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Robert Allen Schalla for the degree of Master of Science

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Title: PALEOZOIC STRATIGRAPHY OF THE SOUTHERN MAHOGANY HILLS, EUREKA COUNTY, NEVADA

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J. G. Johnson

Paleozoic dolomites, limestones, and detrital clastic rocks were mapped in the Bellevue Peak 15 minute quadrangle in the southern Mahogany Hills, Nevada. Sedimentary rock units in this area represent shallow-shelf eastern assemblage deposits.

Shallow-shelf carbonates characterized deposition from at least Ordovician through Late Devonian time, when clastics derived from the Antler orogenic belt overwhelmed the previous environments. The Ordovician Eureka Quartzite, a quartz arenite of unknown thickness in the map area, probably represents a beach-bar-dune environment. The superjacent Hanson Creek Formation comprises limestones and dolomites of probable Late Ordovician-Early Silurian age and represents a semi-restricted lagoonal environment. Total thickness of this unit in the map area is unknown. Above the interval black dolomites which was chosen as the top of the Hanson Creek, are light-colored dolomites which are assigned to the Lone Mountain

Dolomite. These deposits are generally coarse-grained, recrystallized, and lack primary structures. An abrupt contact, interpreted as an unconformity, marks the top of this formation. Extremely fine-grained, largely unfossiliferous, light grey dolomites of the Beacon Peak Dolomite (107 m thick) overlie the Lone Mountain Dolomite in the eastern part of the map area. To the west, bioclastic limestones and dolomites of the McColley Canyon Formation (155 m thick) overlie the Lone Mountain Dolomite. The Beacon Peak Dolomite and the McColley Canyon Formation are thought to be lateral equivalents in this area, with the Beacon Peak having been deposited in a supratidal environment and the McColley Canyon in a subtidal, normal-marine environment. Progressive deepening resulted in an eastward shift of these facies during the late Early Devonian. Evidence of shoaling is present in the crinoidal dolomites of the Sadler Ranch Formation (137 m thick). This shoaling continued and resulted in the westward incursion of a tongue of the upper Oxyoke Canyon Sandstone (21 m thick) during the early Middle Devonian. Deepening of the carbonate shelf is again evident in the eastward retreat of the high-energy Oxyoke Canyon Sandstone environment and the initiation of shallow-water, Middle Devonian Simonson Dolomite (396 m thick) deposition in the map area. The superjacent Devils Gate Limestone represents increased water depth and enhanced circulation over the depositional platform. This shallow water carbonate environment persisted until detrital clastics from the Antler orogenic belt, to the west, terminated carbonate deposition in the map area.

The presence of basinal deposits of the Roberts Mountains Formation and the Denay Limestone, 10 kilometers northwest of the map area at Lone Mountain, indicates that the shelf-slope break probably persisted west of the map area from at least the Late Silurian through the Middle Devonian. The stratigraphic sequence in the map area is typical for the area near Eureka, Nevada.

Paleozoic Stratigraphy of the Southern Mahogany Hills, Eureka County, Nevada

by

Robert Allen Schalla

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Associate Professor of Geology
in charge of major

Redacted for Privacy

Chairman of the Department of Geology

Redacted for Privacy

Dean of Graduate School

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Typed by Opal Grossnicklaus for Robert Allen Schalla

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Edwin Drake and Geoffrey Stone assisted the writer in the field during the summer of 1976 and my wife, Kathleen Benedetto, proved to be an invaluable asset as a field assistant and as a provider of moral support throughout the project. Claudia Regier handled preparations of conodont samples.

Dr. F. K. Oles and Dr. R. D. Lawrence read the thesis and served on the thesis committee.

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INTRODUCTION

Purpose

The thesis project was undertaken to determine what Paleozoic lithofacies are present within the southern Mahogany Hills, and to relate this information to that from other areas in Eureka and northern Nye counties. Reconnaissance mapping by Merriam (1963) indicated considerable exposure of Paleozoic strata in the southern Mahogany Hills and further suggested that lithofacies boundaries between dominantly dolomitic rocks to the east, and limestones to the west might be exposed in this area. Detailed information regarding the lateral relationships of Paleozoic strata is important for reconstructing sedimentologic regimes of the Paleozoic continental shelf. The stratigraphic sections and geologic map presented in this report provide a necessary reference for these reconstructions.

Location and accessibility

The map area is in the northern half of the Bellevue Peak, 15 minute quadrangle, located north of Wood Cone Peak and west of the dry lake. The quadrangle is located approximately 16 kilometers

(10 miles) southwest of Eureka (Figure 1). Dirt roads extending south from U.S. Route 50, 10 kilometers (6 miles) to the north, provide access to much of the thesis area. Jeep trails within the map area allow access to within a kilometer of most exposures.

Previous work

Merriam (1963) completed reconnaissance mapping of Paleozoic rocks surrounding the Antelope Valley and established the stratigraphic section for this area. In this study, Merriam indicated that most of the southern Mahogany Hills comprised undifferentiated Devonian strata.

Gronberg (1967) mapped a part of the southern Mahogany Hills surrounding Table Mountain at a scale of 1/12, 000, and succeeded in differentiating five mappable units between the Lone Mountain Dolomite and the Devils Gate Limestone.

T. B. Nolan is presently mapping the Bellevue Peak quadrangle in association with the U.S. Geological Survey; however, to date none of his work has been published.

Geologic setting

During early and middle Paleozoic time, the site of the present Great Basin was part of the Cordilleran geosyncline, which extended from California north to the Canadian Arctic. During this time

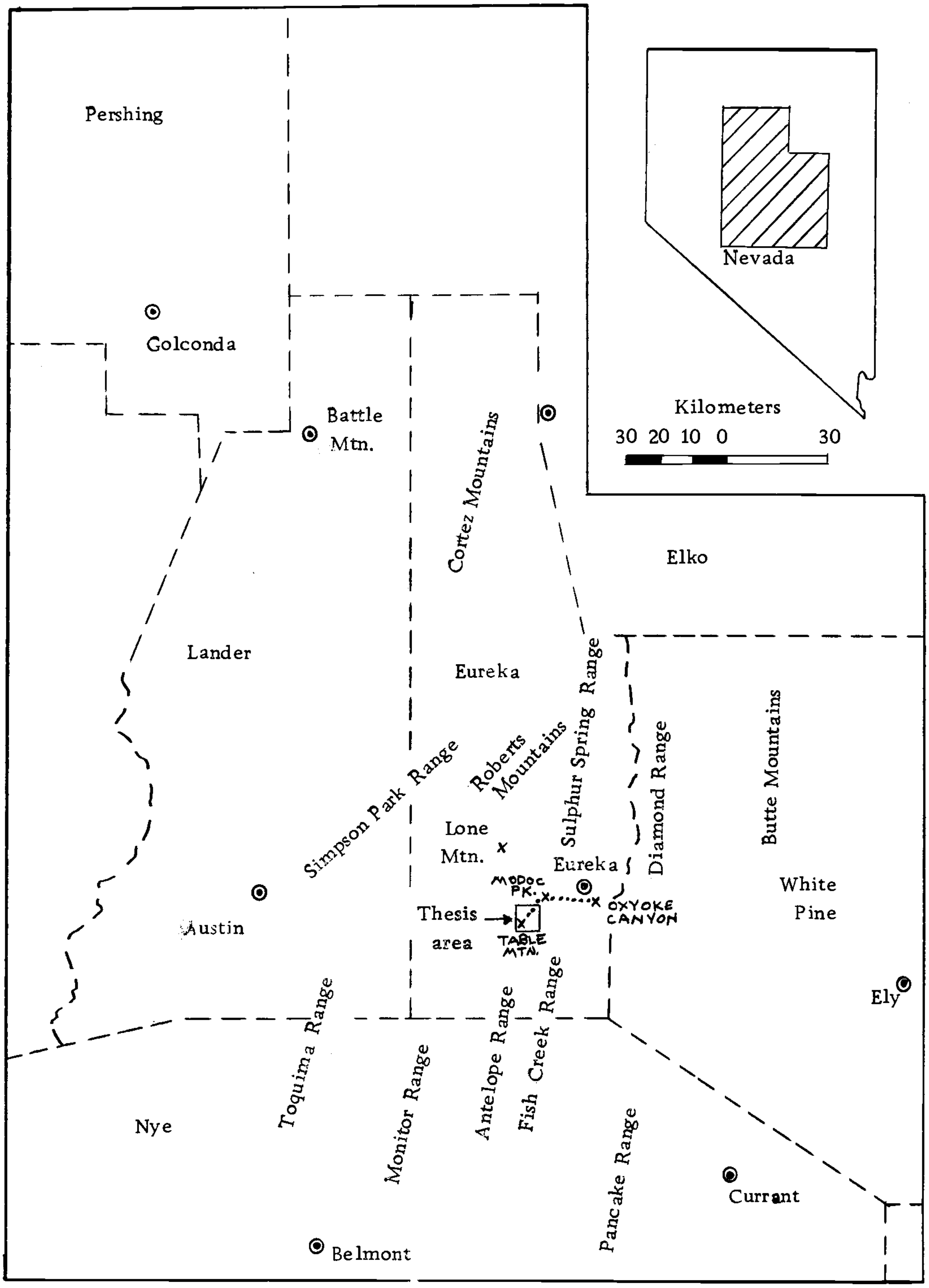


Figure 1. Index map of central Nevada, showing thesis area.

central Nevada is thought to have been at the continental margin, with marginal basins and volcanic island arc systems separating it from an eastward dipping subduction zone farther to the west (Burchfiel and Davis, 1972; Churkin, 1974). Facies belts, which roughly paralleled the continental margin, represent a transition from shallow marine shelf deposition on the east to deeper, basinal environments in the west.

During Late Devonian time the depositional pattern was disrupted by the Antler Orogeny (Johnson, 1971a; Poole, 1974). The emergence of an elongate, north-northeast-trending highland in west-central Nevada with associated deformation and large scale thrust faulting (Roberts Mountains Thrust), resulted in juxtaposition of deep-water cherts and shales over shallow-water carbonates. Associated with this orogenic activity was the deposition of an extensive "clastic wedge" composed of coarse- and fine-grained debris shed eastward from the orogenic belt (Johnson, 1971a).

The thesis area is located within the eastern assemblage, where shallow marine deposition persisted from Cambrian to at least Late Devonian time. During the Early Devonian, the southern Mahogany Hills straddled a lithofacies boundary between peritidal dolomites to the east, as represented by the Beacon Peak and Sevy Dolomites, and subtidal limestones and dolomitic limestones to the west, as represented by the McColley Canyon Formation. During latest Devonian time, clastics from the Antler orogenic belt, to the west, overwhelmed the previously established environments.

Methods

Twelve weeks were spent in the field during the summers of 1976 and 1977 by the writer and his assistant, Kathleen Benedetto, an undergraduate at Oregon State University. Field work involved mapping Paleozoic units and measuring and describing stratigraphic sections (Figure 2). Samples were collected for lithologic and paleontologic study. Studies of lithology included preparation and analysis of thin sections, acetate peels, and oiled slabs. Aerial photographs were used as an aid in determining the structure of the area.

Large collections were made in measured sections for brachiopods and conodonts. Silicified brachiopods were etched free of enclosing carbonate rock by immersion in concentrated hydrochloric acid. The brachiopods were sorted and submitted to J. G. Johnson of Oregon State University for identification. Conodont samples were dissolved in dilute formic acid, the insoluble residue separated in heavy liquid, and the conodonts were handpicked from the heavy fraction by Claudia Regier. Conodont identification and age determinations were made by Gilbert Klapper, University of Iowa.

AGE		ROCK UNIT	THICKNESS meters (feet)
Tertiary		Volcanic rocks	several hundred meters
Cretaceous		Newark Canyon Fm. (?)	? less than 40 (130)
Paleozoic post-Devonian		sandstones, shales, and conglomerates	? less than 40 (130)
		? —— ? —— ? —— ?	
Devonian		Devils Gate Limestone	150 (500) incomplete
Devonian		Simonson Dolomite	400 (1300)
Devonian	Sadler Ranch Fm.	Oxyoke Cyn. ss.	20 (65)
Devonian	Sadler Ranch Fm.		137 (450) to 88 (290)
Devonian	Sadler Ranch Fm.	Crinoidal unit	27 (90)
Devonian	McColley Cyn. Fm.	Coils Crk. Mbr.	46 (150)
Devonian	McColley Cyn. Fm.	Bartine Mbr.	60 (200) to 55 (180)
Devonian	McColley Cyn. Fm.	Kobeh Mbr. / Beacon Pk. Dolomite	37 (120) / 90 (300) ?
Devonian / Silurian		Lone Mountain Dolomite	450 (1500) estimated
Silurian / Ordovician		Hanson Creek Fm.	90 (300) estimated
Ordovician		Eureka Quartzite	?

Figure 2. Summary stratigraphic section for the southern Mahogany Hills.

Terminology

The sandstone classification of Gilbert (1955) and carbonate classification of Dunham (1962), were used for hand sample and thin section descriptions. The term "micrite" is retained from Folk's (1959) carbonate classification and is used as part of some of the sample descriptions. The term "peloid" (McKee and Gutschick, 1969; Bathurst, 1971) is also used in many descriptions for grains composed of micrite or microspar without implying any particular size or mode of formation. Bed thicknesses are the following: thin-bedded, 1 to 10 centimeters; medium-bedded, 10 to 50 centimeters; thick-bedded, over 50 centimeters.

TOPOGRAPHY AND VEGETATION

The map area is centered in the Mahogany Hills and includes all of the Paleozoic exposures west of Spring Valley and the dry lake south of Devon Peak and north of Wood Cone Peak. Topographically, the area is dominated by a single, large, northwest-trending valley (Brown's Canyon), with relief of about 1000 feet (305 meters) between valley floor and surrounding ridge crests. The ridges on either side of Brown's Canyon are fault-bounded, forming peaks separated by northeast-trending valleys. Combs Peak, with a maximum elevation of 8, 631 feet (2, 631 meters), is the highest point in the map area. Maximum total relief is 2, 231 feet (680 meters) from the range front to the top of Combs Peak.

Normal faults and associated gravity slides and rock type are dominant among geologic controls on landforms. Major normal faults are responsible for the overall northwest trend of the topography. Deformation associated with this faulting resulted in the shear cliffs of brecciated and recrystallized limestone which are conspicuous in the area immediately south of Percivalli Canyon. Gravity slides may be responsible for the extremely rugged topography north-northwest of Table Mountain, as well as elsewhere in the map area. Devils Gate Limestone caps the highest topographic features in the area. Locally, dolomite, quartzite, and volcanic rocks form resistant ridges or peaks. Generally, limestones (other than the Devils Gate) are less resistant and form slopes and low-lying ridges.

Vegetation in the southern Mahogany Hills is typical of that found elsewhere in the Great Basin. Juniper, Pinyon Pine, and Mountain Mahogany predominate in mountainous areas, while sage and rabbit brush are generally restricted to valley floors. No reliable relationship was discerned between bed rock type and vegetation.

EUREKA QUARTZITE

General statement

The oldest stratigraphic unit recognized in the southern Mahogany Hills is the Eureka Quartzite. It was first named by Hague (1883), who appears to have considered the exposures within the Eureka District as the type locality (Nolan and others, 1956, p. 29). Within the type area, as designated by Hague, the Eureka Quartzite is highly brecciated, fractured, and recrystallized. This led Kirk (1933) to propose a new type section for the Eureka at Lone Mountain.

Within the map area the Eureka Quartzite occurs as a single, fault-bounded exposure at the base of the east-west ridge extending from Combs Peak. Other small fault-bounded blocks of Eureka Quartzite may be present on the west side of Combs Peak (T. B. Nolan, personal commun., 1977).

Contacts

At no location in the thesis area is either the upper or lower contact of the Eureka Quartzite exposed. At the mapped locality, west of Combs Peak, the Eureka forms a small topographic "knob" with Lone Mountain Dolomite cropping out to the north and east, and McColley Canyon Formation cropping out to the south and west.

T. B. Nolan (personal commun., 1977) considers the Eureka to be in thrust fault contact with the Lone Mountain Dolomite in this area; however, other than the outcrop pattern, no direct evidence for a thrust fault was observed by the writer.

Age

It was not possible to date the Eureka Quartzite directly due to the near universal absence of fossil material in this unit. Merriam (1963, p. 30) has assigned the Eureka, in the vicinity of the Antelope Valley, a late Middle to early Late Ordovician age by bracketing it between known faunas of the overlying Hanson Creek Formation and the underlying Antelope Valley Limestone.

Lithology

In the thesis area, the Eureka Quartzite is a quartz arenite. Its color varies from buff to orangish-yellow, depending largely on the extent of iron oxide staining. In outcrop it is highly fractured, locally brecciated, poorly-bedded, and massive in appearance. It is composed entirely of medium- to fine-grained, sub-angular to well-rounded quartz. The grains are well-sorted and cemented by silica in the form of quartz overgrowths.

