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Stratigraphy and Petroleum Possibilities of lower Upper Devonian (Frasnian and lower Famennian) Strata, Southwestern Utah

By

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This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

ABSTRACT

The lower Upper Devonian rocks in southwestern Utah--the Guilmette Formation and equivalents--represent a final regressive pulse of the major Late Devonian marine inundation of the Western Interior of the United States and record marine carbonate deposition on a wide continental shelf. They consist primarily of limestone, dolomite, and quartz arenite deposited in a shallow north-trending miogeosyncline, which constituted a single major basin of accumulation on this shelf.

The Guilmette Formation and equivalents were deposited in shallow normal to hypersaline marine waters. The environments of deposition include: a moderate- to high-energy intertidal environment, a moderate-energy subtidal environment, a lower energy, deeper subtidal environment below effective wave base, and a high-energy environment in local shallow areas of mud mounds and bioherms.

The carbonate deposition of the Guilmette Formation and equivalents was interrupted periodically by the deposition of quartz arenites. These may represent the breaking up of the miogeosynclinal-cratonic pattern of deposition. In most areas, the Guilmette and equivalents are overlain by a thin transgressive marine quartz arenite deposit--the Cove Fort Quartzite and basal Leatham equivalent.

Previous paleontologic evidence indicated a general Middle to Late Devonian age for the Guilmette Formation. The present study narrows this range and suggests that the age of the Guilmette Formation and its equivalents is late Middle Devonian (Stringocephalus brachiopod zone) to early Late Devonian (Uppermost Palmatolepis gigas conodont zone).

Available subsurface data suggest that the petroleum possibilities of the Guilmette Formation and equivalents in southwestern Utah are poor. Several tests have penetrated the interval with only minor shows of oil in rocks with low porosity and permeability. Nevertheless, many outcrop samples of the same interval appear to have excellent porosity and permeability and a strongly fetid odor.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page

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* Combined on plate 3 in pocket.

LIST OF PLATES

INTRODUCTION

Purpose And Scope

The purpose of this study is to expand on the current petroleum resources investigations of the Great Basin (Sandberg, 1975; Sandberg and Poole, 1975a,b) by investigating the petroleum possibilities of the lower Upper Devonian rocks in southwestern Utah (fig. 1). The main problem concerns the eastward migration of petroleum through these rocks from postulated Upper Devonian source beds in the partly equivalent lower part of the Pilot Shale located westward or basinward. A secondary problem is whether the Guilmette Formation and equivalents, which have a highly fetid odor in outcrop, could have been a source for petroleum. Through this study the author hopes to provide a more complete stratigraphic, tectonic, and petroleum analysis of the lower Upper Devonian in this relatively untested area.

The major studied interval includes rocks of Frasnian and early Famennian age. In terms of conodont zonation, these rocks are represented by the *Pandorinellina insita* Fauna through the Upper *Palmatolepis marginifera* Zone, inclusively (fig. 2).

The primary reasons for investigating this interval are: (1) the intertonguing of probable petroleum source rocks to the west suggests the possibility that this interval has been the migration path for petroleum generated in these source rocks, (2) strata of this age have been incorrectly

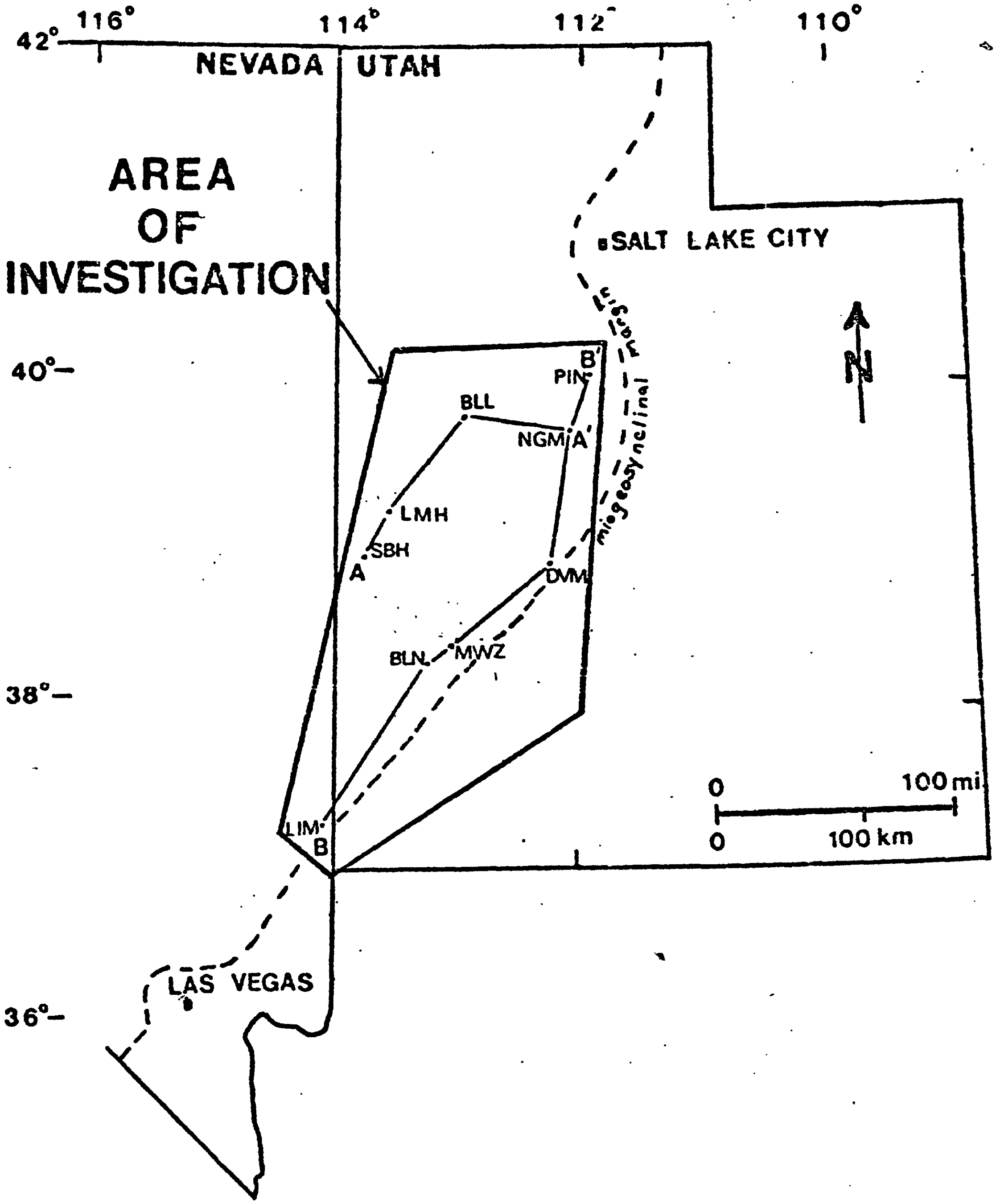

Figure 1. Index map showing area of investigation and locations of measured stratigraphic sections and cross section lines A-A' and B-B'. Measured sections include: SBH, South Burbank Hills; LMH, Little Mile And A Half Canyon; BLL, Bullion Canyon; LIM, Lime Mountain; BLN, Blawn Mountain; MWZ, Mowitza Mine; DVM, Dog Valley Mountain; NGM, North Gilson Mountains; and PIN, Pinyon Peak.

Series	Stage	Zone or Fauna		Samples of C. A. Sandberg	Samples of E. J. Biller
Lower Miss.	Osageian			BHN-1	DVM-1
Lower Miss.	Kinderhookian			BHN-2; EUFB-1; CON-5,13; SBH-1	
Upper Devonian	Famennian	*Protognathodus* Fauna		MWZ-7 — NGM-1C	
Upper Devonian	Famennian	*Bispathodus costatus*	Upper		
			Middle	CON-7C; SBH-2	
			Lower	PIN-5,6	
		Polygnathus styriacus	Upper	CON-16; LDD-1,2,3; LIM-1; MWZ-1,2,3,4; PIN-1,3,4,7,8	BLN-3; NGM-2
			Middle	MWZ-1B	
			Lower		
		Scaphignathus velifer	Upper	BHN-2A	
			Middle		
			Lower	BHN-3	
		Palmatolepis marginifera	Upper	CON-8C,11	
			Lower	CON-9; SBH-5,6,8,9	
		Palmatolepis rhomboidea	Upper	SBH-10	
			Lower		
		Palmatolepis crepida	Upper	SBH-11,11A	
			Middle	SBH-11B,12	
			Lower	CON-14,15	SBH-13
		Palmatolepis triangularis	Upper		
			Middle		
			Lower		
	Frasnian	*Palmatolepis gigas*	Uppermost		
			Upper		SBH-14,15A
			Lower	CON-1,2,3	SBH-17A,18
		Ancyrognathus triangularis			
		Polygnathus asymmetricus (*Pandorinellina insita* Fauna)	Upper	NGM-1E	SBH-20
			Middle		
			Lower		
			Lowermost		
	?	Upper *Schmidtognathus hermanni* – *Polygnathus cristatus*			

Figure 2. Zonally significant conodont samples, collected by E. J. Biller and C. A. Sandberg and determined by C. A. Sandberg, plotted with respect to the standard Devonian conodont zonation of Ziegler (1962), as emended by Ziegler (1971), Klapper and others (1971), Sandberg and Ziegler (1973), Ziegler, Sandberg, and Austin (1974), and Sandberg and others (1975). Only stage assignments are given for Mississippian samples.

mapped and interpreted by some workers, and (3) in some areas strata of this age have not been mapped nor interpreted.

The supporting data for the petroleum evaluation have been derived from the measurement and description in detail of nine stratigraphic sections of the lower Upper Devonian rocks--eight in southwestern Utah and one in southeastern Nevada (fig. 1). These nine measured sections average 370 metres (m) or 1,200 feet (ft) in thickness.

Location

The study area occupies approximately 59,000 square kilometres (km) or 23,100 square miles (mi) in Beaver, Juab, Millard, Tooele, and Utah Counties in southwestern Utah, and Lincoln County in southeastern Nevada. It lies approximately between latitudes 37°00' and 40°00'N and longitudes 112°00' and 114°30'W (fig. 1).

Geologic Setting

The study area is situated in the east-central part of the Basin and Range province. This province is characterized by alternating mountain ranges and intermontane basins formed by extensive Miocene and younger block faulting. The horsts are comprised mainly of Paleozoic marine strata and early Cenozoic volcanic rocks. The grabens are comprised of thick unconsolidated Cenozoic gravels, sands, and clays and are underlain by Paleozoic bedrock.

During the late Precambrian to Devonian, western Utah received a great thickness of marine strata. These strata are mostly shelf-like carbonate rocks with a few sandstones, and were deposited in a miogeosyncline. This miogeosyncline had extended approximately from the craton margin westward to the outer edge of the continent located in approximately central Nevada. Thick biohermal deposits accumulated in many parts of the miogeosyncline especially during the Late Devonian. Shallow-water marine sediments were deposited on the craton to the east.

During the late Paleozoic, large thicknesses of marine strata accumulated in local basins in central and eastern Utah. This change in the depositional pattern was primarily the result of the development of the Stansbury uplift and the Antler orogeny near the end of the Devonian (Poole, 1974). After the late Paleozoic structural events, the mio-geosynclinal-cratonic pattern of deposition returned in early Triassic time. At that time thin sediments were deposited in eastern Utah and thick sediments, in western Utah.

During the late Triassic to early Cenozoic Sevier orogenic phase, Utah became a rugged highland characterized by thrust faulting and folding. The leading edge of the Sevier orogenic belt is approximately coincident with the miogeosynclinal margin shown on figure 1. Rocks west of this line were thrust eastward during late Mesozoic time. Generally, Triassic and Paleozoic rocks are allochthonous and have overridden the autochthonous Jurassic, Cretaceous, and younger beds along most of this belt of thrusting. Estimates of thrust movement range between 10 and 100 miles (Hintze, 1973b).

Mesozoic marine and nonmarine sediments were deposited in eastern Utah. These sediments were essentially shed from the highland created by the Sevier orogeny into coastal plains and shallow seas of eastern Utah.

Much of the Cenozoic was characterized by nonmarine sedimentation in block-faulted basins. These sediments alternated with ash-flow tuffs, lava flows, and volcanic breccias especially during the early Cenozoic. The resulting deposits are generally widespread in western Utah (Poole and others, 1967; Hintze, 1973b; Poole, 1974).

During Quaternary time, much of the northern part of the study area received nonmarine deposition in large inland pluvial lakes. These have left an overprint of abandoned shorelines on many elevated areas (Hintze, 1973a; 1973b).

Previous Work

The earliest significant published work on the Devonian strata of the area was by Butler (1913) who stated that the Devonian in the Star Range, Utah, is represented by the Red Warrior Limestone (Silurian? and Devonian?) and Mowitza

Shale (Devonian). In most of the report area the studied interval of Frasnian age is represented mainly by the Guilmette Formation. The Guilmette was named by Nolan (1930, 1935) for outcrops in Guilmette Gulch on the west side of the Deep Creek Mountains, Utah. The formation in this area is chiefly dolomite but also contains thick limestone beds and several lenticular sandstones. The dolomite is generally finely crystalline, dark to medium gray, weathering lighter shades of gray, and containing numerous vugs mostly filled with white coarsely crystalline dolomite. The formation is also characterized by tubular corals of small diameter (Cladopora sp.) and branching corals (Striatopora sp.). Although Nolan (1935) did not indicate the presence of Amphipora sp., the author did note the presence of this branching stromatoporoid in the Deep Creek Mountains. The author suggests that the abundance of Amphipora may be the most characteristic single feature noted in the Guilmette Formation throughout the study area. Nolan (1935) considered the Guilmette Formation in the type section to be Middle Devonian based on the presence of Stringocephalus sp., but later work indicated a Middle to Late Devonian age for the formation (Merriam, 1940; Cooper and others, 1942).

In the Tintic mining district, Utah (Lindgren and Loughlin, 1919), the Bluebell Dolomite was considered to include rocks of Ordovician, Silurian, and Devonian ages;

the Pinyon Peak Limestone was recognized as a band of shaly limestone, about 45.7 m (150 ft) thick, of Late Devonian age; and the Victoria Quartzite was described as a basal Mississippian sandstone. Petersen (1956) studied the Devonian in the Tintic mining district and suggested that the upper 91 m (300 ft) of Bluebell Dolomite might be subdivided into the Sevy Dolomite (Lower Devonian), Simonson Dolomite (lower Middle Devonian), and Guilmette Formation (middle Middle Devonian). Petersen identified the Victoria Quartzite as upper Middle Devonian and the Pinyon Peak Limestone as Upper Devonian. Morris and Lovering (1961) stated that the Devonian in the Tintic mining district is represented by the Bluebell Dolomite, the Victoria Formation, and the Pinyon Peak Limestone. They considered the Devonian beds in the Bluebell Dolomite to be Middle or lower Upper Devonian. The Victoria Formation, which they considered to underlie rather than to overlie the Upper Devonian Pinyon Peak Limestone, was redefined and also dated as Late Devonian. Morris (1964) mapped the Bluebell Dolomite as Devonian, Silurian, and Ordovician, and the Victoria Formation as Late Devonian. He considered the disconformably overlying Pinyon Peak Limestone to be of Devonian and Mississippian age.

In the Star Range, Utah, Baer (1962) considered the Guilmette Formation to be Middle Devonian. He considered the overlying unit to be Upper Devonian Pilot Shale.

