sand stringers</td>
</tr>
</tbody>
</table>

Units 8-14 Coarse Member Simonson formation:
260 feet; but may not include all of unit 14.

Total thickness of the Simonson formation .......... 1109

Contact Conformable

Top of the Sevy formation

7 Light yellowish and brownish gray weathered,
very light gray fresh surface, semi cliff-forming,
medium bedded (6 inches to 2 feet) cross-bedded,
massive, well sorted, subrounded to subangular,
dolomitic quartz SANDSTONE ......................... 51

6 Grayish orange (10 YR 7/4) to yellowish gray
(5Y 8/1) weathered, olive gray fresh surface
(5Y 5/1), bench to slope-forming, thin to medium
bedded, silty aphanitic DOLOMITE with brown
chert knobs ............................................. 65

5 Very pale grayish orange (10 YR 8/4) to dark
yellowish-olive gray (5Y 7/1) weathered and fresh
surfaces, easily eroded, saddle-forming calcarceous SILTSTONE to sandy shaly CALCISILTITE. 53

Units 5-7 Upper member of the Sevy formation:
169 feet.

4 Aphanitic to very fine phaneritic DOLOMITE: same
as units 1 and 3 with very light gray fresh surface
(5Y 7/1) .................................................. 149
3 Aphanitic to very fine phaneritic DOLOMITE:
same as unit 1 with a few 2-3 foot darker gray
weathered zones. Abundant stylolites spaced
6 inches apart...................................... 208

2 Covered........................................... 124

1 Very light gray (N-8) to light yellowish gray
(5Y 9/1), resistant slope-forming, massive 3 foot
ledges of thin bedded (differential weathering
laminations) aphanitic to very fine phaneritic
DOLOMITE with some sand stringers............. 311

Units 1-4 upper part of lower member of Sevy
formation: 792 feet (incomplete)

Total measured thickness of Sevy formation...... 961

Base of section covered.
Measured Section of the Upper Member of the Sevy Formation, the Simonson Formation, and the Lower Member of the Guilmette Formation near Mount Irish

S 1/2 Sections 2 and 3; N 1/2 Sections 10 and 11,

T 4 S, R 59 E Lincoln County, Nevada

Dip 7-17 Degrees in the Direction N 27-75 Degrees W

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dip Slope (Section Continuously Exposed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guilmette formation (upper member)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>113</td>
<td>Brownish gray weathered, fine phaneritic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DOLOMITE with <strong>amphiporids</strong></td>
<td>20</td>
</tr>
<tr>
<td>112</td>
<td>Light olive gray aphanitic DOLOMITE</td>
<td>3</td>
</tr>
<tr>
<td>111</td>
<td>Brownish gray weathered, fine phaneritic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DOLOMITE with <strong>hydrocarbon odor</strong></td>
<td>7</td>
</tr>
<tr>
<td>110</td>
<td>Medium olive gray weathered, resistant slope-forming, thin bedded (2-6 inches) aphanitic</td>
<td>12</td>
</tr>
<tr>
<td>109</td>
<td>Alternating medium light gray and medium brownish gray weathered, phaneritic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DOLOMITE with <strong>amphiporids</strong></td>
<td>48</td>
</tr>
</tbody>
</table>
108 Medium gray weathered, resistant slope-forming, medium bedded (1-3 feet) fine phaneritic DOLOMITE with amphiporids ......................... 16

107 Partly covered, bench-forming, shaly LIMESTONE. ...................... 40

106 Medium dark gray, slope-forming, medium bedded (6 inches - 1 foot) recrystallized CALCISILTITE with relict corals ......................... 8

105 Very light gray (N-8) to yellowish gray (5Y 8/1) weathered, medium light gray (N-6) to light gray (N-7) fresh surface, semi cliff-forming, massive (no bedding) recrystallized CALCARENITE to CALCISILTITE BIOHERM containing abundant coralline, brachiopod, gastropod and crinoid columnal structures in lower 30 feet of unit which is partly dolomitized. Unit is lens shaped 0-172 feet ................................................................. 172

Units 105-113 lower part of upper member Guilmette formation: 326 feet.

104 Medium gray weathered, darker gray fresh surface, massive cliff of recrystallized LIMESTONE containing locally prolific algal and stromatoporoidea? biscuits, amphiporids? and other organic structures (Algal Biostrome). Unit contains some
interbedded limy phaneritic DOLOMITE. Upper 20 feet contains prolific poorly preserved recrystallized branching, and frondose colonial corals, solitary corals and some brachiopods (Atrypa sp.) .............................................. 290

103 Medium light gray to light olive gray weathered, slope-forming, thin bedded, silty CALCILUTITE... 7

102 Medium gray weathered, medium dark gray fresh surface, algal LIMESTONE with brown spiriferoid brachiopods .................................................. 6

101 Medium dark gray to bluish gray weathered, semi cliff-forming, thin to medium bedded, massive, fine CRYSTALLINE LIMESTONE to CALCILUTITE containing algal bisucits and some interbedded aphanitic DOLOMITE............................ 40

100 Medium light gray weathered, olive gray fresh surface, semi cliff-forming, thin to medium bedded (3 inches to 2 feet), massive phaneritic DOLOMITE with algal structures at base of unit... 11

99 Medium dark gray to bluish gray weathered, semi cliff-forming fine CRYSTALLINE LIMESTONE. 21

98 Medium gray weathered, semi cliff-forming, aphanitic DOLOMITE interbedded about every 4 feet
with a 1 foot ledge of medium dark gray weathered very fine CRYSTALLINE LIMESTONE............. 12

Medium gray (N-5), to light gray (N-7) and light olive gray weathered (5Y 6/1), medium olive gray fresh surface (5Y 5/1), resistant slope-forming, medium bedded, fine CRYSTALLINE LIMESTONE with gastropod castes and algal structures inter-bedded with thin beds containing abundant re-crystallized fossil hash of relict brachiopod, gastropod and algal structures ................. 20

Medium light gray weathered, medium dark gray fresh surface, slope-forming, medium bedded, (6 inches to 1 foot) aphanitic DOLOMITE............. 28

Medium dark gray weathered, semi cliff-forming, medium bedded (6 inches to 3 feet), massive, recrystallized CALCILUTITE with some branching coralline? and amphiporid structures ............... 40

Medium olive to brownish gray weathered, re-sistant slope-forming, 6 inch beds of aphanitic DOLOMITE............................ 8

Alternating medium dark gray and medium light gray weathered, semi cliff-forming, thick to medium bedded CALCILUTITE to CRystALLINE
LIMESTONE containing some **amphiporids**? and **algae** with some partly dolomitized beds ............

92 Medium dark gray to bluish gray weathered, resistant slope to semi cliff-forming, massive ledges of **CALCISILTITE** to **CALCILUTITE** containing abundant **algal biscuits** (**algal biostromes**) and lighter gray weathered, laminated to thin bedded dolomitic **LIMESTONE** ......................

91 Medium dark gray to bluish gray weathered, resistant slope-forming, medium bedded (6 inches to 1 foot) **CALCILUTITE** or extremely fine **CRYSTALLINE LIMESTONE** containing some **amphiporids**? and **algae** alternating with medium light to olive gray weathered, thin beaded to laminated, limy aphanitic **DOLOMITE** ..............

90 Medium dark to bluish gray weathered, massive cliff-forming, **CALCILUTITE** with **algal biscuits** and **amphiporids**? .....................................................

89 Medium dark gray weathered, resistant slope-forming, massive 1-2 foot beds of **CALCILUTITE** ....

88 Medium dark to bluish gray weathered, slope-forming, laminated **CALCISILTITE** alternating with some aphanitic **DOLOMITE** ..........................
87  Moderate grayish yellow (5Y 7/4) to pale
yellowish orange (10 YR 8/6-8/4) weathered,
slightly darker fresh surface, easily eroded,
bench to saddle-forming, laminated to medium
bedded (1/2-6 inches) platy, silty, aphanitic
DOLOMITE to limy dolomitic SILTSTONE
("Yellow beds") ............................................. 52

86  Medium dark gray weathered, resistant slope-
forming, thin bedded CALCILUTITE ................. 18

85  Medium gray to bluish gray weathered, slope-
forming, medium bedded (4-6 inches) CALCI-
SILTITE to CALCARENITE ........................... 23

84  Medium light gray weathered, bench to slope-
forming, laminated to thin bedded (1/4-6 inches),
partially dolomitized CALCILUTITE to limy
aphanitic DOLOMITE ............................................. 15

83  Medium light gray weathered, resistant slope to
semi cliff-forming, massive fine CRYSTALLINE
LIMESTONE to CALCILUTITE ............................. 22

82  Medium light gray weathered dolomitic CALCARENITE 6

81  Medium dark gray to bluish gray weathered, medium
gray fresh surface, resistant slope-forming,
medium bedded (3 inches to 2 feet), CALCILUTITE
to CRYSTALLINE LIMESTONE ............................. 20
Units 81-104 lower member Guilmette formation:

833 feet

**Total measured thickness of Guilmette formation**... 1159

(Lower member and part of upper member only)

Contact Conformable

Top of Simonson formation

80 Fine phaneritic DOLOMITE and fine CRYSTALLINE LIMESTONE: same as unit 79 including **algal**

biscuits and 2 foot ledges of abundant silicified **brachiopods Emanuella subumbona**, **gastropods**, and coquina of **Stringocephalus sp.** (**Stringocephalus** zone) in upper part of unit............... 22

79 Medium light gray to medium dark gray and olive gray weathered, semi cliff-forming, fine phaneritic DOLOMITE grading into and changing abruptly vertically and laterally into bluish gray weathered CALCILUTITE and fine CRYSTALLINE LIMESTONE in upper part of unit............... 100

78 Light gray weathered phaneritic DOLOMITE....... 3

77 Medium gray, semi cliff-forming, massive, sugary phaneritic DOLOMITE......................... 53

76 Medium dark gray weathered, massive, sugary phaneritic DOLOMITE......................... 12
75 Medium gray weathered, semi cliff-forming.
locally brecciated DOLOMITE

74 Medium light gray weathered, aphanitic to fine
phaneritic DOLOMITE

73 Light olive gray weathered, resistant slope-forming,
brecciated phaneritic DOLOMITE with white dolomite veining ("zebra striped", crystal heaving?)

72 Medium light gray weathered aphanitic DOLOMITE

71 Medium gray weathered, resistant slope-forming,
phaneritic DOLOMITE

70 Medium light gray weathered, fine phaneritic
DOLOMITE

69 Light olive gray weathered, slope-forming, silty,
aphanitic DOLOMITE

68 Medium dark gray weathered, phaneritic DOLOMITE

67 Alternating medium dark gray and medium light gray weathered, resistant slope-forming, fine
phaneritic DOLOMITE

66 Medium light gray, slope-forming, aphanitic
DOLOMITE

65 Medium light gray weathered, bench-forming,
aphanitic DOLOMITE
64 Medium light gray weathered, medium gray
fresh surface, resistant slope-forming, aphanitic

DOLOMITE ................................................. 8

Units 64-80 Upper Alternating member Simonson
formation: 309 feet.

63 Dark yellowish to grayish brown weathered,
medium dark gray fresh surface, massive cliff-
forming, fine phaneritic mottled DOLOMITE with
abundant "ghost" relict structures of algae, corals
and organic fragments .......................... 100

Unit. 63 Cliff Member Simonson formation: 100 feet.

62 Gray, resistant slope-forming, aphanitic DOLO-
MITE: same as unit 16 ............................... 8

61 Brown fine phaneritic DOLOMITE: same as unit 13. 12

60 Gray mottled DOLOMITE: same as unit 16...... 4

59 Brown hydrocarbon fine phaneritic DOLOMITE:
same as unit 13 with amphiporids? ............... 3

58 Gray fine phaneritic DOLOMITE: same as unit 16... 5

57 Brown DOLOMITE: same as unit 13............... 7

56 Gray aphanitic DOLOMITE: same as unit 16...... 16

55 Brown hydrocarbon DOLOMITE: same as unit 13... 2

54 Gray aphanitic DOLOMITE: same as unit 16...... 4

53 Brown hydrocarbon DOLOMITE: fine phaneritic -
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<th>Number</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>Medium light gray, slope-forming, aphanitic to fine phaneritic DOLOMITE</td>
<td>4</td>
</tr>
<tr>
<td>51</td>
<td>Brown slope-forming, laminated, aphanitic DOLOMITE with hydrocarbon odor</td>
<td>5</td>
</tr>
<tr>
<td>50</td>
<td>Medium to light gray weathered, partly covered bench-forming DOLOMITE</td>
<td>12</td>
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<tr>
<td>49</td>
<td>Medium light gray weathered, aphanitic DOLOMITE</td>
<td>12</td>
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<tr>
<td>48</td>
<td>Medium to light gray weathered, mottled, aphanitic DOLOMITE</td>
<td>4</td>
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<td>47</td>
<td>Medium gray weathered, phaneritic DOLOMITE</td>
<td>12</td>
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<td>46</td>
<td>Brown slope-forming hydrocarbon DOLOMITE:</td>
<td>4</td>
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<tr>
<td></td>
<td>same as unit 13</td>
<td>5</td>
</tr>
<tr>
<td>45</td>
<td>Covered bench</td>
<td>5</td>
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<tr>
<td>44</td>
<td>Medium light gray weathered, aphanitic DOLOMITE</td>
<td>4</td>
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<td>43</td>
<td>Medium gray weathered, phaneritic DOLOMITE</td>
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<td>42</td>
<td>Medium light gray weathered, aphanitic DOLOMITE: same as unit 16</td>
<td>4</td>
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<td>41</td>
<td>Medium gray weathered, aphanitic DOLOMITE:</td>
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<tr>
<td>40</td>
<td>Brown hydrocarbon DOLOMITE: same as unit 13</td>
<td>2</td>
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<tr>
<td>39</td>
<td>Gray DOLOMITE: same as unit 16</td>
<td>4</td>
</tr>
<tr>
<td>38</td>
<td>Brown hydrocarbon DOLOMITE with amphiporids?</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Description</td>
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</tr>
<tr>
<td>37</td>
<td>Medium light gray weathered, phaneritic DOLOMITE</td>
<td>4</td>
</tr>
<tr>
<td>36</td>
<td>Gray weathered, resistant slope-forming, very fine phaneritic to aphanitic DOLOMITE</td>
<td>4</td>
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<tr>
<td>35</td>
<td>Brown, bench to slope-forming, hydrocarbon DOLOMITE: same as unit 13</td>
<td>9</td>
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<tr>
<td>34</td>
<td>Gray, resistant slope-forming DOLOMITE: same as unit 16</td>
<td>8</td>
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<tr>
<td>33</td>
<td>Brownish gray weathered, aphanitic to fine phaneritic DOLOMITE</td>
<td>12</td>
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<td>32</td>
<td>Gray DOLOMITE: same as unit 16</td>
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<td>31</td>
<td>Brown mottled DOLOMITE: same as unit 13</td>
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<td>30</td>
<td>Gray DOLOMITE: same as unit 16</td>
<td>5</td>
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<tr>
<td>29</td>
<td>Brown DOLOMITE: same as unit 13</td>
<td>3</td>
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<tr>
<td>28</td>
<td>Gray DOLOMITE: same as unit 16</td>
<td>2</td>
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<tr>
<td>27</td>
<td>Brown hydrocarbon DOLOMITE: same as unit 13</td>
<td>6</td>
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<tr>
<td>26</td>
<td>Gray DOLOMITE: same as unit 16</td>
<td>5</td>
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<tr>
<td>25</td>
<td>Brown hydrocarbon mottled DOLOMITE: same as unit 13</td>
<td>9</td>
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<td>24</td>
<td>Gray laminated DOLOMITE: same as unit 16</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>Brown hydrocarbon DOLOMITE: same as unit 13</td>
<td>3</td>
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<td>22</td>
<td>Gray DOLOMITE: same as unit 16</td>
<td>5</td>
</tr>
<tr>
<td>21</td>
<td>Brown DOLOMITE: same as unit 13</td>
<td>8</td>
</tr>
</tbody>
</table>
20 Medium light gray DOLOMITE: same as unit 16... 4
19 Medium gray DOLOMITE............................. 4
18 Gray DOLOMITE: same as unit 16................. 3
17 Brown hydrocarbon DOLOMITE: same as unit 13... 2
16 Medium light gray weathered, very fine phaneritic
to aphanitic DOLOMITE................................. 6
15 Brown hydrocarbon DOLOMITE: same as unit 13... 3
14 Medium light gray weathered, fine phaneritic
vuggy DOLOMITE........................................ 16
13 Pale grayish brown (5 YR 4/2) to medium brownish
gray (5 YR 5/1) weathered, medium dark gray
fresh surface (N-4), resistant slope-forming,
laminated to medium bedded, very fine phaneritic
DOLOMITE with some sand stringers and distinct
hydrocarbon fetid odor .................................. 5

Units 13-62 Lower Alternating member of the
Simonson formation: 312 feet.
12 Medium light gray weathered, massive, vuggy,
sugary phaneritic DOLOMITE.......................... 22
11 Medium light gray weathered, massive, aphanitic
DOLOMITE.................................................. 20
10 Medium light gray weathered, massive, vuggy,
sugary phaneritic DOLOMITE.......................... 20
Medium dark gray weathered, fine phaneritic

DOLOMITE

Light gray (N-7) to very light brownish to pinkish gray (5 YR 8/1) weathered, almost white fresh surface, massive cliff-forming, very coarse sugary phaneritic DOLOMITE with some darker gray weathered ledges and sand stringers in lower quarter of unit

Medium to light gray weathered, resistant slope to semi cliff-forming, massive, sandy aphanitic DOLOMITE with sand stringers at base of unit

Units 7-12 lowermost Coarse Member of the Simonson formation: 284 feet.