Depositional environment

Due to the limited exposure and the tectonically disturbed nature of the Eureka Quartzite in the mapped area little new information can be added to interpretations of its depositional environment. The overall lithologic similarity of the Eureka in the Mahogany Hills with exposures elsewhere in the Great Basin suggests that a beach-bar-dune depositional environment with a quartzose sedimentary source to the east are likely (see Nolan and others, 1956; Merriam, 1963; Potter, 1975).

HANSON CREEK FORMATION

General statement

The Hanson Creek Formation takes its name from Pete Hanson Creek in the northwest Roberts Mountains where the type section was designated by Merriam (1940, p. 11). Merriam applied the name Hanson Creek to rocks lying between the top of the Eureka Quartzite and the base of a black chert unit which served as the base of the superjacent Roberts Mountains Formation.

At its type locality, the Hanson Creek Formation is 170 meters (558 feet) thick and is composed largely of dolomite and dolomitic limestone (Dunham, 1977, p. 160). To the east of the Roberts Mountains, the Hanson Creek and its equivalents are completely dolomitic (Nolan and others, 1956, p. 34; Potter, 1975, p. 32). At Martin's Ridge, to the southwest of the type section, the Hanson Creek totals just over 140 meters (459 feet) and is composed entirely of limestone (Dunham, 1977, p. 161). The thickness of the Hanson Creek Formation in the map area is unknown, because of structural complications.

Within the thesis area, strata assigned to the Hanson Creek Formation form the low-lying topography southwest of Combs Peak. In this area, the Hanson Creek is complicated by numerous faults and folds making detailed study of this unit extremely difficult.

Contacts

The lower contact of the Hanson Creek Formation with the Eureka Quartzite is not exposed within the mapped area. The location of the upper contact is conjectural since the Roberts Mountains Formation was not recognized in the mapped area. Lack of exposure and structural complexities, which obscure stratigraphic relationships, add to the problem of recognizing the top of the Hanson Creek Formation in the area. For these reasons, the writer has chosen to define the upper limit of this formation at the top of a sequence of dark grey to black dolomites. These dark colored dolomites are sparsely fossiliferous and appear to grade over a two to three meter interval to light and medium grey dolomites up section.

Laminated dolomites and edgewise breccias, suggestive of a peritidal depositional environment, such as has been interpreted for the Hanson Creek at Lone Mountain and in the Roberts Mountains (Dunham, 1977), have been observed stratigraphically above the dark dolomites which the writer has designated as the top of the Hanson Creek Formation in the Mahogany Hills (Dunham, written commun., 1977). It is, therefore, emphasized that for mappability the upper contact of the Hanson Creek in this report is based on gross lithologic criteria, rather than on a detailed lithologic and paleontologic examination of the section. This was necessary because of the tectonically disrupted nature of the Hanson Creek in the thesis area.

Age

Merriam (1940) regarded the Hanson Creek Formation to be Middle and Late Ordovician in age. Conodonts from the upper Hanson Creek in Eureka County indicate an Early Silurian age for the upper Hanson Creek Formation in this area (Mullens and Poole, 1972).

Several collections were made within the Hanson Creek of the thesis area. One of these (RM, Plate 1), taken from within the dark dolomite sequence at the top of the Hanson Creek section at Combs Peak, contained Belodina sp., indicating a Middle or Late Ordovician age for these strata.

Lithology

The Hanson Creek Formation of the Mahogany Hills consists of a limestone sequence which is overlain by dolomites. The lower Hanson Creek is composed largely of platy weathering, argillaceous limestone (Figure 3). This limestone is generally medium grey, and is commonly mottled tan, pink, or orange. These beds range from lime mudstone to wackestone, locally containing brachiopod and crinoid debris. Burrow mottling is visible on bedding surfaces. The uppermost 5 to 10 meters of this unit contain dark brown colored chert nodules, 25 to 50 millimeters in length. Within the chert-bearing beds a part of a straight nautiloid was identified.

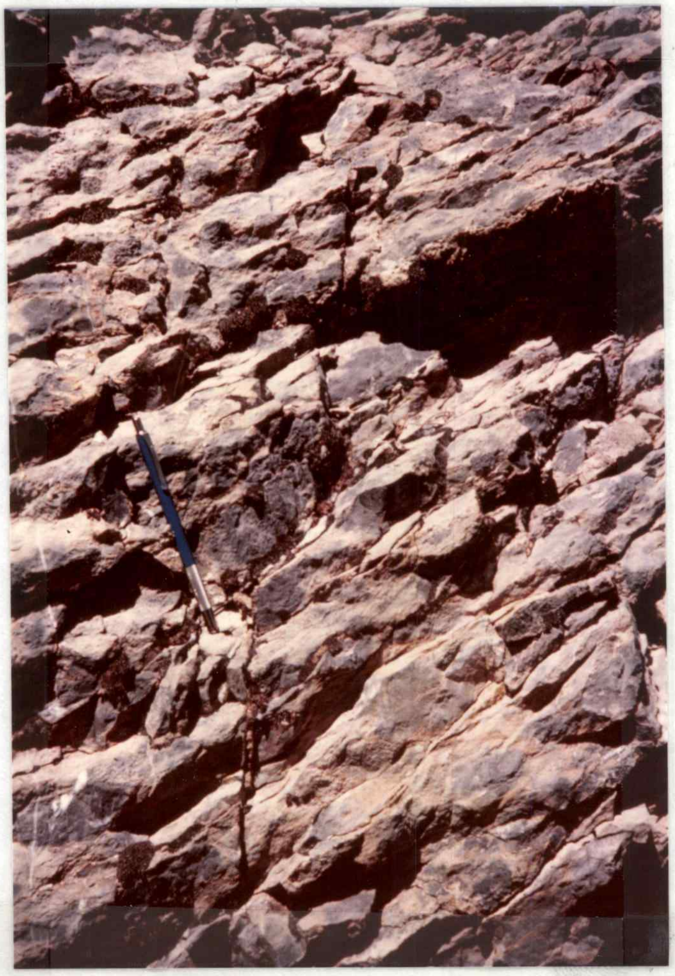


Figure 3. Typical mottled argillaceous limestone of the lower Hanson Creek Formation at Combs Peak. Pen gives scale.

Directly overlying the chert-bearing beds of the lower Hanson Creek at Combs Peak is a sequence of very dark grey to black dolomites. The contact between the limestones and the dolomites is poorly exposed, but appears to occur abruptly. Dunham (written commun., 1977) suggests that this contact may be tectonic in origin.

The dolomite immediately above the lower limestone unit is coarse-crystalline, black, and lacking in primary sedimentary textures. Higher in the section, bioclastic debris including crinoid columnals is locally abundant.

Depositional environment

Dunham (1977, p. 163) indicates that a general progression from lagoonal to tidal flat environments characterized deposition in the vicinity of the Mahogany Hills during Hanson Creek time. Lithologic evidence from the exposures near Combs Peak supports this general interpretation.

Lithologically, the lower argillaceous limestone unit of the Hanson Creek Formation at Combs Peak appears similar to the dolomitic limestones which characterize the lower Hanson Creek at its type locality (Dunham, written commun., 1977). In the Roberts Mountains this unit has been interpreted as representing a quiet water, shelf lagoon (Dunham, 1977). The abundance of burrow mottling in the argillaceous limestone of the Hanson Creek in the

Mahogany Hills militates against extremely restricted or anoxic conditions at the sediment-water interface. Dunham (written commun., 1977) also suggests that the fossiliferous intervals in this unit indicate periodic changes in local environmental conditions that were favorable for benthic faunal development.

Dunham (written commun., 1977) is of the opinion that the dark dolomite which composes the upper Hanson Creek at Combs Peak represents secondary dolomitization of lime mudstones and wackestones. Due to poor exposure and the destruction of original textures, little can be said concerning the probable depositional environment of this unit. The apparent dominance of original lime mudstone and the lack of fossil material is suggestive of increased restriction and continued shallowing of the lower Hanson Creek lagoon. This interpretation is in general agreement with the findings of Dunham (1977) in the Roberts Mountains and at Lone Mountain.

LONE MOUNTAIN DOLOMITE

General statement

The light grey dolomites which overlie the Hanson Creek Formation at Combs Peak are herein assigned to the Lone Mountain Dolomite. This unit crops out extensively along the west side of the southern Mahogany Hills from Combs Peak north to Table Mountain.

As originally defined by Hague (1883), the "Lone Mountain Limestone" comprised the strata lying above the Eureka Quartzite and below the "Nevada Limestone" at Lone Mountain. Merriam (1940, p. 10) restricted the Lone Mountain Dolomite to the largely unfossiliferous dolomites lying above the fossiliferous limestones of the Roberts Mountains Formation.

Contacts

The lower contact of the Lone Mountain Dolomite in the southern Mahogany Hills is placed within a sequence of dolomite, where an abrupt transition between nearly black, and light grey strata occurs. In this report the light grey dolomites are assigned to the Lone Mountain Dolomite, although detailed paleontologic study may reveal them to be more properly included in the underlying Hanson Creek Formation.

Contacts with superjacent units are, in all observed cases abrupt, and suggestive of an unconformity; although no angular discordance was noted. Merriam (1963, p. 40) notes that good exposures of this contact occur at an altitude of 7, 900 feet on the spur which extends westward from Combs Peak. The writer's observations of this contact concur with those of other workers who have studied it elsewhere in Eureka County (Nolan and others, 1956; Winterer and Murphy, 1960; Merriam, 1963).

Age and correlation

The paucity of fossil-bearing strata in the Lone Mountain Dolomite has made dating of this unit difficult. Merriam (1963) regarded it to be entirely of Silurian age. Later work, by Johnson (1965; Johnson, Boucot, and Murphy, 1973), revealed the presence of Lower Devonian brachiopods in the Roberts Mountains Formation, below the upper Lone Mountain Dolomite in the Roberts Mountains. This indicates that the Lone Mountain Dolomite is Late Silurian to earliest Devonian in age.

Fossil collections were not made in the Lone Mountain Dolomite of the study area. The zones of silicified fossil material which Merriam (1963) sampled, north of Wood Cone Peak, were not located by the writer. Faint, recrystallized fossil "ghosts" were observed in beds of medium grey dolomite west of Combs Peak.

To the west of the thesis area, in the Simpson Park and Monitor

Ranges, both the Roberts Mountains Formation and the Windmill Limestone are considered to be laterally equivalent to the Lone Mountain Dolomite (Johnson, 1965; Matti and others, 1975). Osmond (1962) correlated the Lone Mountain, to the east, with the Laketown Dolomite. This correlation may be only partially valid, as Lone Mountain equivalents to the east are thought to have been largely removed by erosion (Poole and others, 1977, p. 44).

Lithology

The Lone Mountain Dolomite of the map area comprises a rather homogeneous sequence of massive, medium- to coarse-grained dolomites. These rocks are predominantly light grey with a slight yellowish tint, however, rare bands of medium grey dolomite were observed, occurring most conspicuously on the west end of the east-west spur which extends from Combs Peak. Extremely clean, coarse-grained, white dolomites also occur in the Lone Mountain. Outcrops of this rock occur near the mouth of the canyon which separates Combs Peak from Table Mountain. These exposures were apparently mistaken, by Merriam (1963), for Eureka Quartzite in his reconnaissance mapping of this area.

The coarsely crystalline nature of the Lone Mountain Dolomite in the thesis area makes determination of original textures difficult. Locally, however, faint parallel laminations and brecciated zones are visible.

Depositional environment

The Lone Mountain Dolomite has been interpreted by Winterer and Murphy (1960) as representing a reef complex, in which the original features have been largely obliterated by dolomitization. The fossiliferous intervals which have been reported in the Lone Mountain (Nolan and others, 1956; Merriam, 1963; Wise, 1976), suggest that the dolomitization was secondary. Observations of this unit by the writer support the interpretations of these earlier workers.

BEACON PEAK DOLOMITE

General statement

The typically fine-grained, light grey dolomite that overlies the Lone Mountain Dolomite on the south slope of Combs Peak is herein assigned to the Beacon Peak Dolomite. The name Beacon Peak was proposed by Nolan and others (1956, p. 42), for the lowest member of the "Nevada Formation" in the vicinty of Eureka. Osmond (1962, p. 2034) proposed that the Beacon Peak is a lateral equivalent of the Sevy Dolomite of western Utah. The observations of Kendall (1975) lend support to this correlation; however, until a thorough petrologic study of both these units is completed caution must be exercised in the application of these names. For this reason, the name Beacon Peak Dolomite is retained in this report for describing the "Sevy-like" rocks which crop out in the thesis area.

In the southern Mahogany Hills, the Beacon Peak is estimated to comprise 107 meters (350 feet) of lithologically homogeneous, largely non-fossiliferous strata. Faults of uncertain displacement occur within the Beacon Peak in both measured sections at Combs Peak, making thickness estimations somewhat unreliable.

Contacts

Abrupt changes in grain size, outcrop character, and color characterize the lower contact of the Beacon Peak Dolomite in the Mahogany Hills. Although this contact is not well exposed within the map area, its location can be determined within a meter or two in nearly all areas studied. A regional unconformity has been identified at the base of the Beacon Peak and Sevy Dolomites to the east of the thesis area (Nolan, 1935; Nolan and others, 1956; Osmond, 1954, 1962). The abrupt character of the Beacon Peak's lower contact in the southern Mahogany Hills suggests that this unconformity may be present in the thesis area.

The upper contact of the Beacon Peak Dolomite in the Mahogany Hills is also abrupt. Increased grain size, darker color, and increased fossil content of the superjacent strata are the most conspicuous changes. Scree from overlying units commonly obscures this contact, although, at at least one location in the mapped area, detailed examination of the contact is possible. At this locality, typically light grey, fine-grained Beacon Peak is overlain by about 15 centimeters of reddish-brown dolomite that contains a few very thin reddish argillaceous partings, numerous calcite veins, and locally appears conglomeratic. This "zone" is concordantly overlain by well-bedded, medium grey, bioclastic dolomitic limestones of the Bartine Member of the McColley Canyon Formation, and may represent a depositional hiatus prior to the initiation of Bartine sedimentation in the area of Combs Peak (Figure 4).

Figure 4. Upper contact of the Beacon Peak Dolomite in Combs Peak I measured section. Head of hammer rests on bioclastic dolomitic limestone of the McColley Canyon Formation; handle of hammer rests on typical Beacon Peak Dolomite; thin zone of reddish argillaceous dolomite separates these two lithologies.

Age and correlation

A near complete lack of fossil material in the Beacon Peak Dolomite has made dating of this unit difficult. Nolan (1935) considered the Sevy Dolomite in western Utah to be Devonian and possibly Middle Devonian in age because of its relationship to the overlying Middle Devonian Simonson Dolomite. Osmond (1962) later suggested that the Sevy (including the Beacon Peak) may be equivalent to Lower Devonian strata of the Nevada Group in central Nevada. Intertonguing of rocks of Sevy lithology with the Lower Devonian McColley Canyon Formation, in Eureka County, was later described by Kendall (1975).

Extensive collections were made for fossil material in the Beacon Peak, from measured sections in the thesis area. Additional collections were made in the upper Beacon Peak at Brush Peak, three kilometers east of the mapped area. For the most part, the material recovered from these collections was not diagnostic. One collection (1220, Plate 5), taken three meters below the upper contact at Combs Peak, contains the conodont Pandorinellina exigua philipi, indicating assignment of these strata to the dehiscens or possibly gronbergi zones of Klapper (1977). In addition, brachiopod collections made less than a meter above the top of the Beacon Peak at both Combs Peak and Brush Peak indicate a lower Eurekaspirifer pinyonensis zone assignment for these strata. These findings lend support to the correlations of Osmond (1962) and Kendall (1975), and indicate an Early Devonian age for the Beacon Peak Dolomite in the southern Mahogany Hills.

The Beacon Peak (Sevy) Dolomite has been correlated with the McColley Canyon Formation and the lower Sadler Ranch Formation, in Eureka County (Kendall, 1975, p. 12) (Figure 5).