Baetcke (1969) considered the Guilmette Formation to be mainly Middle Devonian, although diagnostic fossils are lacking. The term Mowitza Shale (Butler, 1913) was used by Baetcke (1969) to include the so-called Pilot Shale of Baer (1962), and its age was assumed to be Late Devonian.

In the Confusion Range, Utah, Petersen (1956) concluded that the Middle Devonian consisted of the Simonson Dolomite and the Guilmette Formation. He considered the overlying Upper Devonian unit to be the Pilot Shale. Hose (1966) redated the Guilmette Formation in the Confusion Range as Middle and Late Devonian. The base of the formation was found to be 430 m (1,400 ft) below the top of the Middle Devonian and is indicated by the presence of Stringocephalus and Tylothyris. This would make the upper 370 m (1,200 ft) of the Guilmette Formation Late Devonian in age. Hoggan (1975), following conodont identifications of Clark and Ethington (1967), considered the uppermost part of the Guilmette Formation in the Confusion Range to be the Late Devonian Uppermost Palmatolepis gigas Zone, but C. A. Sandberg (oral commun., March, 1976) has made sequential collections that show that these beds actually represent the Lower Palmatolepis gigas Zone (pl. 1, fig. 2).

In the Burbank Hills, Utah, Rush (1951) described 590 m (1,940 ft) of Middle and Upper Devonian Guilmette Formation. He was not able to define the lower limit of the section because of the absence of diagnostic fauna in the lower part. He stated, however, that the lowest recorded unit was younger than the zone indicated by Stringocephalus sp. which is an excellent indicator of the Middle Devonian.

In the Dugway Range, Utah, Staatz and Carr (1964) proposed a local nomenclature for the Devonian rocks. According to them, the lower Upper Devonian, which elsewhere is represented mainly by the Guilmette Formation, consists, in ascending order, of the upper beds of the Engelmann Formation, the Goshoot Formation, and the Gilson Dolomite.

In the southern Pavant Range, Utah, Crosby (1959) described the Guilmette Formation and assigned it to the Middle Devonian. He applied the name Cove Fort Quartzite to a cream-colored vitreous quartzite resting conformably on the Guilmette and correlated it with other Upper Devonian arenites.

The structure and stratigraphy of the Wah Wah Mountains, Utah, was investigated by Miller (1966). The Sevy Dolomite and Simonson Dolomite were recognized to be Early and Middle Devonian in age, respectively. A "basal quartzite member" and part of a "lower limestone member" of a major Mississippian unit, were described as questionable Upper Devonian rocks, but the author herein suggests that Miller's units may correlate with the Cove Fort Quartzite (Crosby, 1959) and Mowitza Shale (Baetcke, 1969), respectively.

In the Gilson Mountains and vicinity, Utah, Costain (1960) referred Lower Devonian rocks to the Sevy Dolomite and Middle Devonian rocks to the Simonson Dolomite and Victoria Formation. The Pinyon Peak Limestone, and lower part of Fitchville Formation were represented as Upper Devonian.

The study of the geology of Lincoly County, Nevada, by Tschanz and Pampeyan (1970), includes the area of Lime Mountain in the Tule Desert. There the Guilmette Formation was considered mostly of Late Devonian age because of the presence of _Paurorhyncha_ brachiopods, but some of the lower beds were dated as Middle Devonian because of the presence of fossils of the _Stringocephalus_ Zone.

Methods Of Investigation

Nine outcrops of the lower Upper Devonian and adjacent rocks were measured and described during July and August 1975. Measurements of stratigraphic sections were made by a combination of: (1) direct tape measurements of steep ledges, (2) Jacob's staff with Abney hand level measurements in the direction of dip on gentle slopes, and (3) tape and Brunton compass measurements in areas of partial cover where beds could not be traversed in the direction of dip. Sites for measured sections to aid in regional correlations were selected on the basis of geographic location, quality of exposures, and accessibility.

To insure relocation, each measured section is identified by land-grid description, plotting on a topographic quadrangle, and the approximate attitude of beds.

Field notes contain preliminary lithologic descriptions, thickness data, sample numbers, and a field-prepared measured section. Emphasis was placed upon describing features that could not be described from hand specimens. Stratigraphic terminology follows McKee and Weir (1953) and grain-size terminology follows Wentworth (1922). Colors of samples were described by comparison with the National Research Council Rock-Color Chart (Goddard and others, 1948).

Detrital rock descriptions are based on the modified classification of Dott (1964, fig. 3), as described by Pettijohn, Potter, and Siever (1972, fig. 5-3). The classification of Dunham (1962) is used for carbonate rocks that retain their original depositional texture. Recrystallized carbonate rocks are classified by quantitative interpretation of calcium-magnesium molal ratios, using a modification of the scheme proposed by Guerrero and Kenner (1955) and described by Sandberg (1967). The grain sizes of these nonclastic carbonate rocks that have lost their original texture are described in terms of crystallinity following Sandberg (1967). The size ranges in the sand classification by Wentworth (1922) are applied to the carbonate crystal sizes. Microcrystalline and cryptocrystalline are used to describe crystals seen under 10x and 27x magnification, respectively.

At regular intervals samples were collected for organic carbon content and calcium-magnesium molal analyses (table 1). Samples for lithologic study and thin-section preparation were collected systematically. Samples for conodont identification and other megafossils were collected in order to date intervals for which age determinations were previously lacking. Previously published measured sections that bound the author's measured stratigraphic sections are plotted with the author's data (pls. 1 and 2) to gain more regional stratigraphic control for the study.

An isopach map of Frasnian age rocks (fig. 3) and two cross sections (pls. 1 and 2) containing the nine measured sections of the lower Upper Devonian were constructed. The explanation on plate 2 is applicable to all other illustrations graphically portraying measured sections. Conodont sample data in the stratigraphic sections measured by C. A. Sandberg and F. G. Poole, as well as all of the author's paleontologic data, are plotted beside the respective columnar section on the two cross sections. All zonally assignable Devonian conodont samples used in this report, collected either by the author or C. A. Sandberg and determined by C. A. Sandberg are plotted in figure 2 in conjunction with the standard Devonian conodont zonation of Ziegler (1962), as emended by Ziegler (1971), Klapper and others (1971), Sandberg and Ziegler (1973), Ziegler, Sandberg, and Austin (1974), and Sandberg and others (1975). Only stage assignments are given for Mississippian conodont samples.

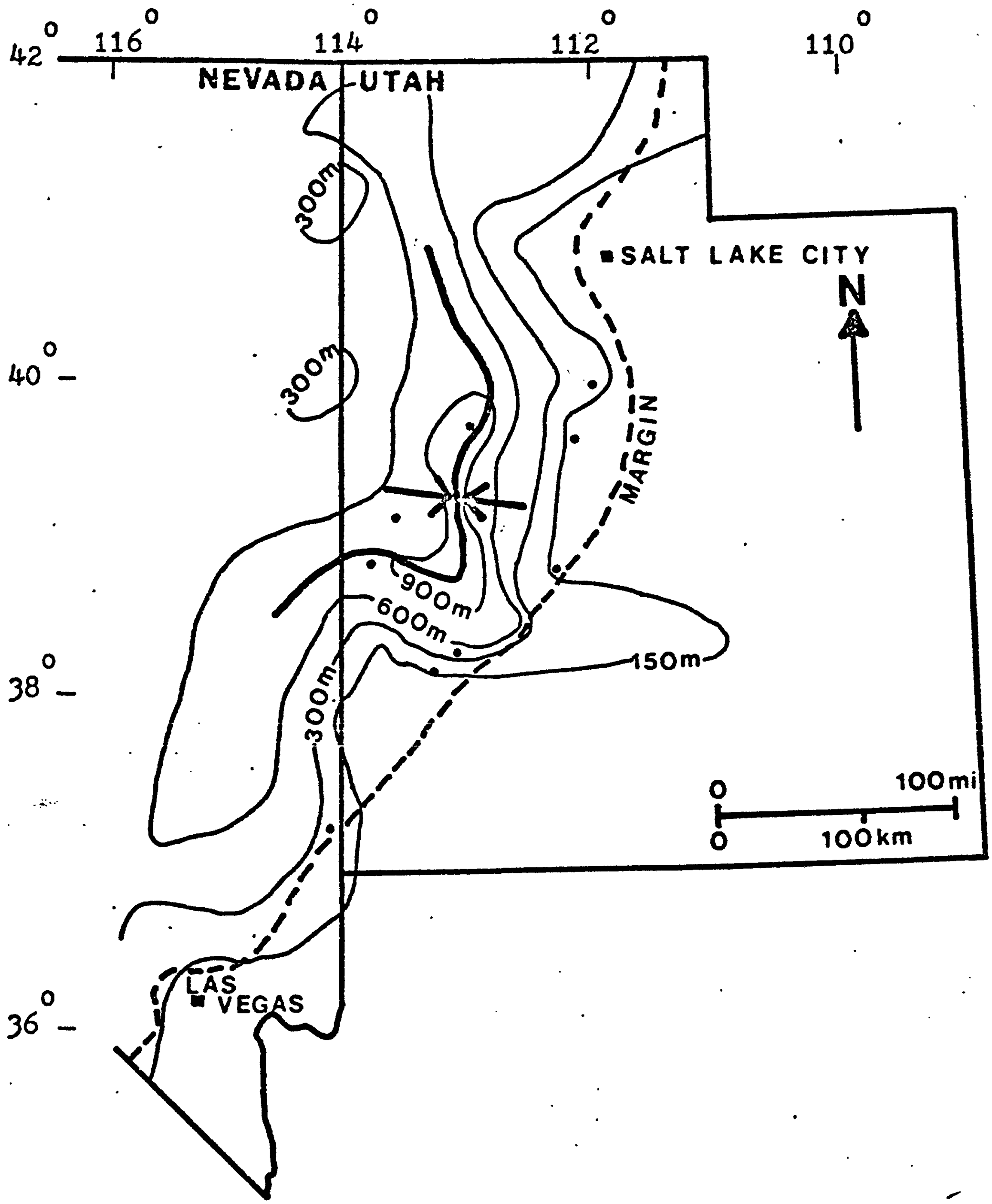

Figure 3. Isopach map of Frasnian age rocks showing basin axis (modified from Poole, 1974). Measured sections are indicated by dots. Refer to figure 1 for section names.

A chart of stratigraphic nomenclature and correlations of the lower Upper Devonian and adjacent rocks at each measured section was prepared (fig. 4). Initials used for measured sections elsewhere in the report are shown in the column headings. This chart includes the author's data, unpublished data of C. A. Sandberg and F. G. Poole, and published data of Rush (1951), Crosby (1959), Costain (1960), Morris and Lovering (1961), Staatz and Carr (1964), Hose (1966), Miller (1966), Baetcke (1969), and Tschanz and Pampeyan (1970).

Acknowledgments

This report was prepared as part of the U.S. Geological Survey Project on the petroleum geology of the Paleozoic rocks of the Cordilleran miogeosyncline under the supervision of C. A. Sandberg, project chief. It was also submitted as a thesis for the degree of Master of Science (Geology) to the Colorado School of Mines in May 1976. I would like to express my appreciation to my thesis committee -- Drs. H. C. Kent and J. D. Haun, both of the Colorado School of Mines, and C. A. Sandberg of the U.S. Geological Survey for their guidance and suggestions during this study.

I would especially like to acknowledge C. A. Sandberg for his determination and dating of all my conodont collections. I would also like to acknowledge the use of the largely unpublished results of his conodont research in related Upper Devonian stratigraphic sections.

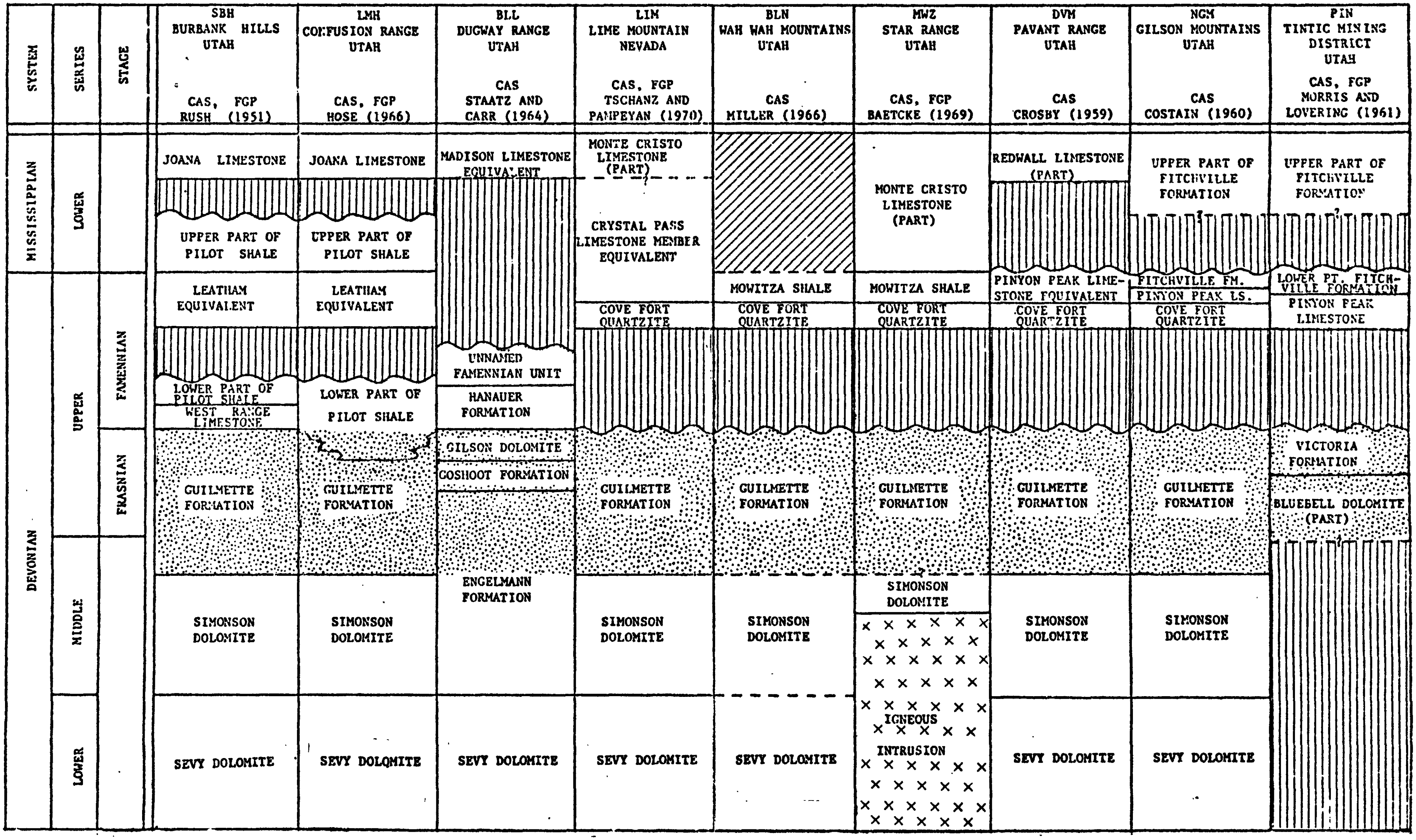

Figure 4. Stratigraphic nomenclature and correlations of lower Upper Devonian and adjacent rocks within the study area. Initials used for sections elsewhere in the report are shown in the column headings. Sources include author's data, unpublished data from C. A. Sandberg (CAS) and F. G. Poole (FGP), and published references as indicated for each column. Vertical hatching indicates nondeposition or erosion, diagonal hatching indicates unstudied interval, stippling indicates the major studied interval.