Total thickness of Simonson formation

Contact Conformable

Top of Sevy formation

Quartz SANDSTONE: same as unit 4

Medium light gray weathered, darker gray fresh surface sandy aphanitic DOLOMITE

Very pale orange (10 YR 8/2) to moderate yellowish brown (10 YR 6/4) weathered, semi cliff-forming, fine grained quartz SANDSTONE

Very pale grayish orange weathered (10 YR 3/2-3/4)
olive gray fresh surface (5Y 4/1), mostly covered
saddle to bench forming, laminated, cherty,
aphanitic DOLOMITE

2 Yellowish gray to pale orange weathered, medium
olive gray fresh surface, mostly covered, saddle-
forming, thin bedded to laminated, platy, aphanitic
DOLOMITE to dolomitic SILTSTONE

1 Yellowish gray (5Y 7/2) weathered and fresh
surface, easily eroded, saddle to bench-forming,
platy, calcareous SILTSTONE

Total thickness of Upper Member Sevy formation:
Sevy formation (lower dolomite member)
Section continuously exposed
Measured Section of the Upper Sevy, Simonson,
Guilmette and Pilot formations at
Downdrop Mountain Repeat

S.W. 1/4 Section 21, N.W. 1/4 Section 28, and Section 29,
T 6 S, R 59 E, West Side Pahranagat Range

Lincoln County, Nevada

Section Dips 23-33 Degrees in the Direction N 70-80 Degrees E

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
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<tbody>
<tr>
<td>202</td>
<td>Section continuously exposed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Joana Limestone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium olive gray (5Y 5/1) weathered, medium</td>
<td></td>
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<tr>
<td></td>
<td>gray fresh surface (N-5), cliff-forming, medium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bedded crystalline LIMESTONE ......................... 50</td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>Gray weathered, resistant slope-forming, thin-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>discontinuously bedded, shale parted CALCARENITE</td>
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<tr>
<td></td>
<td>containing abundant brachiopods, bryozoa, and</td>
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<tr>
<td></td>
<td>other fossil fragments ............................. 20</td>
<td></td>
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<td>Total measured Joana limestone ...................................... 70</td>
<td></td>
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<tr>
<td></td>
<td>Contact conformable and transitional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Pilot formation</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>Pale grayish orange weathered, dark yellowish</td>
<td></td>
</tr>
<tr>
<td></td>
<td>brown to medium dark gray fresh surface, partly</td>
<td></td>
</tr>
</tbody>
</table>
covered, bench-forming, thin bedded platy calcareous SHALE interbedded with some gray weathered 4-6 inch beds of silty fossiliferous CALCILUTITE........................................ 60

199 Pale grayish orange weathered (10 YR 7/4), dark yellowish brown (10 YR 4/2) to medium dark gray (N-4) fresh surface, partly covered, saddle-forming, thin bedded, platy calcareous SHALE with some thin chert ledges........................................ 148

198 Very pale orange (10 YR 8/2) to light grayish orange (10 YR 8/4) weathered, pale yellowish brown fresh surface (10 YR 6/2) easily eroded saddle-forming partly covered, powdery, silty, calcareous SHALE with ferruginous replaced small brachiopods, pelecypods, trilobites and crinoid columnals........ 25

Total thickness of the Pilot formation ............ 234

Contact Paraconformable (West Range limestone absent)

Top of the Guilmette formation

197 Moderate orange pink (10 YR 7/4) to reddish orange and pale reddish brown weathered, vitreous, semi cliff-forming, silica cemented quartz SANDSTONE.. 32
196 Bench to slope-forming dolomitic quartz

SANDSTONE ........................................ 6

195 Semi cliff-forming medium grained quartz

SANDSTONE ........................................ 18

194 Bench to slope-forming limy quartz SANDSTONE
to limy sandy DOLOMITE ........................... 3

193 Resistant slope to semi cliff-forming medium
grained quartz SANDSTONE ....................... 24

192 Medium dark gray weathered, thin-discontinuously
bedded, bench to slope-forming partly dolomitized
CALCILUTITE ..................................... 36

191 Medium light gray weathered CALCILUTITE ..... 6

190 Medium grained resistant quartz SANDSTONE .... 8

189 Medium light gray weathered, slope-forming sandy
LIMESTONE ......................................... 2

188 Medium light to light gray weathered resistant
slope-forming CALCILUTITE ...................... 16

187 Light gray weathered, bench forming, limy
aphanitic DOLOMITE .............................. 4

186 Light gray weathered resistant slope-forming
slightly mottled CALCILUTITE ................... 8

185 Light olive to yellowish gray weathered sandy
bench-forming DOLOMITE ....................... 8
184 Medium to light gray weathered cliff-forming, massive ledges of CALCILUTITE with stromatoporoid structures................................. 34

183 Gray weathered cliff-forming CALCILUTITE with up to 30% sand stringers .............................. 12

182 Medium dark gray weathered cliff-forming CALCILUTITE with relict algal and stromatoporoid structures ......................... 15

181 Medium grained quartz SANDSTONE .................. 20

180 Bluish gray weathered cliff-forming algal LIMESTONE ....................................................... 12

179 Bluish gray weathered, massive ledged, cliff-forming LIMESTONE with abundant relict stromatoporoid structures ......................... 16

178 CALCISILTITE to crystalline LIMESTONE: same as unit 177 but with 6 inch to 1 foot beds, semi-cliff forming......................................................... 20

177 Dark bluish gray weathered, resistant slope forming thin bedded, fine CALCISILTITE. Sandy at base of unit......................................................... 18

176 Dark bluish gray weathered massive cliff-forming CALCILUTITE with algal and valve structures and thin beds of medium light gray weathered (N-6)
medium brownish gray fresh surface (5 YR 5/1)
crystalline LIMESTONE with _amphiporid_ structures
near top of unit................................. 62

175  Very light gray weathered, slope-forming aphanitic
     DOLOMITE..................................... 5

174  Medium dark bluish gray weathered CALCILUTITE.  4

173  Very light gray weathered _amphiporid_ DOLOMITE.. 3

172  Light gray weathered aphanitic DOLOMITE......... 5

171  Dolomitic SANDSTONE resistant slope to semi
     cliff-forming.................................. 2

170  Very light gray bench to slope-forming aphanitic
     DOLOMITE..................................... 9

169  Medium grained resistant slope-forming quartz
     SANDSTONE.................................... 5

168  Very light gray weathered bench to slope-forming
     thin bedded aphanitic DOLOMITE............... 10

167  Resistant slope to semi-cliff-forming dolomitic
     quartz SANDSTONE.............................. 4

166  Light olive gray weathered, bench-forming, thin
     bedded sandy aphanitic DOLOMITE............. 4

165  Medium grained massive, resistant quartz SAND-
     STONE......................................... 20
164 Medium light gray weathered, resistant slope-forming, flaggy CALCILUTITE

163 Light to medium gray weathered, resistant slope-to semi cliff-forming, medium bedded (1 to 1 1/2 feet) dense CALCILUTITE

162 Dark bluish gray weathered, semi cliff-forming

CALCILUTITE with Valve structures and Amphipora sp.

161 Medium to light bluish gray weathered CALCILUTITE with Valve structures

160 Dark bluish gray weathered, cliff-forming CALCI-LUTITE with Valve structures

159 Medium dark bluish gray weathered massive cliff-forming CALCILUTITE with valve structures

158 Dark bluish gray weathered CALCILUTITE with large valve structures

157 Medium to light bluish gray weathered, massive cliff-forming CALCILUTITE with abundant small

(1 1/2" x 3/8") to large (3 1/2" x 7/8") single-valve structures

156 Gray weathered, resistant slope to semi cliff-forming fine phaneritic DOLOMITE
Medium grained quartz SANDSTONE

Medium gray weathered resistant slope to semi-cliff-forming phaneritic DOLOMITE

Dark brownish gray weathered resistant slope-forming phaneritic DOLOMITE with amphiporids

Light olive gray weathered, resistant slope-forming, medium bedded (6 inches) aphanitic DOLOMITE with amphiporid structures at top of unit

Medium dark bluish gray weathered, resistant slope-forming, thin-wavy bedded (3 to 6 inches) CALCILUTITE

Light gray weathered bench to slope-forming fine phaneritic DOLOMITE

Medium dark gray weathered, slope-forming phaneritic DOLOMITE with amphiporid structures

Gray weathered, bench to slope-forming phaneritic DOLOMITE with amphiporid structures at base of unit

Sandy slope-forming DOLOMITE

Olive gray weathered, slope-forming phaneritic DOLOMITE with valve structures and sandy at base of unit
145 Bench-forming calcite veined DOLOMITE ............. 4
144 Medium gray weathered, resistant slope-forming
fine phaneritic DOLOMITE .......................... 14
143 Semi cliff-forming, medium grained quartz SAND-
STONE ............................................. 10
142 Medium dark gray weathered, resistant slope-
forming, fine phaneritic DOLOMITE with amphiporid
structures ............................................. 8
141 Light gray weathered, sandy fine phaneritic
DOLOMITE ............................................. 4
140 Medium gray weathered, fine phaneritic to aphanitic
DOLOMITE ............................................. 5
139 Dark gray weathered fine phaneritic DOLOMITE .... 6
138 Medium gray weathered resistant slope-forming
fine phaneritic DOLOMITE .......................... 10
137 Resistant quartz SANDSTONE ledge ................. 3
136 Medium gray weathered, resistant slope-forming
fine phaneritic DOLOMITE. Gradational contact
with unit 137 ............................................. 4
135 Resistant medium grained quartz SANDSTONE ..... 6
134 Gray weathered bench to slope-forming sugary
phaneritic DOLOMITE .............................. 7
133 Resistant slope-forming sandy DOLOMITE............. 4
132 Slope-forming sugary phaneritic DOLOMITE with calcite veins at base and becoming sandy at top of unit.......................... 14
131 Resistant slope-forming sandy DOLOMITE with quartz sand stringers to dolomitic SANDSTONE grading into SANDSTONE at top of unit............... 22
130 Bench-forming sugary phaneritic DOLOMITE sandy at base and gradational with unit 131....................... 7
129 Semi cliff-forming, medium grained, dolomitic quartz SANDSTONE.............................. 10
128 Reworked blocks of resistant slope to semi cliff-forming SANDSTONE and DOLOMITE. Gradational contact with unit 129................................. 20
127 Medium dark gray weathered, bench to slope-forming sugary phaneritic DOLOMITE with very little sand. Gradational contact with unit 128............ 10
126 Medium gray weathered, sugary phaneritic DOLOMITE with sand lenses and stringers at base of unit.............. 12
125 Medium gray weathered, semi cliff-forming, massive ledges of cross-bedded quartz SANDSTONE with penecontemporaneous deformation near the top of unit which is gradational with unit 126............... 42
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<tr>
<th>Unit</th>
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<tbody>
<tr>
<td>124</td>
<td>Slope-forming fine grained dolomitic quartz</td>
</tr>
<tr>
<td>123</td>
<td>Medium grained, massive torrential cross-bedded quartz SANDSTONE. Gradational into unit 124.</td>
</tr>
<tr>
<td>122</td>
<td>Gray weathered sugary phaneritic DOLOMITE</td>
</tr>
<tr>
<td>121</td>
<td>Very light gray weathered, semi cliff-forming fine grained quartz SANDSTONE</td>
</tr>
<tr>
<td>120</td>
<td>Medium gray weathered, bench to slope-forming fine phaneritic platy DOLOMITE</td>
</tr>
<tr>
<td>119</td>
<td>Medium dark gray weathered, bench to slope-forming fine phaneritic DOLOMITE with amphiporid structures</td>
</tr>
<tr>
<td>118</td>
<td>Gray weathered, massive ledged, semi cliff-forming sugary phaneritic DOLOMITE</td>
</tr>
<tr>
<td>117</td>
<td>Gray weathered, resistant slope-forming, silty dolomitic LIMESTONE thin bedded at base grading into medium bedded in upper part of unit</td>
</tr>
<tr>
<td>116</td>
<td>Light gray weathered, resistant slope-forming phaneritic cherty DOLOMITE</td>
</tr>
<tr>
<td>115</td>
<td>Light olive gray weathered aphanitic DOLOMITE with relict amphiporid? structures</td>
</tr>
<tr>
<td>114</td>
<td>Very silty CALCISILTITE to crystalline LIMESTONE. Same as unit 113 except more resistant slope-forming with corals and brachiopods</td>
</tr>
</tbody>
</table>
Very light brownish to olive gray weathered, medium dark gray fresh surface (N-4), bench to slope-forming, thin bedded flaggy CALCISILTITE interbedded with more massive darker bluish gray weathered CALCILUTITE and containing abundant branching corals, brachiopods, including Atrypa sp. and some small crinoid columnals

Resistant ledge of medium bedded, medium to fine grained, very calcareous quartz SANDSTONE with large horn corals including cf. Macgnea sp.

LIMESTONE: thin discontinuously bedded and very silty

Quartz SANDSTONE: same as unit 108

Light olive gray weathered, bench to slope-forming thin-discontinuously bedded, very fine grained quartz SANDSTONE to limy SILTSTONE

Brown weathered, cliff-forming, massive quartz SANDSTONE

Gray weathered, bench-forming, thin-discontinuously bedded sandy LIMESTONE to limy quartz SANDSTONE

Light brown weathered massive semi cliff-forming medium grained quartz SANDSTONE
105 Medium gray to olive gray, thin bedded, bench-forming LIMESTONE alternating with medium-grained quartz SANDSTONE ......................... 10
104 Brown weathered massive cliff-forming medium-grained quartz SANDSTONE ........................................... 56
103 Yellowish gray weathered, darker fresh surface, resistant slope-forming limy SILTSTONE ............... 4
102 Medium light gray to bluish gray weathered, partly covered bench-forming CALCISILTITE becoming silty at the top of the unit ......................... 20
101 Fine CALCILUTITE with up to 60% quartz sandstone at the base ................................................... 5
100 Medium dark gray weathered, resistant slope-forming, 3 inch thin beds of CALCILUTITE ........... 9
99 Bench-forming CALCISILTITE: same as unit 97 .......... 8
98 Resistant slope-forming CALCILUTITE: same as unit 98 .......................................................... 10
97 Medium bluish gray and light olive gray weathered, bench-forming, thin bedded CALCISILTITE containing Meristella sp. and Pseudodouvillina sp. ......... 8
96 Dark bluish gray weathered, dense, resistant slope-forming, thin-discontinuously bedded CALCILUTITE
with interbeds of thin (1/4 inch) moderate to light
brown weathered chert containing Martinia sp. 

95 Bluish to greenish gray weathered, thin bedded,
bench-forming CALCILUTITE 

94 Medium dark gray weathered mottled CALCISILTITE. 

93 Light olive gray to bluish gray weathered, thin
bedded, platy, bench-forming silty fine CALCISILTITE with Atrypa sp. 

Units 93-197 upper member of the Guelmette
formation: 1572 feet. 

92 Medium dark gray to dark bluish gray cliff-forming
CALCISILTITE to CALCILUTITE to crystalline
Algal LIMESTONE. Algal biscuits up to 8 inches in
diameter. 

91 Dark bluish gray weathered, massive ledges alternate
nating with thin laminated beds of cliff-forming algal
LIMESTONE. 

90 Bluish gray weathered thin bedded to laminated
cliff-forming CALCILUTITE 

89 Medium olive gray weathered (5Y 5/1), dark gray
fresh surface (N-3), massive cliff-forming, partly
dolomitized CALCISILTITE and recrystallized
LIMESTONE with units of small round (up to 1 1/2
inches in diameter) algal biscuits.
Alternating units of resistant slope to semi cliff-forming thin bedded LIMESTONE and massive ledges of partly dolomitized dark bluish gray weathered algal LIMESTONES .................. 42

Bluish gray weathered, resistant slope-forming, thin (2 inches) discontinuously bedded fine CALCISILTITE .................................................. 7

Medium dark gray weathered, medium bedded phaneritic DOLOMITE ................................................. 12

Brownish gray weathered phaneritic DOLOMITE with hydrocarbon odor .................................................. 4

Medium brownish gray, thin bedded, resistant slope-forming, very fine phaneritic DOLOMITE ....... 13

DOLOMITE: finely laminated. Same as unit 79 .... 20

CALCISILTITE to CALCARENITE. Same as Unit 80. 3

DOLOMITE. Same as Unit 79 ......................... 24

Medium bluish gray weathered, resistant slope-forming massive ledge of CALCARENITE .......... 4

Pale grayish orange weathered (10 YR 8/4), light olive gray fresh surface (5Y 6/1), easily eroded bench forming, thin bedded to laminated aphanitic DOLOMITE .................................................. 36
Units 79-92 minimum thickness of the lower
member Guilmette formation 490' but including
transition units 72-78, maximum thickness of
lower member 634'.

78 Medium dark brownish gray weathered, thin
bedded, bench-forming, fine phaneritic DOLOMITE.

77 Medium dark gray weathered phaneritic DOLO-
MITE with calcite veining and Algal? structures...... 3

76 Dark brownish gray weathered fine phaneritic
DOLOMITE with hydrocarbon odor .................... 3

75 Alternations of very light olive gray to olive gray
weathered, resistant slope-forming aphanitic
DOLOMITE............................................. 32

74 Medium olive gray weathered (5Y 5/1), medium
dark gray fresh surface (N-4) sugary phaneritic
DOLOMITE with abundant silicified brachiopod
Emanuella subumbona in lowest 4 feet of unit........... 28

73 Brownish gray weathered, resistant slope-forming,
thin bedded aphanitic DOLOMITE with hydrocarbon
odor.................................................... 20

72 Medium olive gray (5Y 5/1) to medium brownish
gray (5YR 5/1) weathered, medium dark gray fresh
surface (N-4), semi cliff-forming sugary phan-
eritic DOLOMITE with abundant relict structures

of branching corals, brachopods, algae, and
stromatoporoida?........................................... 36

Total minimum thickness of the Guilmette

formation Units 79--196 ................................. 2062

Total thickness of transition zone from top of
Stringocephalus zone to base of "Yellow bed"

Units 72-78; 144'

Total maximum thickness of the Guilmette

formation units 72-196 ................................. 2206

Contact conformable

Top of the Simonson formation

71 DOLOMITE: same as unit 72 but including

Stringocephalus sp. (Stringocephalus zone) ........ 4

70 Medium light gray weathered, resistant slope to

semi cliff-forming sugary phaneritic DOLOMITE.... 40

69 DOLOMITE: same as unit 59......................... 6

68 DOLOMITE: phaneritic to fine phaneritic, resistant

slope to semi cliff-forming: essentially same as

units 59 and 62............................................ 60

67 Medium light gray weathered phaneritic DOLOMITE. 34
DOLOMITE: same as unit 62. 18

DOLOMITE: same as unit 59. 2

DOLOMITE: same as unit 62. 34

DOLOMITE: same as unit 59. 2

Medium light gray weathered partly brecciated fine phaneritic DOLOMITE. 15

DOLOMITE: same as unit 59. 3

Medium gray weathered aphanitic DOLOMITE. 6

Dark yellowish brown weathered, resistant slope-forming aphanitic DOLOMITE with hydrocarbon odor. 4

Medium light gray weathered, semi cliff-forming, sugary phaneritic DOLOMITE. 36

Light gray weathered, resistant slope-forming aphanitic DOLOMITE. 28

Medium light gray weathered, resistant slope to semi cliff-forming aphanitic to very fine phaneritic DOLOMITE. 16

Light gray weathered aphanitic DOLOMITE. 24

Medium gray weathered sugary phaneritic DOLOMITE. 6

Light gray weathered, resistant slope-forming aphanitic DOLOMITE. 8

Units 53-71 Upper alternating member of the Simonson formation: 396 feet.
52  Medium dark gray weathered, massive cliff-forming
fine phaneritic biostromal DOLOMITE with algal,
stromatoporoid and amphiporid structures ......... 100

Unit 52 "Brown cliff" member of the Simonson
formation: 100 feet.