Lithology

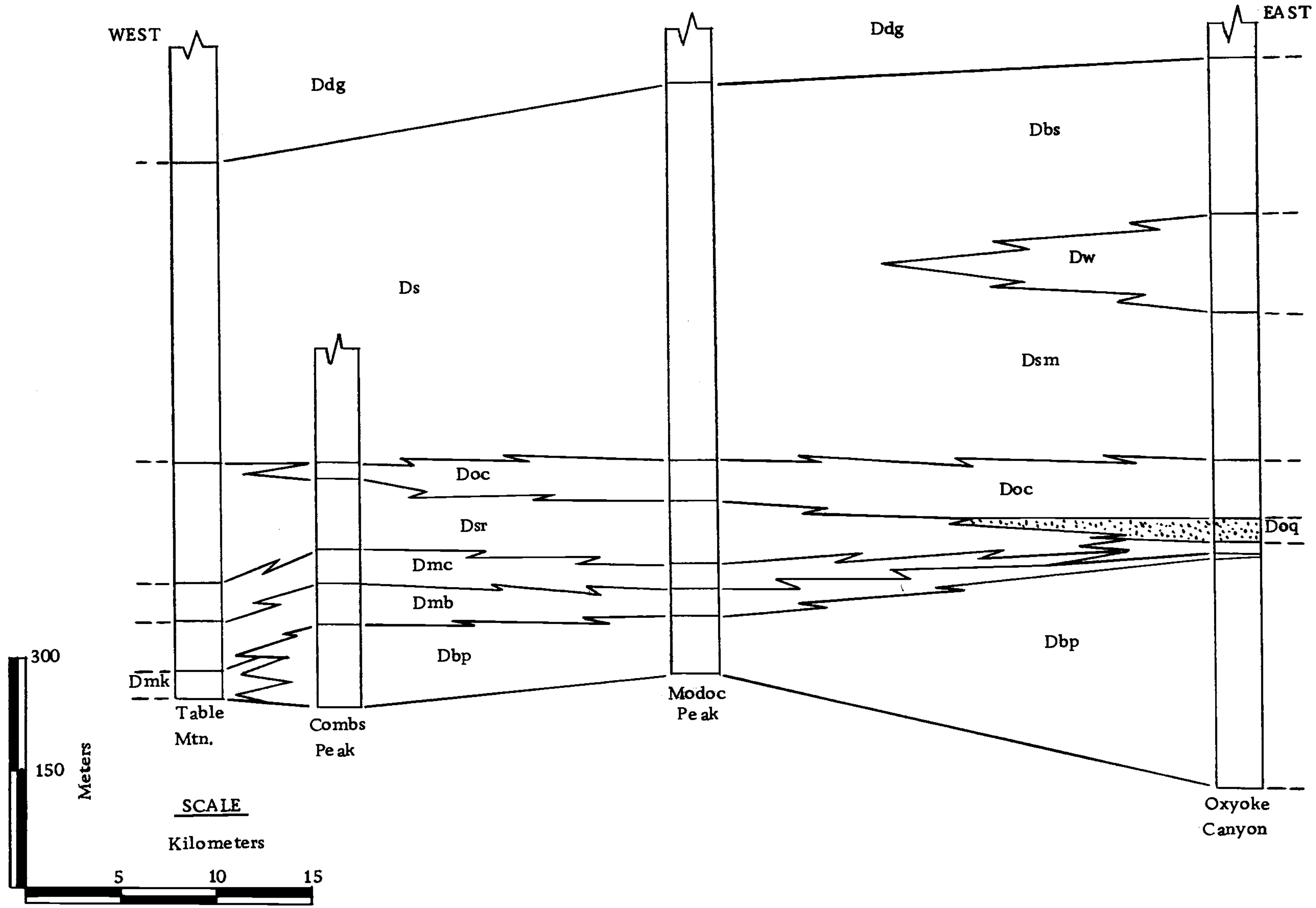
The Beacon Peak Dolomite weathers to form rugged, bench-like exposures (Figure 6). It is less resistant than the underlying Lone Mountain Dolomite, but exhibits significant relief compared with the superjacent McColley Canyon Formation. For the most part, the Beacon Peak is poorly bedded. Weathered color ranges from light grey to nearly white, with a slight bluish tint. Fresh surfaces are typically brownish light grey to medium grey.

Within the study area, the Beacon Peak Dolomite comprises two lithologies. The lower 40 meters is typically finely crystalline dolomite, containing irregular pinkish lenses 2 to 5 millimeters in length, and vugs which have been infilled by sparry calcite. Exposures commonly appear massive, although faint parallel laminations and intraclastic breccias may be present locally. The upper Beacon Peak is micro-crystalline to porcellaneous, and exhibits a finely clastic texture.

Figure 5. Devonian lithofacies relationships in the vicinity of Eureka, Nevada (see Figure 1 for location of transect).

EXPLANATION

Ddg	-	Devils Gate Limestone
Dbs	-	Bay State Dolomite
Dw	-	Woodpecker Limestone
Dsm	-	Sentinel Mountain Dolomite
Ds	-	Simonson Dolomite
Doc	-	Oxyoke Canyon Sandstone - "Coarse Crystalline Member"
Doq	-	Oxyoke Canyon Sandstone - "Quartzose Member"
Dsr	-	Sadler Ranch Formation
Dmc	-	McColley Canyon Fm. - Coils Creek Member
Dmb	-	McColley Canyon Fm. - Bartine Member
Dmk	-	McColley Canyon Fm. - Kobeh Member
Dbp	-	Beacon Peak Dolomite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Ddg
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Doc
Doc
Doq
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Dmc
Dmb
Dbp
Dbp
Dmk
Table Mtn.
Combs Peak
Modoc Peak
Oxyoke Canyon
300
150
Meters
SCALE
Kilometers
5
10
15

Figure 6. Typical exposure of Beacon Peak Dolomite at Combs Peak. Photo was taken at the 50 foot (15 m) level of the Combs Peak I measured section.

Parallel laminations, caused by grain size variations, are common. Pinkish or orange stylolites are also common. At one locality in the upper Beacon Peak, a laterally discontinuous, 15 to 20 centimeter thick gastropod packstone was observed (Figure 7).

At Brush Peak, to the east of the thesis area, thin, irregular, medium to dark grey dolomite interbeds occur in the upper Beacon Peak.

Petrography

Thin sections of the lower Beacon Peak show extensive recrystallization of the dolomite. Biotic "ghosts" which may represent fragments of brachiopods, gastropods, and other organisms are commonly scattered throughout a fine crystalline interlocking dolomite mosaic.

Microscopically, the upper Beacon Peak ranges from peloid wackestone to grainstone. Peloids up to 1.5 millimeters in length, probably represent both intraclasts and fecal pellets (Figure 8). The peloids are sub-rounded to well-rounded, exhibit no internal structure, and commonly appear preferentially oriented, with long axes roughly pareallel to bedding. Parallel laminae, visible in hand sample, are the result of rhythmic variations in peloid size. Interstices are commonly filled by finely crystalline dolomite or dolomite mud.

Figure 7. Polished slab of gastropod packstone (sample 1220) from the upper Beacon Peak Dolomite at Combs Peak. Sample is from the 180 foot (55 m) level of the Combs Peak I measured section.

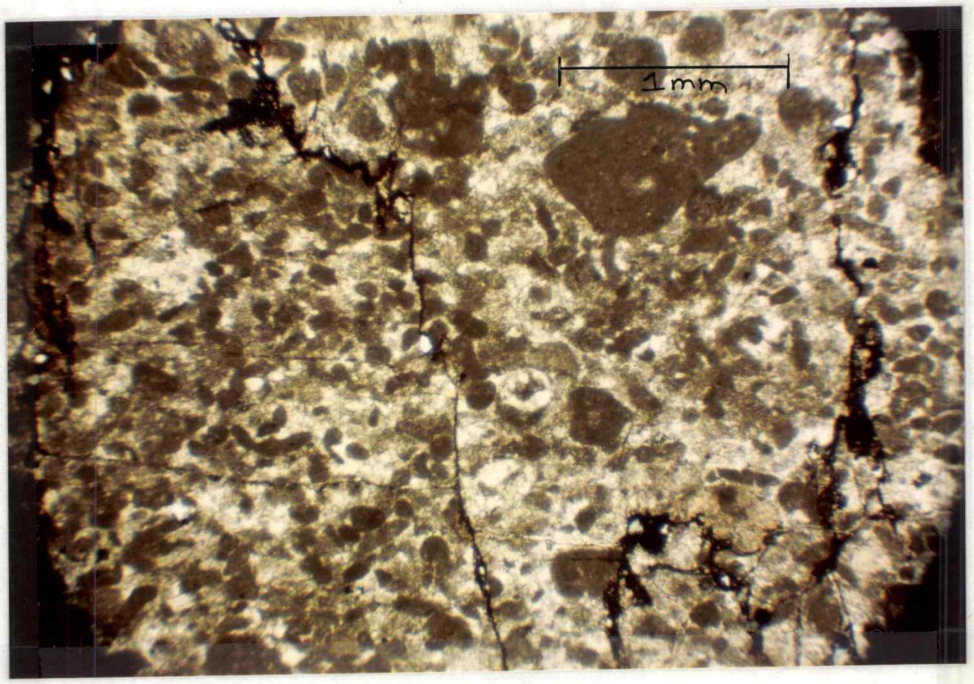

Figure 8. Photomicrograph of lower Beacon Peak peloidal dolomite; note stylolite. Sample is from the 330 foot (101 m) level of the Combs Peak II measured section.

Fine sand- to silt-size quartz grains occur intermixed with peloids in the upper Beacon Peak. These grains are sub-angular to rounded, well-sorted, with an average diameter of 0.10 millimeters, and commonly appear etched by the enclosing dolomite (Figure 9). The grains are scattered throughout most samples, with local concentrations occurring only along stylolites. Total quartz content of typical upper Beacon Peak rocks does not exceed 10% and averages less than 5%.

Depositional environment

Osmond (1962) and Kendall (1975) have interpreted the Sevy (Beacon Peak) Dolomite as having been deposited in an intertidal to supratidal environment. The observations of the writer, in the southern Mahogany Hills, are in agreement with this interpretation. Parallel laminations, vugs suggestive of fenestral fabric, scarcity of fossil material, abundance of peloids, and probable channels are the most compelling evidences of this environment in the Beacon Peak Dolomite of the study area. Terrigenous sand and silt may represent eolian input.

The dark grey beds observed in the upper Beacon Peak at Brush Peak appear similar to units observed in rocks assigned to the Sevy Dolomite elsewhere in Eureka County (Kendall, 1975). Kendall (1975, p. 22) suggests that these beds may represent local deepening

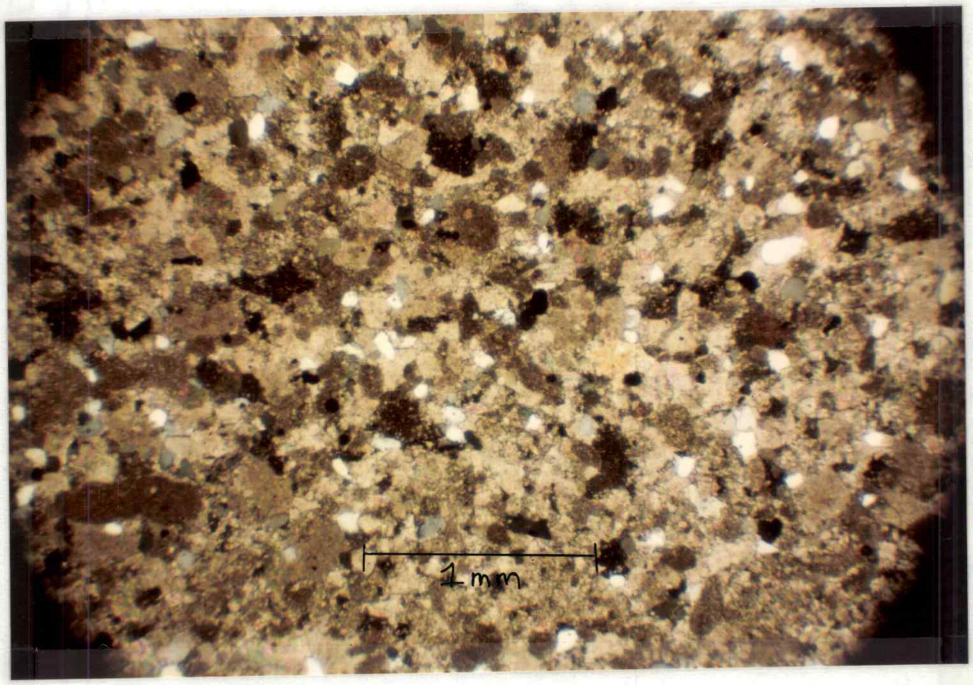

Figure 9. Photomicrograph of sandy dolomite from upper Beacon Peak Dolomite at Combs Peak. Note the presence of both quartz grains and peloids. Sample is from the 165 foot (50 m) level of the Combs Peak II measured section.

along the western edge of the Sevy tidal flat. The occurrence of these deeper water deposits at Brush Peak and their apparent absence at Combs Peak may indicate that the Beacon Peak tidal flat had an outer rim. The reddish zone, which delineates the top of the Beacon Peak at Combs Peak, may represent an unconformity which developed locally on this outer rim.

McCOLLEY CANYON FORMATION

General statement

Originally defined as the lowest member of the "Nevada Formation" in the Sulphur Spring Range (Carlisle and others, 1957), the McColley Canyon was elevated to formational rank by Johnson (1962). Later work by Gronberg (1967) in the Mahogany Hills and at Lone Mountain resulted in the subdivision of the McColley Canyon into three members. These in ascending order are, the Kobeh, Bartine, and Coils Creek (Murphy and Gronberg, 1970).

At Table Mountain, in the southern Mahogany Hills, all three members of the McColley Canyon Formation are developed. A list of the brachiopod faunas found in the McColley Canyon Formation at Table Mountain was published by Johnson, Boucot, and Gronberg (1968). As suggested by Kendall (1975, p. 12), the McColley Canyon thins to the east of Lone Mountain. At Table Mountain, 510 feet (155.5 meters) of McColley Canyon are exposed (Gronberg, 1967); less than three kilometers to the east, at Combs peak, the McColley Canyon is just over 300 feet (91.5 meters) thick.

The McColley Canyon Formation crops out along the western range front of the southern Mahogany Hills, from the extreme south end of the mapped area to immediately north of Table Mountain.

Kobeh Member

The Kobeh Member comprises 135 feet (41 meters) of dolomite and limestone at Table Mountain (Gronberg, 1967, p. 17). To the west of Table Mountain, the Kobeh Member thickens considerably, totaling 185 feet (56.5 meters) at Lone Mountain (Gronberg, 1967, p. 12), 210 feet (64 meters) in the Antelope Range (Trojan, personal commun., 1977), and 480 feet (146 meters) in the Hot Creek Range (Potter, 1975, p. 51). To the east of Table Mountain, the Kobeh appears to thin considerably and is absent along the south side of Combs Peak. Kendall (1975) and others (Johnson and Sandberg, 1977), have suggested that the Kobeh Member and the lower Beacon Peak Dolomite are lateral equivalents (Figure 5). Kendall (1975, p. 31) further stated that rocks of Sevy (Beacon Peak) lithology are included in the Kobeh Member at Table Mountain. Although interfingering of the Beacon Peak Dolomite and the Kobeh Member was not observed by the writer, the increasing dolomite content of the Kobeh immediately southeast of Table Mountain suggests that a transition between these units occurs near Combs Peak. Structural complications and poor exposures hamper resolution of the exact nature of this transition.

The Kobeh Member overlies the Lone Mountain Dolomite with apparent disconformity throughout the map area. At Table Mountain the lower contact is poorly exposed; however, on the spur which extends westward from Combs Peak, the contact is well exposed. At this locality the contact is characterized by abrupt changes from coarse to fine grain size, thick to thin bedding, and light to dark color. Nolan and others (1956, p. 41) reported a well exposed erosional surface at the top of the Lone Mountain Dolomite at this locality.

The Kobeh Member at Table Mountain comprises light grey, very fine-grained, thin-bedded dolomite overlain by medium olive grey, micro-grained, thin-bedded limestone with rare chert nodules. To the southeast, toward Combs Peak, the Kobeh becomes progressively more dolomitic and is characterized by thin-bedded, very fine-grained, olive grey dolomite. At Combs Peak, where the Kobeh is thought to be transitional with the Beacon Peak Dolomite, the characteristic olive grey color is the most useful criterion for distinguishing these units.

The Kobeh Member weathers recessively compared to the Lone Mountain Dolomite, but shows considerable relief over the superjacent Bartine Member of the McColley Canyon Formation.

Kendall (1975, p. 12) suggested that the Kobeh is time-equivalent to the lower Sevy (Beacon Peak) Dolomite in Eureka County. Observations in the southern Mahogany Hills support this interpretation. It is further suggested, on the basis of this lateral equivalency and contained faunas, that the Kobeh represents a subtidal time-equivalent of the Beacon Peak Dolomite, deposited under normal marine conditions to the west of the Beacon Peak tidal flat. This interpretation concurs with that of Kendall (1975) for other areas in Eureka County.