In addition, I would like to acknowledge F. G. Poole for the use of his unpublished data. I also appreciate the many stimulating discussions with him that led me to some of the conclusions of this report. The calcium-magnesium analyses were made by R. F. Gantnier. Rinehart Laboratories, Inc. made the organic carbon analyses for the U.S. Geological Survey.

STRATIGRAPHY

Middle Devonian And Older Units

In the southern and western parts of the study area the Guilmette Formation and equivalents (lower Upper Devonian) are underlain conformably by the Simonson Dolomite of Middle Devonian age. On the northern margin of the study area the Simonson Dolomite is equivalent to the lower part of the Engelmann Formation. Both the upper part of the Engelmann Formation and the equivalent basal part of the Guilmette Formation contain _Stringocephalus_ sp. which most authors believe occurs below the top of the Middle Devonian (Staatz and Carr, 1964; Boucot and others, 1966; Hose, 1966; Poole and others, 1967; Hintze, 1973b).

Where the Simonson Dolomite and equivalent rocks are present, they are underlain conformably by the Sevy Dolomite of Early Devonian age. The Sevy is absent, however, at the Mowitza mine locality, where the Simonson Dolomite is intruded by Tertiary granitic rocks (Baer, 1962; fig. 4). At Pinyon Peak, the Sevy and Simonson Dolomites are both absent, and Upper Devonian strata constituting the upper part of the Bluebell Dolomite rest unconformably on Ordovician strata in the lower one-third of that formation. The Ordovician age of the lower part of the Bluebell is indicated by the colonial corals _Propora_ and _Reuschia_, whose stratigraphic position is plotted in plate 2.

The Silurian Laketown Dolomite was recognized in the North Gilson Mountains on the basis of the coral Halysites (C. A. Sandberg, oral commun., March, 1976). Its contact with the overlying Sevy Dolomite is both conformable and gradational. The Laketown is lithologically similar to some parts of the Sevy and to the lower part of the Bluebell Dolomite at Pinyon Peak.

Budge (1972) suggested that several diastems may be recognized within the Ordovician, Silurian, and Devonian dolomite sequence seen in the northeastern part of the study area. Hintze (1973b) suggested that a hiatus may extend from approximately the North Gilson Mountains where Lower Devonian rocks overlie Middle Silurian rocks to Pinyon Peak where Upper Devonian rocks overlie rocks of Late Ordovician age.

Guilmette Formation And Equivalents

General Discussion

The term, Guilmette Formation and equivalents, is here applied to the dominantly carbonate marine rocks of late Middle to early Late Devonian age in the study area. The nomenclature of rocks equivalent to the Guilmette includes the Engelmann Formation, Goshoot Formation, and Gilson Dolomite in the Dugway Range, and the upper part of the Bluebell Dolomite and the Victoria Formation in the East Tintic Mountains (fig. 4).

The Guilmette Formation and equivalents, which are mainly very dark gray to brownish-gray coarsely crystalline carbonate rocks interbedded with a few quartz arenites, are easily distinguished from the underlying units which are generally light-gray finely crystalline dolomite. The upper part of the Guilmette Formation and equivalents is generally seen as a dolomite but in places the lithology is composed of sandy carbonates or quartz arenites. At South Burbank Hills, Little Mile And A Half Canyon, and Bactrian Mountain in the Pahranagat Range, Nevada (Sandberg and Ziegler, 1973), the Guilmette includes all the quartz arenites found below the overlying West Range Limestone and equivalent. In the western and northwestern part of the study area, shale, siltstone, or a sequence of quartz arenites conformably overlie the Guilmette Formation. In other parts of the study area the formation is overlain unconformably by quartz arenite.

Distribution And Thickness

The Guilmette Formation and equivalents are exposed in many mountain ranges throughout the study area. An entire section of the formation was measured in each of the nine localities discussed in this study except at the South Burbank Hills where the base is not exposed in the core of an anticline, and at Lime Mountain where the middle part of the formation is involved with thrust faults of Jurassic or younger age. The formation is also present in the subsurface of the intervening basins, although it is generally faulted and structurally complex.

The nine measured outcrops of Guilmette Formation and equivalents have a range in thickness from 47.8 m (156 ft) at North Gilson Mountains to 1,185 m (3,886 ft) at Bullion Canyon. The outcrop belt of the formation trends about N. 30° E. and approximately parallels the miogeosynclinal margin (fig. 1). Generally the formation thickens westward or basinward and is thickest in a trough or miogeosynclinal basin which is about 150 km (93 mi) long and 25 to 60 km (16 to 37 mi) wide. The axis of this basin trends north and seems to be coincident with the local Stansbury uplift which was emergent in the area between Salt Lake City and the study area later in Devonian time (Hintze, 1973b; Poole, 1974). An area of gradual thinning extends eastward from the center of the study area beginning near Blawn Mountain and Mowitza mine. This thinning may possibly be due to deposition of Devonian rocks in a narrow arm of the Devonian sea. However, the anomalous thickness of Devonian rocks at the Mowitza mine in the Star Range, Utah, may possibly be due to thrust faulting during the Sevier orogenic phase in which deeper basinal carbonate rocks were thrust eastward.

Lithologic And Physical Character

The Guilmette Formation and equivalents are characteristically dolomite as exemplified by the type section of the Guilmette Formation in the Deep Creek Mountains (Nolan, 1935). The dolomite is largely finely crystalline but in a few localities it is coarsely crystalline. It is also thin to thick bedded, medium to dark colored, limonitic, slightly hematitic, and highly fossiliferous. The fresh rock surfaces are most commonly medium light gray, medium gray, medium dark gray, and brownish-gray. Common fossils include the branching stromatoporoid *Amphipora* sp., algal heads and oncolites, bulbous stromatoporoids, brachiopods, and gastropods.

Where dolomitization was not pervasive, the Guilmette Formation is characterized by limestone, for example at Little Mile And A Half Canyon (fig. 15, pl. 1) and South Burbank Hills (fig. 23, pl. 1). The limestone is microcrystalline, thin to thick bedded, medium to medium dark gray, silty, limonitic, hematitic, in places nodular and mottled, pelletal, and highly fossiliferous. The fresh rock surfaces are most commonly medium light gray, medium gray, olive gray, and medium dark gray. The silty limestone contains scattered to abundant very fine, angular to rounded, coarse-grained, and frosted quartz sand grains. The sand in these limestones is commonly bimodal. Common fossils include *Amphipora* sp., bulbous stromatoporoids, brachiopods, conodonts, crinoids, oncolites, and fish remains.

In outcrop, both the limestone and dolomite lithologies generally form ledges that are easily traced laterally. In places they will form reentrants just below similar more resistant units. In some localities these lithologies may form weakly resistant slopes.

The upper part of the Guilmette Formation and equivalents commonly contain a few interbeds of quartz arenite, although other quartz arenites or sandy carbonates are present at many different stratigraphic horizons. The arenite lithology is laminated and cross laminated, light to medium colored, hematite stained, in places calcareous, and composed almost entirely of quartz sand grains. The fresh rock surfaces are most commonly light gray, light red, grayish orange, and light brownish-gray. The quartz grains are commonly silt-size to coarse sand size. The smaller grains tend to be subangular, and the larger grains tend to be rounded and frosted. Fossils are uncommon. The South Burbank Hills is the only area in which trace fossils were noted. Here the trace fossils appear to be horizontal boring tubes or tracks.

In outcrop, the quartz arenites generally form ledges that may be traced laterally for short distances. Where present these usually form massive resistant cliffs and ledges. However, the quartz arenites are difficult to trace between measured sections because of their lenticularity or lateral gradation into sandy carbonates.

Age

Diagnostic megafossils are generally difficult to find in the Guilmette Formation and equivalents. Nolan (1935) assigned a Middle Devonian age to the formation because of the presence of *Stringocephalus* sp. at the base. Rush (1951) considered the strata to be Middle and Upper Devonian. Crosby (1959) assigned a Middle Devonian age to the formation based on the occurrence of *Coenites cryptodens* at the base. Baer (1962) assigned a Middle Devonian age to the formation based on similarities with the type Guilmette. Baetcke (1969) was unable to find any diagnostic guide fossils and therefore concurred with Baer's Middle Devonian correlation. Staatz and Carr (1964) have assigned a Middle to Late Devonian age to the Engelmann Formation. The middle part of the Engelmann Formation is Middle Devonian in age and, because of the presence of *Stringocephalus* sp., is equivalent to the basal beds of the Guilmette Formation in other areas. Hose (1966) noted *Tylothyris* sp. and *Stringocephalus* sp. and considered the formation to be Middle and Late Devonian. C. A. Sandberg (oral commun., July, 1975) found a large specimen of the ammonoid *Manticoceras* sp., which is a Frasnian index genus, in the South Burbank Hills section (pl. 1). Thus megafossil collections have generally provided epoch, or at best stage, determinations for the Guilmette.

Conodonts have provided the most reliable and exact means of dating the Guilmette Formation and the intertonguing and overlying lower part of the Pilot Shale. Conodont faunas in these formations have been found to represent most zones between the _Pandorinellina insita_ Fauna through the Upper _Palmatolepis marginifera_ Zone (fig. 2). Based on the author's paleontologic data, unpublished data of C. A. Sandberg, and published data, the Upper Devonian part of the Guilmette Formation and equivalents ranges from the _Pandorinellina insita_ Fauna through the Uppermost _Palmatolepis gigas_ Zone. Considering both the megafossil and conodont evidence, the entire Guilmette ranges in age from very late Middle Devonian (_Stringocephalus_ brachiopod zone) to early Late Devonian (Uppermost _Palmatolepis gigas_ conodont zone). Plates 1 and 2 show the stratigraphic location of all supporting paleontologic data within the Guilmette Formation and equivalents as well as for underlying and overlying units.

Correlation

The Guilmette Formation and equivalents are easy to identify lithologically across the study area. Problems arise in some areas (North Gilson Mountains and Pinyon Peak) in differentiating the underlying units from the Guilmette Formation because of the similar textures and compositions of these underlying units. The top formational boundaries of the Guilmette Formation and equivalents are easily identifiable throughout the study area. The dominant criteria for locating this contact includes both the absence of _Amphipora_ sp. and the apparent lithologic change in the overlying rocks (pls. 1 and 2). Lithologic continuity within the formation is difficult to establish owing to differences in lithologic character and resistance and the absence of correlatable marker beds. Successful chronocorrelation within the formation has been based on detailed stratigraphic and paleontologic investigations.

Upper Devonian (Famennian) And Lower Mississippian Units

Lower Upper Devonian rocks in the South Burbank Hills are conformably overlain by the West Range Limestone and lower part of the Pilot Shale. The same units have been described and dated by Sandberg and Ziegler (1973) and Sandberg and Poole (1970) at Bactrian Mountain, Pahranagat Range, Nevada, approximately 206 km (128 mi) southeast of the South Burbank Hills locality.

At Bactrian Mountain, the West Range Limestone is 74 m (243 ft) thick. It is a cliff-forming nodular limestone and has interbeds of slope-forming marlstone in the upper part. The West Range overlies disconformably the Guilmette Formation and grades lithologically upward into the lower part of the Pilot Shale. The age of the West Range Limestone at this locality is early Famennian (Middle *Palmatolepis crepida* through basal part of Lower *Palmatolepis marginifera* Zone), according to Sandberg and Ziegler (1973).

The Pilot Shale at Bactrian Mountain consists of three informal units (Sandberg and Ziegler, 1973). The lower unit, of early Famennian age, is 28 m (92 ft) thick. It consists of a basal medium-dark-gray silty sandy fossil-fragmental limestone. The middle part of the lower unit is a grayish-black and dark-yellowish-orange dolomitic carbonaceous shale with a few stringers of sandstone and siltstone. The upper part of the lower unit is a nonfossiliferous dolomitic siltstone containing thin stringers of grayish-black carbonaceous shale.

A major regional unconformity separates the lower and middle units of the Pilot Shale. This unconformity is represented by eight missing conodont zones--the Upper Palmatolepis marginifera through the Lower Bispathodus costatus Zones.

The middle unit of the Pilot Shale, of latest Devonian age is 10 m (33 ft) thick at Bactrian Mountain and consists of a basal ledge-forming grayish-red shale, chert, grayish-red lag sandstone, or greenish-gray to light-olive-gray claystone and mudstone; and an upper ledge-forming olive-gray calcareous siltstone. The middle unit is sequentially and faunally equivalent to the Devonian part of the Leatham Formation of northeastern Utah.

The upper unit of the Pilot Shale, of Early Mississippian (Kinderhookian) age, is 92 m (302 ft) thick in the Burbank Hills. It is comprised of a lower calcareous carbonaceous shale and an upper silty limestone (C. A. Sandberg, written commun., 1975).

The lower part of the Pilot has also been measured and described in unpublished measured sections by C. A. Sandberg, F. G. Poole, and E. J. Biller (C. A. Sandberg, written commun., 1975) in the Little Mile And A Half Canyon area, Confusion

Range, Utah. There the lower part of the Pilot is partly a time-equivalent of the West Range Limestone and the upper part of the Guilmette Formation of the South Burbank Hills area, thus suggesting an intertonguing or facies relationship between these formations (fig. 4). Conodont dating and graphic descriptions of the West Range Limestone and lower part of the Pilot Shale are shown on figure 2 and plate 1.

At Bullion Canyon, beds equivalent to the West Range Limestone and lower part of the Pilot Shale are identified as the Hanauer Formation and an overlying unnamed upper Famennian unit. This correlation is based on: (1) the faunal and lithologic similarity of the conformably underlying Gilson Dolomite, which contains Amphipora sp. and fossiliferous carbonate rocks interbedded with thin quartz arenites, to the Guilmette Dolomite; and (2) the approximate age equivalence (early Famennian) of the Hanauer Formation and unnamed upper Famennian unit to the West Range Limestone and lower part of the Pilot Shale. The contacts of the Hanauer as recognized by the author are in agreement with those proposed by Staatz and Carr (1964). However, the unnamed upper Famennian unit as recognized herein is the same unit as the lower part of the Madison Limestone equivalent, which was thought to be entirely Mississippian by Staatz and Carr (1964).

Genetic units within the Hanauer Formation consist of thin sandy limestones grading upward into thick quartz arenites and are bounded at the base and top by sharp contacts. These genetic units occur repeatedly and are indicative of cyclic deposition. The arenite is massive and forms prominent vertical faces separated by reentrants of limestones or weakly resistant arenites. It is light to medium colored, limonitic, hematitic, and in places calcareous. The arenite is composed almost entirely of very fine to coarse, subrounded to rounded, and well sorted quartz sand grains. The limestone interbeds contain similar quartz sand. Cross lamination dips generally south-southwesterly and indicates current flow in that direction.

The unnamed upper Famennian unit is commonly a pelletal, fossiliferous, slightly sandy, light- to medium-colored, ledge-forming limestone. The top of the unit has been dated in outcrops 3.2 km (2 mi) southeast in Buckhorn Canyon (C. A. Sandberg, oral commun., 1975). The unit is represented by Upper _Palmatolepis marginifera_ to Middle or Upper _Scaphignathus velifer_ Zone.