<table>
<thead>
<tr>
<th></th>
<th>DOLOMITE: same as unit</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>33</td>
<td>4</td>
</tr>
<tr>
<td>50</td>
<td>22</td>
<td>4</td>
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<tr>
<td>49</td>
<td>33</td>
<td>4</td>
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<td>48</td>
<td>22</td>
<td>14</td>
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<td>47</td>
<td>33</td>
<td>4</td>
</tr>
<tr>
<td>46</td>
<td>22</td>
<td>12</td>
</tr>
<tr>
<td>45</td>
<td>23 and 33</td>
<td>16</td>
</tr>
<tr>
<td>44</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>43</td>
<td>33 and 23</td>
<td>4</td>
</tr>
<tr>
<td>42</td>
<td>22</td>
<td>6</td>
</tr>
<tr>
<td>41</td>
<td>23 and 33</td>
<td>19</td>
</tr>
<tr>
<td>40</td>
<td>slightly mottled, same as unit 22</td>
<td>4</td>
</tr>
<tr>
<td>39</td>
<td>33</td>
<td>8</td>
</tr>
<tr>
<td>38</td>
<td>22</td>
<td>2</td>
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<tr>
<td>37</td>
<td>33</td>
<td>8</td>
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<tr>
<td>36</td>
<td>22</td>
<td>4</td>
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<tr>
<td>35</td>
<td>33</td>
<td>7</td>
</tr>
<tr>
<td>34</td>
<td>22</td>
<td>4</td>
</tr>
</tbody>
</table>
33 Light gray weathered aphanitic DOLOMITE as
  unit 22.......................... 22
32 DOLOMITE: mottled, same as unit 22.......... 6
31 Light olive gray to light gray weathered aphanitic
  DOLOMITE as unit 23................. 8
30 DOLOMITE: same as unit 22.................. 8
29 DOLOMITE: light gray weathered, same as unit 23. 2
28 DOLOMITE: same as unit 22.................. 2
27 DOLOMITE: aphanitic, same as unit 23.......... 4
26 DOLOMITE: aphanitic, same as unit 22.......... 8
25 DOLOMITE: same as unit 23.................. 2
24 DOLOMITE: fine phaneritic to aphanitic, same as
  unit 22.......................... 3
23 Light olive gray (5Y 6/1) to medium dark gray
  weathered (N-4), medium dark to dark gray fresh
  surface (N-4 to N-3), resistant slope-forming, fine
  phaneritic to aphanitic DOLOMITE................. 16
22 Pale yellowish brown (10 YR 6/2) to dark yellowish
  brown weathered (10 YR 4/2), medium dark gray
  (N-3) to grayish black (N-2) fresh surface, resistant
  slope-forming, fine phaneritic laminated DOLOMITE
  with hydrocarbon fetid odor...................... 3
Medium to light gray weathered fine phaneritic
to aphanitic DOLOMITE .............................................. 48

Units 21-51 Lower alternating member of the
Simonson formation: 258 feet. Contact with sub-
ajacent lowest "coarse" member not definitely de-
termined but units 16-20 may also be placed in
Lower alternating member giving maximum total of
308 feet.

Medium to light gray weathered sugary phaneritic
DOLOMITE ............................................................... 12

Medium to light gray weathered fine phaneritic
DOLOMITE ............................................................... 16

Medium dark gray weathered fine phaneritic
DOLOMITE ............................................................... 4

Medium gray weathered sugary phaneritic DOLO-
MITE ............................................................... 14

Medium dark gray weathered sugary phaneritic
DOLOMITE ............................................................... 4

DOLOMITE: same as unit 13 ......................... 62

Medium gray to olive gray weathered sugary phaneritic
DOLOMITE with hydrocarbon odor ...................... 6

Light olive to yellowish gray weathered (5Y 7/1) very
light gray fresh surface (N-8), massive ledged resistant
slope to semi cliff-forming coarse phaneritic

<table>
<thead>
<tr>
<th>Layer Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slightly limy Dolomite</td>
<td>46</td>
</tr>
<tr>
<td>Light gray weathered aphanitic Dolomite</td>
<td>12</td>
</tr>
<tr>
<td>Dark brownish gray weathered (5 YR 3/1) fine phaneritic Dolomite with hydrocarbon odor</td>
<td>5</td>
</tr>
<tr>
<td>Dark gray weathered, resistant slope-forming aphanitic Dolomite</td>
<td>9</td>
</tr>
<tr>
<td>Olive gray weathered, sugary phaneritic Dolomite</td>
<td>9</td>
</tr>
<tr>
<td>Light gray weathered aphanitic Dolomite with sand stringers</td>
<td>40</td>
</tr>
<tr>
<td>Light gray weathered sugary phaneritic Dolomite</td>
<td>6</td>
</tr>
<tr>
<td>Very light olive gray weathered aphanitic Dolomite with some sand stringers at base of unit</td>
<td>8</td>
</tr>
<tr>
<td>Quartz Sandstone ledge</td>
<td>3</td>
</tr>
<tr>
<td>Gray weathered resistant slope-forming, massive ledged sandy aphanitic Dolomite</td>
<td>23</td>
</tr>
</tbody>
</table>

Units 4-15 definite Coarse Dolomite member of the Simonson formation; minimum thickness 229 feet. Contact with superjacent Lower Alternating member not satisfactorily determined but coarse member might also include units 16-20 to maximum thickness of 279 feet.

Total thickness of the Simonson formation .......... 1033
Contact conformable

Top of the Sevy formation

3 Yellowish gray weathered, resistant slope-forming, cross bedded, subrounded, well sorted
medium grained quartz SANDSTONE.................. 44

2 Very pale yellowish orange (10 YR 9/6) to grayish
yellow (5Y 8/4) weathered, medium olive gray fresh
surface (5Y 5/1) thin bedded, bench forming cherty,
aphanitic to very fine phaneritic silty DOLOMITE... 54

Units 2-3 Upper member of the Sevy formation:
98 feet.

1 Very light gray (N-8) weathered, light brownish
gray (5 YR 6/1) to light olive gray (5 Y 6/1) fresh
surface, partly covered, bench forming, sandy
aphanitic to fine phaneritic DOLOMITE.............. 100

Total measured Sevy formation..................... 198

base of section covered.
Measured Section of the Simonson, Guilmette, and Pilot formations at Lower Downdrop Mountain, West Side, Pahranagat Range S 1/2 Sections 19 and 20, T 6 S, R 59 E Lincoln County, Nevada

Dip from 33-39 Degrees in the direction N 85° E - S 85° E.

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section Continuously Exposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joana limestone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>Gray weathered, resistant slope to semi cliff-forming, fossiliferous CALCISILTITE to CALCILUTITE.</td>
<td></td>
</tr>
<tr>
<td>Contact Conformable - partly covered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top of Pilot formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>124</td>
<td>Pale yellowish orange to dark yellowish brown weathered, slope-forming, platy CALCAREOUS SHALE</td>
<td>48</td>
</tr>
<tr>
<td>123</td>
<td>Covered saddle with CALCAREOUS SHALE float same as unit 124.</td>
<td>192</td>
</tr>
<tr>
<td>Total thickness of the Pilot formation</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>Contact Paraconformable (West Range formation absent)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Top of Guilmette formation

122 Bench forming, thin bedded SANDY LIMESTONE to LIMY QUARTZ SANDSTONE .................. 32

121 Sandy fine CRYSTALLINE LIMESTONE .............. 6

120 Dip slope-forming, thin bedded (6 inches) quartz SANDSTONE ................................. 10

119 Light bluish gray weathered, bench-forming, sandy (30%) recrystallized CALCILUTITE interbedded with ledges of gray weathered sandy (60%) re-
crystallized CALCARENITE ....................... 24

118 Dip slope-forming, platy, sandy (30%) fine CALCARENITE ........................................ 4

117 Medium dark gray weathered, slope-forming, massive CRYSTALLINE LIMESTONE ............. 6

116 Medium olive gray weathered, slope-forming, massive CALCILUTITE with some recrystallized brachiopods ................................. 6

115 Quartz SANDSTONE ................................. 14

114 Medium gray weathered CALCILUTITE ............... 24

113 Thin bedded, flaggy, sandy DOLOMITE .............. 4

112 LIMESTONE: same as unit 110 ....................... 5

111 Gray weathered, slope to bench-forming, thin flaggy
bedded, medium to fine grained quartz SANDSTONE
interbedded with light olive gray weathered flaggy

DOLOMITE ................................. 10

110 Medium gray weathered, resistant slope-forming
CALCISILTITE to CRYSTALLINE LIMESTONE with
thin (1/4 inch) sand stringers .................... 34

109 Medium gray weathered CRYSTALLINE LIMESTONE
with some 1 foot phaneritic DOLOMITE ledges .... 16

108 Light yellowish brown weathered, light gray fresh
surface, resistant slope to semi cliff-forming,
subrounded, well-sorted, fine to medium grained
quartz SANDSTONE ............................... 22

107 Medium gray weathered, resistant slope-forming,
massive ledged, locally sandy CALCILUTITE to
CRYSTALLINE LIMESTONE with few valve struc-
tures and amphiporids ........................... 110

106 Medium light gray weathered fine CRYSTALLINE
LIMESTONE with abundant Amphipora sp ........... 8

105 Medium dark to bluish gray weathered CALCILUTITE
to very fine CRYSTALLINE LIMESTONE with
abundant amphiporid structures .................... 3

104 Medium gray weathered, lighter gray fresh surface,
bench to slope-forming, fine phaneritic to aphanitic
DOLOMITE ................................. 8
<table>
<thead>
<tr>
<th>Page</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>103</td>
<td>Quartz SANDSTONE</td>
<td>6</td>
</tr>
<tr>
<td>102</td>
<td>Light olive gray weathered DOLOMITE</td>
<td>5</td>
</tr>
<tr>
<td>101</td>
<td>Quartz SANDSTONE</td>
<td>4</td>
</tr>
<tr>
<td>100</td>
<td>Slope to bench-forming sandy DOLOMITE</td>
<td>10</td>
</tr>
<tr>
<td>99</td>
<td>Quartz SANDSTONE</td>
<td>4</td>
</tr>
<tr>
<td>98</td>
<td>Medium light gray weathered, limy aphanitic DOLOMITE</td>
<td>6</td>
</tr>
<tr>
<td>97</td>
<td>Light yellowish brown weathered, light gray fresh surface, resistant slope-forming, massive ledged, subrounded, well sorted, fine to medium grained quartz SANDSTONE</td>
<td>10</td>
</tr>
<tr>
<td>96</td>
<td>Medium gray weathered, slope-forming, fine CRYSTALLINE LIMESTONE to CALCILUTITE with few valve structures and sandy zone near the top of unit</td>
<td>86</td>
</tr>
<tr>
<td>95</td>
<td>Light gray weathered CALCILUTITE</td>
<td>4</td>
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<tr>
<td>94</td>
<td>Medium dark gray weathered, darker gray fresh surface, massive, mottled CALCILUTITE to CRYSTALLINE LIMESTONE with large valve structures (single valve 3 1/2 x 1 inch)</td>
<td>36</td>
</tr>
<tr>
<td>93</td>
<td>Light bluish gray weathered fine CRYSTALLINE LIMESTONE with valve structures</td>
<td>28</td>
</tr>
</tbody>
</table>
92  Gray weathered CALCISILTITE with sand
    stringers increasing upward to constitute 60%
    of unit .............................................. 38
91  Sandy LIMESTONE ................................. 10
90  Medium light gray weathered, slope-forming
    CALCISILTITE with valve structures .......... 8
89  Quartz SANDSTONE ................................. 16
88  Sandy DOLOMITE with valve structures ........ 6
87  Medium light gray weathered and fresh surface,
    very fine phaneritic to aphanitic DOLOMITE with
    valve structures. Sandy at base of unit ........ 12
86  Quartz SANDSTONE: same as unit 84 ............ 16
85  Light gray weathered, bench to slope-forming
    phaneritic DOLOMITE. Upper and lower contacts
    of unit gradational .............................. 8
84  Light yellowish brown weathered, light gray fresh
    surface, cross bedded, subrounded, well sorted
    fine grained dolomitic quartz SANDSTONE ...... 12
83  Medium dark gray weathered, medium light gray
    fresh surface, resistant slope to semi cliff-
    forming, massive, calcite veined fine phaneritic
    DOLOMITE .............................................. 74
82 Light olive gray weathered and fresh surface, slope-forming, vuggy, phaneritic DOLomite........ 22

81 Phaneritic DOLomite: same as unit 30 but weathers darker gray.............................. 22

80 Gray weathered and fresh surface, resistant slope to semi cliff-forming, massive phaneritic DOLomite with calcite veining, 5-10% sand at base, amphiporids in lower part and algae at top of unit........................................ 56

79 Medium to light gray weathered and fresh surface, very sandy phaneritic DOLomite grading into dolomitic quartz SANDSTONE .................. 26

78 Dolomitic quartz SANDSTONE ...................... 4

77 Light gray weathered, resistant slope-forming, massive ledged, sandy phaneritic DOLomite with amphiporids at base of unit................. 24

76 Quartz SANDSTONE................................. 20

75 Medium dark weathered and fresh surface, bench to slope-forming, sandy phaneritic DOLomite..... 7

74 Resistant slope to semi cliff-forming, fine grained quartz SANDSTONE............................. 50

73 Medium grained, subrounded, quartz SANDSTONE.. 60
DOLOMITE: same as unit 70

Quartz SANDSTONE: same as unit 69

Medium light gray weathered and fresh surface,
slope-forming, massive phaneritic DOLOMITE

Grayish orange weathered, very light gray fresh
surface, resistant slope to semi cliff-forming,
massive ledged cross-bedded, dolomite-silica
cemented, subrounded to subangular, well sorted,
fine grained quartz SANDSTONE

Light yellowish brown weathered, cliff-forming
massive medium grained quartz SANDSTONE with
torrential cross-bedding

Medium light gray weathered, lighter fresh surface,
semi cliff-forming, massive 2 foot beds of limy
silty, fine phaneritic DOLOMITE

Massive cliff-forming, medium grained quartz
SANDSTONE

Light yellowish brown weathered, massive, resistant,
thin-discontinuously bedded, very fine grained
quartz SANDSTONE to limy SILTSTONE with chert

Massive, medium grained dolomitic quartz
SANDSTONE
<table>
<thead>
<tr>
<th>Page</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>Flaggy SILTSTONE</td>
</tr>
<tr>
<td>62</td>
<td>Very fine grained, semi cliff-forming dolomitic quartz SANDSTONE</td>
</tr>
<tr>
<td>61</td>
<td>Slope-forming, flaggy, irregular bedded SILTSTONE</td>
</tr>
<tr>
<td>60</td>
<td>Massive cliff-forming, fine grained quartz SANDSTONE</td>
</tr>
<tr>
<td>59</td>
<td>Light olive gray weathered, light gray fresh surface, resistant slope-forming, 1-2 inch discontinuous bedded SILTSTONE to fine grained quartz SANDSTONE</td>
</tr>
<tr>
<td>58</td>
<td>Medium light gray weathered, darker fresh surface, bench-forming, flaggy, lime cemented SILTSTONE</td>
</tr>
<tr>
<td>57</td>
<td>Massive cliff-forming, fine to medium grained, limy quartz SANDSTONE with occasional <em>brachiopod</em> fragments</td>
</tr>
<tr>
<td>56</td>
<td>Slope-forming, sandy LIMESTONE with chert stringers and nodules, <em>Amphipora sp.</em></td>
</tr>
<tr>
<td>55</td>
<td>Light to yellowish brown weathered, cliff-forming, fine to medium grained quartz SANDSTONE</td>
</tr>
<tr>
<td>54</td>
<td>Gray weathered, resistant slope-forming, massive sandy LIMESTONE with interbedded flaggy LIMESTONE and poorly preserved <em>brachiopod</em> fragments</td>
</tr>
</tbody>
</table>
53 Gray weathered, slope-forming, thick-massive
ledges of mottled LIMESTONE with relict
coralline structures ......................... 16

52 Medium olive gray weathered (5Y 5/1), medium
gray fresh surface (N-5), bench-forming, thin,
flaggy bedded CALCISILTITE containing abundant
brachiopods Meristella sp. ....................... 8

Units 52-122 Upper member of Guilmette
formation: 1634 feet.

51 Medium light to medium dark bluish gray
weathered, massive Algal LIMESTONE with local
penecomtemporaneous brecciation. Lower half of
unit resistant slope to semi cliff-forming, thick
algal biostrome ledges that coalesce upward to
form a massive cliff in upper half of unit........ 344

50 Light bluish gray weathered, slope-forming,
laminated, fine phaneritic DOLOMITE............. 8

49 Medium light gray weathered (N-6), medium dark
gray fresh surface (N-4), semi cliff-forming,
massive ALGAL LIMESTONE ...................... 25

48 LIMY DOLOMITE.............................. 3

47 Medium dark gray weathered, massive LIMESTONE
with spheroidal and tubular algal structures...... 9
DOLOMITE: same as unit 40........................... 3
LIMESTONE: same as unit 39.......................... 8
DOLOMITE: same as unit 40........................... 3
CRISTALLINE LIMESTONE: same as unit 39........... 10
Medium light gray weathered aphanitic DOLOMITE.... 6
CALCILUTITE to CRISTALLINE LIMESTONE:
same as unit 39 with algal structures................. 22
Olive gray weathered aphanitic DOLOMITE............ 4
Medium dark gray to dark bluish gray weathered,
medium to dark gray fresh surface, resistant
slope-forming, massive ledges of thin bedded
very fine CRISTALLINE LIMESTONE...................... 38
Light olive gray weathered (5Y 6/1), medium to
dark gray fresh surface, slope-forming dense
aphanitic DOLOMITE with pink and white calcite
veining................................................... 24
Dark bluish gray weathered mottled, CRISTALLINE
LIMESTONE.............................................. 2
Medium dark gray weathered CALCILUTITE to
CRISTALLINE LIMESTONE............................. 4
Pale grayish orange weathered (10 YR 8/4), light
olive gray fresh surface, bench to saddle-forming,
thin bedded to laminated aphanitic DOLOMITE...... 28
Medium dark gray weathered and fresh surface, phaneritic DOLOMITE with calcite veining, becoming very thin bedded and flaggy in upper part of unit. 

Medium to light yellowish gray weathered, darker gray fresh surface, bench-forming, thin bedded, limy, very fine phaneritic DOLOMITE. 

Units 34-51 Lower member Guilmette formation: 598 feet. 

Total thickness of the Guilmette formation 2232

Contact Conformable

Top of Simonson formation

Medium gray to light olive gray weathered, bench to slope-forming, thin to medium bedded, limy, very fine phaneritic DOLOMITE. Unit terminated by 4 foot ledge of very light yellowish gray weathered phaneritic DOLOMITE containing abundant large silicified Stringocephalus sp. (Stringocephalus Zone). 