Bartine Member

The Bartine Member of the McColley Canyon Formation conformably overlies the Kobeh Member at Table Mountain. On the south side of Combs Peak the Bartine overlies the Beacon Peak Dolomite with probable disconformity (see section on Beacon Peak Dolomite). The Bartine thins significantly across the mapped area, comprising 210 feet (64 meters) of strata at Table Mountain (Gronberg, 1967, p. 18), and less than 140 feet (42.5 meters) three kilometers to the east, at Combs Peak, where the section is complicated by faulting. To the west of the Mahogany Hills, at Lone Mountain, the Bartine is 455 feet (139 meters) thick (Gronberg, 1967, p. 13) and in the Antelope Range, only 110 feet (33.5 meters) of Bartine strata are present (Trojan, personal commun., 1977).

Throughout the thesis area and at localities to the west the Bartine Member comprises a distinctive, topographically recessive sequence of medium grey, thin-bedded, micro-grained, bioclastic, argillaceous limestones. Macrofossil material includes brachiopods, trilobites, corals, bryozoans, and crinoids. At Combs Peak and

Brush Peak, where the Bartine overlies the Beacon Peak Dolomite, the basal Bartine is typically bioclastic dolomite or limy dolomite. This basal dolomitic unit is up to three meters thick and is thought to represent the "lower limy dolomite" of the Bartine Member, observed by Kendall (1975, p. 53) elsewhere in Eureka County.

The basal dolomitic unit of the Bartine Member at Combs Peak and Brush Peak is interpreted as representing a shallow water, high-energy environment. At Brush Peak, dolomitic packstones composed of broken and abraded brachiopod valves reveal a crude imbrication. Highly fragmental bioclastic dolomites are also characteristic of the basal Bartine at Combs Peak. These deposits are interpreted as representing the initial deposits of a transgressive sequence which overwhelmed the Beacon Peak tidal flat. These observations are in agreement with those of other workers in Eureka County (Kendall, 1975; Johnson and Niebuhr, 1976).

Collections from the basal Bartine Member at Combs Peak indicate a lower Eurekaspirifer pinyonensis brachiopod zone and a dehiscens or gronbergi conodont zone assignment for these strata. On the basis of these faunas and the eastward thinning of the McColley Canyon Formation, the Bartine Member at Table Mountain is considered to be partially correlative with the upper Beacon Peak Dolomite at Combs Peak. This interpretation is in agreement with the findings of Kendall (1975) to the north and east of the thesis area.

Coils Creek Member

Conformably overlying the Bartine Member of the McColley Canyon Formation is a sequence of medium grey limestones which compose the Coils Creek Member. Gronberg (1967) originally proposed a thickness of 165 feet (50 meters) for the Coils Creek Member at Table Mountain. Murphy and Gronberg (1970) revised the Coils Creek to include approximately 100 feet (30.5 meters) of the overlying dolomites, which in this report are assigned to the Sadler Ranch Formation. Most recently, Kennedy (1977, p. 24) has indicated that only 120 feet (36.5 meters) of true Coils Creek lithology strata are present at Table Mountain and that the Coils Creek at this locality is overlain and underlain by relatively thick sequences of transitional strata. For the purposes of this report the name Coils Creek is applied as it was first proposed by Gronberg (1967) and later utilized by Kendall (1975). At Combs Peak a total of 150 feet (46 meters) of Coils Creek are present.

The lower contact of the Coils Creek with the Bartine Member is characterized by a change in bedding thickness and outcrop character. The Coils Creek is typically thin-bedded, with argillaceous blebs and partings and is more resistant to weathering than the underlying Bartine. On the basis of these criteria the contact is transitional over a meter or two at most localities, although it is commonly obscured by scree.

The upper contact of the Coils Creek is also transitional. This contact is characterized at Combs Peak, by an abrupt change from medium grey, chert-bearing limestone to brownish grey dolomite. At Table Mountain this color change is not apparent. Bedding character remains largely unchanged across this contact. At Combs Peak a one to two meter thick limy dolomite transition zone is present at the contact. A decrease in bioclasts across the contact and the presence of thin, graded intervals in the upper Coils Creek at Combs Peak help distinguish this contact.

Texturally, the Coils Creek ranges from laminated mudstone to bioclastic packstone, which contains brachiopods, corals, and crinoids. Locally, dacryoconarid tentaculites are common on bedding surfaces, especially in exposures to the northwest of Table Mountain. Horizontally burrowed surfaces are common locally and chert nodules up to 50 millimeters in length are present in the upper part of this unit. Thin, graded beds containing mostly fine bioclastic debris occur interbedded with non-graded bioclastic units in the upper five meters of the Coils Creek at Combs Peak.

The Coils Creek Member of the thesis area has been correlated, on the basis of brachiopod and conodont faunas, with the Bartine Tongue of Kendall (1975) and the upper Sevy (Beacon Peak) Dolomite (Kendall, 1975, p. 12).

Kennedy (1977) has suggested that the Coils Creek Member at Table Mountain was deposited in deeper water than the Bartine Member. This interpretation is supported by the observations of Potter (1975) to the west, in the Hot Creek Range. Within the area studied, the relative decrease in shelly faunas in the Coils Creek compared with the shallow-water Bartine Member, the local abundance of both burrows and pelagic tentaculites, and the fine grain size within bioclastic units, are all taken as indicators of a low-energy, deep-water environment. The graded intervals in the upper Coils Creek may represent allochthonous debris derived from high-energy environments farther east. Although the Coils Creek may have been deposited in shallow-water elsewhere in Eureka County (Murphy, personal commun., 1977), no evidence of shallow-water deposition was found in the thesis area.

SADLER RANCH FORMATION

General statement

Kendall (1975) recognized a distinctive sequence of fossiliferous dolomites within the Union Mountain Member of the "Nevada Formation" in the Sulphur Spring Range. The name Sadler Ranch Formation was informally proposed for these strata, with a type section in the southern Sulphur Spring Range (Kendall, 1975, p. 82).

At the type locality, these dolomites overlie limestones of the McColley Canyon Formation and underlie quartzose dolomites and dolomitic quartz arenites which Kendall (1975) assigned to the "Coarse Crystalline Member" of the Oxyoke Canyon "Formation." The Sadler Ranch Formation is 408 feet (124 meters) thick at its type section, where it can be divided into three informal members: 1) a lower dolomite, 2) a middle crinoidal dolomite, and 3) an upper dolomite (Kendall, 1975, p. 83).

In the southern Mahogany Hills, strata assigned to the Sadler Ranch Formation crop out along the entire western range front, from north of Table Mountain to the south side of Combs Peak. At Combs Peak the Sadler Ranch is similar to the type section, with McColley Canyon Formation underlying it and Oxyoke Canyon "Formation" overlying it. At Table Mountain, where the Oxyoke Canyon is not recognized, the Sadler Ranch is overlain by Simonson Dolomite.

Within the southern Mahogany Hills the informal three-fold subdivision recognized by Kendall (1975) in the Sulphur Spring Range is also applicable.

Kendall (1975, p. 83) assigned 450 feet (137 meters) of dolomite and limestone to the Sadler Ranch Formation at Table Mountain. These strata include part of the upper Coils Creek Member of the McColley Canyon Formation as it was originally defined by Murphy and Gronberg (1970). At Combs Peak, 390 feet (119 meters) of Sadler Ranch strata are present.

Contacts

The Sadler Ranch Formation conformably overlies the Coils Creek Member of the McColley Canyon Formation throughout the thesis area. This contact is characterized at Combs Peak by an abrupt change from medium grey, chert-bearing limestones of the Coils Creek Member to brown grey dolomite in the Sadler Ranch (Figure 10). At Table Mountain this color change was not recognized. Bedding character remains largely unchanged across this contact. In the vicinity of Combs Peak a one to two meter thick limy dolomite transition zone delineates this contact. A decrease in bioclastic debris and the absence of graded beds in the Sadler Ranch at Combs Peak help distinguish this contact.

At Table Mountain, the Sadler Ranch Formation is conformably

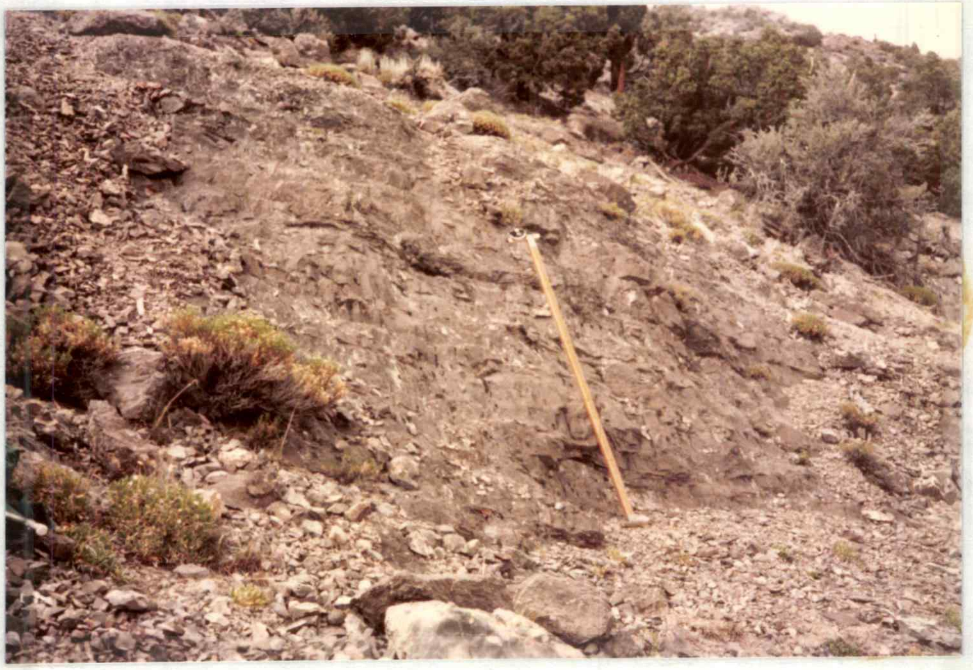

Figure 10. Typical exposure of the lowermost Sadler Ranch Formation at Combs Peak. Photo was taken at the 670 foot (204 m) level of the Combs Peak II measured section.

overlain by Simonson Dolomite. Along the south side of Combs Peak, quartzose dolomites of the upper Oxyoke Canyon Member overlie the Sadler Ranch. The gradational contact between the Sadler Ranch Formation and the Simonson Dolomite is discussed in detail in a later section of this report. The contact between the Sadler Ranch and the Oxyoke Canyon is placed at the base of the first quartzose dolomite unit. The presence of faint cross-bedding helps delineate the initial influx of sand, which signifies the beginning of Oxyoke Canyon sedimentation in this area.

Age and correlation

Brachiopod and conodont collections, from the Sadler Ranch Formation in the Sulphur Spring Range, indicate a maximum age range of late Emsian through early Eifelian (Kendall, 1975, p. 105). On this basis, Kendall (1975) correlated the Sadler Ranch with the Coils Creek Member of the McColley Canyon Formation and the lower Denay Limestone to the west. To the east, the Sadler Ranch is considered to be correlative with the upper Sevy (Beacon Peak) Dolomite and the Oxyoke Canyon Sandstone Member of the Nevada Formation. The apparent lateral equivalency of the upper Sadler Ranch Formation and upper Oxyoke Canyon, in the southern Mahogany Hills, supports this later correlation.

Lithology

The Sadler Ranch Formation in the southern Mahogany Hills comprises a sequence of dominantly dolomitic strata, which weather to form rugged, blocky exposures. Lithologically, the Sadler Ranch varies considerably within the thesis area. In the vicinity of Table Mountain, the Sadler Ranch comprises a lower unit of dolomite, limestone, and limy dolomite, a distinctive middle unit composed entirely of crinoidal dolomite, and a thick upper dolomite unit, which is lithologically similar to the superjacent Simonson Dolomite. In the vicinity of Combs Peak, the lower and middle units are generally similar to the exposures at Table Mountain; however, the upper unit is considerably abbreviated and does not include strata of Simonson lithology.

The lower unit of the Sadler Ranch at Table Mountain includes dolomites, limy dolomites, and limestones, that are light to medium grey, fine- to coarse-grained, and thin-bedded. Crinoid ossicles occur throughout the unit, but increase in abundance up section, where the lower unit grades into the middle crinoidal unit. The crinoidal unit is composed entirely of light to dark grey dolomite. The most characteristic feature of this unit is the notable abundance of crinoidal debris, including numerous dilumenate ossicles described by Johnson and Lane (1969). Locally the unit becomes nearly an encrinite. Thin section examination reveals the presence of scattered, angular, silt-size quartz grains in some beds. This unit is thin- to thick-bedded and locally contains breccias and stylolites. Its contact with the superjacent unit is gradational, being determined largely on the abundance of crinoidal debris. The upper unit of the Sadler Ranch at Table Mountain is composed of fine- to coarse-grained, medium to dark grey, thin- to thick-bedded, vuggy dolomite (Figure 11). Locally, these strata are bioclastic, containing recrystallized brachiopods, corals, and other organisms.

At Combs Peak, the lower unit of the Sadler Ranch is entirely dolomite, except for a thin limy dolomite transition zone immediately above the McColley Canyon Formation. These strata differ from the rock at Table Mountain largely in that they possess a characteristic brown grey coloration. The crinoidal unit also differs in color from its counterpart at Table Mountain, with olive grey being most common. The upper unit at Combs Peak is entirely fine- to very fine-grained, medium- to thick-bedded, light to dark grey dolomite. It is locally bioclastic, but lacks the vugs which characterize the upper unit at Table Mountain.

Texturally, the entire Sadler Ranch ranges from mudstone to packstone, with local patches of encrinite in the middle unit. Abundance of bioclastic debris is highly variable from bed to bed, with changes from mudstones to wackestones or packstones occurring

Figure 11. Typical exposure of the upper Sadler Ranch Formation at Table Mountain.

abruptly, without apparent grading.

Faint parallel laminations occur in mudstone units throughout the Sadler Ranch Formation. These laminations commonly are associated with thin intraclastic conglomerates or breccias. At one locality, near Combs Peak, probable scour channels were observed.

Depositional environment

Kendall (1975, p. 105) interpreted the Sadler Ranch Formation as representing a transitional facies between the deep-water Denay Limestone and the shallow-water Oxyoke Canyon Sandstone Member of the Nevada Formation. This interpretation is in agreement with observations made in the thesis area, where a moderate energy, shallow-water environment is thought to have existed throughout most of Sadler Ranch deposition.

Parallel laminations, intraclastic breccias, and scour channels all indicate current activity within the depositional environment. The intraclastic breccias and scour channels probably represent periodic events of abnormally high energy, such as storms or local shallowing. The abundance of bioclastic debris, especially crinoid ossicles, in most of the Sadler Ranch suggests an abundant benthic fauna. The apparent absence of graded intervals within the bioclastic units suggests that this material may not have undergone transport. It is further postulated that the dense crinoidal forests which existed during Sadler Ranch time may have acted as baffles, significantly reducing current energy at the sediment-water interface. This would have allowed the accumulation of mud, which under normal conditions would have been winnowed by currents.

Kendall (1975, p. 104) states that the upper Sadler Ranch represents a shallowing of the previous environment and that the overlying Oxyoke Canyon Sandstone represents a westward shift of the nearshore depositional environment. At Table Mountain, this shallowing resulted in a gradational shift from Sadler Ranch to Simonson Dolomite type deposition, as evidenced by the upper unit of the Sadler Ranch at that locality.

OXYOKE CANYON SANDSTONE

General statement

The Oxyoke Canyon Sandstone was designated by Nolan and others (1956, p. 43) as one of five members of the Nevada Formation in the vicinity of Eureka. Kendall (1975) recognized two lithologically distinct members within the Oxyoke Canyon Sandstone and informally designated it the Oxyoke Canyon Formation. In this report the Oxyoke Canyon Sandstone is utilized as it was first designated by Nolan and others (1956) and is considered as a member of the Nevada Formation.

Sandstones, thought to be equivalent to the Oxyoke Canyon, were first recognized at Combs Peak, in the southern Mahogany Hills, by Nolan and others (1956). Not until detailed mapping in the vicinity of Table Mountain was completed (Gronberg, 1967), did it become apparent that the Oxyoke Canyon Sandstone pinched-out within the southern Mahogany Hills.

Within the thesis area, exposures of Oxyoke Canyon Sandstone occur only at Combs Peak. In this area the sandstone attains a maximum thickness of 21 meters (70 feet) and because of its relative resistance to weathering, can be observed to thin and pinch out a short distance to the west.

Contacts

The presence of faint cross-laminations and scattered sand grains marks the base of the Oxyoke Canyon Sandstone in the southern Mahogany Hills. An abrupt change from light grey dolomite with scattered quartz grains to medium grey, laminated, bioclastic dolomite, marks the upper contact of the Oxyoke Canyon with the Simonson Dolomite. Although this contact is generally not well exposed, no evidence of an unconformity was noted.