In most of the study area a major unconformity directly underlies rocks of the Upper _Polygnathus styriacus_ Zone. This is part of the widespread western North American unconformity recognized by Sandberg and others (1975). At Bullion Canyon, however, Mississippian erosion has truncated rocks represented by the _Polygnathus styriacus_ Zone.

Thus the Kinderhookian part of the Madison Limestone equivalent overlies unconformably rocks of late Famennian age. The evidence for this Early Mississippian erosion is shown diagrammatically in figure 5 and plate 1. The top of the pelletal, nodular, fossiliferous limestone of the unnamed upper Famennian unit, shown at the bottom of figure 5, provides an excellent horizon for correlation between Buckhorn Canyon and Bullion Canyon sections. At Buckhorn Canyon (BHN) excellent exposures have permitted the detailed measurement and sampling for conodont beds above this limestone. At Bullion Canyon (BLL), the correlative of the sandstone at Buckhorn Canyon is thought to be a sandy dolomite. The overlying partly covered interval contains float that suggests a correlation with the Kinderhookian exposures at Buckhorn Canyon. On this basis an unconformity is postulated to truncate northward the strata between Buckhorn Canyon samples BHN-3 and 2A. The alternative possibility is that these missing strata might be present in the covered interval of supposed Mississippian strata at Bullion Canyon.

The pre-Upper Polygnathus styriacus Zone regional unconformity is overlain by a quartz arenite or sandy zone, that might be considered a transgressive lag deposit (pls. 1 and 2). This transgressive deposit is relatively thick in some sections, particularily at the Dog Valley Mountain locality in the southern Pavant Range, Utah,

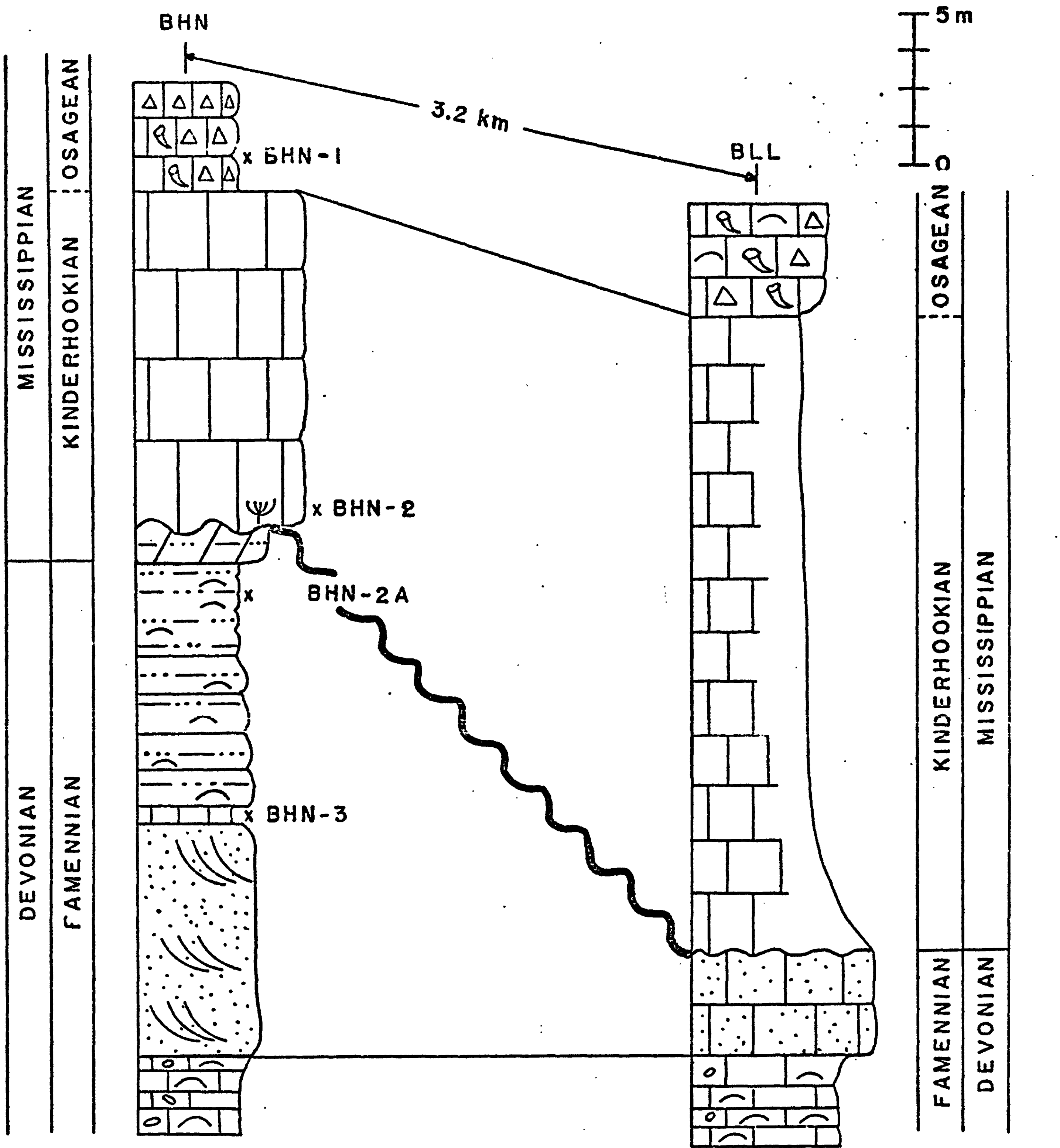

Figure 5. Detailed stratigraphic cross section from Buckhorn Canyon (BHN), Utah, and Bullion Canyon (BLL), Utah, showing how the two localities constitute the composite section depicted at Bullion Canyon (fig. 9 and pl. 1). Measured section at Buckhorn Canyon is from unpublished data of C. A. Sandberg (written commun., 1975). See figure 2 for specific conodont zones of samples BHN-1,2,2A, and 3.

where it was named the Cove Fort Quartzite by Crosby (1959). This name has been extended by the author to equivalent outcrops throughout most of the study area. A sandy unit equivalent to the Cove Fort Quartzite may be present in the covered interval at the base of the Pinyon Peak Limestone at Pinyon Peak (pl. 2). The sandy basal beds of the Leatham equivalent in the South Burbank Hills and Little Mile And A Half Canyon localities also are equivalent to this transgressive sand.

The Cove Fort Quartzite and basal Leatham equivalent are overlain conformably by other rocks of the Upper *Polygnathus styriacus* Zone and by younger Upper Devonian rocks. Depending on the locality, these rocks have been measured and described as the Crystal Pass Limestone, lower part of the Fitchville Formation, and upper beds of the Leatham equivalent (fig. 4, pls. 1 and 2). This interval is commonly composed mainly of ledge-forming pelletal, fossiliferous limestones and partly of fossiliferous dolomites, shales, siltstones, and sandstones. Depending on the locality these units may or may not be conformable with overlying rocks of Mississippian age. At the South Burbank Hills and Little Mile And A Half Canyon localities, the Mississippian upper part of the Pilot Shale rests conformably on Devonian strata assigned to the Leatham equivalent. At these two localities a major unconformity separates the upper part of the Pilot Shale and the overlying Mississippian Joana Limestone. This is the same unconformity that may truncate rocks of the Upper *Palmatolepis marginifera* Zone or younger Devonian age between Buckhorn and Bullion Canyons (fig. 5, pl. 1). Other localities at which Mississippian strata appear to conformably overlie Devonian strata (fig. 4) are Lime Mountain where the Monte Cristo Limestone rests on beds of the Crystal Pass Limestone Member equivalent and Mowitza mine where the Monte Cristo Limestone rests on the Mowitza Shale. At Dog Valley Mountain the Mississippian Redwall Limestone unconformably overlies the Pinyon Peak Limestone. Conodont sample EUFB-1 (fig. 2, pl. 2), collected by Gutschick (1976, fig. 4B) from a measured section at Mammoth Peak, very close to the Pinyon Peak locality in the East Tintic Mountains, has provided evidence that Mississippian beds in the upper part of the Fitchville Formation also unconformably overlie Devonian beds in the lower part of that formation. This unconformity extends to a similar stratigraphic position in the North Gilson Mountains. Unconformities also may be present in the Wah Wah Mountains and Star Range, Utah, at this same position but substantiating data is lacking.

The lithology of the Mississippian rocks is commonly fossiliferous, chertified limestone, but some quartz arenites, shales, and siltstones are present in the western part of the study area. The Kinderhookian strata conformably underlie Osagean strata.

ENVIRONMENTS OF DEPOSITION

Middle Devonian And Older Units

Hintze (1973b) stated that the general environments in which Upper Ordovician and Silurian rocks were deposited were stable and existed into Early Devonian time. The uniformity of faunal composition (including crinoids, chain corals, and brachiopods), lithologic character, and known tectonic setting suggest a widespread, warm, shallow miogeosynclinal marine environment distant from clastic sources.

The total thickness pattern of Middle Devonian rocks appears to be similar to both Early Devonian and Silurian deposition (Hintze, 1973b). These strata of Silurian, Early Devonian, and Middle Devonian ages tend to be thick in the miogeosyncline of western Utah and thin eastward onto the craton. The Middle Devonian strata were also deposited in a widespread, warm, shallow, marine environment far from a source of clastics.

Guilmette Formation And Equivalents

In the Guilmette Formation and equivalents the most abundant preserved organisms are stromatoporoids. Branching forms, such as Amphipora sp., and bulbous forms are most common. Hoggan (1975) suggested that stromatoporoids may have adapted to many ecological conditions, and therefore are found in many rock types. Many organisms, such as algae (both oncolites and heads), and syringoporid corals, are associated with the stromatoporoids throughout the study area.

Amphipora sp., a branching stromatoporoid, usually is found in a horizontal position. Hoggan (1975) suggested that the branching forms grew upright with the long axis vertical. Storm or strong current activity may have caused the organisms to break at the base and be deposited in biostromal or biohermal deposits. Leavitt (1968) believed that *Amphipora* sp. thrived in quiet waters such as a back-reef environment, but could grow in any quiet environment. Evidence that *Amphipora* also may have flourished in higher energy environments was noted at Goshoot Canyon in the Thomas Range, approximately 19 km (12 mi) southeast of Bullion Canyon, where *Amphipora* occurs in close association with cyclical, silty quartz arenites of the Hanauer Formation.

Observations at Little Mile And A Half Canyon and South Burbank Hills indicate that bulbous stromatoporoids are closely associated with other mixed biota owing to the many ecological adaptations and they commonly occur in growth position. This suggests that they were wave resistant and may have grown in turbulent, shallow-water environments of normal salinity. Their association with lower energy organisms indicates that bulbous stromatoporoids were not restricted to high-energy environments but also flourished in low-energy environments. Throughout the study area these organisms appear to have had more sucess in the lower energy environments.

The presence of algal mat structures as compared with modern day environments indicate moderate- to high-energy and possible restricted marine conditions in some parts of the Guilmette environment. Most of the Devonian seas probably had normal salinity as evidenced by brachiopods, conodonts, crinoids, and gastropods. These organisms are found in finely crystalline, thin-bedded, micritic limestone or dolomite that is pelletal or peloidal in places.

In order to support the growth of the observed diversified biota, the overall shallow shelf environment of the early Late Devonian sea would probably have needed an irregular sea floor with many different environments. By using the lithologic and fossil occurrences, it is possible to reconstruct the environments that existed in the shallow shelf seas during early Late Devonian time (fig. 6). The basic environments of the Guilmette Formation in the study area include: a moderate-energy intertidal environment where algal mats, mounds, and oncolites existed; a moderate-energy subtidal environment that contained bulbous stromatoporoids, conodonts, crinoids, gastopods, and solitary corals; a low-energy environment, below effective wave base, that contained Amphipora sp., brachiopods, gastropods, bulbous stromatoporoids, and tabulate corals; and a high-energy environment, located on local mud mounds or biohermal buildups, that contained bulbous stromatoporoids, tabulate

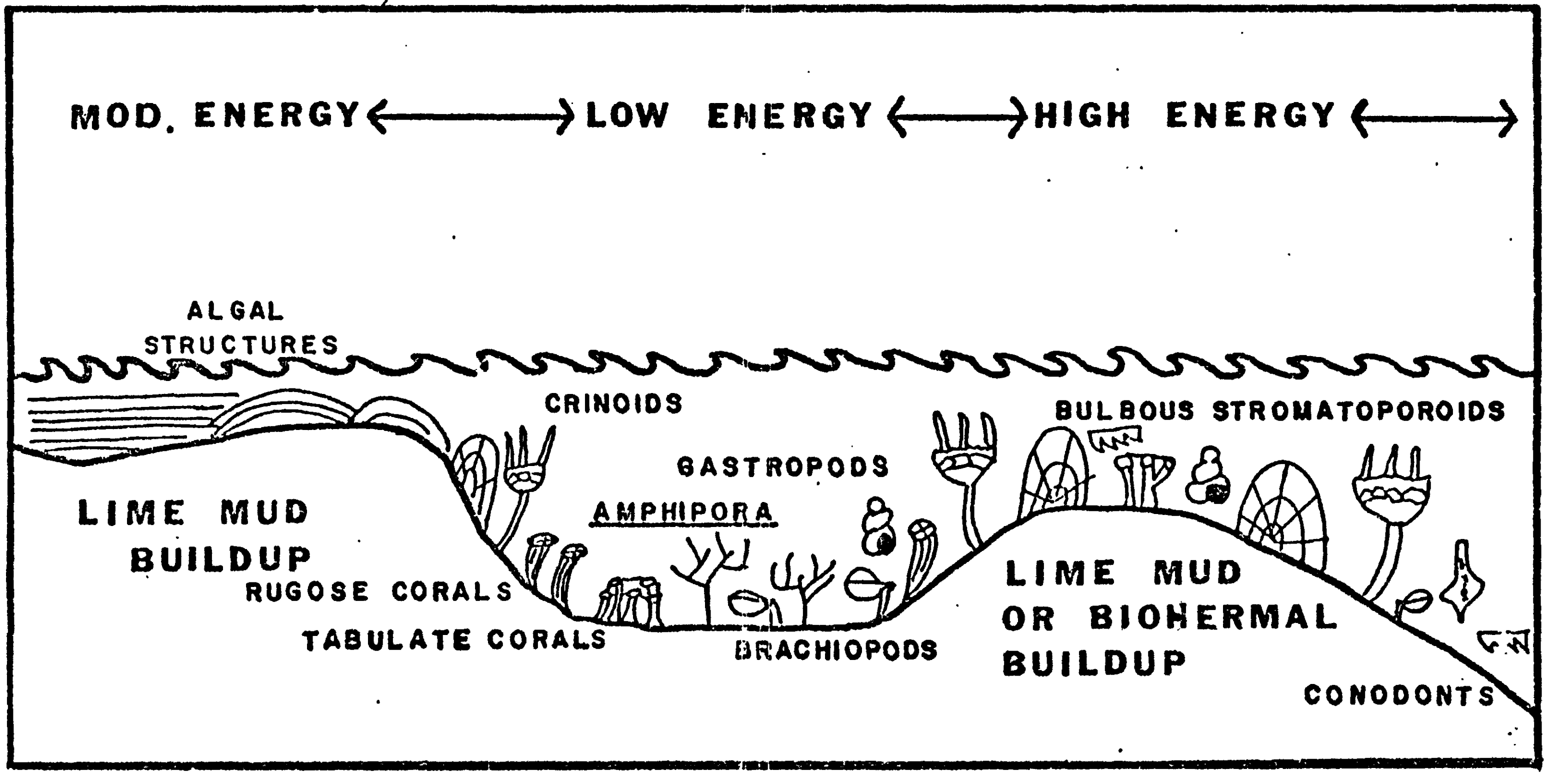

Figure 6. Interpretive diagram of the paleogeography of the Guilmette sea floor (revised from Hoggan, 1975). Horizontal and vertical scales are exaggerated.

corals, gastropods, crinoids, and conodonts. Each of these environments produced distinctive lithologies. Rocks of the intertidal environment are laminated, possibly burrowed, finely crystalline dolomite. The subtidal environment resulted in massive, skeletal, pelletal and peloidal, micritic, mottled limestone or dolomite. The low-energy environment, below effective wave base, formed horizontally bedded, fossiliferous, pelletal, micritic, mottled, limestone or dolomite. The high-energy environment produced peloidal, horizontally bedded, slightly cross stratified, fossil-fragmental, limestone or dolomite.