Medium light gray weathered (N-6), medium dark gray fresh surface (N-4), cliff-forming, thin continuously bedded (2-4 inches) fine CRystalline LIMESTONE with relict fossil fragments interbedded
with, and changing abruptly both vertically and horizontally, with light olive gray weathered 5Y 7/1), light gray fresh surface, sugary phaneritic DOLomite containing some silicified large brachiopod fragments (Stringocephalus? ?)............. 28

31

Brownish gray weathered (5 YR 4/1), resistant slope to semi cliff-forming, massive phaneritic DOLomite with hydrocarbon odor ................. 32

30

Medium light gray to medium gray weathered, phaneritic DOLomite with some brownish gray weathered zones................................. 76

29

Undifferentiated alternating 2 to 10 foot units of semi cliff-forming massive medium light gray and medium dark to brownish gray weathered, coarse, sugary phaneritic DOLomite with local penecontemporaneous deformation breccias...... 172

28

Light to medium gray massive semi cliff-forming phaneritic DOLomite with penecontemporaneous deformation DOLomite breccias at top of unit...... 40

27

Medium light gray weathered, sugary phaneritic DOLomite.................................................. 8
26 Undifferentiated alternating medium light gray and medium dark to brownish gray DOLOMITES.

25 Light olive gray weathered DOLOMITE.

24 Medium dark to brownish gray weathered DOLOMITE.

Units 24-33 Upper Alternating member of Simonson formation: 430 feet. Possibly including Unit 23 total maximum thickness of 452 feet.

23 Medium light gray weathered phaneritic DOLOMITE.

22 Medium dark gray weathered massive cliff-forming, mottled phaneritic DOLOMITE with amphiporid, gastropod and other organic relict structures.

Unit 22 definite Brown Cliff Member of Simonson formation: 72 feet. Possibly including unit 23 total maximum thickness 94 feet.

21 Light gray weathered DOLOMITE: same as unit 1.

20 Brown DOLOMITE: same as unit 2.

19 Medium light gray weathered DOLOMITE.

18 Medium gray weathered DOLOMITE.

17 Medium light gray weathered, resistant slope-forming, massive ledged, laminated? (weathering laminae) medium phaneritic DOLOMITE.
Brown and gray color banded (1/2 inch laminated alternations) of fine phaneritic DOLOMITE........... 2
Light gray weathered DOLOMITE.................... 6
Medium gray weathered DOLOMITE................... 3
Light gray weathered DOLOMITE.................... 4
Brown DOLOMITE: same as unit 2.................... 8
Medium light gray weathered, fine phaneritic DOLOMITE........................................ 8
Brown DOLOMITE: same as unit 2 - laminated..... 4
Gray DOLOMITE: same as unit 1..................... 7
Brown DOLOMITE: same as unit 2, resistant slope-forming........................................ 8
Covered.................................................. 20
Brown DOLOMITE: same as unit 2.................... 4
Medium light gray weathered, fine phaneritic DOLOMITE........................................ 14
Brown DOLOMITE: same as unit 2.................... 5
Medium light gray DOLOMITE....................... 7
Medium brownish gray (5 YR 5/1), dark gray fresh surface (N-3), fine phaneritic DOLOMITE with hydrocarbon fetid odor................................. 6
Light olive gray to medium gray weathered,
slightly darker fresh surface, slope-forming,
very fine phaneritic DOLOMITE.................. 4

Units 1-21 Lower Alternating member of
Simonson formation: 166 feet-incomplete, base
covered.

Total measured thickness of Simonson formation.... 690

Base of Section covered
Measured Section of the Simonson, Guilmette, and  
Pilot formations at Devonian Ridge, West Side  
Pahranagat Range  
N.W. 1/4 Section 15; N 1/2 Section 16, T 7 S, R 59 E  
Lincoln County, Nevada  
Dip 22-30 Degrees in the Direction N 75-88 Degrees East

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (In feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Section Continuously Exposed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Joana limestone (Mississippian)</td>
<td></td>
</tr>
<tr>
<td>203</td>
<td>Medium gray weathered, resistant slope-forming, thin-discontinuously wavy bedded CALCARENITE with chert and abundant brachiopods, bryozoa and other fauna</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Total measured thickness of Joana limestone</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Contact Conformable and Gradational</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of the Pilot formation</td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>Medium gray to dark gray weathered fissile to powdery calcareous SHALE</td>
<td>22</td>
</tr>
<tr>
<td>201</td>
<td>Argillaceous SHALE to CALCISILTITE: same as unit 199</td>
<td>60</td>
</tr>
<tr>
<td>200</td>
<td>Medium dark gray to black dense resistant CHERT</td>
<td>6</td>
</tr>
</tbody>
</table>
Grayish orange (10 YR 7/4) to moderate
yellowish brown (10 YR 5/4) weathered, saddle
to bench-forming, laminated to thin bedded
(1/16-4 inches), platy, silty calcareous SHALE
to argillaceous CALCISILTITE......................... 163

Total thickness of Pilot formation.................. 251
Contact Paraconformable (West Range formation
absent)

Pale reddish brown (10 R 5/4-4/4) to yellowish
brown (10 YR 6/4) weathered, massive, subangular,
medium to fine grained quartz SANDSTONE cemented
by dolomite and silica................................. 153

Medium gray weathered, sugary phaneritic DOLO-
MITE with white "zebra-striped" dolomite veining... 7

Quartz SANDSTONE.................................... 3

Light gray weathered phaneritic DOLOMITE with
white "Zebra-striped" dolomite veining (crystal
heaving?)............................................. 13

Moderate yellowish brown to light gray weathered,
rounded to subrounded fine to medium grained
quartz SANDSTONE................................. 22

Medium, dark gray CALCARENITE.................. 3
192 Quartz SANDSTONE........................................ 7

191 Medium dark to bluish gray weathered CALCARENITE
with 30% 1/16-2 inch sand stringers....................... 16

190 Quartz SANDSTONE ........................................ 4

189 Medium dark bluish gray weathered CALCARENITE. .... 9

188 Medium gray weathered, thin bedded, very sandy
(20-60% sand) CALCARENITE................................. 10

187 Bluish gray weathered, massive ledged, recrystal-
lized CALCISILTITE to CALCARENITE with some
brachiopod relict structures ............................. 11

186 Quartz SANDSTONE with platy, silty LIMESTONE
containing some brachiopod profiles at base of unit... 9

185 Medium gray weathered, semi cliff-forming
CALCILUTITE.................................................. 33

184 Light yellowish brown weathered (10 YR 6/4),
sub-rounded, well sorted, medium grained quartz
SANDSTONE cemented by silica and lime.............. 8

183 Medium to light bluish gray weathered semi cliff-
forming, massive ledged (2 1/2 feet) CALCILUTITE. ... 33

182 Medium dark bluish gray CALCISILTITE to CALCIL-
LUTITE with small algal structures up to 2 inches
in diameter.................................................. 5
181 Medium gray weathered, massive ledged, sandy
(up to 20% quartz sand) CALSILUTITE to CRYSTAL-
LINE LIMESTONE.......................... 15

180 Medium dark Bluish gray weathered (N-4 to 5B
4/1), massive ledged CALCILUTITE with relict
organic structures............................ 16

179 Grayish orange weathered (10 YR 7/4) subrounded
to subangular, well sorted, medium to coarse
grained quartz SANDSTONE. Dolomitic lime
cement and friable weathered surface.............. 20

178 Medium to dark Bluish gray weathered, cliff-forming,
massive, locally sandy CALCILUTITE. Valve
structures in lower, amphiporids in middle, and
large stromatoporoids in upper part of unit......... 100

177 Medium gray weathered phaneritic DOLOMITE.....  2

176 Moderate brown weathered (5 YR 4/4), subrounded,
fine to medium grained dolomitic quartz SANDSTONE. 10

175 Medium dark to Bluish gray weathered, massive
CALCILUTITE with abundant valve structures...... 10

174 Gray weathered, laminated sandy CALCILUTITE..... 4

173 Brownish gray weathered, aphanitic DOLOMITE
with amphiporids............................. 5
172 Bluish gray weathered, mottled CALCILUTITE
with valve structures and small algal biscuits...... 9
171 Light olive gray weathered aphanitic DOLOMITE.... 19
170 Quartz SANDSTONE..................................... 2
169 Medium light gray weathered aphanitic DOLOMITE.. 4
168 Yellowish gray to grayish orange weathered, sub-
angular, medium to coarse grained, lime cemented,
quartz SANDSTONE..................................... 8
167 CALCILUTITE: same as unit 165...................... 2
166 Quartz SANDSTONE..................................... 3
165 Medium bluish gray weathered, massive ledged
dense CALCILUTITE to CRYSTALLINE LIMESTONE. 16
164 Quartz SANDSTONE..................................... 4
163 CALCILUTITE to CRYSTALLINE LIMESTONE:
same as unit 161 with small (1/2 to 1 inch diameter)
algal? -stromatoporoid structures, abundant valve
structures and some sandstone...................... 16
162 Quartz SANDSTONE..................................... 1
161 Medium light to medium bluish gray weathered,
massive ledged very fine CRYSTALLINE LIMESTONE
with gastropod castes and some valve structures... 53
160 Quartz SANDSTONE..................................... 4
159 Medium light gray to bluish gray weathered,
CALCILUTITE to CRYSTALLINE LIMESTONE with abundant large valve structures, brachiopod castes, and occasional sand stringers

158 Light olive gray phaneritic DOLOMITE

157 Medium to bluish gray weathered, semi cliff to cliff-forming, massive ledged CALCILUTITE with abundant gastropod castes and valve structures

156 Quartz SANDSTONE

155 Light olive gray weathered fine phaneritic DOLOMITE

154 Bluish gray weathered cliff-forming, massive ledged, thin bedded to laminated CALCILUTITE to CRYSTALLINE LIMESTONE with some valve structures and amphiporid relict structures

153 Medium dark gray weathered phaneritic DOLOMITE with valve structures and amphiporids

152 Bluish gray weathered CALCILUTITE

151 Gray weathered phaneritic DOLOMITE

150 Light bluish gray weathered, cliff-forming, fine CALCARENITE to CALCILUTITE with algae, corals, and brachiopods. Lower half of unit thin to medium wavy bedded (2 - 6 inches); upper half massive ledged
149 Medium gray weathered fine phaneritic DOLOMITE ........................................ 3
148 Bluish gray weathered mottled CALCILUTITE with relict coralline structures ..................... 3
147 Gray weathered, massive phaneritic DOLOMITE with intermittent sand stringers....................... 12
146 Bluish gray weathered massive CALCILUTITE ...... 5
145 Light olive gray weathered, fine phaneritic DOLOMITE ........................................ 21
144 Medium bluish gray weathered CRUSTALLINE LIMESTONE ........................................ 10
143 Quartz SANDSTONE ledge ................................. 4
142 Medium bluish gray weathered, massive CALCILUTITE with small valve structures and becoming sandy in upper half of unit ........................................ 10
141 Medium gray weathered phaneritic DOLOMITE ............ 3
140 Medium gray to bluish gray weathered, cliff forming, massive ledged CALCILUTITE with valve structures ........................................ 22
139 Phaneritic DOLOMITE ....................................... 4
138 Medium gray weathered CALCARENITE ............... 3
137 Medium gray weathered, semi cliff-forming CALCILUTITE ....................................... 4
136 Quartz SANDSTONE................................. 2
135 Bluish gray weathered, slope-forming CALCILUTITE with sand stringers in upper part of unit... 6
134 Medium gray weathered phaneritic DOLOMITE...... 3
133 Bluish gray weathered, resistant slope-forming CALCILUTITE........................................... 3
132 Medium dark to brownish gray weathered, phaneritic DOLOMITE with hydrocarbon odor ................... 6
131 Bluish gray weathered, semi cliff-forming CALCISILTITE................................................... 5
130 Massive, fine grained quartz SANDSTONE.............. 12
129 Medium dark gray weathered, massive phaneritic DOLOMITE............................................... 9
128 Medium bluish gray weathered, massive CALCILUTITE 5
127 Medium light gray weathered, phaneritic DOLOMITE with wavy sand stringers............................. 3
126 Medium bluish gray weathered, cliff-forming, massive CALCILUTITE with intermittent sand stringers and some relict valve structures?................. 76
125 Quartz SANDSTONE ....................................... 4
124 Light bluish gray weathered CALCILUTITE........... 7
123 Light brownish gray weathered, very SANDY LIMESTONE to LIMY SANDSTONE......................... 12
122 Quartz SANDSTONE ................................. 3
121 Medium bluish gray weathered massive CALCI-
LUTITE.................................................. 23
120 Medium dark gray weathered, massive, coarse
phaneritic DOLOMITE with relict coralline
structures ............................................ 11
119 Medium gray weathered, massive, fine phaneritic
DOLOMITE with amphiporids ....................... 15
118 Bluish gray weathered, cliff-forming, massive
ledged CALCILUTITE with some sand at base of
unit and relict fossil structures .................... 50
117 Medium light to medium gray weathered, sugary
phaneritic DOLOMITE with some aphanitic
DOLOMITE and local sand ......................... 36
116 Light brownish gray weathered, massive quartz
SANDSTONE ........................................... 18
115 Medium light gray weathered, massive fine
phaneritic DOLOMITE ............................... 28
114 Light bluish gray weathered, semi cliff to cliff-
forming, massive ledged phaneritic DOLOMITE
with amphiporids ................................. 17
113 Medium light gray weathered, semi cliff-forming,
massive ledged, silty DOLOMITE to dolomitic
SILTSTONE with superficial sand stringers and
amphiporid structures .................................. 14

112 Brownish gray weathered, sandy DOLOMITE.....  5

111 Medium to dark brownish gray weathered, cliff-
forming, massive 1-3 foot ledges of phaneritic
DOLOMITE with white dolomite veining.............. 18

110 Medium dark to bluish gray weathered, massive
cliff-forming, wavy bedded, fine CALCISILTITE
to CALCILUTITE with some mottling and a few
corals in upper part of unit.......................... 38

109 Olive gray to medium bluish gray weathered,
massive cliff-forming, thin wavy bedded silty
CALCISILTITE to CALCILUTITE with abundant
corals Macgeea sp., Tabuliphyllum sp. cf.
T. mcconnelli Whiteaves, T. sp., Papiliphyllum?
sp. cyathophyllloid horn coral and Thamnopora? sp.
of lower upper Devonian age and a few brachopods.. 10

108 Light olive gray weathered (5Y 6/1), slightly
darker fresh surface, slope-forming, thin bedded,
platy, powdery, silty, CALCISILTITE with abundant
branching corals, brachiopods and gastropods...... 88
107 Resistant ledge of fine CRYSTALLINE LIMESTONE:

same as unit 105 with branching corals .................. 8

106 Flaggy, silty, CALCILUTITE to CRYSTALLINE
LIMESTONE: same as unit 104 with large gastropods,
small brachiopods and abundant brachiopod Meristella
sp.......................................................... 40

105 Medium gray (N-5) to medium olive gray (5Y 5/1)
weathered, slightly darker fresh surface, resistant
ledge of CRYSTALLINE LIMESTONE with abundant
brachiopods Pseudodouvillina sp., Meristella sp.
and Atrypa sp.............................................. 10

104 Light olive to yellowish gray weathered (5Y 7/1),
medium dark to olive gray (5Y 4/1) fresh surface,
bench to saddle-forming, thin wavy bedded, platy,
powdery, shaly CALCILUTITE to fine CRYSTALLINE
LIMESTONE with abundant ferruginous replaced
brachiopods Pseudodouvinella sp. and some Atrypa
sp. of lower-upper Devonian age....................... 72

Units 104-198 upper member of the Guilmette
formation: 1639 feet.

103 Medium dark gray to dark bluish gray weathered,

massive cliff-forming, thick to thin bedded, CALCILUTITE to CALCARENITE to CRYSTALLINE
LIMESTONE with some DOLOMITE zones up to 20 feet thick with abundant Algal biscuits up to 8 inches in diameter making up to 50% of the rock in some zones.................. 328

102 Medium olive gray weathered, medium dark gray fresh surface, resistant slope to semi-cliff-forming CRYSTALLINE LIMESTONE with small round (1-2 inch diameter) algal biscuits ............ 10

101 Medium gray weathered, resistant slope-forming, massive ledged CALCISILTITE with amphiporid? and algal structures. Upper 2 feet of unit medium light gray dolomitic LIMESTONE............. 16

100 Medium dark gray weathered, slope-forming, massive ledged LIMY DOLOMITE to DOLOMITIC LIMESTONE............................ 56

99 Grayish orange weathered aphanitic DOLOMITE:
same as unit 97................................. 56

98 Light bluish gray weathered, resistant ledge of CALCILUTITE................................. 2

97 Pale grayish orange weathered (10 YR 8/4), light olive gray fresh surface (5Y 6/1), easily eroded bench to saddle-forming, thin bedded to laminated aphanitic DOLOMITE.......................... 35
96 Medium light gray weathered, limy phaneritic
DOLOMITE........................................... 2

95 Medium light to bluish gray weathered, massive
ledged, CRYSTALLINE LIMESTONE.............. 9

94 Medium dark gray to bluish gray weathered, re-
sistant slope-forming, thin bedded CALCILUTITE
and Algal LIMESTONE ............................ 14

93 Brownish gray weathered, phaneritic DOLOMITE
with hydrocarbon fetid odor ..................... 6

92 Medium light gray weathered aphanitic DOLOMITE.. 22

91 Medium dark gray weathered, slope-forming, thin
bedded phaneritic DOLOMITE.................... 24

90 Light olive gray weathered, slope-forming
phaneritic DOLOMITE............................ 20

89 Medium dark gray weathered, coarse phaneritic
DOLOMITE.......................................... 30

88 Medium gray weathered, coarse phaneritic
DOLOMITE.......................................... 12

87 Medium light gray weathered, resistant slope to
semi cliff-forming, massive ledges of phaneritic
DOLOMITE and partly dolomitized Algal LIMESTONE
with relict organic and algal structures........ 20
86 Medium dark gray weathered phaneritic DOLOMITE .................................. 8

85 DOLOMITE: same as unit 84 with algal and relict organic structures .................. 26

Units 85-103 lower member Guilmette formation:

696 feet.

Total thickness of the Guilmette formation ............ 2335

Contact Conformable

Top of the Simonson formation

84 Medium to light olive gray weathered, medium gray fresh surface, cliff-forming, massive ledged, fine phaneritic DOLOMITE with large silicified fragments of brachiopod Stringocephalus sp.