Age and correlation

Due to the absence of diagnostic fossils in the Oxyoke Canyon Sandstone, precise dating of this unit is difficult. Conodont collections, taken above and below the Oxyoke Canyon in the Sulphur Spring Range, indicate that the "Coarse Crystalline Member" (i.e., upper Oxyoke Canyon) is probably no younger than early Couvinian (J. G. Johnson, personal commun., 1977).

Lithologic correlations in the southern Mahogany Hills and elsewhere in Eureka County, suggest that, to the west of the thesis area, the Oxyoke Canyon Sandstone is equivalent to part of the Sadler Ranch Formation. To the east, the "Coarse Crystalline Member" of the Oxyoke Canyon is thought to be correlative with the lower Simonson Dolomite (Osmond, 1962; Kendall, 1975; Johnson and Sandberg, 1977).

Lithology

The Oxyoke Canyon Sandstone of the southern Mahogany Hills comprises two lithologies; upper and lower dolomites and quartzose dolomites, and a middle dolomitic quartz arenite. Both lithologies are included in the "Coarse Crystalline Member" as designated by Kendall (1975).

The upper and lower units are lithologically similar to the subjacent Sadler Ranch Formation. The dolomite is medium- to very finely crystalline, medium-bedded, and light to light medium grey in color. Faint cross-laminations and scattered quartz grains visible on weathered surfaces, especially along laminae, distinguish these rocks from the Sadler Ranch Formation. Quartz content of these strata is variable, but locally exceeds 10% of the total rock, especially in the lower unit.

The middle unit is a dolomitic quartz arenite which stands in considerable relief over the surrounding dolomites. Weathered exposures possess a distinctive rusty brown coloration due to iron oxide staining. Planar cross-laminations and parallel laminations stand out on weathered exposures (Figure 12).

Petrography

In thin section, the upper and lower units of the Oxyoke Canyon Sandstone are largely composed of quartzose dolomite with minor

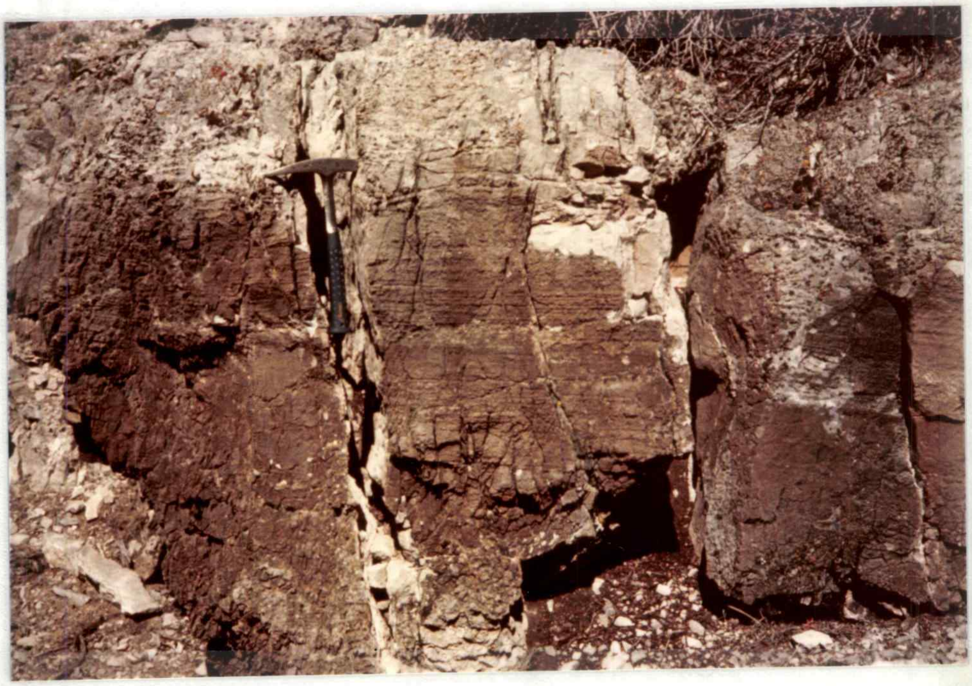

Figure 12. Typical exposure of the dolomitic quartz arenite unit of the Oxyoke Canyon Sandstone at Combs Peak.

intervals of peloidal (intraclastic?) dolomite. The quartzose dolomites are typically composed of 10% sub-rounded to well-rounded, well-sorted quartz grains, 10% well-rounded, well-sorted peloids, and 80% fine-grained dolomite matrix (Figure 13). The quartz grains are in the size range of fine to medium sand; the peloids are slightly larger, with a maximum diameter of 0.75 millimeters. The peloids are dark, recrystallized, and structureless and probably represent intraclasts. The quartz grains are nearly all mono-mineralic and very few exhibit undulatory extinction. The peloidal dolomite intervals are essentially identical to the quartzose dolomites, with the exception of a complete absence of quartz. In both these rock types the sand grains occur randomly scattered throughout the dolomite matrix. The matrix material is finely crystalline dolomite in an interlocking mosaic.

In thin section, the dolomitic quartz arenite, which composes the middle unit of the Oxyoke Canyon Sandstone, consists of 60 to 70% sub-rounded to well-rounded, well-sorted quartz, 30 to 40% dolomite cement, and up to 1% peloids (Figure 14). The quartz grains are fine to medium sand-size, mono-mineralic, non-undulatory extinction; weathered quartz overgrowths are conspicuous on many grains. Etching of the quartz grains by the surrounding carbonate cement is apparent in most cases. Some pressure solution of the quartz grains appears to have taken place, as concavo-convex grain

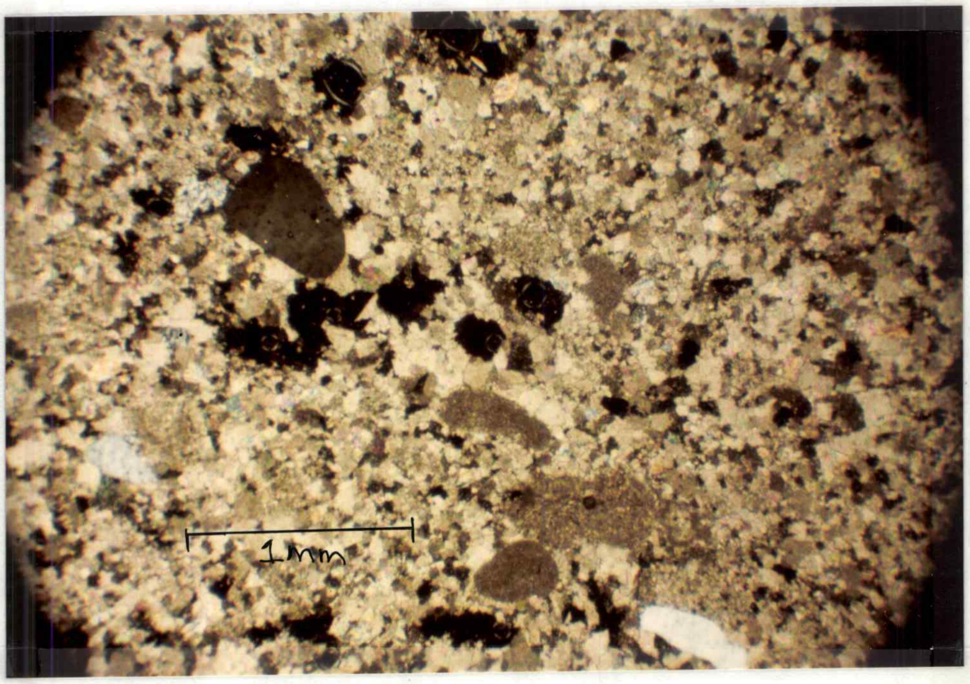

Figure 13. Photomicrograph of quartzose dolomite from the lower Oxyoke Canyon Sandstone at Combs Peak. Note the presence of both quartz grains and peloids. Sample is from the 1004 foot (306 m) level of the Combs Peak II measured section.

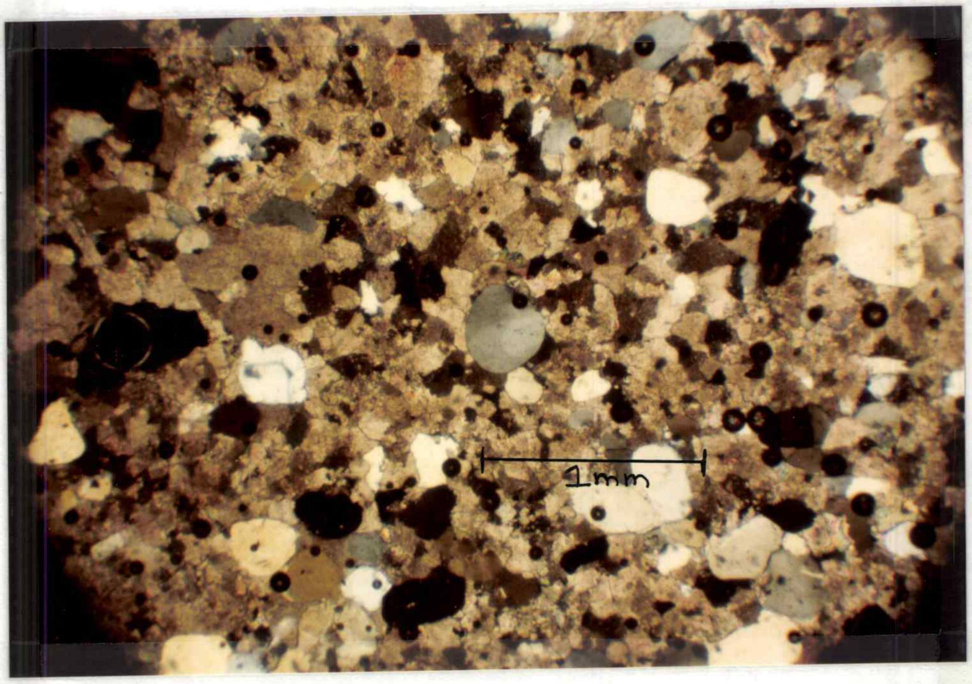

Figure 14. Photomicrograph of dolomitic quartz arenite from the Oxyoke Canyon Sandstone at Combs Peak. Sample is from the 990 foot (302 m) level of the Combs Peak II measured section.

contacts and quartz fracture fillings are common. A vague alignment of the quartz grains, parallel to bedding, is apparent throughout the sample. Sand-size peloids, identical to those described earlier, occur intermixed with the quartz grains. The cementing agent is a fine- to very fine-grained interlocking mosaic of dolomite.

Depositional environment

Well-rounded, well-sorted peloids and quartz grains, as well as abundant parallel and cross-laminations, suggest a high-energy depositional environment for the Oxyoke Canyon Sandstone. Observations to the north and east of the thesis area (Kendall, 1975) indicate an intertidal or possibly supratidal environment. The dolomitic quartz arenite may represent a beach-bar-dune type deposit, whereas the quartzose dolomites and peloidal dolomites may have been deposited in a tidal flat. Kendall (1975) reached similar conclusions after examining the Oxyoke Canyon Sandstone north of Eureka. Kendall further suggested that the "Coarse Crystalline Member" of the Oxyoke Canyon was deposited under higher energy conditions and better circulation than the lower Simonson Dolomite.

SIMONSON DOLOMITE

General Statement

The Simonson Dolomite was named by Nolan (1930, p. 427; 1935, p. 19) for Simonson Canyon, in the Deep Creek Mountains of western Utah. Later workers (Osmond, 1954; Gronberg, 1967), have shown that the Simonson can be traced from the type area, westward, as far as Lone Mountain and the Mahogany Hills, in Eureka County.

In the thesis area, the Simonson is predominantly dolomite with a total thickness of 1300 feet (396 meters). Extensive outcrops of Simonson Dolomite occur along the western range front of the southern Mahogany Hills, from north of Table Mountain to the vicinity of Combs Peak, and also along the east side of Brown's Canyon. To the east of the thesis area, Osmond (1954) subdivided the Simonson into four members; however, these units were not recognized within the mapped area.

Contacts

The lower contact of the Simonson Dolomite is exposed only on the western slope of Table Mountain and Combs Peak. At Table Mountain the Simonson overlies the Sadler Ranch Formation and the contact is placed at the base of the first sequence of rhythmically alternating, dark and light colored dolomites. This contact is gradational, because alternating dark and light dolomites also occur in the upper Sadler Ranch. The base of the Simonson Dolomite is, therefore, drawn at the level where the frequency of the vertical color variations increases markedly. At Combs Peak, the Simonson Dolomite overlies the Oxyoke Canyon Sandstone. The contact is sharp and planar.

The upper contact of the Simonson Dolomite is also gradational, with limestone interbeds replacing the dolomite over about a 20 meter interval.

Age and correlation

The occurrence of Stringocephalus within the Simonson Dolomite at its type locality prompted Nolan (1935) to assign the Simonson a Middle Devonian age. More recent investigations in eastern and central Nevada (Osmond, 1954; Nolan and others, 1956; Johnson, Boucot, and Gronberg, 1968), lend support to this age assignment.

The Simonson Dolomite is a laterally extensive unit which has been recognized throughout much of western Utah and eastern Nevada. It is considered to be equivalent to the Telegraph Canyon Member of the "Nevada Formation" in the Sulphur Spring Range (Johnson, Boucot, and Gronberg, 1968, p. 412), and to the Sentinel Mountain, Woodpecker, and Bay State Members in the vicinity of Eureka (Johnson and Sandberg, 1977, p. 125). To the west of the thesis area, the Simonson correlates to part of the Denay Limestone (Johnson and Sandberg, 1977). Probable interfingering of these two units was described by Gronberg (1967, p. 23) at Lone Mountain, 18 kilometers northwest of the thesis area.

Lithology

The Simonson Dolomite in the southern Mahogany Hills comprises a thick sequence of alternating, dark and light colored dolomites, which weather to form ledges and step-like exposures (Figure 15). For the most part, the dolomites are light, medium, and dark grey, micro- to coarsely crystalline, and thin- to thick-bedded. Exposures along the south side of Combs Peak typically exhibit a brownish cast, which is most apparent in dark colored beds. Color variations in the Simonson south of Combs Peak range from light grey to chocolate brown, as described by Nolan and others (1956, p. 44) in equivalent strata in the vicinity of Eureka.

The Simonson Dolomite is finely laminated, recrystallized, and locally vuggy throughout the area studied (Figure 16). Commonly, the laminae are contorted, exhibiting numerous tight folds suggestive of soft sediment deformation; cut-and-fill structures are also present in some beds (Figure 17). Rare flame structures occur where intraclastic conglomerates have been deposited on an unconsolidated substrate. The conglomerates are typically composed of sub-angular

Figure 15. Typical outcrop of Simonson Dolomite within the southern Mahogany Hills, showing weathering character and color variation.

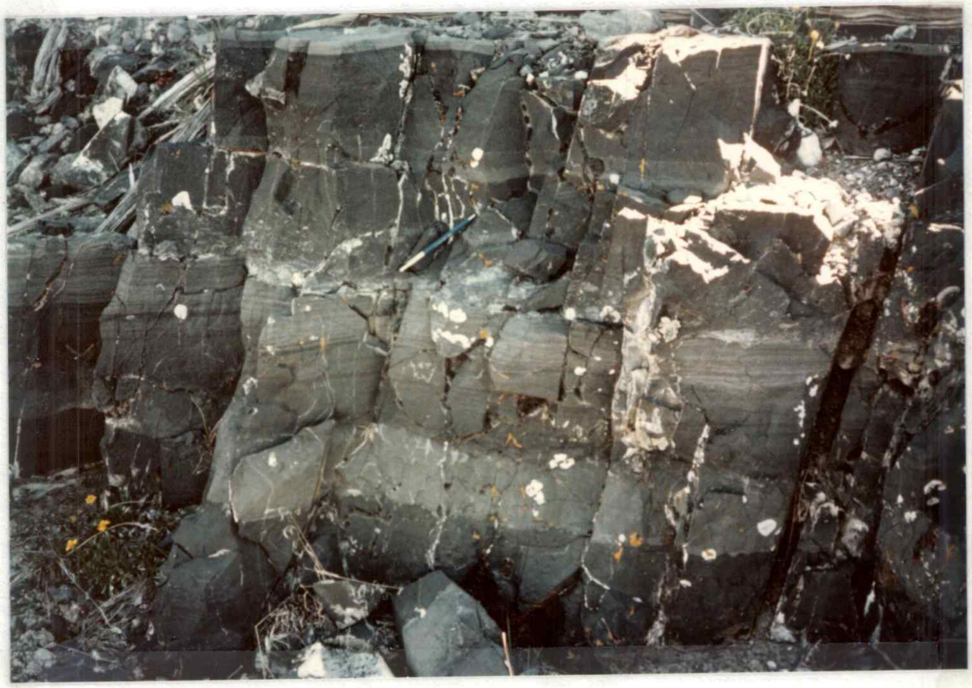

Figure 16. Typical appearance of finely laminated Simonson Dolomite at Table Mountain. Pen gives scale.