Dolomitization of the lime sediments probably took place penecontemporaneously in and around the many local restrictions and therefore was probably the result of a refluxing of brines. As the shelf carbonate rocks prograded seaward and as the total shelf environment was uplifted in the Late Devonian, total dolomitization probably took place by the percolation of meteoric and high magnesium solutions (Hanshaw and others, 1971).

Evidence of two distinct periods of dolomitization is seen in thin sections in which the penecontemporaneous dolomitization is represented by cryptocrystalline or microcrystalline dolomite and the regional dolomitization is represented by coarse to very coarse-grained dolomite crystals. Much of the strata in the lower Upper Devonian appears to have been differentially dolomitized. These differentially dolomitized sediments are characteristically seen as either alternating light to dark beds or as beds having a mottled appearance.

Although the carbonate shelf sediments predominate, the Guilmette Formation and equivalents underwent several periods of sand deposition. This sand deposition is due to the break up of the miogeosynclinal-cratonic pattern of deposition which had persisted since late Precambrian time and had begun to break up later in the Devonian (Hintze, 1973b). Erosion of the Stansbury uplift in the north and northeast and of the craton in the east provided many of the sands within the Guilmette Formation and equivalents.

In places sand of bimodal grain-size distribution was deposited with limy sediments. This sand is usually composed of angular quartz grains of silt to very fine sand size and rounded, frosted, medium to very coarse quartz sand grains. This bimodality in silty to sandy carbonates may indicate a mixing of sand from two different sources within an environment of carbonate deposition. A possible simultaneous reworking of a beach and an aeolian sand deposit with subsequent deposition in a marine environment during periodic storm activity would be necessary.

Upper Devonian (Famennian) Units

During the latest Devonian, the Pilot Shale was deposited in a basin, the eastern edge of which lay in the western part of the study area. This basin was the result of a regional warping of the shelf that produced many local positive and negative features throughout the Great Basin. This Pilot basin was a rapidly subsiding basin on a carbonate shelf. Normal marine (as evidenced by normal marine faunas) limy siltstones and shales interbedded with thin, normal marine, fossiliferous limestone of the Pilot Shale were deposited in the Pilot basin. Underlying these sediments is the shallow marine West Range Limestone which was deposited as a shallow carbonate shelf facies of the lower part of the Pilot Shale.

During the latest Devonian the Stansbury uplift provided most of the detritus, which was deposited as the Hanauer Formation on the east side of this Pilot basin. The Hanauer Formation was deposited in a marine environment by small subsea fans as evidenced by prominent south-southwesterly current directions and the presence of normal marine faunas in interbedded limestones.

After the deposition of the Hanauer Formation, a deepening of the marine environment resulted in the deposition of the unnamed upper Famennian unit above the Hanauer Formation. The highly peloidal nature of this unit may indicate that the environment of deposition of this unnamed upper Famennian unit was primarily a small, shallow, high energy, carbonate platform.

A major unconformity, which interrupted the deposition of uppermost Devonian shelf sediments, may be seen throughout the study area at the base of Polygnathus styriacus Zone (pls. 1 and 2). Poole (1974) suggested that the shelf seas to the east of the Antler orogenic belt in central Nevada were restricted, and this caused greatly shallowed water conditions for the remainder of latest Devonian time. This unconformity is suggested to reflect regional warping during emplacement of the Roberts Mountains allochthon. Sandberg and others (1975, p. 718) cited evidence for the widespread extent of the unconformity beneath the Upper Polygnathus styriacus Zone in western North America. In most of the study area, later warping affected the miogeosyncline and permitted the deposition of a widespread, transgressive, shallow marine shelf sand (Cove Fort Quartzite--Leatham equivalent) directly overlying the unconformity. Normal shelf carbonates with some sands and shales were then deposited until uplift during the Antler orogeny in the regions to the west accompanied by erosion produced an unconformity representing earliest Mississippian time.

PETROLEUM POSSIBILITIES

Isopach and structure contour maps of Cambrian through Mississippian strata in western Utah (Hintze, 1973b) indicate the sedimentation of a thick miogeosynclinal carbonate sequence that includes beds favorable for petroleum generation and migration. The subsiding tectonic framework of middle Paleozoic time permitted the accumulation of sediments which may have provided the needed depth of burial for the maturation of hydrocarbons to generate petroleum. Thick post-Devonian sediments probably through Late Mississippian age would have provided enough overburden to permit generation or migration in Late Devonian rocks. Assuming this did occur, the shelf may have provided the updip direction for petroleum migration.

Dominantly carbonate lower Upper Devonian rocks of the continental shelf do not contain many organic rich shale source beds, although the thick stromatoporoid bioherms may have acted as petroleum sources. The carbonate shelf sediments are likely to have acted as conduits for petroleum migration either laterally or vertically from the Pilot Shale source beds (Sandberg, 1975; Sandberg and Poole, 1975a).

Assuming petroleum was present for migration, the porosity needed for possible carbonate carrier beds is more likely to have been secondary. Thin section study of stromatoporoid material, especially from the *Amphipora* sp.

bioherms, shows that framework porosity and permeability was preserved by early dolomitization. Later dolomitization also appears to have enhanced porosity and permeability owing to the formation of large dolomite crystals. The medium-grained quartz arenites of the Guilmette Formation and equivalents also may have been carrier beds. These arenites appear to be well sorted and loosely packed, although, in many areas, the pore space is presently filled with calcareous and siliceous cement.

Assuming that petroleum migration had occurred within the study interval before the destruction of the needed porosity and permeability, the author randomly collected samples for the geochemical analysis of organic carbon content within this interval throughout the study area. It was assumed that previous carrier beds may have had traces of petroleum left behind during migration. The percentage of organic carbon content contained within the samples is dependent on the speed of migration, the completeness of flushing of the petroleum from the effective pore system, the actual amount of porosity and permeability at the time of migration, the amount of diagenesis since the time of migration, and the effects of weathering on the outcrops. Table 1 gives the analyses of organic carbon which was determined by a direct, rather than indirect method, for the collected samples.

Table 1. Sample analyses for organic-carbon content and calcium-magnesium molal ratio. Ls. is limestone, dolo. is dolomite, q.a. is quartz arenite, fossil. is fossiliferous, A. is *Amphipora*, m. is medium, lt. is light, dk. is dark, v. is very, brn. is brownish, gr. is gray. Stratigraphic locations of samples are plotted within the individual measured columnar section from each locality (figs. 2, 4, 6, 8, 10, 12, 14, 16, 18).

SECTION LOCALITY	SAMPLE # 75-EB-	LITHOLOGY	COLOR	ORGANIC CARBON (%)	Ca/Mg MOLAL RATIO
Pinyon Peak (PIN)	4	fossil. ls.	m.dk.gr.	0.08	5.52
	5	pelletal ls.	dk.gr.	0.01	100.00
	6	pelletal ls.	olive gr	0.01	100.00
	7	dolo.	m.lt.gr.	0.03	1.05
	8	pelletal ls.	lt.gr.	0.04	100.00
	9	dolo.	m.dk.gr.	0.04	1.18
	10	silty dolo.	m.dk.gr.	0.07	1.15
	11	dolo.	m.dk.gr.	0.09	1.10
	12	dolo.	m.lt.gr.	0.09	1.18
	13	dolo.	m.lt.gr.	0.09	1.09
Little Mile And A Half Canyon (LMH)	14	ls.	m.dk.gr.	0.12	60.71
	15	ls.	dk.gr.	0.08	70.25
	16	ls.	m.dk.gr.	0.06	74.34
	17	ls.	m.dk.gr.	0.10	62.45
	18	ls.	olive gr.	0.09	87.81
	19	algal ls.	dk.gr.	0.10	62.29
	20	ls.	m.dk.gr.	0.14	1.05
	21	ls.	m.dk.gr.	0.10	74.34
	22	calcareous q.a.	m.lt.gr.	0.05	1.78
	45	A. ls.	m.gr.	0.09	46.18
South Burbank Hills (SBH)	24	ls.	m.lt.gr.	0.06	1.14
	25	ls.	m.dk.gr.	0.12	13.86
	26	ls.	olive gr.	0.11	1.20
	27	ls.	olive gr.	0.11	50.87
	28	ls.	olive gr.	0.08	52.07
	29	ls.	m.lt.gr.	0.08	2.17
	30	ls.	dk.gr.	0.09	28.23
	31	ls.	m.lt.gr.	0.03	9.31
	32	dolo.	m.gr.	0.07	1.12
	33	dolo.	brn.gr.	0.03	1.10
	34	q.a.	m.lt.gr.	0.02	1.05
	35	dolo.	m.dk.gr.	0.09	1.04
	36	dolo.	lt.gr.	0.04	1.03
	37	dolo.	dk.gr.	0.12	1.04
	38	dolo.	m.gr.	0.04	1.48
	39	ls.	m.gr.	0.08	38.55
	40	ls.	m.dk.gr.	0.08	57.58
	41	ls.	m.dk.gr.	0.06	38.86
	42	ls.	m.gr.	0.05	28.80
Bullion Canyon (BLL)	46	pelletal ls.	m.lt.gr.	0.05	90.12
	47	ls.	m.gr.	0.05	90.12
	48	ls.	m.gr.	0.08	73.78
	49	dolomitic q.a.	m.lt.gr.	0.02	1.25
	50	pelletal ls.	m.gr.	0.03	100.00

Table 1 (cont.).

SECTION LOCALITY	SAMPLE # 75-EB-	LITHOLOGY	COLOR	ORGANIC CARBON (%)	Ca/Mg MOLAL RATIO
Bullion Canyon (cont.)	51	calcareous q.a.	lt.brn.gr.	0.01	50.08
	52	qtz. sandy ls.	lt.gr.	0.005	43.97
	53	pelletal ls.	m.gr.	0.05	91.50
	54	fossil. pelletal ls.	m.lt.gr.	0.03	13.06
	55	fossil. pelletal ls.	m.lt.gr.	0.05	56.69
	56	ls.	m.lt.gr.	0.07	100.00
	57	pelletal ls.	m.lt.gr.	0.05	90.81
	58	silty pelletal ls.	lt. olive gr.	0.04	100.00
	59	silty pelletal ls.	m.lt.gr.	0.03	100.00
North Gilson Mountains (NGM)	60	fossil. ls.	m.dk.gr.	0.04	61.50
	61	pelletal fossil. ls.	m.lt.gr.	0.03	100.00
	62	coarse dolo.	m.lt.gr.	0.06	1.11
	63	silty fossil. ls.	m.lt.gr.	0.05	50.73
	64	dolo.	lt.gr.	0.04	1.06
	65	dolo.	lt.gr.	0.04	1.20
	66	dolo.	lt.gr.	0.02	1.07
	67	dolo.	lt.gr.	0.05	1.09
	68	dolo.	m.lt.gr.	0.04	1.05
	69	dolo.	olive gr.	0.15	1.08
	70	qtz. sandy dolo.	lt. olive gr.	0.07	1.12
	71	dolo.	m.lt.gr.	0.04	1.15
	72	sucrosic dolo.	m.gr.	0.02	1.06
Dog Valley Mountain (DVM)	73	pelletal fossil. ls.	m.gr.	0.05	74.16
	74	fossil. dolo.	m.lt.gr.	0.02	1.06
	75	fossil. dolo.	m.lt.gr.	0.07	1.10
	76	fossil. ls.	m.gr.	0.10	46.41
	77	dolomitic q.a.	m.lt.gr.	0.05	1.18
	78	dolo.	lt.brn.gr.	0.06	1.06
	79	dolo.	lt.brn.gr.	0.05	1.09
	80	dolo.	lt.brn.gr.	0.05	1.04
	81	dolo.	lt.brn.gr.	0.04	1.05
	82	A. dolo.	lt.brn.gr.	0.04	1.13
	83	dolo.	m.lt.gr.	0.05	1.03
	84	dolo.	brn.gr.	0.06	1.01
	85	dolo.	m.lt.gr.	0.08	1.05
Mowitza Mine (MWZ)	87	calcareous q.a.	m.lt.gr.	0.04	100.00
	88	ls.	m.gr.	0.03	100.00
	89	fetid A. dolo.	m.dk.gr.	0.08	1.12
	90	dolo.	m.lt.gr.	0.005	1.05
	91	fossil. dolo.	m.gr.	0.05	1.03

Table 1 (concluded).

SECTION LOCALITY	SAMPLE # 75-EB-	LITHOLOGY	COLOR	ORGANIC CARBON (%)	Ca/Mg MOLAL RATIO
Mowitza Mine (cont.)	92	dolo.	m.lt.gr.	0.03	1.03
	93	dolo.	m.lt.gr.	0.03	1.02
	94	fossil. dolo.	m.lt.gr.	0.03	1.03
	95	dolo.	m.lt.gr.	0.04	1.03
	96	cherty ls.	m.lt.gr.	0.07	30.19
	97	dolo.	lt.gr.	0.04	1.13
	98	ls.	m.lt.gr.	0.06	57.58
	99	dolo.	m.lt.gr.	0.02	1.59
	100	silty dolo.	m.gr.	0.02	1.52
	101	dolo.	v.lt.gr.	0.04	1.35
	102	dolo.	v.lt.gr.	0.03	1.04
	103	dolo.	v.lt.gr.	0.05	1.03
Blawn Mountain (BLN)	104	A. algal dolo.	m.gr.	0.05	1.04
	105	dolo.	m.gr.	0.02	1.05
	106	dolo.	m.gr.	0.04	1.08
	107	dolo.	m.gr.	0.05	1.05
	108	dolo.	m.lt.gr.	0.06	1.06
	109	dolo.	m.lt.gr.	0.07	1.04
	110	dolo.	m.gr.	0.06	1.08
	111	pelloidal ls.	m.lt.gr.	0.02	90.35
	112	dolo.	lt.brn.gr.	0.04	1.16
Lime Mountain (LIM)	113	ls.	m.lt.gr.	0.03	61.82
	114	fossil. ls.	m.lt.gr.	0.02	88.31
	115	ls.	lt.gr.	0.04	91.04
	116	dolo.	m.lt.gr.	0.005	1.02
	117	dolo.	m.gr.	0.08	1.03
	118	fossil. dolo.	m.gr.	0.05	1.05
	119	lime mudstone	m.lt.gr.	1.27	100.00
	120	pelletal ls.	m.lt.gr.	0.04	91.27
	121	pelletal ls.	m.lt.gr.	0.04	100.00
	122	ls.	m.dk.gr.	0.08	86.46
	123	ls.	m.gr.	0.06	90.12
	124	ls.	m.lt.gr.	0.06	100.00
	125	dolo.	lt.gr.	0.08	1.19
	126	dolo.	m.lt.gr.	0.06	1.06
	127	fossil. dolo.	m.lt.gr.	0.05	1.02
	128	dolo.	m.lt.gr.	0.04	1.04
	129	fossil. dolo.	m.lt.gr.	0.05	1.04

The values of organic carbon in all samples analyzed appear to be usually low, averaging only 0.07 percent for carbonate rocks, 0.03 percent for quartz arenites, and 0.06 percent overall. C. A. Sandberg (oral commun., 1975) suggested 0.5 percent organic carbon as a lower limit for petroleum source beds. This percentage might also serve as the upper limit of organic carbon content for petroleum carrier beds. Lower Paleozoic rocks in Arkansas, Missouri, and Oklahoma, which do not seem to include any possible source beds have an average organic carbon content ranging from 0.22 to 0.28 percent (Connor and Shacklette, 1975). This percentage range is used by the author for establishing a lower limit for petroleum carrier beds. Thus petroleum carrier beds are considered to have a range of 0.22 to 0.49 percent. As the average for all analyzed samples is only 0.06 percent, it is concluded that the studied interval of Frasnian and lower Famennian rocks lies below the range of potential carrier beds.