(Stringocephalus zone) .................................. 12

83 Medium gray weathered, cliff-forming, massive phaneritic DOLOMITE with relict organic structures including branching colonial corals .................. 48

82 Medium light gray weathered phaneritic DOLOMITE with extensive "zebra striped" white dolomite veining (crystal heaving?) ......................... 6

81 Medium dark to brownish gray weathered, resistant slope to semi cliff-forming phaneritic DOLOMITE with relict organic structures .................. 14
Medium light gray weathered, resistant slope-forming phaneritic DOLOMITE.................. 66
Brown phaneritic DOLOMITE: same as unit 72........ 2
Medium light to medium gray weathered, resistant slope-forming phaneritic DOLOMITE with calcite veining in upper part of unit....................... 80
Brown DOLOMITE: same as unit 72 with hydro-carbon odor........................................ 2
Medium light gray weathered DOLOMITE.......... 8
Gray weathered phaneritic DOLOMITE: same as unit 73 ............................................... 36
Brown phaneritic DOLOMITE: same as unit 72..... 5
Medium light gray to dark yellowish gray weathered, light gray fresh surface, resistant, massive phaneritic to aphanitic DOLOMITE.................... 9
Medium yellowish brown (10 YR 5/2) to medium brownish gray weathered (5 YR 5/1), medium dark gray fresh surface (N-4), resistant slope to semi cliff-forming fine phaneritic DOLOMITE with hydro-carbon odor. ........................................ 12
DOLOMITE BRECCIA.................................................. 3
Medium gray weathered DOLOMITE............... 24
Medium dark gray phaneritic DOLOMITE............ 4
Medium light gray weathered, resistant slope-forming DOLOMITE: same as unit 66. 4

Brownish gray weathered, resistant slope-forming, phaneritic DOLOMITE with hydrocarbon odor. 12

Medium light gray weathered, bench to slope-forming, fine phaneritic to aphanitic DOLOMITE. 12

Units 66-84 Upper Alternating member Simonson formation: 359 feet.

Medium dark gray weathered, massive cliff-forming, mottled fine phaneritic DOLOMITE with relict organic structures. 92

Medium dark gray weathered, resistant slope-forming DOLOMITE. 16

Medium light gray weathered, bench-forming DOLOMITE. 4

Medium dark gray, bench to slope-forming, thin bedded DOLOMITE. 12

Medium dark gray weathered, cliff-forming, massive phaneritic DOLOMITE with distinctive mottling in lower half of unit. 52

Units 61-65 mottled Cliff Member Simonson formation: 176 feet.
Light gray DOLOMITE: same as unit 52 with organic relict structures and amphiporids

Dark gray weathered, cliff-forming DOLOMITE:
same as unit 51 with amphiporid structures and chert nodules

Light gray DOLOMITE: same as unit 52

Dark gray DOLOMITE: same as unit 51, resistant slope to semi cliff-forming

Light gray DOLOMITE: same as unit 52

Dark gray DOLOMITE: same as unit 51, resistant slope-forming

Light gray DOLOMITE: same as unit 52

Dark gray DOLOMITE: same as unit 51

Medium light to medium olive gray weathered,
slope-forming, fine phaneritic to aphanitic DOLOMITE

Medium dark to medium brownish gray weathered,
slope-forming, fine phaneritic DOLOMITE

Medium light gray weathered DOLOMITE: same as unit 22

Medium dark gray weathered DOLOMITE: same as unit 21

Gray DOLOMITE: same as unit 22
Covered, bench-forming, light olive gray

DOLOMITE................................. 20

Dark gray DOLOMITE: same as unit 21.............. 4

Medium light gray DOLOMITE: same as unit 22..... 8

Brown DOLOMITE: same as unit 21.................... 3

Gray DOLOMITE: same as unit 22.................... 4

Partly covered, bench-forming, medium gray and

brown fine phaneritic DOLOMITE..................... 20

Brown, slope-forming DOLOMITE: same as unit 21. 8

Gray DOLOMITE: same as unit 22..................... 6

Brown DOLOMITE: same as unit 21.................... 6

Gray DOLOMITE: same as unit 22.................... 12

Brown DOLOMITE: same as unit 21 with hydrocarbon

odor ............................................. 12

Gray DOLOMITE: same as unit 22..................... 4

Brown DOLOMITE: same as unit 21 but mottled..... 12

Gray DOLOMITE: same as unit 22..................... 4

Brown DOLOMITE: same as unit 21 with hydrocarbon

odor ............................................. 12

Gray DOLOMITE: same as unit 22..................... 3

Brown DOLOMITE: same as unit 21 with hydrocarbon

odor ............................................. 4
30 Light olive gray weathered DOLOMITE: same
   as unit 22................................. 6
29 Dark gray mottled fine phaneritic DOLOMITE...... 8
28 Gray DOLOMITE: same as unit 22.................. 5
27 Brown DOLOMITE: same as unit 21.................. 4
26 Gray DOLOMITE: same as unit 22.................. 3
25 Brown DOLOMITE: same as unit 21.................. 6
24 Gray DOLOMITE: same as unit 22.................. 4
23 Brown DOLOMITE: same as unit 21.................. 4
22 Light olive gray (5Y 6/1) to medium (N-5) and
   medium light gray (N-6) weathered, medium to
   dark gray fresh surface (N-5 to N-3), resistant
   slope-forming, massive ledged, fine phaneritic
   to aphanitic DOLOMITE....................... 4
21 Light brownish gray (5 YR 6/1) to dark brownish
   gray (5 YR 3/1) and medium dark gray (N-4)
   weathered surfaces, medium dark gray (N-4) to
   dark gray (N-3) fresh surface, resistant slope-
   forming, massive ledged, thin bedded to laminated,
   fine phaneritic DOLOMITE with hydrocarbon fetid
   odor ........................................... 4
20 Very light olive gray weathered, fine phaneritic
   DOLOMITE .................................... 10
Medium dark to brownish gray weathered, fine phaneritic DOLOMITE with hydrocarbon odor

Light olive gray weathered, fine phaneritic DOLOMITE

Brownish to olive gray weathered, sugary phaneritic DOLOMITE

Light olive gray, massive ledged, laminated aphanitic DOLOMITE

Units 16-65 Lower Alternating member Simonson formation: 368 feet.

Light olive gray weathered, resistant slope to semi cliff-forming, massive ledged, sugary phaneritic DOLOMITE

Light gray weathered aphanitic DOLOMITE

Light olive gray weathered, massive ledged, fine phaneritic DOLOMITE

Light olive to yellowish gray weathered (5Y 7/1), very light gray fresh surface (N-8), semi cliff-forming, massive ledged, coarse phaneritic DOLOMITE

Medium brownish gray weathered, resistant slope to semi cliff-forming, phaneritic DOLOMITE with hydrocarbon odor
10 Light gray weathered, phaneritic DOLOMITE

9 Medium gray weathered aphanitic DOLOMITE

8 Brownish gray weathered (5 YR 4/1), fine phaneritic DOLOMITE with hydrocarbon fetid odor

7 Medium light gray weathered, massive ledged, aphanitic DOLOMITE

6 Light olive gray weathered, semi cliff-forming sugary phaneritic DOLOMITE with sand stringers in lower part of unit

5 Medium light gray weathered sandy DOLOMITE alternating with medium dark gray weathered DOLOMITE without sand

4 Medium light gray weathered, cliff-forming, massive ledged DOLOMITE with sand stringers decreasing toward top of unit

3 Gray weathered DOLOMITE

2 Gray weathered, semi cliff-forming, sandy aphanitic DOLOMITE

Units 2-15 lowermost Coarse Member Simonson formation: 265 feet.

Total thickness of Simonson formation 1168
Contact Conformable and Gradational

Top of Sevy formation

1 Grayish brown weathered (5 YR 3/2), very light gray fresh surface (N-8), semi cliff-forming, fine grained quartz SANDSTONE.

Section Continuously Exposed
Measured Section of the Guilmette Formation

West of the Hiko Narrows

S.E. 1/4 Section 6, N.E. 1/4 Section 7, T 3 S, R 61 E

Lincoln County, Nevada

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top of Section Covered</td>
<td>Guilmette formation (incomplete)</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Olive gray weathered (5Y 4/1), dark gray fresh surface (N-3), bench to slope-forming, thin to medium bedded (3 inches to 2 feet) CALCISILTITE alternating with light gray weathered (N-7) CALCILUTITE and containing light olive gray weathered (5Y 6/1) DOLomite stringers with amphiporids and some quartz SAND ledges</td>
<td>128</td>
</tr>
<tr>
<td>18</td>
<td>Light olive gray weathered (5Y 6/1), medium light gray fresh surface (N-6), thin to medium bedded (3 inches to 1 foot) slightly calcareous medium phaneritic DOLomite alternating with some yellowish gray weathered (5Y 3/1), light olive gray fresh surface (5Y 6/1) fine phaneritic DOLomite and intermittent thin to medium beds and stringers of quartz SANDSTONE</td>
<td></td>
</tr>
</tbody>
</table>
Unit becomes increasingly calcareous upward in section. Zone of corals and algae 60 feet above base of unit........................................ 108

17 Light olive gray weathered (5Y 6/1), medium light gray fresh surface, thin bedded, platy CALCILUTITE irregularly interbedded with moderate reddish brown (10 R 4/9) weathered, grayish pink fresh surface (5R 8/2), thinly laminated (5-10 laminations per inch), medium grained quartz SANDSTONES in lower half of unit. Upper half of unit contains abundant small and large horn corals, branching colonial corals e.g. "Cladopora" and Alveolites sp., syringoporoid corals, Algal biscuits and brachiopoda including Cyrtospirifer sp.. 64

16 Light gray (N-7) to light brownish gray (5 YR 6/1) weathered, medium dark gray (N-4) to dark gray (N-3) fresh surface, thin to medium bedded (1 inch to 1 foot), shale parted CALCILUTITE containing abundant large horn corals, syringoporoid corals, and colonial branching corals with large algal? - stromatoporoida masses up to 6 inches in diameter. "Coral" reef .......................... 8
15 Light brownish gray weathered (5 YR 6/1), light olive gray fresh surface (5Y 4/1), resistant slope-forming, thin to medium bedded (2 inches to 2 feet), shale parted CALCILUTITE with small horn corals and organic detritus throughout upper half of unit, and intermittent 2 to 4 foot moderate brown weathered (5 YR 4/4), grayish orange pink fresh surface (5 YR 7/2) medium grained, calcareous quartz SANDSTONES.......... 146

14 Medium dark gray weathered (N-4), grayish black fresh surface (N-2), resistant slope to semi cliff-forming, thin to medium bedded (1 inch to 1 foot), shale parted CALCISILTITE with small corals and common Amphipora sp. ...................... 88

13 Dull brownish gray weathered, brownish gray fresh surface (5 YR 4/1), semi cliff-forming, medium bedded (6 inches to 2 feet) CALCI-SILTITE with thin zones of light brownish gray weathered (5 YR 6/1) medium gray fresh surface (N-5) limy DOLOMITE................................. 272

12 Light gray (N-7) to medium light gray (N-6) weathered, light olive gray fresh surface (5Y 6/1), semi cliff-forming, thin to thick bedded
(2 inches to 2 feet) shale part CALCISILTITE

with abundant horn corals and Algal biscuits .......... 196

11 Medium gray (N-5) to yellowish gray (5Y 7/2)
weathered, dark gray fresh surface (N-3), resistant slope to semi cliff-forming, medium bedded,
mottled CALCISILTITE ........................................ 72

10 Light olive gray weathered (5Y 6/1), medium light
gray fresh surface (N-6), resistant slope-forming,
medium bedded (2 inches to 1 foot), medium
phaneritic DOLOMITE with amphiporids ............... 60

9 Brownish gray weathered (5 YR 4/1), medium dark
gray fresh surface (N-4), semi cliff-forming,
massive 5 foot ledges of ALGAL LIMESTONE ....... 42

8 Yellowish gray (5Y 3/1) to light olive gray (5Y 4/1)
weathered, medium light gray (N-6) to dark gray
(N-3) fresh surface, resistant slope-forming,
medium to thin bedded (2 feet to 2 inches) fine
phaneritic DOLOMITE with abundant corals and
Algae .............................................................. 76

7 Medium dark gray weathered (N-4), medium gray
fresh surface (N-5), cliff-forming, massive 2 to
5 foot ledges of ALGAL REEF LIMESTONE ........... 132
Brownish gray weathered (5 YR 4/1), grayish brown fresh surface (5 YR 3/2), semi cliff-forming, medium bedded (5 inches to 1 foot)
highly organic CALCILUTITE to CALCISILTITE and CRYSTALLINE LIMESTONE with amphiporids, hydrocarbon odor and relict fossil fragments

Medium light gray (N-6), light gray fresh surface (N-7), cliff-forming, massive ledged (2-4 feet)

Light brownish gray weathered (5 YR 6/1), medium gray fresh surface (N-5), slope-forming medium bedded (1-2 feet), medium phaneritic DOLOMITE with chert zone 32 feet above base of unit

Light gray weathered (N-7), olive gray fresh surface (5Y 4/1), thin to medium bedded (3 inches to 2 feet) CALCILUTITE with some small horn corals 3 feet above base of unit

Pale yellowish orange weathered (10 YR 8/6), light olive brown fresh surface (5Y 5/6), bench to saddle-forming, easily eroded, thin bedded (3 to 6 inches) limy DOLOMITE

Grayish orange weathered (10 YR 7/4), dark gray fresh surface (N-3), bench-forming, medium bedded
(3 inches to 1 foot), medium phaneritic DOLOMITE. 72

Total measured thickness of Guilmette formation... 1670

(lower member and lower part of upper member combined)

Contact Conformable

Top of Simonson formation

Stringocephalus Zone

Section continuously exposed
**Measured Section of the Guilmette, West Range, and**

**Pilot Formations at Bactrian Mountain**

Section 11, T 5 S, R 59 E, Lincoln County, Nevada.

Dip 12-20 Degrees in the Direction S 50-60 Degrees W

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Section Continuously exposed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Joana limestone</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Medium gray weathered, cliff-forming, massive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-4 foot beds of CALCARENITE.</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Medium light gray weathered, resistant slope-forming, thin-discontinuously bedded, shale</td>
<td></td>
</tr>
<tr>
<td></td>
<td>parted, highly fossiliferous CALCISILTITE to</td>
<td></td>
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<tr>
<td></td>
<td>CALCARENITE containing abundant brachiopods</td>
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<tr>
<td></td>
<td>echinoderm debris, corals, bryozoa and gastropods:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leptaena sp. cf. L. analoga Phillips, Camarotoechia</td>
<td></td>
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<tr>
<td></td>
<td>sp. cf. C. tuta Miller or C. metallica white,</td>
<td></td>
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<tr>
<td></td>
<td>Spirifer sp. cf. S. pellanesia Weller, Spirifer sp.</td>
<td></td>
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<tr>
<td></td>
<td>cf. E. blari, Fenestella sp. A (large fenestrules),</td>
<td></td>
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<tr>
<td></td>
<td>Fenestella sp. B (small fenestrules), Schuchertella?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sp. Composita sp. Fauna lower to middle Kinderhookian</td>
<td></td>
</tr>
</tbody>
</table>

age-Mississippian) ............................................. 23
Total measured thickness of the Joana limestone....  28

Contact conformable and gradational

Top of Pilot formation

41 Medium gray (N-5) to medium dark gray (N-4)
weathered and fresh surface, shaly, silty CALCI-
SILTITE to calcareous SHALE with occasional 2-3
inch CALCILUTITE beds. SHALE predominates
and CALCILUTITE interbeds increase in upper part
of unit................................. 116

40 Yellowish gray to pale grayish orange weathered,
pale yellowish brown fresh surface, slope-forming,
laminated, platy CALCISILTITE becoming darker
weathered and more fissile to medium dark gray
calcareous SHALE in upper half of unit............. 130

39 Yellowish gray (5Y 3/1) weathered, medium yellow-
ish brown (10 YR 5/2) fresh surface, bench to
slope-forming, thin wavy discontinuously bedded,
shaly, silty CALCISILTITE containing small
gastropods, brachiopods Camarotoechia sp.,
Shellwienella sp. other brachiopods, crinoid stem
fragments, cephalopod? fragments, and small
horn corals: Neozaphrentis sp. ....................... 30

38 Very pale orange (10 YR 8/2), yellowish brown
(10 YR 6/2), and grayish orange (10 YR 7/4)
weathered and fresh surfaces, slope-forming, laminated, platy and fissile, silty CALCISILTITE to silty CALCAREOUS SHALE

Total thickness of Pilot formation

Contact Conformable

Top of West Range formation

37b Medium gray weathered resistant ledges of shaly recrystallized CALCISILTITE to CALCILUTITE:
same as unit 36 interbedded with less resistant benches of light grayish yellow to pale yellowish orange powdery CALCISILTITE to silty CALCAREOUS SHALE. Upper 20 feet of unit contains prolific brachiopod fauna:

Cyrtospirifer portae Merriam, Cyrtospirifer sp.