Figure 17. Hand sample of finely laminated Simonson Dolomite showing soft sediment deformation. Sample is from the 60 foot (18 m) level of the Table Mountain measured section.

to sub-rounded clasts up to 10 centimeters in length, which differ from the surrounding material only in color.

Breccias composed of dolomite clasts up to 15 centimeters in diameter, in a compositionally similar dolomite matrix occur in the upper half of the Simonson. These intraclastic breccia beds average 25 centimeters in thickness, but may range up to over a meter.

Numerous units within the Simonson contain abundant biotic remains. Fragmental bun-shaped and dendroid stromatoporoids are common. In addition, brachiopods, digitate corals, and probable bryozoans are also present. The diverse faunal content of these units suggests that they may represent dolomitization of lime wackestones and packstones. Fresh surfaces characteristically exude a fetid odor. The vuggy character of many units appears to be related to selective solution of skeletal material.

Depositional environment

Osmond (1954, p. 1952) suggested that the alternating dark and light colored units of the Simonson Dolomite were deposited on an extensive shallow-marine platform. Broad topographic depressions and ridges allowed the development of distinct environments in laterally adjacent areas. It is probable that stromatoporoids and other organisms inhabited the topographic highs, where circulation was enhanced. Skeletal remains of these organisms were later transported off the highs and deposited in adjacent depressions. Additionally, the sites of deposition are thought to have migrated on the sea floor through time, thus forming a continuous record of sedimentation. Osmond (1954) indicates that periodicity in the transporting media may account for the well laminated character of the Simonson Dolomite.

Intraclastic conglomerates and breccias are indicative of a relatively high energy environment, and may indicate periodic shallowing or sub-aerial exposure of local areas within the depositional platform. This suggests that maximum water depths may have been on the order of only a few meters. Soft sediment deformation may have occurred on the slopes of these shallows or from loading.

DEVILS GATE LIMESTONE

General statement

Originally designated as part of Hague's (1883) "Nevada Limestone," the "Devils Gate Formation" was first proposed as a separate geologic formation by Merriam (1940). Merriam, however, defined the limits of the "Devils Gate Formation" more on the basis of contained faunas than on physical or lithologic criteria. Nolan and others (1956) subsequently discovered that the "Devils Gate Formation" could also be recognized on the basis of lithology and redefined it as the Devils Gate Limestone.

The Devils Gate Limestone forms the bulk of the Paleozoic outcrop within the southern Mahogany Hills. From its type section at Devils Gate Pass, at the extreme north end of the Mahogany Hills, to a point slightly south of Percivalli Canyon in the southern Mahogany Hills, virtually all of the Paleozoic strata exposed are assigned to the Devils Gate Limestone. South of Percivalli Canyon the Devils Gate forms the rugged cliff topography which characterizes the upper extremities of Table Mountain, Combs Peak, Temple Peak, and several unnamed summits in the thesis area.

Within the thesis area, faulting and gravity slides in the Devils Gate has been extensive and has resulted in the development of extensive cataclastic breccias. These breccias are most conspicuous along the eastern side of Brown's Canyon in the area of Dougherty Canyon and at the mouth of Brown's Canyon, where rugged cliffs of recrystallized Devils Gate Limestone breccia form much of the topography. Merriam (1963, p. 51) mentioned the presence of "badly deformed" cataclastic breccias composed of Devils Gate Limestone at a locality slightly northwest of the thesis area and suggested that the breccia may have been the result of thrust faulting. The outcrop pattern of the breccias in the thesis area indicates that Merriam's (1963) explanation may not be wholly satisfactory. The cataclastic breccias in the thesis area are dealt with in greater detail in a later section of this report.

Stratigraphic sections of the Devils Gate Limestone were studied at two locations in the thesis area and the writer additionally examined the type section at Devils Gate Pass, while attempting to establish mappable sub-units within this formation. Although lithologic differences were found to exist between the "upper" Devils Gate at the type section, as described by Sandberg and Poole (1977), and the lower Devils Gate in the thesis area, no mappable boundary separating these lithologies was found. Strata lithologically similar to the Upper Devils Gate of Sandberg and Poole (1977) appear to be restricted to the extreme north end of the mapped area, along the ridge crest which extends south from Devon Peak, and are not dealt with in detail in this report.

The total thickness of the Devils Gate Limestone in the Mahogany Hills is not known as no complete section was found. At the type section, the Devils Gate is in excess of 355 meters thick (Sandberg and Poole, 1977, p. 153); however, the lower contact is not exposed at that locality. Merriam (1963, p. 54) stated that a "relatively unbroken" section of Devils Gate Limestone east of Eureka totals about 1,200 feet (366 meters). Within the thesis area an unbroken sequence of the lowermost 500 feet (152 meters) of the Devils Gate was measured at Table Mountain and a section totaling 350 feet (107 meters) was measured within the lower Devils Gate at Percivalli Canyon.

Contacts

The lower contact of the Devils Gate Limestone is exposed at many locations in the southern Mahogany Hills (Figure 18). In all instances this contact is gradational from the underlying dolomites, with limestones alternating with and replacing the dolomites over about a 20 meter interval. The thickness of this interval compares well with the 30 to 75 foot (9 to 23 meters) transition zone described by Merriam (1963, p. 51). Gronberg (1967, p. 27) defined the lower contact of the Devils Gate at Table Mountain as occurring at the base of the first thick-bedded limestone cliff. On the basis of lithologies, the writer chose a contact approximately 70 feet (22 meters) lower.

Figure 18. Appearance of Simonson Dolomite - Devils Gate Limestone contact on the north side of Brown's Canyon, directly north of Table Mountain. Field assistant gives scale.

The limestone cliff noted by Gronberg is a distinctive physical feature throughout much of the map area and can be used as a field criterion when mapping this contact.

The nature of the upper contact of the Devils Gate Limestone in the map area is unknown. Contacts with overlying sandstones and conglomerates represent either a depositional unconformity or they may be tectonic in origin.

Age and correlation

As originally defined by Merriam (1940, p. 16) the "Devils Gate Formation" comprised the strata lying above the highest occurrence of Stringocephalus, through the beds containing the Cyrtospirifer fauna. However, the "Stringocephalus sp." illustrated by Merriam (1940, pl. 8, figs. 1, 2), from Denio Canyon north of Table Mountain, are now known to be Geranocephalus truncatus (Johnson, Boucot, and Gronberg, 1968). This fossil occurs well down in the Simonson Dolomite as mapped in this report or as mapped by Gronberg (1967). This means that when Nolan and others (1956) redefined the Devils Gate on the basis of lithology they shifted some hundreds of feet of "Devils Gate Formation" to the subjacent formation. This explains Merriam's (1940, p. 17) statement that the lower 900 feet of Devils Gate Formation in the type area resembles the upper part of the Nevada Formation.

Extensive collections for both brachiopods and conodonts were made in the lower Devils Gate Limestone at Table Mountain and elsewhere in the thesis area. For the most part, these collections yielded little of value. One collection (T 580), however, taken approximately 13 meters above the base of the Devils Gate contained significant conodonts, including Polygnathus xylus xylus and Icriodus subterminus. These conodonts are indicative of the insita fauna and indicate a late Givetian to early Frasnian age for the basal deposits of the Devils Gate in this area. This age contrasts with the age of the basal Devils Gate at Lone Mountain, where Stringocephalus sp. (Murphy and Dunham, 1977) dates these deposits as early to middle Givetian. These findings indicate that the onset of Devils Gate sedimentation was diachronous in Eureka County.

The Devils Gate Limestone has been correlated to the east with the Guilmette Formation in eastern Nevada and western Utah (Nolan, 1935; Osmond, 1962; Sandberg and Poole, 1977; Johnson and Sandberg, 1977). Johnson (1971b) indicated that the lower part of the Devils Gate in the Sulphur Spring Range and east of Eureka is equivalent to the upper Denay Limestone of the Roberts Mountains. This correlation suggests a westward progradation of the Devils Gate lithofacies through time. However, the relatively late (Frasnian) onset of Devils Gate sedimentation in the thesis area suggests that this westward progradation may not have significantly affected sedimentation in the southern Mahogany Hills.

Lithology

Throughout most of the thesis area the Devils Gate Limestone forms distinctive, rugged, cliff exposures. Where the underlying Simonson Dolomite is exposed this physiographic phenomenon becomes most striking, and serves as a reliable method for distinguishing these two units.

The Devils Gate Limestone comprises three distinct rock types. The bulk of the Devils Gate is composed of thin- to thick-bedded, bioclastic and intraclastic limestones, which weather to form massive appearing cliffs. Interbedded with the limestones are thin-bedded argillaceous limestones and calcareous shales which weather recessively, forming notches in the limestone cliffs. Dolomites and limy dolomites are also present throughout the Devils Gate and it is estimated that as much as 10 percent of the lower 200 meters of the Devils Gate is composed of these rock types.

The bioclastic and intraclastic limestones which compose most of the Devils Gate Limestone in the thesis area are actually a complex suite of lithologies which replace each other in an undetermined manner both vertically and laterally throughout the area studied. These limestones range in color from medium grey to nearly black, and may appear slightly bluish when viewed from a distance.

The most common bioclastic lithology within the lower Devils Gate includes the so called "spaghetti corals." This rock type ranges from mudstone to packstone and is composed of various forms of digitate corals, bryozoans, and stromatoporoids. Field identification of these organisms is difficult; however, it is thought that Cladopora sp. and Amphipora sp. are the most common forms (Figure 19). According to Osmond (1954, p. 1950), these organisms can be distinguished by means of their diameter, with Cladopora being the largest (5 millimeters). On this basis the dendroid stromatoporoid Amphipora is estimated to be numerically the most significant organism in the "spaghetti" strata of the lower Devils Gate Limestone. Field observations also support Osmond's (1954) suggestion that the various organisms which compose the "spaghetti" beds may be mutually exclusive, and probably represent distinct environments.

Lithologically, the "spaghetti coral" beds are highly variable, locally showing some grading and current alignment of the tubulars. The "spaghetti" organisms commonly occur in masses composed of only a single type of organism. Less often the tubulars are intermixed with fragmental bun-shaped stromatoporoids, brachiopods, and gastropods.

Rare beds composed entirely of bun-shaped stromatoporoids, which appear to be in growth position, occur closely associated with

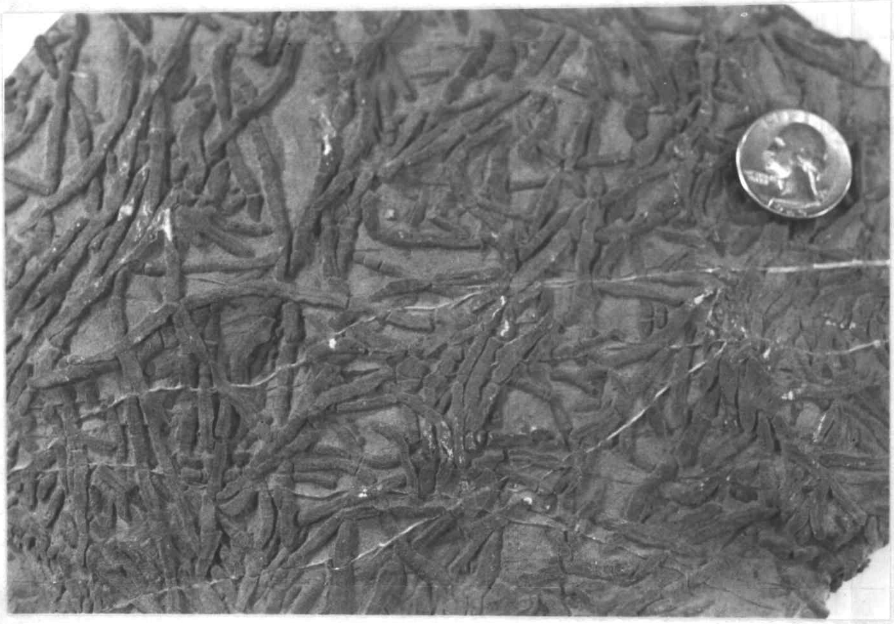

Figure 19. Hand sample of Amphipora packstone from lower Devils Gate Limestone at Table Mountain. Photo taken perpendicular to bedding plane.

the bioclastic strata. These biostromal beds generally appear complexly intergrown and seldom exceed 30 centimeters in thickness. The stromatoporoids which compose these biostromes are surrounded by micrite, which locally may be finely bioclastic.

Probable algal mat structures were also noted in the Devils Gate Limestone of the thesis area. These structures are commonly broken and are always recrystallized, making identification of the internal fabric difficult. The "mats" generally are 20 to 50 millimeters thick and commonly appear undulatory. Bulbous stromatolites were not recognized in these beds.

Intraclastic conglomerates are also common in the lower Devils Gate Limestone. Merriam (1963, p. 51) stated that this rock type is "widespread" in the Devils Gate of the Mahogany Hills and that conglomerates of this sort have been recognized in the Devils Gate as far west as the Diamond Mountains. Clast size is highly variable, averaging between 10 and 50 millimeters, with rare clasts up to 200 millimeters. Within the study area the clasts in the conglomerate units are most commonly sub-rounded to well-rounded; however, Merriam (1963, p. 51) stated that angular clasts are also common in these beds. The intraclasts are generally mudstones containing fine bioclastic debris, which are imbedded in a matrix of similar appearing sediment that usually differs slightly in color. Locally these beds are graded or laminated.

The argillaceous units which occur as interbeds or as partings within the "massive" limestone units are most often yellowish and mottled, less commonly they have a pinkish cast. The argillaceous limestones and calcareous shales generally exhibit platy weathering and are rarely fossiliferous. At Percivalli Canyon in the northern part of the thesis area, Atrypa sp. was found to be locally abundant within a bed of argillaceous limestone (PC-5).

Dolomites and limy dolomites in the lower Devils Gate Limestone are generally micro- to finely crystalline and are commonly laminated. The color is highly variable, ranging from olive grey to medium grey. In the lower 200 meters of the Devils Gate these rock types occur randomly interbedded with other lithologies, in beds which seldom exceed one meter in thickness.

Petrography

Microscopic examination of acetate peels and thin sections of the Devils Gate Limestone reveals extensive recrystallization of the original sedimentary fabrics. Where recrystallization has been less severe a characteristic peloid fabric can be distinguished. The internal structure of the peloids has been totally obliterated by recrystallization and micritization making identification impossible.

The peloids range in size from less than 0.25 up to 1.0 millimeters or more, and they may represent ooids, coated grains, and fecal pellets. In some samples the peloids occur as discrete grains cemented by calcite micro-spar, forming a peloid grainstone micro-fabric (Figure 20). In other samples the peloids appear to have coalesced, probably as a result of pressure-solution and diagenesis, producing a micro-fabric which resembles "pure" micrite (Figure 21). In some rocks the peloids are rhythmically graded, imparting a finely laminated appearance to the hand sample. Rarely, faint cross-laminations also are present. Fine bioclastic debris including ostracod valves and crinoidal hash is common throughout most of the limestone beds in the Devils Gate of the thesis area. This debris is commonly intermixed with peloids or is completely encased in "massive" micrite.