However, the technique by which the samples for this study were analyzed is one in which the organic carbon is measured directly after the mineral carbon has been removed by acidization. According to C. A. Sandberg, (written commun., March, 1976), direct organic carbon analyses of carbonate rocks, such as those provided for this study, generally result in much lower values than do indirect organic carbon analyses of carbonate rocks, such as those reported by Connor and Shacklette (1975). Thus the 0.07 percent average for carbonate rocks in this study may actually be much closer to the 0.22 to 0.28 percent average reported by Connor and Shacklette (1975).

Sample number 75-EB-119 from Lime Mountain is the only geochemically analyzed sample that has a high organic carbon content. Its percentage of 1.27 is well above the lower limit of source beds. In explanation of this high value, this same sampled stratigraphic horizon, which is approximately 15 to 20 m (49 to 66 ft) above the Cove Fort Quartzite, may be compared with the same horizon at Blawn Mountain, Dog Valley Mountain, North Gilson Mountains, and Pinyon Peak. It is seen from these localities that this same stratigraphic horizon contains an average of 0.04 percent organic carbon. Also organic carbon values stratigraphically above and below sample 75-EB-119 at Lime Mountain average 0.05 percent. Therefore the anomalously high organic carbon percentage of this sample does not appear to represent an important horizon for regional migration. However, it may represent a local horizon where organic matter has been generated into petroleum.

Thin section examination of several dolomite samples reveals the presence of organic matter coating dolomite crystals. Consequently, the author suggests that either small amounts of petroleum were generated in situ or other generated petroleum migrated into the effective pore system and much of the residue emplaced by generation or migration has been lost during later diagenesis or recent weathering.

Also the evidence for generation or migration may have been masked by extensive flushing of the petroleum from an effective pore system, which may also have resulted in the observed low organic carbon content in the samples geochemically analyzed.

Recently there has been renewed interest in the petroleum exploration of the Great Basin and several wells have been drilled into and through Devonian rocks. To date there is no petroleum production from Devonian rocks in the study area, although exploration wells show that the rocks commonly have oil shows and strongly fetid odors.

A test, the Shell #1 Sunset Canyon well in sec. 21, T. 22S., R. 4 W., Millard County, Utah, had poor to medium oil shows in both the Pinyon Peak equivalent and Guilmette Formation, above and below the Cove Fort Quartzite. This well, which is located approximately 30 km (19 mi) northeast of Dog Valley Mountain, is probably a typical Devonian test because strata in subsurface sections in the study area apparently have quite different thicknesses as compared to the measured outcrop sections. For example, in the Sunset Canyon well, the Pinyon Peak equivalent appears to be 29 m (96 ft) thicker, the Cove Fort Quartzite, 23 m (75 ft) thicker, and the Guilmette Formation, 57 m (188 ft) thicker than the corresponding units in the nearby Dog Valley Mountain surface section. These thickness differences may be due to the dip of strata in the subsurface. However trigonometric calculations based on outcrop and well thicknesses indicate that the observed dips that would result in the thickness differences in the well are inconsistant for each unit. Therefore the thickness differences in the subsurface may be the result of incorrectly measured outcrop sections or well sections owing to different formational contacts.

There is the slim possibility, particularly in the eastern part of the study area that petroleum accumulations exist in Devonian strata because many outcrop samples appear to have excellent porosity and permeability and a strongly fetid odor. This petroleum, if present, would have had to survive the intense diagenesis that occurred during latest Devonian time and also all the structural deformations since, including the Sevier orogenic phase, Laramide uplifts, and Miocene to Holocene block faulting. Finally, if Devonian petroleum does exist today, it is more likely to occur in structural traps or combinations of structual and stratigraphic traps rather than in purely stratigraphic traps because of the extensive post-depositional structural and diagenetic history.

CONCLUSIONS

The lower Upper Devonian in southwestern Utah, the Guilmette Formation and equivalents, is a massive dark dolomite that is commonly biostromal and locally biohermal, contains prolific stromatoporoid material and has a varied content of other shallow-water biotas. In places the formation consists of limestone instead of dolomite but the limestone also contains a similar faunal assemblage. Throughout the interval are interbedded thin- to thick-bedded, well sorted, medium-grained quartz arenites. The formation was deposited as a miogeosynclinal shelf deposit which included intertidal, subtidal, offshore (below effective wave base), biohermal, and subsea fan environments.

Dolomitization was probably penecontemporaneous with deposition, and generally took place because of local restrictions that resulted in refluxing of brines. Probably after lithification of the lime sediments, regional dolomitization took place due to saturation of meteoric or high magnesium solutions.

The age of the Guilmette Formation and equivalents has been defined in the past as Middle to Upper Devonian, but recent evidence suggests that it ranges from latest Middle Devonian through early Late Devonian (latest Frasnian). The *Stringocephalus* brachiopod zone occurs at the base of the section and the Uppermost *Palmatolepis gigas* conodont zone at the top.

In Late Devonian time, the miogeosynclinal-cratonic pattern of deposition that had existed since late Precambrian time began to change. This change was marked by the occurrence of local uplifts in the miogeosyncline and finally by the Antler orogeny in the eugeosyncline farther to the west. These structural events are represented in the stratigraphic record by the deposition of detrital sediments into small, rapidly subsiding basins, as well as by many disconformities. In latest Devonian time the continental shelf became more shallow and this shallowing resulted in the deposition of normal-marine, carbonate-shelf sediments.

The many structural events that have taken place in the area since Devonian time have tended to greatly limit petroleum possibilities. Whether the studied interval had a relationship to petroleum generation and migration still remains a question. It may be concluded at present that these rocks have limited petroleum potential.

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MEASURED SECTIONS

Nine surface sections were measured by the author in the study area. These localities are: Blawn Mountain (BLN), Wah Wah Mountains, Utah; Bullion Canyon (BLL), Dugway Range, Utah; Dog Valley Mountain (DVM), Pavant Range, Utah; Lime Mountain (LIM), Tule Desert, Nevada; Little Mile And A Half Canyon (LMH), Confusion Range, Utah; Mowitza Mine (MWZ), Star Range, Utah; North Gilson Mountains (NGM), Gilson Mountains, Utah; Pinyon Peak (PIN), Tintic mining district, Utah; and South Burbank Hills (SBH), Burbank Hills, Utah. In addition to the measured sections, published stratigraphic data of other workers have been incorporated with the author's sections to complete the stratigraphic control. The total columnar section at each locality is included on plates 1 and 2.

Included in this chapter are the author's measured columnar sections from each locality, a topographic map indicating the exact location of the measured section, and a lithologic and faunal description of the lithologic units within each measured section. The explanation for the columnar sections is given on plate 2.

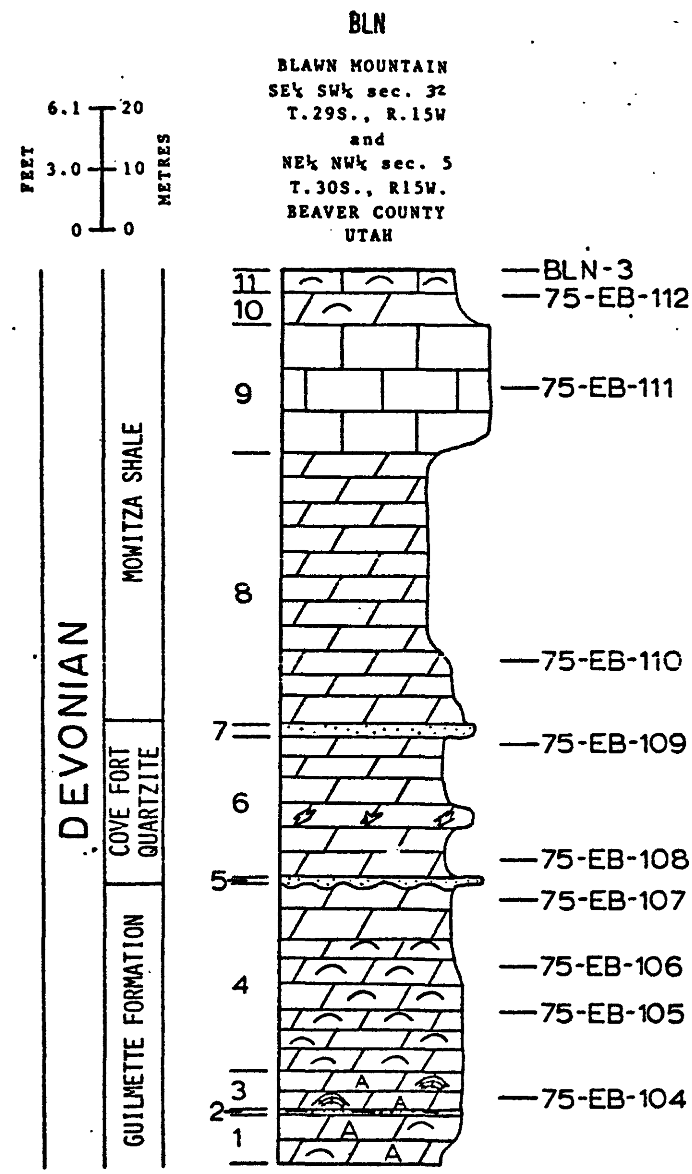

Figure 7. Measured section at Blawn Mountain.

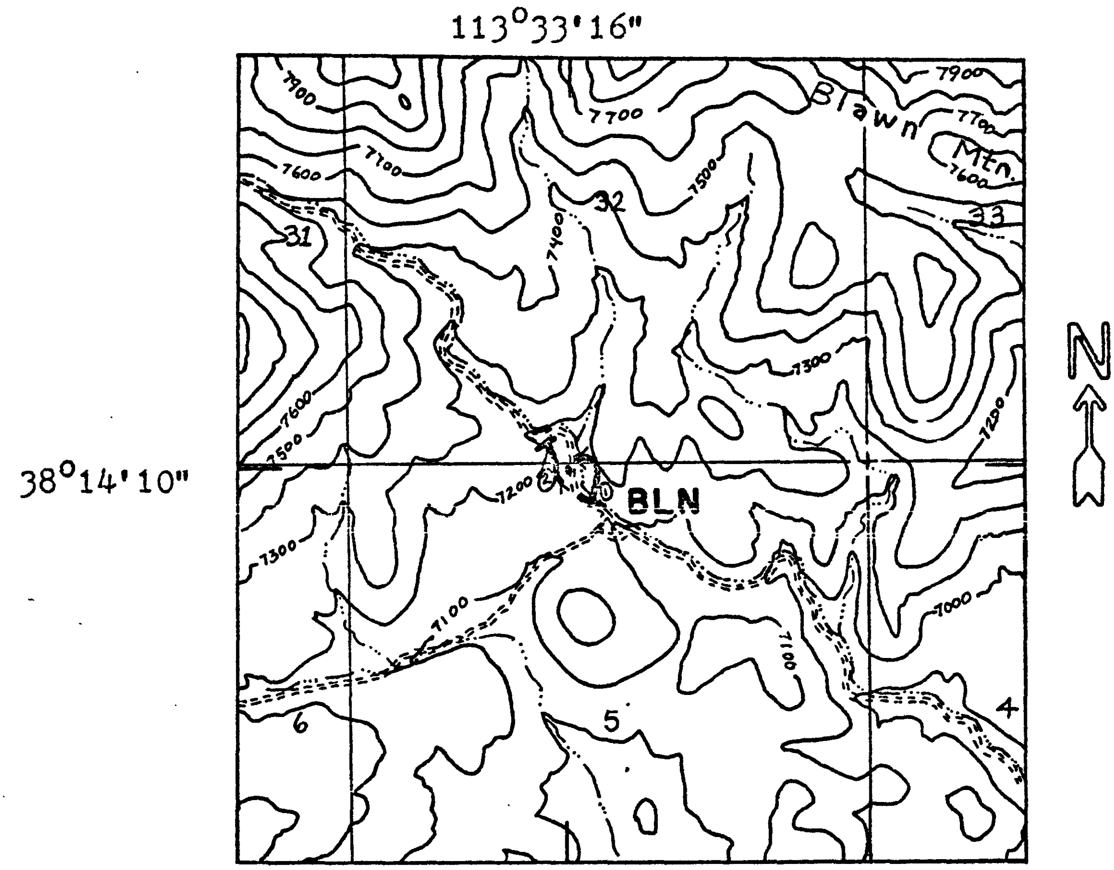

Figure 8. Blawn Mountain (BLN), SE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 32, T. 29 S., R. 15 W. and NE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 5, T. 30 S., R. 15 W., Beaver County, Utah. The Tetons 7$\frac{1}{2}$-minute quadrangle. C. I. = 100 feet, scale = 1:24000.

Blawn Mountain (BLN), Wah Wah Mountains, Utah

On slope along road southwest of Blawn Mountain, SE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 32, T. 29 S., R. 15 W. and NE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 5, T. 30 S., R. 15 W., Beaver County, Utah (fig. 7). The Tetons 7$\frac{1}{2}$-minute quadrangle (fig. 8). Measurements made by tape. All thicknesses rounded to the nearest tenth of a metre. Beds strike approximately N. 5° W. and dip 30° SW. Unit 1 is at south end of traverse leg 1 and unit 11 is at north end of traverse leg 2.