Cf. C. whitneyi Hall, Cyrtospirifer animasensis

(Girty), Cyrtospirifer sp. (Cyrtospirifer portae faunal zone.) 20-30 feet below top of unit (and formation) occur abundant brachiopods: Schizophoria simpsoni Merriam, Ambocoelia sp. cf. A. parva

Weller, Athryis angelica Hall, Nudirostra walcotti (Merriam), Pustula sp., productellic brachiopods small, and Camarotoechia sp. in pale grayish orange weathered easily eroded bench-forming, slightly recrystallized silty CALCISILTITE to

CALCAREOUS SILTSTONE
Medium light gray (N-6), weathered, light olive gray (5Y 6/1) to medium yellowish brown (10 YR 5/2) fresh surface, bench to slope-forming, thin to medium wavy, knobly, discontinuously and continuously bedded, shale partied, partly recrystallized CALCISILTITE to CALCILUTITE. Unit forms resistant ledges of CALCITITES interbedded with bench-forming pale grayish orange (10 YR 8/4) shaly zones with abundant fauna: orthoceroid and breviconic Cephalopods (Brevicoceratidae - aff. Eleusoceras sp.), gastropods, pelecypods and brachiopods: Tenticospirifer sp. cf. T. keleticus Crickmay, Cleiothyridina? sp. Productella sp., Cyrtospirifer sp. cf. C. breviposticus, Stainbrook, Athyris angelica, Schizophoria sp. ......................... 88 Total thickness of the West Range formation...... 223 Contact conformable and sharp Top of Guilmette formation Yellowish brown weathered, resistant slope-forming, massive, well sorted, subrounded, fine to medium grained quartz SANDSTONE............ 13
35  Medium light gray (N-6) to light olive gray weathered (5Y 6/1), pale yellowish brown fresh surface (10 YR 7/2), slope-forming, arenaceous (30-40% quartz) LIMESTONE ................. 4

34  Yellowish gray (5Y 8/1) to grayish orange (10 YR 7/4) weathered, resistant slope to semi cliff-forming, subrounded, well sorted, lime cemented, clean, medium grained quartz SANDSTONE .... 17

33  Slope-forming arenaceous LIMESTONE ........... 6

32  Medium gray to pale yellowish brown weathered, pale grayish orange fresh surface (10 YR 8/4), semi cliff-forming, subrounded, well sorted, lime cemented quartz SANDSTONE gradational with some sandy LIMESTONE containing abundant sand stringers ......................... 44

31  Resistant slope-forming calcareous SANDSTONE to arenaceous LIMESTONE ................. 15

30  Yellowish gray weathered and fresh surface (5Y 8/1), semi cliff-forming, subrounded, fine grained dolomitic quartz SANDSTONE to QUARTZITE .... 17

29  Pale yellowish brown weathered, subrounded, lime cemented, medium grained quartz SANDSTONE .... 7
28 Light gray weathered, resistant slope-forming, massive, fine CRystalline LIMESTONE with sand stringers at top of unit.......................... 18

27 Semi cliff-forming quartz SANDSTONE............. 22

26 Light olive gray weathered, resistant slope-forming, fine phaneritic DOLOMITE............... 3

25 Bench to slope-forming LIMESTONE: same as unit 23........................................... 14

24 Resistant slope-forming quartz SANDSTONE...... 7

23 Light gray weathered (N-7), medium light gray (N-6) to medium brownish gray (5YR 5/1) fresh surface, massive cliff-forming, fine CRystalline LIMESTONE with some poorly preserved spiriferoid brachiopods ........................................ 30

22 Gray weathered, slope to bench-forming, laminated to thin bedded, platy, fine phaneritic to aphanitic DOLOMITE. Upper half of unit 6-18 inch parted ledges finely laminated............................... 18

21 Light olive gray weathered and fresh surface (5Y 6/1), cliff-forming, fine CRystalline LIMESTONE with some relict algal structures at base of unit................................. 43
20 Very light olive gray weathered (5Y 7/1), light olive gray fresh surface (5Y 6/1), resistant slope to semi cliff-forming, very fine phaneritic DOLOMITE

19 Medium light gray (N-6) to medium olive gray weathered, resistant slope-forming, fine CRYSTALLINE LIMESTONE

18 Quartz SANDSTONE

17 DOLOMITE: same as unit 15

16 Quartz SANDSTONE

15 Light olive to medium gray weathered, semi cliff-forming, sandy, aphanitic to fine phaneritic DOLOMITE with amphiporids and some interbedded quartz SANDSTONE ledges

14 Dolomitic quartz SANDSTONE

13 DOLOMITE: same as unit 11 with some SANDSTONE ledges and dolomitic SANDSTONE in lower part of unit

12 Medium gray weathered ledge of CRYSTALLINE LIMESTONE with abundant Amphiopora sp. (amphiporid biostratone)

11 Medium light gray (N-6) to light olive gray (5Y 6/1) weathered, medium dark gray fresh surface (N-4),
resistant slope to semi cliff-forming, massive
ledges of fine phaneritic DOLOMITE with inter-
mittent sandy beds and some amphiporid biostrome
ledges........................................ 88

10 Light olive gray weathered, resistant slope-forming,
sandy aphanitic DOLOMITE to dolomitic SANDSTONE. 50

9 Sandy DOLOMITE: like unit 8 but containing less
sand stringers................................. 35

8 Yellowish gray weathered (5Y 8/1), medium olive
gray fresh surface (5Y 5/1), resistant slope to
semi cliff-forming, laminated, sandy, aphanitic
DOLOMITE with brown sand stringers, differential
weathering laminae, and distinctive penecontemporan-
eous flow and brecciation.................... 30

7 Alternating 3–8 foot units of very light olive gray
weathered (5Y 7/1), medium olive gray fresh surface
(5Y 5/1), thin bedded aphanitic DOLOMITE and
medium gray weathered fine CRYSTALLINE LIME-
STONE............................................. 26

6 Medium light gray weathered (N-6), medium gray
fresh surface (N-5), resistant slope-forming, fine
CRYSTALLINE LIMESTONE to CALCISILTITE with
some DOLOMITE LIMESTONE. Upper part of unit
weathers grayish orange to yellowish gray. Unit contains abundant spiriferid and other brachiopods (Atrypa sp. small; Atrypa sp. large), small horn corals including Macgeea sp. "Cladopora"? sp., and Amphipora? sp. ................................. 120

5 DOLOMITE: same as unit 4; sandy at base of unit... 48

4 Quartz SANDSTONE: like unit 2. ...................... 2

3 Undifferentiated interbedded medium gray (N-5), medium olive gray (5Y 5/1), and yellowish gray weathered, slope-forming, phaneritic DOLOMITE with some sandy beds and intermittently abundant amphiporid beds (dolomitized amphiporid biostromes) 144

2 Pale yellowish brown weathered (10 YR 5/2), very light gray fresh surface (N-8), bench to slope-forming, subrounded, well sorted, fine to medium grained dolomitic quartz SANDSTONE ............... 4

1 Medium olive gray weathered (5Y 5/1), medium gray fresh surface (N-4), partly covered bench-forming, 4-8 inch beds of fine phaneritic DOLOMITE with amphiporids ................................................. 23

Total measured thickness of Guilmette formation... 1081

(Upper member only)

Base of Section covered.
Measured Section of the Upper Guilmette, West Range, and Pilot formations near Mount Irish.

N.W. 1/4 Section 3, T 4 S, R 59 E; S.W. 1/4 Section 34, E 1/2 Section, 33 T 3 S, R 59 E, East Side

Pahranagat Range, Lincoln County, Nevada

Dip of Section decreases from 30-40 Degrees in the Direction N 25 Degrees West in lower part to 13-33 Degrees in the direction N 20-45 Degrees West in the upper part.

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section continuously exposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joana Limestone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Pale orange weathered (10 YR 8/2), medium gray fresh surface (N-4), partly covered, slope-forming, thin to thick bedded (2 inches to 6 feet) fossiliferous CALCISILTITE to CALCARENITE that grades upward into medium gray weathered, medium light gray fresh surface, cliff-forming crystalline LIMESTONE</td>
<td></td>
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<tr>
<td>Contact Conformable</td>
<td></td>
<td></td>
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<tr>
<td>Top of Pilot formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37 SHALE: same as unit 35</td>
<td></td>
<td>106</td>
</tr>
</tbody>
</table>
Dusky yellow (5Y 6/4) weathered, grayish black fresh surface (N-2), mostly covered, slope forming, thin bedded (1 to 6 inches) to laminated CHERT with yellowish brown weathered, thin wavy bedded, calcareous SHALE partings

Yellowish gray weathered (5Y 7/2), medium dark gray fresh surface (N-4), partly covered bench to saddle-forming, thin bedded to finely laminated platy, fissile, calcareous SHALE with grayish orange weathered (10 YR 7/4), light brown fresh surface (5 YR 5/6), mostly covered, thin bedded (2 inches to 1 foot) well indurated, medium grained, poorly sorted quartz SANDSTONE ledges in lower 10 feet of unit

Total thickness of the Pilot formation

Contact Paraconformable

Top of West Range formation

Medium gray weathered (N-5), olive gray (5Y 4/1) to medium dark gray fresh surface (N-4), bench forming, thin discontinuously, wavy and knobbly bedded (2 inches to 1 foot), and more resistant 1 to 2 foot beds of shale parted CALCISILTITE to CALCILUTITE containing poorly preserved cephalopods, gastropods,
and brachiopods .................................. 140

Total thickness of the West Range formation ....... 140

Contact Paraconformable

Top of Guilmette formation

33 Yellowish gray (5 Y 8/1), medium red (5R 5/6), and reddish brown weathered hues, very light gray (N-3) to white (N-9) fresh surface, resistant, subrounded, medium grained, lime and silica cemented quartz SANDSTONE. Orange, yellow and brownish black lichens........................................... 12

32 Olive gray (5Y 4/1), with tints of blue, weathered, medium gray fresh surface (N-5), resistant slope-forming, massive ledges of thin bedded (2 inches) crystalline LIMESTONE becoming sandy and cross-bedded near top of unit......................... 14

31 Yellowish gray weathered and fresh surface (5Y 8/1), slope-forming, subrounded to sub-angular, well sorted, fine to medium grained lime cemented friable quartz SANDSTONE................. 46

30 Medium light to medium dark gray weathered, slope-forming, massive ledges of thin to thick beds of CALCILUTITE and crystalline LIMESTONE with
quartz sand stringers in the upper 10 feet of unit...

29 Light gray (N-7) with tints of yellow and brown weathered, medium gray fresh surface (N-6), slope-forming, very fine phaneritic DOLOMITE interbedded with medium brownish gray weathered (5 YR 5/1), medium gray (N-5) to medium dark gray (N-4) fresh surface fine phaneritic DOLOMITE with Amphiporid biostromes and intermittent 1 foot quartz SANDSTONE ledges......................... 180

28 Quartz SANDSTONE .................................. 24

27 DOLOMITE: same as unit 25 ......................... 16

26 Yellowish gray weathered (5Y 6/1), slightly darker fresh surface, fine phaneritic to aphanitic sandy DOLOMITE with thin quartz sand stringers........ 6

25 Medium to dark gray weathered, resistant slope to semi cliff-forming phaneritic DOLOMITE ............ 40

24 Light brownish gray weathered (5YR 5/1) phaneritic DOLOMITE interbedded between two ledges of yellowish gray weathered, subrounded to subangular, moderately well sorted quartz SANDSTONE. Gradational contact with unit 25........................................ 8

23 Medium to dark gray weathered fine phaneritic DOLOMITE................................. 28
22 Very light gray weathered and fresh surface (N-8)
   sandy aphanitic DOLOMITE with quartz sand
   stringers .............................................. 12

21 Very pale yellowish-orange-gray weathered, very
   light gray to white fresh surface, subrounded to
   subangular, medium grained quartz SANDSTONE.
   Orange lichens ........................................... 14

20 Medium brownish gray weathered (5 YR 5/1), medium
   gray fresh surface (N-5), resistant slope-forming,
   medium bedded (2 inches to 1 foot), fine to very
   fine phaneritic DOLOMITE with relict chertified
   organic fragments ........................................ 58

19 Quartz SANDSTONE: thin bedded and like unit 17.... 6

18 Interbeds of very light gray weathered (N-8), slightly
   darker fresh surface, resistant slope-forming, thin
   bedded, sandy aphanitic DOLOMITE with abundant
   1/4 inch laminated wavy quartz sand stringers and
   2 to 3 foot ledges of mottled CALCILUTITE with
   medium brownish gray weathered (5YR 5/1), medium
   dark gray fresh surface, fine phaneritic to aphanitic
   DOLOMITE ................................................. 44

17 Light grayish brown weathered, very light gray to
   white fresh surface, massive cross-bedded, subrounded
to subangular, moderately well sorted, medium
grained quartz SANDSTONE cemented by silica and
limy dolomite. Dip on foreset beds 20 degrees
N 35° W, but also some S.E. foreset dips............ 15

16 Medium light gray weathered (N-6), medium gray
fresh surface (N-5), resistant slope-forming,
massive ledged, mottled CALCILUTITE interbedded
with thin bedded to laminated platy CALCILUTITE
in lower half of unit becoming progressively thicker
bedded (3 inches to 2 1/2 feet) in upper half of unit
with increasing recrystallization and dolomitization
terminating in 10 feet of DOLOMITE at top of unit.... 38

15 Light gray (N-7) to yellowish gray (5 Y 7/1) to pale
yellowish-orange (10 YR 8/4) weathered, medium
dark gray fresh surface (N-4), bench to slope-
forming, thin to medium bedded (1 inch to 2 feet)
wavy continuous and discontinuous bedding, shaly
parted, mottled fossiliferous CALCISILTITE to
CALCILUTITE containing abundant brachiopods
including Atrypa sp. and Cyrtospirifer sp., small
corals and some pelecypods. 4 feet of light brown
weathered quartz SANDSTONE at base of unit....... 30
14 Intermittent alternations of very light gray (N-8) to very light olive gray (5Y 7/1) weathered, semi cliff-forming massive 3 foot ledges of thin to medium bedded aphanitic DOLOMITE with medium gray (N-5) to moderate brownish gray (5YR 5/1) weathered, medium dark gray fresh surface(N-4) fine phaneritic DOLOMITE containing 1 to 2 foot Amphiporid biostromes. Contacts between alternations irregular, disconformable, paraconformable, and transitional. Several 2 to 3 foot light olive to yellowish gray (5Y 7/1) weathered, subrounded, well sorted, silica and dolomite cemented, medium grained (1/4 - 1/2 mm) QUARTZITE units occur in upper 50 feet of unit................................. 140

13 Very light gray (N-8) to yellowish gray (5Y 3/1) weathered, very light gray to white fresh surface, massive, slope-forming, coarse phaneritic DOLOMITE with some relict algal structures intermittently interbedded with medium brownish gray weathered (5 YR 5/1), slightly lighter and olive fresh surface, resistant slope-forming 1 to 2 foot ledges of phaneritic DOLOMITE. Unit contains large gastropod castes,
abundant relict coral structures and 2 to 4 foot massive semi cliff-forming amphiporid and algal biostromes, light brown weathered (10 YR 6/4) 1 foot thick subrounded, dolomite cemented, quartz SANDSTONE ledges occur at 40' and 103' from base of unit. Interbedded dolomite units become finer grained to aphanitic near top of unit....................

12 Medium bluish gray weathered, easily eroded slope-forming fine crystalline LIMESTONE and light olive gray weathered phaneritic DOLOMITE ledges increasing in the upper 28 feet of unit. CALCILUTITE contains recrystallized horn corals, brachiopods and gastropods. .................................

10 Medium dark gray weathered, resistant slope to semi cliff-forming fine phaneritic DOLOMITE as unit 9 with abundant amphiporid structures and dolomitized algal structures followed by medium gray weathered, cliff-forming CALCILUTITE as unit 10 with abundant algal and stromatoporoid reef structures .........................

10 Medium gray weathered, resistant ledge of CALCILUTITE............................
9  Medium dark gray (N-4) to brownish gray  
    (5YR 4/1) weathered, medium gray fresh sur-
    face (N-5), medium bedded (1 foot) resistant  
    slope-forming, fine phaneritic DOLOMITE with  
    abundant veining and prolific amphiporid  
    biostromes.  

Last 4 feet of unit weathers light gray .............. 36

8  Light gray weathered (N-7), slightly lighter fresh  
    surface, massive ledged, thin to medium bedded,  
    resistant slope to semi cliff-forming crystalline  
    LIMESTONE ....................................... 12

7  Pale yellowish grey (10 YR 6/2) weathered  
    medium gray fresh surface (N-5), resistant  
    slope-forming, medium bedded fine phaneritic  
    DOLOMITE with some chert knobs ................. 48

6  Medium gray (N-5) to bluish gray (5B 5/1)  
    weathered, medium dark gray fresh surface (N-4),  
    medium bedded (3 to 6 inches), resistant ledge of  
    partly recrystallized CALCILUTITE with abundant  
    chert stringers ................................... 4

5  Light bluish grey weathered, light gray fresh  
    surface (N-7), slope forming, massive ledges of
thin bedded (2 to 4 inches) aphanitic DOLOMITE
with intermittent chert ........................................ 70

3 Very light gray (N-8) to yellowish gray (5Y 8/1)
fresh and weathered surface, bench to slope-forming,
very sandy cross-bedded fine phaneritic DOLOMITE
to dolomitic subrounded quartz SANDSTONE. Orange
and yellow lichens ........................................... 20

2 Pale grayish to yellowish orange weathered, slightly
darker to medium olive gray fresh surface partly
covered, bench-forming aphanitic DOLOMITE ....... 20

1 Medium dark gray (N-4) to brownish gray (5YR 4/1)
weathered, medium light gray fresh surface (N-6),
massive 4 foot ledges of medium bedded (6 inches to
2 feet) mostly covered, slope-forming fine phaneritic
DOLOMITE ...................................................... 24

Total measured Guillmette formation ............... 1547
(All part of Upper Member)

Section Covered
Measured Section of the Guilmette, West Range, Pilot
and Joana Formations at Curtis Canyon

S 1/2 Sections 28-29 and N 1/2 Sections 32-33, T 6 S, R 60 E,
Lincoln County, Nevada

Dip 12-22 Degrees in the direction S 50-75 Degrees West

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Section incomplete (reversal of dip in syncline) but probably within 75 feet from top of formation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Joana limestone</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Medium gray weathered, medium dark gray fresh surface, slope-forming, CALCARENITE with large horn corals in bottom 8 feet and chert bands in upper 8 feet of unit</td>
<td>28</td>
</tr>
<tr>
<td>45</td>
<td>Medium gray weathered, dark gray fresh surface, alternating slope to semi cliff-forming, medium bedded (6 inches to 1 foot) cherty, CALCISILTITE to CALCILUTITE</td>
<td>76</td>
</tr>
<tr>
<td>44</td>
<td>Medium light gray to medium gray weathered, medium to dark gray fresh surface, resistant slope-forming, medium bedded (6 inches to 1 foot),</td>
<td></td>
</tr>
</tbody>
</table>
lithographic CALCILUTITE to very fine CRYSTAL-LINE LIMESTONE with minor chert in lower part of unit and brachiopods Productus altonensis Norwood and Pratten and Spirifer subaequalis Hall in upper half of unit......................... 152

43 Medium gray weathered, medium dark gray fresh surface, resistant slope-forming, medium bedded (6 inches to 3 feet), CALCILUTITE to CALCARENITE with 3 inch chert bands decreasing in upper part of unit and large Syringopora sp. colonies throughout lower half of unit (1 foot thick and 3 feet in diameter) and Lithostrotionella sp. ........................................ 176

42 Medium light gray weathered, medium gray fresh surface, bench to resistant slope-forming, medium bedded, (6 inches to 1 foot) recrystallized CALCILUTITE with colonies of Syringopora sp. and Lithostrotionella sp. in upper half of unit............. 92

41 Medium light gray weathered, medium dark gray fresh surface, resistant slope-forming, medium bedded (6 inches to 1 foot) recrystallized CALCILUTITE with some chert and large horn corals near top of unit (Visculo phillum ? sp.)................. 84
40 Light gray weathered (N-7), light brownish gray fresh surface, resistant slope to semi cliff-forming, medium bedded (6 inches to 3 feet), re-crystallized fine CALCISILTITE to CALCILUTITE.
(Unit is upper part of lower Joana cliff)......... 40

39 Light gray weathered, medium light gray fresh surface, massive cliff-forming, medium to thick bedded (2-6 feet) CRYSTALLINE LIMESTONE with abundant chert banding in upper half of unit and containing abundant crinoidal fragments and corals Triplophyllites ? sp. (Homalophyllites ? sp)......... 266

38 Light olive to yellowish gray (5Y 7/1) and medium light gray (N-6) weathered medium gray (N-5) fresh surface, resistant slope-forming, thin to medium wavy continuously and discontinuously bedded (1-3 inches), calcareous shale parted, partly re-crystallized CALCARENITE containing prolific fauna: brachiopods-Camarotoechia sp. cf. C. tuta, Productus aff. P. arcuatus Hall, P. blari Miller, P. ovatus Hall, P. samsoni Weller, P. sedaliensis Weller, Spirifer sp. cf. S. pellanensis Weller, Schizophoria chouteauensis Weller, Spirifer centronatus, Composita opposita (White and Whitfield),
Ambocoelia aff. minuta White, Leptaena sp. cf. 
L. analoga Phillips, Schuchertella? sp., gastropods - Bellerophon aff. B. bleri, Platyceras sp., 
Eumophalus sp. (Straporallus), bryozoa-Fenestella 
sp. small horn corals and colonial corals Syringopora 
sp. cf. S. aculeata Girty, Cladochonus sp., trilobite 
Proetus loganensis  Hall and Whitfield, crinoid stems 
and rare crinoid calyx (indet.)...................... 28 
Total measured thickness of Joana limestone...... 942 
Contact Conformable and Gradational 
Top of Pilot formation 

37 Medium gray (N-5) to medium dark gray (N-4) 
weathered and fresh surface, slope-forming, thin 
bedded to laminated, flaky shaly CALCISILTITE 
grading upward into dark gray powdery fissile 
SHALE with several interbeds of light gray weathered 
(N-7), medium light gray fresh surface (N-6), 
dense CALCILUTITE and rounded limestone "con-
cretions" up to 6 inches in diameter................. 60 

36 Medium gray weathered, slope-forming, thin to 
medium bedded, shaly CALCISILTITE interbedded 
with grayish orange weathered platy CALCISILTITE 
and several 1-3 foot beds of CHERT and thin beds of 
CALCILUTITE........................................... 194
Pale grayish orange weathered, resistant slope-forming, laminated to thin bedded (1/4–3 inches), platy calcareous Siltstone with 4 foot ledges of grayish orange (10 YR 7/4) and very pale orange (10 YR 8/2) weathered crust, medium bluish gray fresh surface (5B 5/1), very finely laminated dense Chert at bottom and at top of unit.............