Depositional environments

The Devils Gate Limestone of the Mahogany Hills is interpreted as representing a shallow-water, low-energy, lagoonal, depositional environment. Wilson (1975, p. 128) stated that in western Europe, vertically alternating beds of bioclastic limestone, fenestrate laminites, globular stromatoporoids, and micritic limestones are present in many shallow-water Devonian carbonate sequences. A similar vertical alternation of lithologies is present in the Devils Gate Limestone of the Roberts Mountains (Murphy and Dunham, 1977) and in the southern Mahogany Hills. Murphy and Dunham (1977)

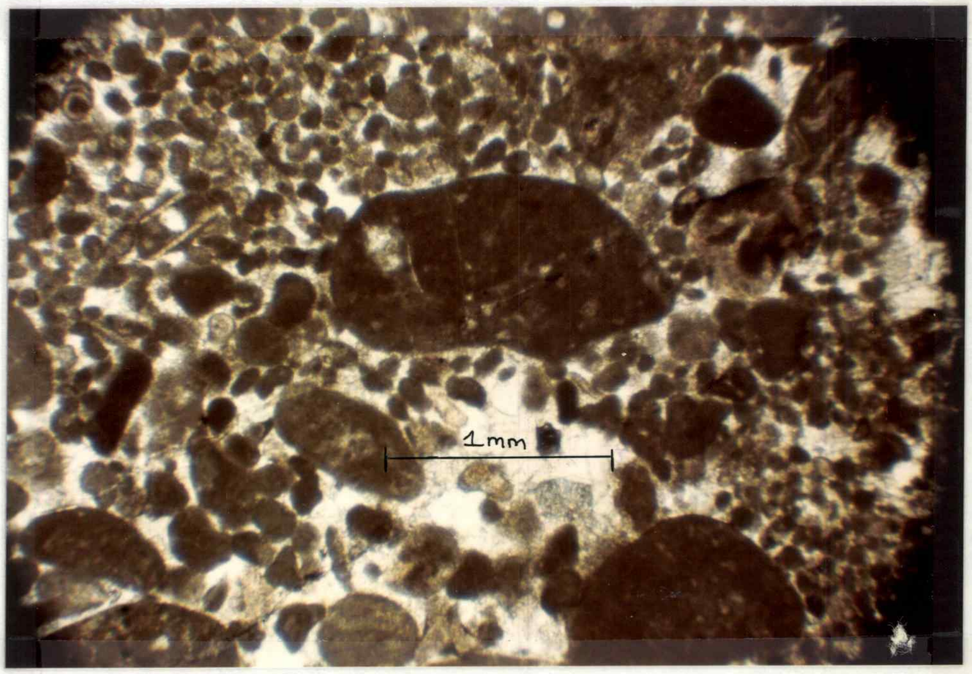

Figure 20. Photomicrograph showing peloidal grainstone micro-fabric in the lower Devils Gate Limestone at Table Mountain. Sample is from the 730 foot (223 m) level of the Table Mountain measured section.

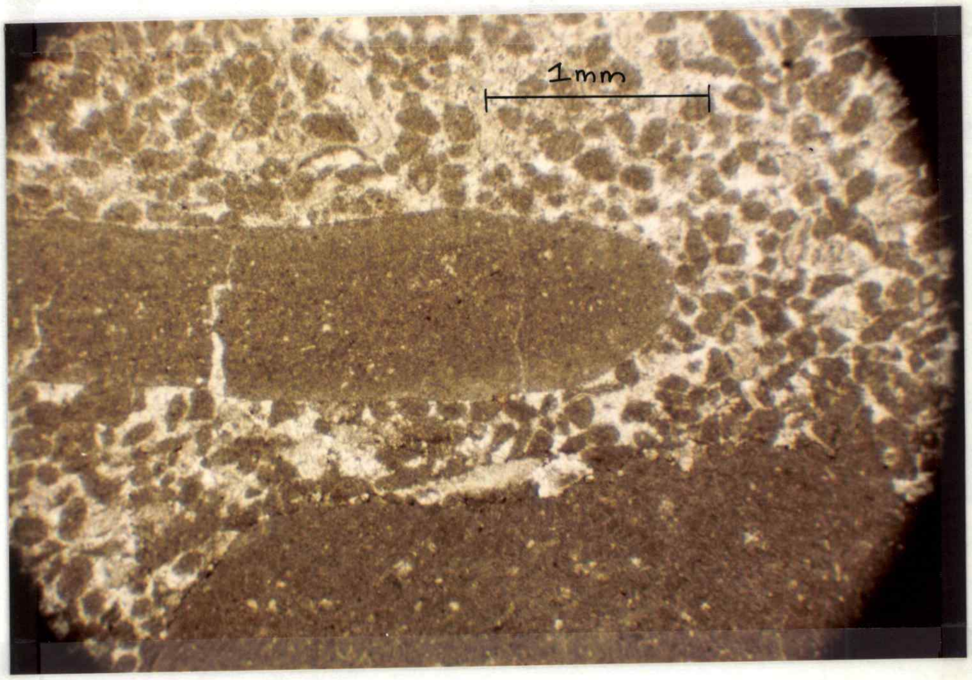

Figure 21. Photomicrograph showing intraclasts in the lower Devils Gate Limestone at Table Mountain. Note peloids in the lower right have coalesced giving the appearance of "pure" micrite. Sample is from the 665 foot (203 m) level of the Table Mountain measured section.

have reported laterally extensive "stromatoporoid boundstones" in the Devils Gate of the Roberts Mountains and have inferred from this that relatively slow platform subsidence characterized early Devils Gate deposition. Krebs (1974) described a series of carbonate facies in the Devonian of western Europe which bear a striking resemblance to the Devils Gate Limestone. Krebs' (1974) interpretations of the environments represented by these facies are similar to the interpretations of Murphy and Dunham (1977). At least four of the lithofacies described by Krebs (1974) have direct counterparts within the diverse suite of Devils Gate lithologies; these are the: 1) dark bulbous-stromatoporoid and Amphipora facies; 2) dark Amphipora facies; 3) dark fossil-poor micrite facies; 4) rudite facies.

The dark bulbous-stromatoporoid and Amphipora facies was probably the most common depositional environment during early Devils Gate time in the southern Mahogany Hills. This facies is primarily characterized by bulbous-stromatoporoids (bun-shaped) up to 25 centimeters in diameter, Amphipora, branching tabulate corals (Cladopora?), ostracodes, and echinoderm debris (Krebs, 1974, p. 184). The matrix material is always dark and argillaceous, and autochthonous biostromal carbonates locally are present (Krebs, 1974, p. 186). This facies is represented in the Devils Gate by the interbedded sequences of bioclastic limestones, and argillaceous limestones and calcareous shales, as well as the stromatoporoid biostromes.

Krebs' (1974) interpretation of the depositional environment for the dark bulbous-stromatoporoid and Amphipora facies is a low-energy, subtidal, shelf lagoon. Low relief banks and shallows were common and low patch reef buildups may have been present and must have required normal marine salinities for continued development. Murphy and Dunham (1977) suggest that the development of stromatoporoid biostromes in the Devils Gate indicates persistent favorable conditions, involving temperature, oxygen supply, and nutrient replenishment. Aside from the lack of observed buildups in the Devils Gate of the thesis area, the interpretations of Krebs (1974) are in agreement with the observations of the writer.

The dark Amphipora facies is characterized by dark, fine-grained, well-bedded limestones and amphiporoids in masses 5 to 25 centimeters thick. A pelletal micro-fabric is also very characteristic (Krebs, 1974, p. 188). This facies is represented in the Devils Gate Limestone by the packstones of "spaghetti corals" and probably in part by other bioclastic and peloid limestones. It is probable that a continuous gradation exists between the dark bulbous-stromatoporoid and Amphipora facies and the dark Amphipora facies in the Devils Gate Limestone.

Krebs' (1974) interpretation of the depositional environment of the dark Amphipora facies is that of a quiet, semi-restricted, back-reef lagoon in which extensive "meadows" of *Amphipora* may have been common. Heckel (1974) supports this interpretation and indicates that both the dark bulbous-stromatoporoid and *Amphipora* facies, and the dark *Amphipora* facies, probably were very common in shallow-water carbonate environments during the Devonian. Wilson (1975, p. 121) also describes this Devonian environment and interprets it as "micro-facies" within carbonate bank interiors.

These interpretations appear valid for the "spaghetti coral" beds of the Devils Gate Limestone; however, the graded bedding and current alignment of the tubulars, along with the faint cross-laminations noted in some rare peloidal beds, may indicate more current activity in this depositional environment in Nevada than Krebs (1974) has suggested, studying the European Devonian.

The dark, fossil-poor micrite facies is characterized by dark largely non-fossiliferous lime mudstones, which commonly are partially or wholly dolomitized (Krebs, 1974, p. 188). This facies is represented in the Devils Gate by the rare beds of "pure" lime mudstone and probably by the limy dolomites and dolomites.

The dark fossil-poor micrite facies is interpreted (Krebs, 1974) as having been deposited in relatively deep, highly restricted areas within the back-reef or shelf lagoon, where water agitation is reduced. Euxinic or hypersaline conditions probably existed, thus inhibiting benthonic life. Krebs (1974) indicates that this environment is closely associated with both the dark Amphipora facies and with fine-grained intertidal laminites. Although some of the structureless, fine-grained dolomites and limy dolomites in the Devils Gate Limestone are probably of secondary origin, having been derived from lime mudstones, the proximity of this facies to the intertidal zone (Krebs, 1974, p. 188) suggests that some of the dolomites, especially those having fine parallel laminations, may represent primary tidal flat or sabhka dolomitization (Wilson, 1975, p. 297).

The rudite facies is characterized by intraclastic conglomerates composed of clasts of fine-grained limestone up to 30 millimeters in diameter and some bioclastic debris (Krebs, 1974, p. 189). The matrix in these conglomerates consists of micrite to pelmicrite (Krebs, 1974, p. 191). This facies is represented in the Devils Gate Limestone by numerous intraclastic limestone conglomerates.

The rudite facies is interpreted (Krebs, 1974, p. 191) as representing either local erosion on tidal flats or erosion of underlying carbonate muds when a new transgression of the sea resulted from minor subsidence. Erosion of partly hardened carbonate muds in a tidal flat environment indicates intertidal to subaerial exposure of the sediment. The occurrence of algal mat structures and intraclastic conglomerates in the southern Mahogany Hills, and the presence of oncolites in the Devils Gate Limestone to the west, in the Hot Creek Range (Potter, 1975, p. 85), suggest that the rudite facies in the thesis area probably represents a local erosional environment within the intertidal zone.

Devils Gate Limestone lithologies indicate a protected, low-energy environment; however, the lack of fragmental boundstones and the dearth of rugose corals and other normal marine organisms in the lower Devils Gate indicates either that no wave-resistant structure was present at the shelf edge during early Devils Gate time or that the Mahogany Hills area was sufficiently distant from the buildup so that detrital input was not significant there.

The lack of observed ooids and coated grains in the lower Devils Gate of the thesis area may not be a significant environmental indicator. Recrystallization has so completely altered the original fabric of most of the Devils Gate rocks that it is impossible to state that these components did not, at one time, compose a part of the exposed strata.

The upper Devils Gate Limestone, as exposed at the type section at Devils Gate Pass, and in the northernmost part of the thesis area, represents a marked change in depositional environment (Sandberg and Poole, 1977). Conspicuous rugose corals, brachiopods, and a few well-graded beds indicate the development of a less restricted, slope environment during late Devils Gate time.

POST-DEVONIAN SANDSTONES, SHALES, AND CONGLOMERATES

Exposures of reddish-brown, detrital clastics occur throughout much of the thesis area. At no locality do these rock types occur as outcrop. Exposures are characterized by a reddish soil with scattered, angular blocks of sandstone, shale, and conglomerate littering the surface; typically, blocks of surrounding carbonate lithologies are also present (Figure 22). The areal extent of these exposures is generally very limited. The largest continuous exposure of this rock type occurs along the east side of Brown's Canyon, just south of Denio Canyon (Plate 1). Rocks identical to those in Brown's Canyon occur in at least one area in the northern Mahogany Hills, north of the mapped area (Drake, personal commun., 1977).

Lithologically, these rocks range from shale to conglomerate, with medium- to coarse-grained sandstones composing the bulk of most exposures. Shales compose only a small fraction of the material exposed on the surface. Where exposed, the shales are red-brown and appear to be interbedded with sandstones and conglomerates. Representative samples of both the sandstones and the conglomerates were selected for thin-section examination.

The sandstone is composed of about 50% sub-angular to well-rounded, monomineralic quartz, ranging in size from 0.25 to 0.5 millimeters (Figure 23). Approximately 40% of the sample is

Figure 22. Typical exposure of post-Devonian sandstones, shales, and conglomerates in Denio Canyon.

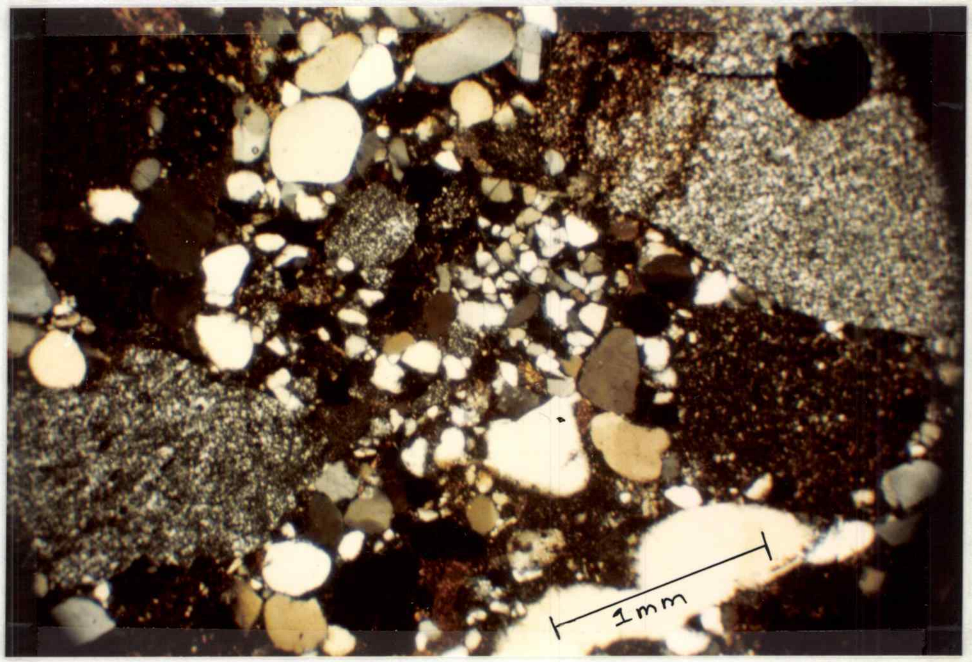

Figure 23. Photomicrograph of cherty quartz arenite. Note rounded lithic fragment at center composed of fine, angular to sub-rounded, quartz and chert grains; also note abundance of chert and strained and unstrained quartz grains.

composed of sub-angular to sub-rounded chert fragments, some of which exhibit conspicuous biotic "ghosts." These grains range up to three millimeters in diameter, but average slightly less than one millimeter. The remaining 10% of the sandstone examined is composed of a variety of lithic fragments including shale, fine-grained sandstone, and possible volcanic and metamorphic rock fragments. Rare grains of glauconite were also identified. The sample is poorly sorted and is classified as a cherty quartz arenite (Gilbert, 1955).

The conglomerate is composed of approximately 70% sub-angular to sub-rounded chert pebbles. These grains range in size up to 20 millimeters, with an average size of about 5 millimeters. Many of the chert pebbles have conspicuous biotic "ghosts," including radiolaria and sponge spicules. Approximately 25% of this rock is composed of sub-rounded to well-rounded, monomineralic quartz grains. These grains typically range in size from 0.25 to 0.5 millimeters. The remainder of this sample is composed predominantly of fine-grained sandstones, probable volcanic rock fragments and rare glauconite. Overall, the rock is poorly sorted with a distinctive bi-modal size distribution. A general parallel alignment of elongate grains is visible in hand sample and locally some grading is also apparent among the larger clasts. This sample is classified as a chert pebble conglomerate.

At all localities studied, these clastics overlie Devils Gate

Limestone. The nature of the contact between the clastics and the subjacent Devils Gate is not known, however, an unconformable contact with some angular discordance is possible. The pattern of exposures within the Mahogany Hills suggests that these sandstones, shales, and conglomerates may represent erosional remnants of an areally extensive, post-Devonian deposit. T. B. Nolan (personal commun., 1977), considers these rocks to be representative of the Dale Canyon Formation, which has been dated as Mississippian in the area of Pinto Summit, east of Eureka, because of its stratigraphic position between the Joana Limestone and Chainman Shale (Nolan and others, 1974).

The abundance of post-Devonian Paleozoic detrital clastic deposits in the area of Eureka and the apparent lack of fossil material in the exposures of the map area, precludes assignment of these rocks to a particular formation. It is assumed that these deposits were derived from the Antler orogenic belt, to the west, and that they represent part of the "clastic wedge" which was shed eastward from this orogenic belt during the late Paleozoic (Johnson, 1971a).

NEWARK CANYON FORMATION(?)

Poorly exposed mudstones, siltstones, and sandstones, which overlie deformed Devils Gate Limestone, approximately three kilometers northwest of Table Mountain, were tentatively assigned to the Cretaceous Newark Canyon Formation by Nolan and others (1956, p. 69). These strata were later mapped by Merriam (1963), although no formal description was given.

Surficially, these rocks appear similar to the post-Devonian sandstones, shales, and conglomerates described above (Figure 24). The presence of a reddish soil and the abundance of coarse-grained reddish sandstone at this locality are the most striking similarities. Outcrop is not visible because of the extensive development of soils. The presence of mudstone and siltstone clasts intermixed with the sandstones at this locality makes this exposure distinctive, and serves to distinguish it from other non-fossiliferous detrital clastics in the map area.