DEVONIAN:

Mowitza Shale:

Unit	Description	Metres (Feet)
11	Lime grainstone, fossiliferous, limonitic, slightly sandy (<2%, very fine- to fine-grained, subrounded quartz sand), dark-gray. Contains brachiopods, conodonts, crinoidal debris, syringopora, corals, fish remains. Conodont sample, BLN-3, contains conodont fauna (Apatognathus varians, Bispathodus stabilis, Diplododella, Hindeodella, Icriodus cf. I. costatus, Neoprioniodus, Pelekysgnathus inclinatus, Polygnathus communis, Polygnathus perplexus, Polygnathus semicostatus) indicative of Upper Polygnathus styriacus Zone and brachiopod fauna (Ambocoelia) indicative of Upper Devonian. Weathers dark gray; thin bedded; moderately resistant; ledge-forming.............	3.0 (10)
10	Dolomite, fossiliferous, limonitic, light-brownish-gray and brownish-gray, finely to medium crystalline. Contains brachiopods. Weathers light brownish gray and brownish gray; white dolomite fills fractures; thin bedded; weakly resistant; slope-forming.	5.0 (16)
9	Lime grainstone, peloidal, some local vein dolomitization near top, medium-light-gray. Weathers medium light gray; very thick bedded; highly resistant; ledge-forming........................	21.1 (69)
8	Dolomite, hematitic, slightly silty, medium-gray, cryptocrystalline. Weathers medium light gray; laminated to thin bedded; fetid odor emitted when struck with hammer; moderately resistant; ledge-and slope-forming................................	43.8 (144)

Cove Fort Quartzite:

Unit	Description	Metres (Feet)
7	Quartz arenite, siliceous cement, very light-gray and light-gray, medium-grained, subangular, moderately sorted. Weathers very light gray and light gray; laminated; highly resistant; forms one ledge..	1.6 (5.3)
6	Dolomite, limonitic, silty in places, medium-light-gray, coarsely crystalline. Weathers medium light gray; laminated to thin bedded; calcite filled fractures; breccia fragments are angular and equidimensional (½-10 cm. in size) and are similar in lithology to the matrix material; moderately resistant; ledge-and slope-forming...........	22.8 (75)
5	Quartz arenite, siliceous cement, light-red and medium-dark-gray, medium-grained, rounded, well sorted. Weathers light red and medium dark gray; thick bedded; basal medium dark gray layer is 8 cm. thick and individual grains are difficult to observe; highly resistant; forms one ledge...................	1.1 (3.6)
	Total Cove Fort Quartzite................	25.5 (84)

Disconformity

Guilmette Formation:

Unit	Description	Metres (Feet)
4	Dolomite, fossiliferous, limonitic, medium-gray, coarsely crystalline. Contains brachiopods, crinoidal debris, gastropods, rugose corals. Weathers medium gray; thick bedded; moderately resistant; ledge-forming.......................................	30.2 (99)
3	Dolomite, chertified, limonitic, fossiliferous, medium-gray, coarsely crystalline. Contains *Amphipora* sp., crinoidal debris, gastropods, chertified bulbous stromatoporoids. Weathers medium gray; thin to thick bedded; moderately resistant; ledge-forming.......................................	6.4 (21)
2	Dolomite, silty, limonitic, moderate-yellowish-brown, coarsely crystalline. Weathers moderate yellowish brown; very thin bedded; calcite filled fractures; weakly resistant; slope-forming...	0.5 (1.6)

1 Dolomite, fossiliferous, limonitic, medium-gray, coarsely crystalline. Contains Amphipora sp., brachiopods, crinoidal debris. Weathers medium gray; laminated to very thin bedded; calcite filled fractures; fetid odor emitted when struck by hammer; weakly resistant; slope-forming...... 8.0 (26)

Total measured section.................. 143.5 (471)

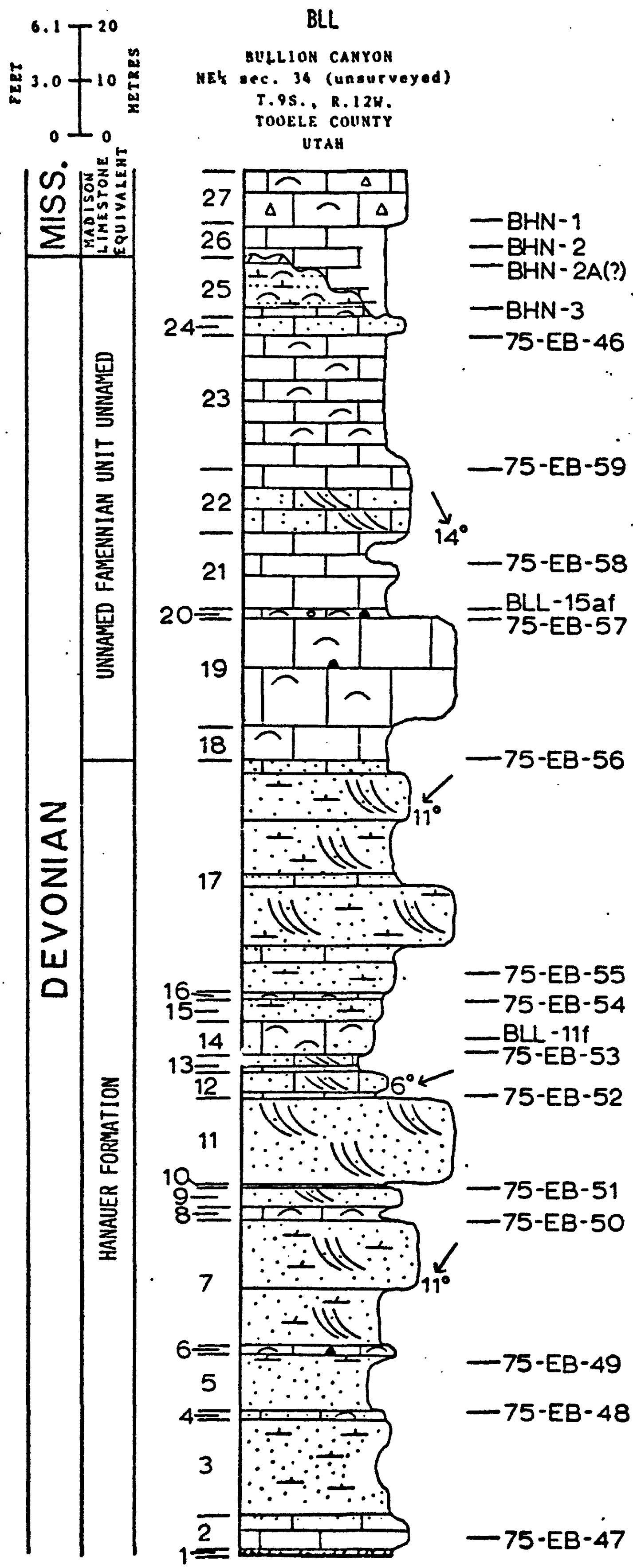

Figure 9. Measured section at Bullion Canyon.

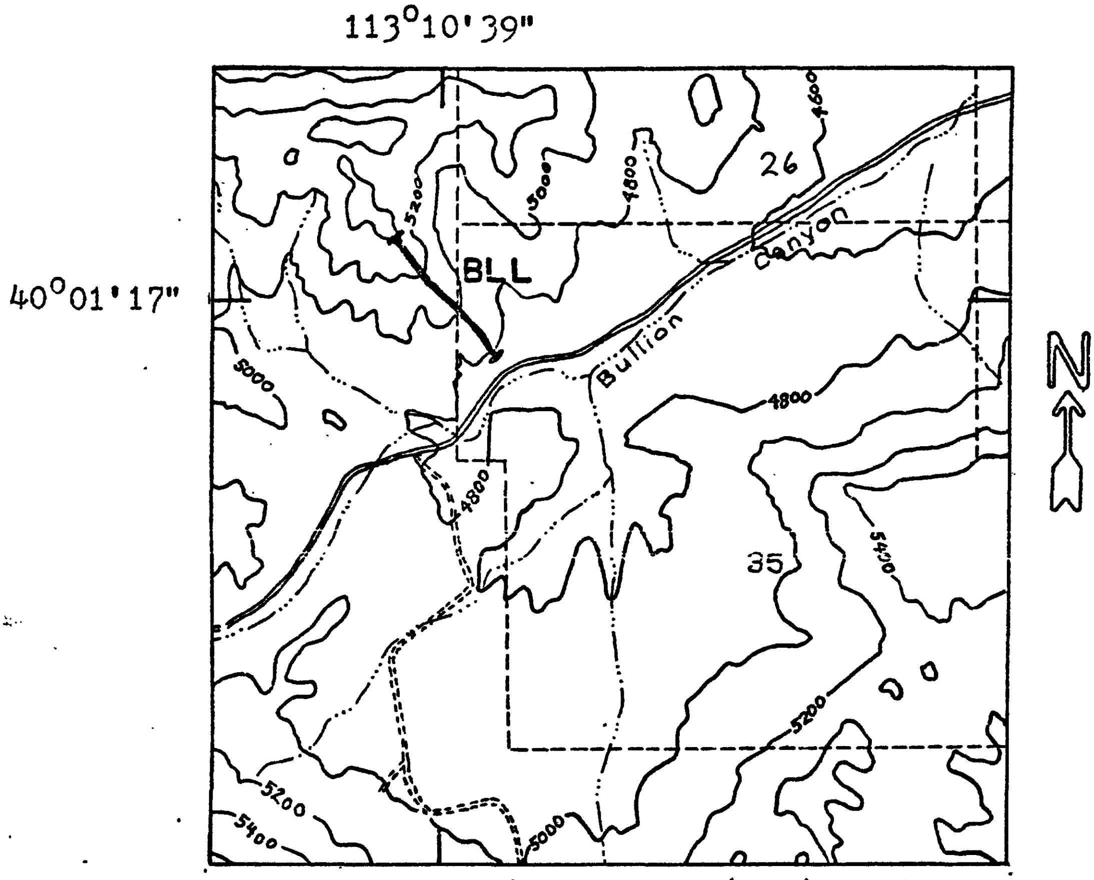

Figure 10. Bullion Canyon (BLL), NE$\frac{1}{4}$ sec. 34, T. 9 S., R. 12 W. (unsurveyed), Tooele County, Utah. Dugway Proving Ground $7\frac{1}{2}$-minute quadrangle. C. I. = 200 feet, scale = 1:24000.

Bullion Canyon (BLL), Dugway Range, Utah

On slope extending from Bullion Canyon road northwest to the crest of the ridge, NE$\frac{1}{4}$ sec. 34, T. 9 S., R. 12 W. (unsurveyed), Tooele County, Utah (fig. 9). Dugway Proving Ground 7$\frac{1}{2}$-minute quadrangle (fig. 10). Measurements made by tape. All thicknesses rounded to nearest tenth of a metre. Beds strike approximately N. 30° W. and dip 20° SW. Unit 1 is at southeast end of traverse.

MISSISSIPPIAN:

Madison Limestone equivalent (upper part of Madison Limestone equivalent according to Staatz and Carr, 1964):

Unit	Description	Metres (Feet)
27	Lime grainstone, fossiliferous, chertified, light-olive-gray. Contains crinoidal debris, rugose corals. Conodont sample, BHN-1, collected from this unit by C. A. Sandberg in 1975 from Buckhorn Canyon, in NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 1, T.10S., R12W., Tooele County, Utah, contains fauna indicative of Early Osagean age. Weathers olive-gray; chert nodules and layers are medium dark gray and brownish gray; thick bedded; highly resistant; ledge-forming.	9.5 (31)
26	Limestone, pelletal, fossiliferous, medium-light-gray to medium-gray, medium crystalline. Contains brachiopods, crinoidal debris, syringopora corals. Conodont sample, BHN-2, collected from this unit by C. A. Sandberg in 1975 from Buckhorn Canyon, in NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 1, T.10S., R.12W., Tooele County, Utah, contains fauna indicative of Kinderhookian age. Weathers medium light gray to medium gray; nodular appearance; in Buckhorn Canyon this unit is 6.0 m. thick and is ledge forming; in Bullion Canyon this unit is 16.5 m. thick, slightly covered, and is slope-forming...........................	16.5 (54)

Angular Unconformity

DEVONIAN:

Unnamed upper Famennian unit (lower part of the Madison Limestone equivalent of Staatz and Carr, 1964):

Unit	Description	Metres (Feet)
25	Buckhorn Canyon N½ sec. 1, T. 10 S., R. 12 W., Tooele County, Utah: upper 5.0 m: Dolomite, microcrystalline. middle 8.0 m: Siltstone, calcareous, fossiliferous, phosphatic, medium-light-gray. Conodont sample, BHN-2A, collected from this unit by C. A. Sandberg in 1975 from Buckhorn Canyon, contains fauna indicative of Middle to Upper *Scaphignathus velifer* Zone. lower 2.0 m: Limestone, fossiliferous, medium-gray. Contains bryozoa, crinoidal debris. Cododont sample, BHN-3, collected from this unit by C. A. Sandberg in 1975, contains fauna indicative of Upper *Palmatolepis marginifera* to Lower *Scaphignathus velifer* Zone. Bullion Canyon: The unconformity underlying the Mississippian truncates the equivalent Buckhorn Canyon units (Upper *Palmatolepis marginifera* Zone, Lower *Scaphignathus velifer* Zone).	
24	Limestone, pelletal, quartz sandy (20-30%), light-olive-gray, microcrystalline. Weathers olive gray; thick bedded; highly resistant; ledge-forming.	3.0 (10)
23	Limestone, pelletal, nodular, fossiliferous, medium-light-gray, cryptocrystalline. Contains brachiopods, gastropods. Weathers medium light gray; thick bedded; small cave formation (60-90 cm. diameter); many stylolites; weakly resistant; slope-forming...	24.0 (79)

Note: see figure 5 for the detailed stratigraphic correlation between Buckhorn Canyon and Bullion Canyon for units 23, 24, 25, 26, and 27.

Unit	Description	Metres (Feet)
22	Limestone, pelletal, quartz sandy (30%, rounded, very fine-grained), limonitic, medium-light-gray, cryptocrystalline. Weathers medium light gray; sand weathers light brownish gray; cross laminated; average bearing and plunge of transport direction is S.26°E.14°; many fractures filled with calcite which offset sandy cross laminations; highly resistant; forms cliff........................	11.8 (39)

21 Limestone, pelletal, silty, light-olive-gray, mottled, very finely crystalline. Weathers medium light gray; very thick bedded; many stylolites; weakly resistant; upper half forms reentrant, lower half is slope-forming.................. 14.9 (49)

20 Limestone, algal, fossiliferous, silty, moderate-reddish-brown to medium-gray, nodular, cryptocrystalline. Contains algal heads, crinoidal debris, gastropods, bulbous stromatoporoids. Brachiopod fossil collection, BLL-15af, contains fauna (<u>Atrypa</u> sp.) indicative of Early Silurian (Llandovery) through Late Devonian (Frasnian). Weathers medium light gray to medium gray; laminated; moderately resistant; ledge-forming.. 2.0 (7)

19 Limestone, pelletal, limonitic, fossiliferous, medium-light-gray, cryptocrystalline. Contains brachiopod outlines, gastropods, oncolites, bulbous stromatoporoids. Weathers medium light gray; very thick bedded; massive; cave formation at base (1.8-3.0 m. diameter); many fractures filled with calcite; highly resistant; forms cliff................ 20.0 (66)

18 Limestone, pelloidal, fossiliferous, medium-light-gray, cryptocrystalline. Contains brachiopods. Weathers medium light gray; thick bedded; weakly resistant; forms reentrant.................. 6.7 (22)

Total unnamed upper Famennian unit...... 82.4 (270)

Hanauer Formation:

Unit	Description	Metres (Feet)

17 Quartz arenite, calcareous, limonitic, hematitic, light-brownish-gray to medium-light-gray, fine-to medium-grained, subrounded to rounded, poorly sorted. Weathers brownish gray to medium light gray; cross laminated; averate bearing and plunge of transport direction is S. 46° W. 11°; sieve analysis of sample 75-EB-55 indicates good sorting, silt sized to very coarse-grained, mostly medium-grained; few beds of peloidal, quartz sandy, moderately resistant limestone; highly resistant, ledge-and slope-forming... 42.4 (139)