Alternating laminated and thin bedded (1/16–6 inches), moderate yellowish brown to grayish orange (10 YR 6/4) and very pale yellowish brown (10 YR 7/2) weathered and fresh surface, bench to slope-forming, platy, silty, calcareous Shale to silty Calcisiltite containing several thin zones of medium dark gray finely laminated Calcisiltite and calcareous cherty Siltstones with small crinoid stems and columnals .................

Total thickness of the Pilot formation..............

Contact Conformable

Top of West Range formation

Medium gray (N-5), light olive gray (5Y 6/1) and medium light gray (N-6) weathered, medium to light gray and yellowish gray fresh surfaces, resistant ledges of thin, wavy knobly, continuous and
discontinuously bedded, shaly CALCISILTITE to CALCILUTITE interbedded with easily eroded benches of moderate yellowish brown to grayish orange shaly CALCISILTITE containing several zones of rare cephalopods, gastropods, and abundant brachiopods which include: *Tenticospirifer* sp. cf. *T. keleticus* Crickmay, *Athyris angelica*, *Schizophoria* sp. cf. *S. simpsoni* Merriam, *Cyrtospirifer* sp. cf. *C. whitneyi* Hall, *Cyrtospirifer portae* (Merriam), *C. sp.*, *Cleothyrhellina sp.*, *Camaroteocha* sp. *Ambocoea* sp. cf. *A. parva*, *Nudirostra walcotti* (Merriam) and other brachiopods (faunal zones occur at approximately O, 70, 140, 370 and 390 feet from base of unit)...

Total thickness of West Range formation

Contact Conformable

Top of Guilmette formation

32 Light olive gray weathered (5Y 6/1), slightly lighter gray fresh surface, dolomitic CRYSTALLINE LIMESTONE with some sand stringers and caliche weathered crust

31 Resistant slope-forming quartz SANDSTONE: same as unit 27
30 Light gray weathered, darker gray fresh surface, slope-forming, phaneritic DOLOMITE

29 Quartz SANDSTONE: same as unit 27

28 Light gray weathered, slope-forming, fine phaneritic DOLOMITE that grades into unit 29

27 Resistant slope to semi cliff-forming, medium bedded (6 inches to 2 feet), subrounded, well sorted, medium to fine grained quartz SANDSTONE

26 Very light gray to yellowish gray weathered and fresh surface, coarse phaneritic DOLOMITE with calcite veining becoming finer grained toward top of unit

25 Quartz SANDSTONE

24 Sandy DOLOMITE

23 Medium light gray very fine CRYSTALLINE LIMESTONE

22 Quartz SANDSTONE

21 Medium light gray weathered CALCILUTITE

20 Very light gray weathered (N-8), light olive gray fresh surface (5Y 6/1) aphanitic DOLOMITE

19 Friable quartz SANDSTONE

18 Medium gray to light olive gray weathered, darker fresh surface, resistant slope-forming, massive
ledged fine CRYSTALLINE LIMESTONE with several 1-4 foot sandy zones and intermittent 
amphiporid beds........................................... 158

17 Quartz SANDSTONE: same as unit 7 .................... 2

16 Medium olive gray weathered (5Y 5/1), medium dark gray (N-4) to olive gray (5Y 4/1) fresh surface, slope-forming, medium bedded (6 inches to 2 feet) fine CRYSTALLINE LIMESTONE with 5% disseminated subrounded to rounded quartz grains and some sandy zones. Well preserved 

Amphipora sp. at top of unit............................ 54

15 Quartz SANDSTONE: same as unit 7.................... 3

14 Very light olive gray weathered, slightly darker and brownish fresh surface, resistant slope-forming, phaneritic DOLOMITE with calcite veining.......... 16

13 Medium dark gray weathered, slope-forming, coarse phaneritic DOLOMITE with amphiporids .......... 4

12 Medium olive gray weathered, resistant slope- forming, sandy DOLOMITE gradational with well sorted, subrounded, loosely cemented, medium grained quartz SANDSTONE.............................. 13

11 Dark yellowish brown to dusky yellowish brown weathered (10 YR 3/2), slightly darker fresh surface,
slopet-forming, vuggy, sugary, phaneritic

DOLOMITE........................................ 15

10 Light olive to yellowish gray weathered (5Y 7/1),
medium light gray fresh surface, slope-forming,
sandy, vuggy aphanitic DOLOMITE.............. 7

9 Medium dark gray weathered, resistant slope to semi
cliff-forming aphanitic DOLOMITE with amphiporids. 3

8 DOLOMITE: same as unit 4.......................... 12

7 Medium to grayish brown weathered, resistant
slope-forming, massive, subrounded, well sorted,
medium grained quartz SANDSTONE............... 7

6 DOLOMITE: same as unit 4......................... 8

5 Very light olive to yellowish gray weathered (5Y
8/1), light olive gray fresh surface (5Y 6/1),
laminated aphanitic DOLOMITE interbedded with
moderate to grayish brown weathered, cross-
laminated, rounded, medium to coarse grained
dolomitic quartz SANDSTONE..................... 8

4 Light gray weathered, medium bedded (1 foot),
aphanitic DOLOMITE with 1/8 inch differential
weathering laminae............................... 8

3 Moderate light brown weathered (5YR 5/4), white
fresh surface (N-9), massive 1-3 foot ledges of
cross bedded, subrounded, well sorted, medium
grained clean quartz SANDSTONE with friable
weathering surface.......................... 30

2 Light gray (N-7) weathered, medium olive gray
(5Y 5/1) to medium yellowish brown (10 YR 5/2)
fresh surface, resistant slope to semi cliff-
forming, massive 3 foot ledges of fine CRYSTAL-
LINE LIMESTONE with occasional bed of moderately
well preserved Amphipora sp................... 78

1 Medium olive gray weathered (5Y 5/1), medium
gray fresh surface (N-5), resistant slope-forming,
massive 2-4 foot parted ledges of very fine
phaneritic to aphanitic DOLOMITE with inter-
mittent amphiporid biostrome ledges .......... 52

Total measured thickness of Guilmette formation... 585

Base of section covered
Measured Section of the West Range and Pilot Formations

North of Summit Road near Mount Irish

N.E. 1/4 of S.E. 1/4 Section 4, T 4 S, R 59 E

Lincoln County, Nevada

Dip 15-40 Degrees in the direction N 80 Degrees West

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Joana limestone (Mississippian)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contact Conformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Pilot formation</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mostly covered, thin bedded calcareous SHALE....</td>
<td>114</td>
</tr>
<tr>
<td>3</td>
<td>Dusky yellow calcareous SHALE with prominent CHERT ledge at top of unit.</td>
<td>146</td>
</tr>
<tr>
<td></td>
<td>Total thickness of the Pilot formation</td>
<td>260</td>
</tr>
<tr>
<td></td>
<td>Contact covered (considered Paraconformable)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of West Range formation</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Medium gray weathered, slope to bench-forming, thin wavy bedded CALCISILTITE</td>
<td>156</td>
</tr>
<tr>
<td></td>
<td>Total thickness of the West Range formation</td>
<td>156</td>
</tr>
<tr>
<td></td>
<td>Contact conformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top of Guilmette formation</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Pale reddish brown weathered, resistant slope-forming, fine grained, dolomit</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>quartz SANDSTONE</td>
<td></td>
</tr>
</tbody>
</table>
Total measured Guilmette formation ............... 62

(terminating sand of upper member only)

Section continuously exposed
**Measured Section of the Joana Limestone at**

**Bactrian Mountain**

S.E. 1/4 Section 10; S.W. 1/4 Section 11; N.W. 1/4 Section 14;

N.E. 1/4 Section 15, T 5 S, R 59 E, East Side

Pahranagat Range, Lincoln County, Nevada

Section Dips 24-34 Degrees in the direction S 45-60 Degrees West

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section Covered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chainman formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Medium yellowish orange (10 YR 6/6) to grayish orange (10 YR 7/4) weathered, very dark gray</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N-3) fresh surface, mostly covered bench-forming,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>thin bedded calcareous SILTSTONE interbedded</td>
<td></td>
</tr>
<tr>
<td></td>
<td>with gray SHALE in lower part of Unit giving way</td>
<td></td>
</tr>
<tr>
<td></td>
<td>to medium dark gray weathered and fresh surface,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>very thin bedded, saddle-forming, fissile SHALE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>containing dusky red (5R 3/4) to dark reddish brown (10R 3/4) concretions (up to 2 inches in</td>
<td></td>
</tr>
<tr>
<td></td>
<td>diameter)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>with fish scales?</td>
<td>100</td>
</tr>
<tr>
<td>Total measured Chainman formation</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

Contact Conformable

Top of Joana Limestone
10 Very light gray (N-8) to light gray (N-7) weathered (weathers slightly lighter than Unit 9), olive gray (5Y 4/1) to dark gray (N-3) fresh surface, thin to medium bedded, slope-forming, partly recrystallized CALCILUTITE containing abundant crinoid columnals, fenestellid bryozoa, and some spiriferoid brachiopods and small solitary corals. Little or no chert .......................... 24

9 Light olive gray (5Y 6/1) to very light gray (N-7) weathered (weathers slightly lighter than unit 8), medium olive gray (5Y 5/1) to medium gray (N-6) fresh surface, medium bedded (6 inches to 2 feet) continuously bedded, resistant bench-forming, partly recrystallized CALCILUTITE with abundant chert lenses and abundant small to large solitary corals and syringoporoid colonial corals .................. 92

8 Medium light gray (N-6) to medium gray (N-5) weathered medium to dark gray fresh surface (N-3 to N-4), continuously parted ledges of medium bedded (6 inches to 1 foot) almost lithographic CALCILUTITE with abundant large (3 to 4 inch) solitary corals, colonial corals including Lithostromationella sp., spiriferoid and other small brachio-

pods. No chert .......................... 224
7 Medium gray (N-5) to medium light gray (N-6)
weathered, medium gray fresh surface (N-5), re-
sistant semi cliff-forming, medium bedded (6 inches
to 2 feet) CALCILUTITE with abundant small solitary
corals, long thin horn corals, organ pipe corals and
some banded chert from 1 to 4 inches thick......... 84

6 Medium light gray weathered (N-6), medium olive
gray fresh surface (5Y 5/1), medium bedded (1 foot),
continuously bedded, lower part of unit bench-forming,
upper part resistant slope-forming, shaly parted
(parting weathers grayish orange (10 YR 7/4) partly
recrystallized CALCILUTITE with intermittent chert
and small solitary corals and colonial corals including
Syringopora sp., (colonies up to 4 feet in diameter and
2 feet high) Aulopora sp. Lithostrotionella sp. aff. L.
hemisphaerica and brachiopods including Ciothyridina
sp. cf. C. glenparkensis Weller..................... 200

5 Medium gray (N-5) to medium light gray (N-6)
weathered, medium dark gray fresh surface (N-4),
thin bedded, bench to slope-forming, cherty, partly
recrystallized crinoidal CALCISILTITE to CALCI-
LUTITE with small brachiopods, abundant fenestellid
bryozoa and small solitary corals in upper part of
unit, Chert weathers moderate brown (5YR 3/4-4/4)
and decreases in upper part of unit................. 104
4 Light gray weathered (N-7), light brownish gray fresh surface (5YR 6/1), resistant slope to semi cliff-forming, medium bedded (6 inches to 2 feet) partly recrystallized crinoidal CALCISILTITE to CALCARENITE. Crinoid stems up to 8 inches in length and 1/2 inch diameter. Contains corals Syringopora sp., and Triplophyllites sp. With chert Unit is upper part of lower Joana Cliff. 72

3 RECRYSTALLIZED LIMESTONE same as Unit 2 but with prolific knobs and discontinuous lenses 1 to 4 inches wide of chert (Unit is middle part of lower Joana Cliff). 78

2 Very light gray (N-8) to light gray (N-7) weathered, medium gray fresh surface (N-5), medium bedded (6 inches to 2 feet), continuously bedded, cliff-forming recrystallized LIMESTONE containing crinoid stems several inches long and with a diameter of 1/8-1/2 inch. (Unit is lower part of lower Joana Cliff). 110

1 Very light gray (N-8) to yellowish gray (5Y 8/1) weathered, medium light gray (N-6) to light olive gray (5Y 6/1) fresh surface, knobby, wavy, thin (1/2 inch to 3 inches), discontinuously bedded, CALCARENITE with shale partings that weather moderate pink to pale
yellowish orange (10 YR 8/6), some chert lenses
1-2 inches thick to 8 inches wide, and containing
abundant brachiopods including Camarotoechia sp.
 cf C. tuta Miller, Leptaena analoga Phillips,
Spirifer sp. aff. S. pellanensis Weller, gastropods
including Bellerophon sp. aff. E. blari and Eu-
mophalus sp., rare solitary corals and colonial
corals i.e. Syringopora sp. and Archimedes sp.
bryozoa .......................................................... 26
Total thickness of the Joana Limestone ............. 1014
Contact conformable and transitional
Top of Pilot Shale
Very dark gray to light yellowish gray weathered,
platy, calcareous SHALE.
Section continuously exposed.
Measured Section of the Uppermost Joana and Lower Chainman Formations North Fork Curtis Canyon

S 1/2 Section 20, T 6 S, R 60 E, Lincoln County, Nevada.

Dip 12-20 Degrees in the direction South 75 Degrees West.

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Section covered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chainman formation</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Medium to dark gray, mostly covered, saddle-forming, flaky, fissile SHALE with dark dusky red (5R 2/4) concretions containing fish? scales, abundant small brachiopods and goniatite ammonites: Cravenoceras sp. cf. C. nevadense</td>
<td>120</td>
</tr>
<tr>
<td>8</td>
<td>Covered brown SHALE slope with bright yellow (5Y 8/6) concretionary material</td>
<td>64</td>
</tr>
<tr>
<td>7</td>
<td>Light brown weathered (5YR 6/4-7/4), medium dark gray fresh surface (N-4) slightly calcareous SILTSTONE</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>Pale yellowish brown (10 YR 6/2), bench-forming, laminated (1/16-1/4 inch) calcareous SILTSTONE to SHALE with paper thin medium dark gray (N-4) to dark gray (N-3) flaky silty SHALE at top of unit</td>
<td>56</td>
</tr>
</tbody>
</table>
5 Light brownish gray weathered (5Y 6/1), medium
dark gray fresh surface (N-4), slope-forming,
slightly calcareous shaly SILTSTONE...................2

4 Pale brown weathered (5YR 5/2), medium dark gray
(N-4) to brownish gray (5Y 4/1) fresh surface,
mostly covered, thin bedded, platy, cherty, slightly
calcareous SILTSTONE and SHALE.....................8

Total measured thickness Chainman formation......338

(Lower part only)
Contact Conformable
Top of Joana limestone

3 Light gray (N-7) weathered, dark gray fresh surface
(N-3), slope to bench-forming, thin bedded CALCI-
LUTITE to very fine CRYSTALLINE LIMESTONE
with shaly partings that weather light brown (5YR
6/4), some chert, and abundant crinoidal fragments,
small corals, fenestellid bryozoa and some spiriferoid
brachiopods.............................................30

2 Medium light gray (N-6) pitted, powdery, weathered,
medium dark gray fresh surface (N-4), slope-forming,
slightly wavy continuously bedded CALCILUTITE and
fine CRYSTALLINE LIMESTONE with abundant thick
(1-6 inch) discontinuous chert bands.................48
1 Medium olive gray weathered (5Y 5/1), medium dark gray fresh surface (N-4), resistant slope-forming, 1-2 foot uniform and continuously bedded, very fine CRYSTALLINE LIMESTONE with fat (1-2 inches), long (6-8 inches) horn corals and some brachiopods Dielesia sp. cf. *D. illinoiensis* Weller.......................................................... 30

Total measured thickness of Joana limestone........ 108

(Upper part only)

Section continuously exposed
Measured Section of the Scotty Wash and Ely Limestone

Formations at Hill 25-1, East Side Pahranagat Range.