Figure 24. Characteristic appearance of Newark Canyon Formation(?) at mapped locality north of Table Mountain.

STRUCTURE

General statement

At least two major episodes of tectonic deformation have affected rocks within the southern Mahogany Hills. The first episode involved generally east-west compressional forces which formed north-south and northwest-trending folds. Later tensional forces resulted in the formation of a complex series of normal faults and gravity slides. Dating of these two periods of tectonic activity is difficult; however, major east-west compressional events occurred in the Great Basin during the late Paleozoic (Antler orogeny) and the late Mesozoic (Sevier orogeny), and tensional tectonics have characterized the Great Basin throughout the Tertiary (Armstrong, 1972). The normal faults are therefore assumed to be of Tertiary age and the folds of pre-Tertiary age.

Allochthonous rocks of the Roberts Mountains thrust of the Antler orogeny do not occur in the thesis area. Exposures of these strata 12 kilometers to the north, near Devils Gate Pass, suggest that the Roberts Mountains thrust may have originally overridden the thesis area.

Folds

Two sets of folds were recognized within the thesis area. One set occurs near the south end of the mapped area, southwest of Combs Peak. Other folds are present at the extreme north end of the mapped area in the vicinity of Percivalli Canyon.

The folds southwest of Combs Peak trend northwest and deform strata of early Paleozoic age. Poor exposure and Tertiary faulting hampers resolution of these structures.

In the vicinity of Percivalli Canyon at least three major north-south-trending folds deform the Devils Gate Limestone into a series of gently dipping anticlines and synclines. These structures are terminated to the south by a major normal fault which effectively divides the thesis area into two distinct structural provinces. To the south of this major high-angle fault, structure is largely controlled by normal faulting, which has exposed lower and upper Paleozoic strata. To the north, the Mahogany Hills comprise largely undeformed Devils Gate Limestone (Drake, personal commun., 1977) and are in distinct contrast with typical Basin and Range structures. Merriam (1963, p. 7) observed the anomalous nature of the structure in the northern part of the Mahogany Hills and suggested that the "Dry Lake arch" formed as a result of east-west compressional forces related to the Roberts Mountains thrust. Observations in the northern Mahogany Hills by T. B. Nolan (personal commun., 1977), indicate that the entire "Dry Lake arch" may represent the upper plate of a major overthrust. It is clear that east-west compression has been the major deformational force in the vicinity of Percivalli Canyon; however, the timing and exact nature of that deformation remains in question.

Normal faults

A sequence of at least three periods of high-angle normal faulting is apparent in the southern Mahogany Hills. These three periods are represented by: 1) major northwest-trending "range front" faults, along which the initial uplift of the southern Mahogany Hills probably occurred; 2) east-west-trending faults, which cut the range front faults and probably represent post-uplift adjustments of the range front fault blocks; and 3) major northeast-trending faults, which represent a later period of post-uplift extension.

At least two major northwest-trending fault systems are inferred to be present within the area studied. These faults are not well displayed in surface exposures, but their presence may be inferred by the attitude and outcrop pattern of adjacent strata. One of these fault systems bounds the western range front of the southern Mahogany Hills and is exposed only in the area southwest of Table Mountain. The second fault system is inferred to follow the trend of Brown's Canyon, where it is obscured by post-uplift gravity slides and alluvium.

Southwest of Table Mountain northwest-trending faults form a complex series of exposures. These exposures suggest that uplift along the western range front did not occur along a single fault, but was the result of a series of uplifts along roughly parallel faults of northwesterly trend. Total displacement along these faults is estimated to be on the order of hundreds of meters.

The trace of the Brown's Canyon fault system is not directly observable. Its inferred trace is subparallel to the range front fault system. In Brown's Canyon, directly east of Table Mountain, northwest-trending high-angle, normal faults form a graben. This structure is consistent with large-scale Basin and Range structures and its presence may explain the topographic expression of Brown's Canyon. Elsewhere along Brown's Canyon this structure is not clearly developed, because of later deformation. Displacements along the Brown's Canyon fault appear to have been of the same order of magnitude as the western range front fault system.

East-west and east-southeast-trending high-angle, normal faults which occur to the west and southwest of Table Mountain and southwest of Combs Peak, are interpreted as being the result of post-uplift adjustments of the large fault blocks formed by the range front and Brown's Canyon fault systems. Displacements along these faults appear to have generally been on the order of a few tens of meters in most cases.

A final tensional episode resulted in the development of numerous northeast-trending faults which are roughly perpendicular to the range front and to the Brown's Canyon faults. Faults of this sort are best shown to the south and southwest of Combs Peak. Major faults of this type also occur to the north and south of Table Mountain. The major east-west fault near the north end of the mapped area, just south of Percivalli Canyon, may also be related to this period of deformation. Displacements along these faults ranges from a few tens of meters to several hundred meters.

Cataclastic breccias

Cataclastic breccias occur throughout the thesis area. These breccias are largely composed of angular clasts of Devils Gate Limestone, which range in size from less than a millimeter to over a meter, "floating" in a matrix of fine rock powder, which locally is recrystallized (Figures 25 and 26).

Breccias of this sort have been reported by numerous workers in the Great Basin (see Armstrong, 1972). The mode and time of formation of these deposits has, however, been the source of considerable controversy in recent years (see Armstrong, 1972; Coney, 1974; and others).

Merriam (1963, p. 51) observed cataclastic breccias near the Mahogany Hills and suggested that they may represent the "lower plate of a thrust." The distribution of breccias in the mapped area

Figure 25. Outcrop of cataclastic Devils Gate Limestone breccia on west side of Brown's Canyon near Table Mountain.

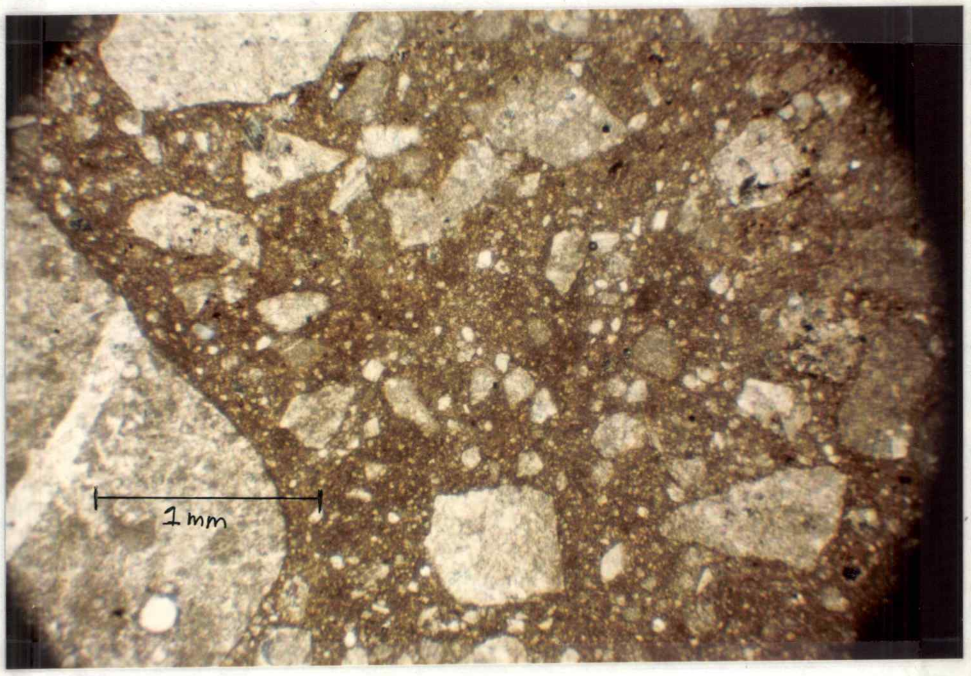

Figure 26. Photomicrograph of cataclastic breccia showing rock powder matrix.

does not lend itself readily to Merriam's interpretation. Cataclastic breccias and younger-over-older faulting observed by Armstrong (1972) in eastern Nevada and western Utah bear a striking resemblance to deposits in the southern Mahogany Hills. Armstrong (1972) believes that these breccias are the result of regional extension during Tertiary time. Within the thesis area, not all of the observed breccias and low-angle faults are readily explained in terms of gravity sliding, and in some area thrust faults may be responsible for some of the observed brecciation.

CONCLUSIONS

Shallow-marine shelf deposition characterized sedimentation in the area of the southern Mahogany Hills from at least the late Ordovician through most of the Late Devonian. Peritidal deposits of Eureka Quartzite gave way to the shallow-water carbonate environment of the Hanson Creek Formation, which was in turn overwhelmed by the Lone Mountain Dolomite reef complex. The first two formations represent a progressive increase in water depth, although shallowing began again during Lone Mountain Dolomite time.

The absence of deep-water deposits of the Roberts Mountains Formation is significant and indicates that shelf-type sedimentation persisted in the southern Mahogany Hills throughout Ordovician and Silurian time. The presence of the Roberts Mountains Formation at Lone Mountain indicates that the shelf-slope break was probably near the longitude of the southern Mahogany Hills during the Early Silurian. Local slope conditions may have influenced Lone Mountain Dolomite deposition in the thesis area during that time.

The unconformity which marks the top of the Lone Mountain Dolomite in the thesis area indicates sub-aerial exposure of the carbonate platform; probably during the latest Silurian and Early Devonian. Renewed transgression during Early Devonian time brought about establishment of new shallow-water carbonate environments. In the southern Mahogany Hills the initial deposits of this transgression are seen in the McColley Canyon Formation and the Beacon Peak Dolomite. As transgression continued, the Beacon Peak tidal flat was flooded and the shallow-water, high-energy facies shifted eastward, as evidenced by the basal deposits of the McColley Canyon Formation at Brush Peak. The Coils Creek Member of the McColley Canyon Formation respresents a state of maximum transgression in the thesis area, during the late Early Devonian.

The onset of Sadler Ranch sedimentation is indicative of a shallowing trend which reached its peak in the thesis area just prior to the westward incursion of the Oxyoke Canyon Sandstone during late Oxyoke time. A second Devonian transgression was responsible for the eastward retreat of the high-energy sandstone environment and brought about the reestablishment of shallow-marine carbonate deposition in the thesis area. Continued transgression and increasing water depth, as well as enhanced circulation, resulted in a gradual shift from Simonson Dolomite type deposition to Devils Gate Limestone deposition during the early Late Devonian. This sedimentologic regime continued until terrigenous clastics shed eastward from the Antler orogenic belt terminated carbonate deposition in the thesis area; probably near the end of the Late Devonian.

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APPENDIX

FAUNAL LISTS AND LOCALITIES

All localities in Bellevue Peak 15 minute quadrangle.

Identification and age assignments as follows:

Brachiopods: J. G. Johnson

Conodonts : Gilbert Klapper

Percivalli Canyon Measured Section (Plate 3)

Location: Ridge north side of Percivalli Canyon, 3.0 miles (4.9 km) NW of Dry Lake Well, entire section within lower Devils Gate Limestone.

Collection: PC - 3

Footage: 0 feet (0 m)

indet. ramiform elements

Collection: PC - 4

Footage: 4 feet (1.2 m)

indet. atrypid sp. (fine costae) 3

Icriodus subterminus

Age: *insita* fauna to Frasnian

Collection: PC - 5

Footage: 5 feet (1.5 m)

Atrypa sp. 1

Icriodus subterminus

Age: Middle or early Late Devonian; *insita* fauna to Frasnian

Collection: PC - 6

Footage: 8 feet (2.5 m)

twig-like algae

Collection: PC - 11

Footage: 128 feet (39 m)

Pandorinellina insita?

Collection: PC - 15

Footage: 255 feet (78 m)

Pandorinellina insita

Icriodus subterminus

Age: probably *insita* fauna

Table Mountain Measured Section (Plate 4)

Location: West face of Table Mountain, begins at approximately the 7600 foot level proceeds ENE toward summit; section includes the upper Simonson Dolomite and the lower Devils Gate Limestone; Simonson - Devils Gate contact at 525 feet (162 m).

Collection: T 580

Footage: 580 feet (177 m)

Polygnathus xylus xylus

Icriodus subterminus

Age: <u>insita</u> fauna to Frasnian

Collection: T 624

Footage: 624 feet (190 m)

<u>Polygnathus</u> sp.

Collection: TM - 1

Footage: 665 feet (203 m)

<u>Icriodus subterminus</u>

<u>Ozarkodina</u> sp.

Age: <u>insita</u> fauna to Frasnian

Collection: TM - 4

Footage: 723 feet (220 m)

<u>Athyris</u> sp. 6

small twig-like algae

Age: early Frasnian, very shallow water environment; may only occur in the Lower and Middle <u>Polygnathus asymmetricus</u> conodont Zone

Collection: TM - 3

Footage: 727 feet (222 m)

<u>Athyris</u> sp. 28

calcareous algae (abundant)

stromatoporoids

Age: early Frasnian, very shallow water environment; may only occur in the Lower and Middle <u>Polygnathus asymmetricus</u>

conodont Zone.

Collection: TM - 8

Footage: 778 feet (237 m)

calcareous algae

Collection: TM - 9

Footage: 792 feet (241 m)

indet. ramiform elements

Combs Peak I Measured Section (Plate 5)

Location: 1.4 miles (2.3 km) south of Combs Peak summit; section includes the Beacon Peak Dolomite and the lower McColley Canyon Formation; Beacon Peak - McColley Canyon contact at 190 feet (58 m).

Collection: 1220

Footage: 180 feet (55 m)

Pandorinellina exigua philipi

Icriodus sp. indet.

Age: dehiscens Zone to ? gronbergi Zone

Collection: 1229

Footage: 189 feet (58 m)

Icriodus sp. indet.

Collection: 1231

Footage: 191 feet (58.2 m)

Pandorinellina exigua philipi

Polygnathus gronbergi?

Icriodus sp. indet.

Age: dehiscens Zone to ? gronbergi Zone

Collection: 1250

Footage: 210 feet (64 m)

Icriodus sp. indet.

Combs Peak II Measured Section (Plate 6)

Location: 1.6 miles (2.7 km) south of Combs Peak summit; section includes the Beacon Peak Dolomite, 0 - 350 ft. (0 - 106.7 m); McColley Canyon Formation, 350-660 ft. (106.7 - 201.2 m); Sadler Ranch Formation, 660-950 ft. (201.2 - 289.6 m); Oxyoke Canyon Sandstone, 950-1020 ft. (289.6-311 m); lower Simonson Dolomite, 1020-1530 ft. (311-466 m).

Collection: 2403

Footage: 353 feet (107.6 m)

Pandorinellina exigua exigua

Icriodus sp. indet.

Age: gronbergi Zone to costatus costatus Zone

Collection: 2410

Footage: 360 feet (110 m)

Pandorinellina exigua subsp. indet.

Icriodus sp. indet.

Collection: 2411

Footage: 361 feet (110 m)

Phragmostrophia merriami 2

Brachyspirifer pinyonoides abund.

"Strophochonetes" sp. 2

Chonetes sp. (with dorsal median ridge) 2

Age: Middle or Upper pinyonensis Zone (I11-13)

Collection: 2445

Footage: 395 feet (120 m)

Atrypa sp. 3

Eurekaspirifer sp. 3

Pandorinellina exigua philipi

Icriodus sp.

Age: Brachiopods indicate Lower or Middle pinyonensis Zone (I11-13); conodonts indicate dehiscens Zone to ? gronbergi Zone.

Collection: 3318

Footage: 1030 feet (314 m)

Icriodus sp.

Icriodus n. sp. A CHATTERTON (MS, Pl. 6, fig. 19-25)

Polygnathus sp. indet.

Pelekysgnathus sp.

Age: Eifelian (Couvinian)

ISOLATED COLLECTIONS

Collection: RF - 3

Location: 2.3 miles (3.7 km) NW of Table Mountain

Elythyna cf. E. kingi 6

Age: probably Elythyna fauna (114)

Collection: BP - 2

Location: 0.25 miles (0.37 km) SW of Brush Peak

Eurekaspirifer? sp. 5

Atrypa sp. 3

Icriodus sp. indet.

Age: probably Lower pinyonensis Zone

Collection: "A"

Location: 2.4 miles (3.8 km) west of Combs Peak

Atrypa sp. 2

Eurekaspirifer sp. 10

Collection "M"

Location: 2.2 miles (3.6 km) SW of Table Mountain

Leptaena sp. 1

Megastrophia sp. 8

Parachonetes macrostriatus 9

Spinella or Eurekaspirifer sp. 25

Age: Lower or Middle *pinyonensis* Zone (I10 or 11)

Collection: "RM"

Location: 2.0 miles (3.1 km) SW of Combs Peak

Drepanoistodus *suberectus*

Belodina sp.

Panderodus sp.

Plectodina sp.

Age: Middle to Late Ordovician