S.E. 1/4 Section 23, S.W. 1/4 Section 24, T 5 S, R 59 E,
Lincoln County, Nevada

Dip from 50-55 Degrees in the direction S 75-85 Degrees West
decreasing up section to 28-40 Degrees in the direction
N 70-85 Degrees West

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>Section terminated by fault</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ely limestone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very light gray (N-8) to medium gray (N-6) weathered, medium dark gray fresh surface (N-4), resistant slope-forming, laminated (1/8-1/2 inch), platy, fine CALCISILTITE to CALCILUTITE with small to large (1/2 to 2 1/2 inches in diameter) pale yellowish brown weathered (10 YR 6/2), medium dark gray fresh surface CHERT BALL CONCRETIONS and poorly preserved gastropods and brachiopods</td>
<td>35</td>
</tr>
<tr>
<td>27</td>
<td>Very dark gray to black weathered and light orange brown weathered, bench-forming</td>
<td></td>
</tr>
</tbody>
</table>
26 Light gray weathered and fresh surface, resistant slope-forming, medium bedded (4 inches to 1 foot) fine CALCISILTITE to CALCILUTITE with abundant recrystallized brachiopods, fenestellid bryozoa, and corals Aulopora sp. and Cladochonus fragilis Mather .......................................................... 4

25 Light yellowish gray weathered, medium dark gray fresh surface, slope-forming, laminated (1/8-1/2 inch), flaggy, platy, CALCISILTITE with some fossil fragments ....................................................... 48

24 Medium gray weathered, resistant slope-forming, massive ledged CALCARENITE with some chert bands, abundant crinoid stems, and large productid brachiopods: Dictyoclostus hermonsanus and Dictyoclostus sp. ......................................................... 20

23 Medium gray weathered (N-8), bench-forming, 1-2 foot ledges of CALCARENITE interbedded with soft olive gray SHALE. Large colonial coral in float; Pleurodictyum? sp .......................................................... 64

22 Light to medium gray weathered (N-7 to N-8), resistant slope-forming, thin bedded to laminated, sandy CALCISILTITE interbedded with dark yellow
orange weathered (10 YR 6/6), moderate yellowish
brown fresh surface (10 YR 5/4), platy, flaggy,
calcareous SILTSTONE .................................. 19

Pale grayish orange weathered (10 YR 8/4), light
to yellowish gray fresh surface, slope-forming,
sandy CALCARENITE and thin bedded CALCI-
SILTITE .................................................. 65

Medium light gray weathered (N-6), resistant slope-
forming, thin to medium bedded (4 inches to 1 foot),
laminated, sandy CALCARENITE ................. 3

Very light olive to yellowish gray (5Y 7/1), with
hues of grayish orange weathered bench-forming,
thin bedded (1/2 inch), flaggy, shaly CALCISILTITE
with abundant 1/2 inch diameter crinoid stems and
columnals, brachiopods Dictyoclostus hermosanus
(Girty), Dictyoclostus sp., cf. D. inflatus, Productus
sp. cf. P. semireticulatus var. hermosanus Girty,
Spirifer occidentalis Girty or Spirifer sp. cf. S
Fayettevillensis Snider, Neospirifer cameratus,
Reticularina? sp., Cleiothyridina pecosi Marcou,
Leptaea sp., small solitary horn coral Neozaphrentis
sp., stenoporoid, rhomboporoid, and fistuliporoid bryozoa

18 Light to medium gray weathered, resistant slope-forming fossiliferous CALCARENITE with some chert; interbedded with somewhat less resistant shaly CALCISILTITE.

17 Pale brown to brownish gray weathered, resistant, massive ledge of cross-bedded, subangular fine quartz SANDSTONE. Foreset beds dip southward...

16 Pale olive gray to light olive gray weathered, resistant slope-forming, massive ledges of medium bedded (6 inches to 2 feet), silty CALCARENITE interbedded with less resistant very pale yellowish brown weathered (10 YR 7/2) SHALE and CALCISILTITE. Unit weathers with slight brown hue but less brown than subjacent unit 15. Resistant and non-resistant interbeds of about equal thickness giving cyclic aspect. Chert stringers and nodules 1/2 to 3 inches thick in lower 20 feet of unit.

Fossils same as unit 15.

15 Medium light to brownish gray and very pale orange (10 YR 3/2) weathered, slope-forming resistant
ledges of fossiliferous CALCARENITE inter-bedded with non-resistant bench-forming shaly

CALCARENITE containing abundant fauna including brachiopods; Squamularia-persplexa

McChesney, Echinoconchus semipunctatus

(Shepard), Neospirifer camaratus, Punctospirifer kentuckiensis (Shumard), Composita

subtilita Hall, Composita elongata Dunbar and

Condra, Cleiothyridina orbicularis McChesney,

Rhipidomella sp., cf. R. nevadensis Meek,

Rhipidomella sp., Schizophoria resupinoides Cox,

Schizophoria sp. large (up to 1 1/2'' wide x

1 1/2'' long x 1'' thick), Spirifer occidentalis

Girty, stenoporoid, rhomboporoid and fenestellid

bryozoa aff. Fenestella sp., some small solitary

corals, Blastoid Pentremites ? sp., crinoid

columnals. ........................................ 192

Covered ........................................... 52

Total thickness of Ely Limestone .................. 764

(Total exposed incomplete section of lower member

only)

Contact covered (considered conformable)

Top of Scotty Wash formation
Moderate to dusky brown weathered (5 YR 3/4-2/2), light to moderate brown fresh surface, resistant slope-forming, thin bedded (2-6 inches), tidal-flat ripple marked, cross bedded, SILTSTONE interbedded with some light olive gray SHALE................................. 10
Light olive gray, saddle-forming SHALE............ 30
Light to moderate weathered, resistant ledge-forming, thin bedded (2-6 inches), fossiliferous CALCARENITE essentially composed of brachiopod fragments and crinoid columnals ...................... 7
Light olive gray saddle-forming SHALE with dark red concretionary fragments......................... 24
Medium yellow brown weathered (10 YR 5/4)
CALCARENITE essentially composed of small crinoid columnals................................. 3
Dark yellow brown weathered (10 YR 4/2) SHALE... 15
Light brown resistant ledge of CALCARENITE...... 2
Light olive gray (5 Y 6/1), saddle-forming flaky SHALE with included light to medium brown (5 YR 5/6-4/4), calcareous MUDSTONE pieces...... 40
5 Covered (possible fault?): Some outcrops like unit 4 but probably mostly SHALE as unit 6 .......... 100

4 Medium gray weathered, slope-forming, partly covered, CALCARENITE with spiriferoid and productid brachiopods ........................................... 12

3 Dark to moderate yellow-orange (10 YR 5/5) and medium gray weathered fossiliferous CALCARENITE interbedded with light olive gray (5Y 6/1) flaky SHALE ................................................................. 6

2 Dark dusky red (5 R 2/4) weathered and fresh surface, resistant slope-forming, silty, lime cemented CALCIRUDITE COQUINA to calcareous SILTSTONE with abundant brachiopods Orbiculoidea missouriensis Shumard and Composita subtilita (Hall) ............... 6

1 Light to medium olive brown (5Y 4/4) to moderate yellow brown (10 YR 5/4) weathered, resistant, massive, thin bedded (3-6 inches) cross-bedded, shaly, limy, SILTSTONE ........................................... 8

Total maximum thickness of Scotty Wash formation 263

Base of section covered
**Measured Section of the Hells Bells Canyon Formation**

at Hells Bells Canyon

S 1/2 Section 4, T. 7 S., R. 60 E., East Side

Pahranagat Range, Lincoln County, Nevada

Section measured by Abraham Dolgoff, 1959

* Thin section on file at the Geological Laboratory, The Rice Institute, Houston, Texas.

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curtis Canyon ignimbrite</td>
<td>Light brown gray, cliff-forming, massive, jointed, hard, &quot;pseudo-granitic&quot; welded crystal-vitric TUFF. Black glass streaks at base of unit.</td>
<td>Unit 2: base of welded tuff member of the Curtis Canyon ignimbrite.</td>
</tr>
<tr>
<td>1</td>
<td>White, slope-forming, thick bedded (3-4 feet), semi-consolidated biotitic TUFF</td>
<td>24</td>
</tr>
</tbody>
</table>

Unit 1: Basal ash member of the Curtis Canyon ignimbrite. Contact with superjacent member gradational.

Total measured thickness Curtis Canyon ignimbrite = 24

Contact disconformable

Top of Hells Bells Canyon formation
10 White, resistant slope-forming, massive, semi-consolidated, pumiceous TUFF................. 40
9 Light gray, resistant slope-forming, massive, silty, sandy, pumiceous TUFF with gray fine grained volcanic fragments......................... 24
8 Gray, resistant slope to semi cliff-forming, 2 inch beds of semi-consolidated, cross bedded, silty, fine grained, water laid TUFF with channel fills, lenses, and unconformable sedimentary features alternating with 2 inch beds of white PUMICE fragments. Upper 60 feet of unit contains intercalated 2 foot beds of sandy fine grained PUMICEOUS TUFFS..... 80
7 White, 2-3 inch fragments, massive PUMICE TUFF. 8
6 Water worked semi consolidated TUFFS. 2 inch to 5 foot (average 1 foot) beds of white PUMICE TUFF BRECCIA (pebbles up to 1 inch) alternating with gray silty TUFF BRECCIA exhibiting good cross-bedding, minor unconformities and occasional small (measured in inches) channel fillings. Unit also has sand size TUFFS; reworked pink TUFF BRECCIA containing 8 inch fragments near base of unit, and differential compaction features......................... 37
5* White, massive PUMICE TUFF containing 3 inch fragments. In thin section 95% PUMICE, 5% quartz and sanidine, fair sorting, no orientation.

Probable pyroclastic ........................................ 16

4 Water worked white PUMICE TUFF BRECCIAS:
similar to unit 6.................................................. 92

3 Semi-consolidated PUMICE TUFF BRECCIA
containing 1-3 inch angular rhyolite fragments............. 2

2 Water worked white PUMICE TUFF BRECCIAS:
similar to units 4 and 6......................................... 63

1 White, bench to cliff-forming, massive, semi-consolidated PUMICEOUS TUFF containing angular chert fragments up to 3 inches....................... 32

Total thickness of the Hells Bells formation............. 394

Angular unconformity

Joana limestone (Mississippian)

Note: In general the Hells Bells Canyon formation weathers to oddly rounded, platy forms.
Measured Section of the Hells Bells Canyon, the Curtis Canyon, and the Alamo Range formation at

Bactrian Mountain

S 1/4 Section 4, Section 9, and W 1/4 Section 10, T. 5 S.
R. 59 E. Pahranagat Range, Lincoln County, Nevada

Section measured by Abraham Dolgoff, 1959.

Note: Section was measured on series of three fault blocks in which successively higher strata have been dropped down to the north. Lowest strata, (those in contact with the Paleozoic) are at the south end. The limestone beds of the Hells Bells Canyon formation (units 5-6) and the two dark members in the Alamo Range formation were used to trace strata from block to block.

* Thin section on file at the Geological Laboratory, The Rice Institute.

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Description</th>
<th>Thickness (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alamo Range formation</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Brown crust weathered, light pink fresh surface, cliff-forming, small blocky, very hard, cliff-forming lithic-vitrific TUFF with slightly aligned pumice fragments, feldspar, biotite in 65% aphanitic matrix</td>
<td>16</td>
</tr>
<tr>
<td>13*</td>
<td>Badly altered welded fritic-pumice latite? TUFF. On fresh surface slightly aligned pumice fragments, feldspars and lithic fragments in 90% orange to pink, hard, glassy matrix</td>
<td>24</td>
</tr>
</tbody>
</table>
12* Dark soot gray weathered, non-welded, vitric
TUFF. Glassy pitchstone matrix contains 5-6mm
fragments of black perlite. Pyroxene in thin section. 15
11 Light pink to orange brown weathered, joint con-
trolled rounded knobs, slope-forming (Base of unit
at top of cliff), slightly welded vitric crystal
rhyolite TUFF. Well indurated light gray fresh
surface. 1mm quartz and feldspar fragments with
occasional inclusions (2 inches) in 60% aphanitic
matrix........................................ 116
10* Light, slightly pink to brown weathered, joint con-
trolled (5-15 foot) blocks of massive, very hard,
cliff-forming, welded vitric-crystal rhyolite TUFF.
Fresh surface shows well aligned, streaked pumice
(4 inches), 3mm quartz sanidine in 60-70% dark
pink-brown glassy matrix slightly altered in thin
section. A few flow rock inclusions. Unit is less
welded at top than at base......................... 160
9b Hard brown crust pitted weathered surface, rec-
tangular joint controlled 10 foot blocks of welded
vitric-lithic TUFF. Lithic fragments increase to
7 inches toward top of unit which becomes harder.
In hand specimen, 2 mm obsidian fragments in 70%
aphanitic matrix................................. 48
9a Light pink-brown pitted weathered surface
(covered with red lichens?), resistant slope to
semi cliff-forming, crudely bedded vitric-lithic
TUFF. On fresh surface fair induration. 1mm
quartz, magnetite, in 80% cream colored aphanitic
matrix.................................................. 84

x Covered............................................. 92

8* Orange pink stained, semi cliff-forming, closely
jointed blocky mass of slightly welded vitric quartz-
latite TUFF. On fresh surface, medium gray, fine
grained, sugary texture, 1/2 mm inclusions in
90% aphanitic matrix............................... 4

7 Resistant slope to semi cliff-forming, jointed,
blocky, Rhyo-dacite vitric TUFF (sillar?). Fresh
surface shows 1/2 mm quartz and feldspar fragments
in light blue-pink matrix. Thin section shows ex-
tensive alteration. Degree of welding, if any,
difficult to detect................................. 34

6* Red weathered and fresh surface, bench-forming,
massive, jointed, welded rhyolite vitric TUFF
which closely simulates a flow rock. In thin section,
strongly banded, altered, distorted shards. 10 mm
feldspar laths aligned in 90% aphanitic ground
mass ........................................ 84

5* Black to dark red weathered (occasionally to
globules, resistant slope to semi cliff-forming,
massive, vitric rhyolite TUFF which simulates a
flow rock. In thin section shards distorted. In hand
specimen few feldspars in 95% glass groundmass.... 16

4 Soot gray weathered and fresh surface, bench-
forming (probable) welded vitric TUFF. 2mm
feldspars, quartz and 10 mm pumice, well aligned
in 70% waxy vitreous matrix..................... 52

Units 4-5 Upper dark band member: 68 feet

3 Light pink brown weathered, semi cliff-forming,
crudely bedded, jointed, blocky, welded vitric
TUFF. Fresh surface light gray, hard, aligned
1/2 mm biotite needles.............................. 60
x Covered........................................ 32

Offset to fault block immediately south (see Note)

2* Small cliff and bench forming, well jointed,
dacite-crystal-vitic TUFF (non welded).
Similar to unit 1.................................. 164
1* Dusty gray weathered, resistant slope-forming, closely jointed, welded? dacite crystal-vitric TUFF. Fresh surface medium gray hard, dense, well foliated. 3mm quartz, feldspar, and 1/2 mm biotite with some 4mm inclusions in 45% dark vitreous matrix. No distortion or alteration of shards in thin section. Difficult to account for hardness in hand specimen

units 1-2 lower dark band member of the Alamo Range formation: 180 feet

Total thickness of the Alamo Range formation

Contact disconformable?

Top of Curtis Canyon ignimbrite

2* Light pink weathered, resistant slope to semi-cliff-forming, joint controlled, columnar-like pinnacles of welded dacite crystal vitric TUFF exhibiting pitting from weathered out 4 inch crudely aligned pumice fragments. Fresh surface light gray, hard, pseudo-granitic. 2mm quartz and feldspars with 1/2 mm biotite needles in 40-50% aphanitic matrix. Thin section shows fresh broken euhedral crystals and extensive distortion of shards and pumice fragments. Harder (field observation)
and glass less altered (thin section) 100 feet from base of unit. Gradational change to step and bench resistivity 368 feet from base of unit. At 500 feet from base slightly welded dacite vitric-crystal TUFF. In field-tuff less dense, less indurated, less crystalline. Thin section shows crystals down to 35-40% from greater than 50% and less distortion of shards. At 584 feet from base of unit 20% crystals; no distortion of shards.

Unit 2 welded tuff member of the Curtis Canyon ignimbrite: 608 feet

1* Light gray to pink weathered, slope-forming, crude slabby bedded, exfoliated, rounded knobs of dacite crystal-vitric TUFF. Light gray pseudo-granitic fresh surface. 3-4mm quartz, feldspar,

1/2 mm biotite, occasional 5mm pumice fragments.

Crude alignment.

Unit 1: Basal Ash member of the Curtis Canyon ignimbrite: 108 feet.

Total thickness of the Curtis Canyon ignimbrite.

Contact paraconformable?

Top of Hells Bells Canyon formation

Offset to fault Block immediately south (see Note)
6* Very light gray to pink weathered, resistant slope to semi cliff-forming, thin bedded (1-4 inches) dense fresh water CALCILUTITE with common cherty streaks and crust. Unit contains local zones of laminated curved, brown and brownish gray banded material. Locally marly. Frequent crenulated travertine? - tufa structures. Top of unit fine grained sugary. Gastropod casts and molds locally distributed. 5-6 foot algal colonies. Thin section shows interlocking, fine anhedral calcite with dusty gray, silty, irregular patches of rounded forms suggestive of cellular organisms? .......................... 64

5* Olive brown gray weathered, slope-forming, thin bedded (4 inches), brittle, compact CALCILUTITE with druzy calcite veining. Wavy-discontinuous bedding and some chert increasing upward in unit. Base of unit locally interbedded with gray, water laid sands and gravels. Algal? or travertine structures 80 feet from base of unit .................. 104

Units 5-6 Bactrian lake member of the Hells Bells Canyon formation: 168 feet.
Pink to dark brown weathered, cliff-forming, laminated to thin crude slabby bedded (1/4-5 inches), pitted, rectangular jointed (15-20 feet), moderately consolidated, welded, crystal-vitric, quartz latite TUFF. Fresh surface gray, hard, pseudo-granitic with abundant 2-3 mm euhedral biotite on bedding planes. 1/2 inch pumice fragments in 50% aphanitic matrix; some streaking. In thin section occasional small glassy volcanic fragments................. 153

Pink weathered, cliff-forming, semi-consolidated soft, friable, cavernous (5-6 foot hollows controlled by bedding) vitric-crystal rhyo-dacite TUFF. Rounded outcrop. Fresh surface light blue gray, poorly sorted. Unaltered glass in thin section............................................... 32

Resistant slope-forming welded dacite crystal vitric TUFF. Essentially same as unit 1 except less welded in thin section.............................. 120

Light brown crust weathered, slope-forming, massive, blocky, jointed, welded vitric-crystal rhyo-dacite TUFF (crystals 40-45%). Fresh surface light gray, hard, pseudo-granitic. 2-3mm quartz and euhedral biotite. Crude alignment of weathered
Out pumice making 2-3 inch pitted surface. Varies from slightly welded in lower part to moderately welded toward center and top of unit. Gradational contact into unit 2 .......................... 410

Units 1-4 Basal ignimbrite member of the Hells Bells Canyon formation: 715 feet.

Total thickness of the Hells Bells Canyon formation. 883

Angular Unconformity

Joana limestone (Mississippian)
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Summary of Geological History


Additions and Corrections


page 212, end of first paragraph, add:

A disconformity between the Upper Ordovician Ely Springs (Fish Haven) formation and the Silurian Laketown dolomite has been noted at Ward Mountain, about 15 miles southwest of Ely, Nevada, by Shank (1955, p. 11).
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