16 Limestone, dolomitic, pelletal, silty, fossiliferous, medium-light-gray, cryptocrystalline. Contains, crinoidal debris, gastropods. Weathers medium gray; thin bedded; moderately resistant; ledge-forming.......... 1.0 (3.3)

15 Quartz arenite, calcareous, light-brownish-gray, fine- to medium-grained, rounded, well sorted. Weathers brownish gray; very thick bedded; massive; highly resistant; ledge-forming...................... 4.3 (14)

14 Limestone, pelletal, fossil-fragmental, slightly sandy, medium-light-gray to medium-gray, mottled, cryptocrystalline. Contains crinoidal debris, gastropods. Brachiopod fossil collection, BLL-11f, contains fauna (Cyrtospirifer whitheyi?) indicative of Upper Devonian. Weathers medium light gray to medium gray; thin bedded; moderately resistant; ledge-forming.................................. 6.5 (21)

13 Limestone, pelletal, quartz sandy (40-50%, fine- to medium-grained, rounded), limonitic, light-brownish-gray and medium-gray, cryptocrystalline. Weathers light brownish gray to medium gray; cross laminated; weakly resistant; slope-forming.................................... 3.7 (12)

12 Same as unit 13. Average bearing and plunge of the transport direction is S.69°W.6°......... 4.4 (14)

11 Quartz arenite, siliceous cement, pinkish-gray, fine- to medium-grained, rounded, well sorted. Weathers brownish gray; laminated; cross laminated; massive; highly resistant; forms cliff....... 16.5 (54)

10 Limestone, pelletal, fossil fragmental, quartz sandy (< 2%), medium-light-gray, mottled, microcrystalline. Contains bulbous stromatoporoids. Weathers medium light gray; very thin bedded; weakly resistant; slope-forming.......................... 0.6 (2)

9 Same as unit 11................................ 3.2 (11)

8 Same as unit 10................................ 2.4 (8)

7 Same as unit 11. Dolomitic(?). Average bearing and plunge of transport direction is S.32°W.11°. Upper part forms cliff, lower part is slope-forming. 23.9 (78)

6 Lime grainstone, pelletal, slightly fossiliferous, silty, medium-gray, mottled, microcrystalline. Contains crinoidal debris, small oncolites. Weathers medium gray; thick bedded; small cave formation (1.2 m. diameter); moderately resistant; ledge-forming................................ 1.7 (6)

5 Quartz arenite, dolomitic at top, light-red to moderate-red, coarsening upward from very fine- to coarse-grained, rounded, well sorted, poor porosity and permeability. Weathers dark reddish brown; laminated; weakly resistant; slope-forming.............. 11.5 (38)

4 Limestone, pelloidal, medium-gray, mottled, cryptocrystalline. Weathers medium gray; thin bedded; many fractures filled with hematitically stained calcite; weakly resistant; slope-forming...................................... 1.2 (4)

3 Quartz arenite, calcareous, light-brown, fine- to medium-grained, subrounded, well sorted. Weathers dark reddish brown; slightly covered; weakly resistant; slope-forming.............. 17.4 (57)

2 Limestone, pelletal, micritic, medium-dark-gray, cryptocrystalline. Weathers medium light gray; thick bedded; moderately resistant; ledge-forming...................................... 6.8 (22)

1 Quartz arenite, dolomitic, light-brownish-gray, fine- to medium-grained, subrounded, well sorted. Weathers brownish gray; laminated to thin bedded; moderately resistant; slope-forming.......... 0.8 (2.6)

Total Hanauer Formation.................. 148.3 (486)

Total measured section................... 256.7 (842)

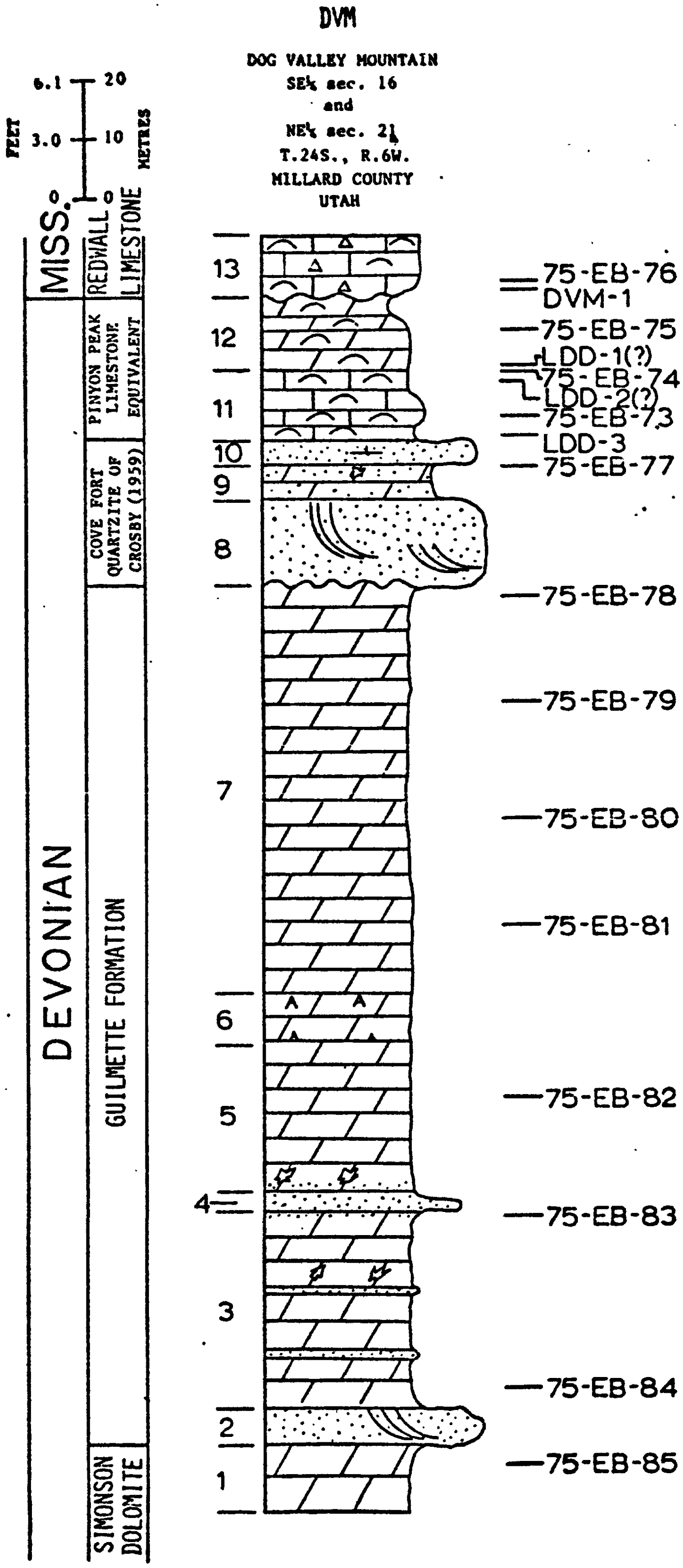

Figure 11. Measured section at Dog Valley Mountain.

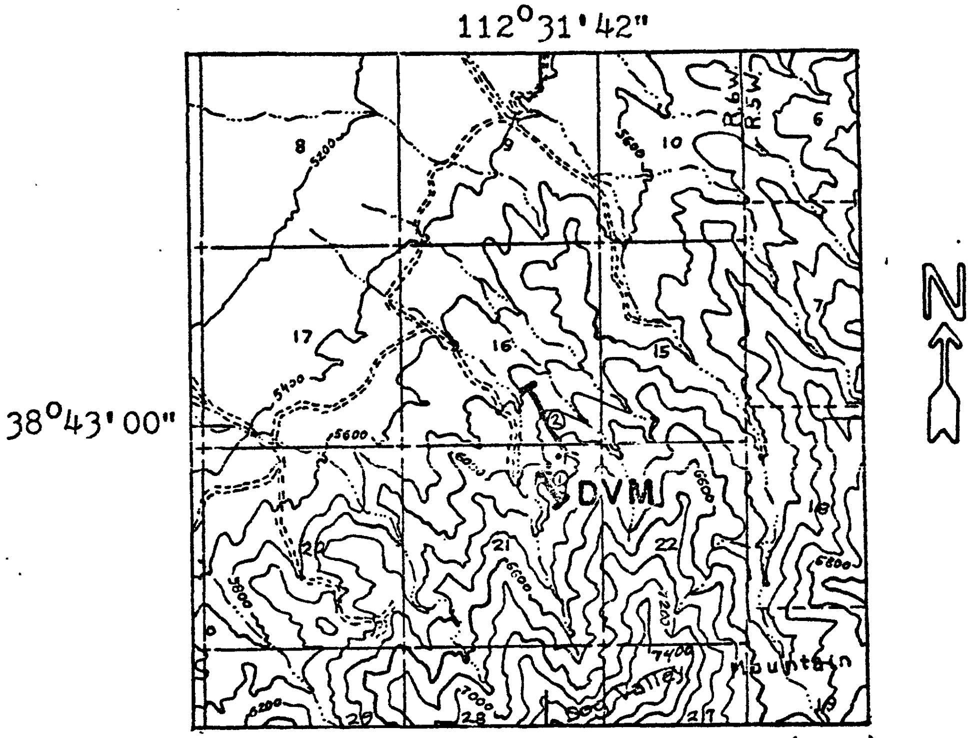

Figure 12. Dog Valley Mountain (DVM), SE$\frac{1}{4}$ sec. 16 and NE$\frac{1}{4}$ sec. 21, T. 24 S., R. 6 W., Millard County, Utah. Cove Fort 15-minute quadrangle. C. I. = 200 feet, scale = 1:62500.

Dog Valley Mountain (DVM), Pavant Range, Utah

On third and fourth ridge southwest of Widemouth Canyon and northwest of Dog Valley Mountain, SE$\frac{1}{4}$ sec. 16 and NE$\frac{1}{4}$ sec. 21, T. 24 S., R. 6 W., Millard County, Utah (fig. 11). Cove Fort 15-minute quadrangle (fig. 12). Measurements by a combination of tape and Jacob's staff. All thicknesses rounded to the nearest tenth of a metre. Beds are overturned, strike approximately N. 45° E. and dip 35° NW. Unit 1 is at north west end of traverse leg 2 and unit 13 is at southeast end of traverse leg 1.

MISSISSIPPIAN:

Redwall Limestone:

Unit	Description	Metres (Feet)
13	Lime packstone, fossiliferous, chertified, slightly dolomitic, medium-gray, the chert is medium light gray to moderate reddish orange. Contains crinoidal debris, fish fragments, rugose corals. Conodont sample, DVM-1, contains fauna (<u>Hindeodella</u>, <u>Ligonidina</u>, <u>Neoprioniodus</u>, <u>Spathognathodus</u> <u>crassidentatus</u>, <u>Spathognathodus</u> <u>elongatus</u> <u>sensu</u> Thompson, <u>Polygnathus</u> <u>communis</u> <u>communis</u>) indicative of Early Osagean or Late Kinderhoodian age. Weathers medium light gray; the chert weathers moderate reddish orange; very thin to thick bedded; fetid odor emitted when struck by hammer; highly resistant; ledge-forming................................	10.1 (33)

Disconformity

DEVONIAN:

Pinyon Peak Limestone Equivalent:

Unit	Description	Metres (Feet)
12	Dolomite, fossiliferous, pelletal, medium-light-gray, finely crystalline. Contains crinoidal debris, rugose corals. Conodont sample, LDD-1 Limekiln-Dameron Divide, six ridges to the northeast in C NW$\frac{1}{4}$ sec. 8, T.24S., R.5W., Millard County, Utah), collected from this unit by C. A. Sandberg in 1975, contains fauna indicative of Upper <u>Polygnathus</u> <u>styriacus</u> Zone. Weathers brownish gray; thin to thick bedded; moderately resistant; ledge-forming................................	11.9 (39)

11 Lime packstone, fossiliferous, silty, pelletal, olive-gray to medium-gray. Contains brachiopods, cephalopods, crinoidal debris, rugose corals. Conodont sample, LDD-2 and 3 (Limekiln-Dameron Divide, six ridges to the northeast in C NW¼ sec. 8, T.24S., R.5W., Millard County, Utah), collected from this unit by C. A. Sandberg in 1975, contains fauna indicative of Upper <u>Polygnathus</u> <u>styriacus</u> Zone. Weathers medium light gray; thin to thick bedded; weakly resistant; slope-forming...... 12.3 (40)

Total Pinyon Peak Limestone Equivalent.. 24.2 (79)

Cove Fort Quartzite of Crosby (1959):

Unit	Description	Metres (Feet)
10	Quartz arenite, siliceous cement, slightly calcareous, moderate-pink, medium- to coarse-grained, rounded, well sorted, poor porosity and permeability. Weathers light brownish gray; very thick bedded; massive; highly resistant; ledge-forming..............	4.5 (15)
9	Dolomite, quartz sandy, slightly silty, brecciated, medium-light-gray, microcrystalline. Weathers moderate reddish orange and light gray; thin bedded; intraformational, angular, and equidimensional breccia fragments; weakly resistant; slope-forming......................................	6.0 (20)
8	Quartz arenite, light-gray, medium- to coarse-grained, rounded, well sorted, poor porosity and permeability. Weathers light red and moderate reddish orange; cross laminated; massive; highly resistant; ledge-forming......................	14.5 (48)

Total Cove Fort Quartzite................. 25.0 (82)

Disconformity

Guilmette Formation:

Unit	Description	Metres (Feet)
7	Dolomite, hematitic and limonitic, light-brownish-gray to brownish-gray, finely to coarsely crystalline. Conodont sample, 75-EB-81, yielded one nondiagnostic ramiform element. Weathers brownish gray; thin to thick bedded; many calcite filled fractures;	

weakly resistant; slope-forming............... 67.7 (222)

6 Dolomite, fossiliferous, medium-light-gray, cryptocrystalline in middle part and coarsely crystalline in upper and lower parts. Contains Amphipora **sp. in** the upper and lower parts. Weathers pale red and medium light gray; laminated in the middle part and thin bedded to thick bedded in the upper and lower parts; moderately resistant; slope-forming................................ 8.7 (28)

5 Dolomite, hematitic, light-brownish-gray, medium crystalline. Weathers brownish gray; thin bedded; hematitically stained calcite in abundant fractures; intraclastic breccia and quartz sandy at base; weakly resistant; slope-forming.............. 24.0 (79)

4 Quartz arenite, light-gray, medium- to coarse-grained, rounded, well sorted, poor porosity and permeability. Weathers light red and moderate reddish orange; cross laminated; massive; highly resistant; forms one ledge.............................. 3.0 (10)

3 Dolomite, hematitic, medium-light-gray to light-brownish-gray, finely to medium crystalline. Weathers medium light gray to brownish gray; thin bedded; cross laminated; intraclastic rip up type breccia (≤1 cm. and tabular in shape); Cove Fort Quartzite seen as float in two zones 30 cm. thick; quartz sandy near top; moderately resistant; slope-forming..................................... 33.0 (108)

2 Same as unit 4................................ 6.0 (20)

Total Guilmette Formation................ 142.4 (467)

Simonson Dolomite:

Unit	Description	Metres (Feet)
1	Dolomite, medium-light-gray to light-brownish-gray, medium crystalline. Weathers medium light gray to brownish gray; laminated; 11 m. below top is a light gray to medium light gray dolomite; weakly resistant; slope-forming..............	11.0 (36)

Total measured section................... 212.7 (698)

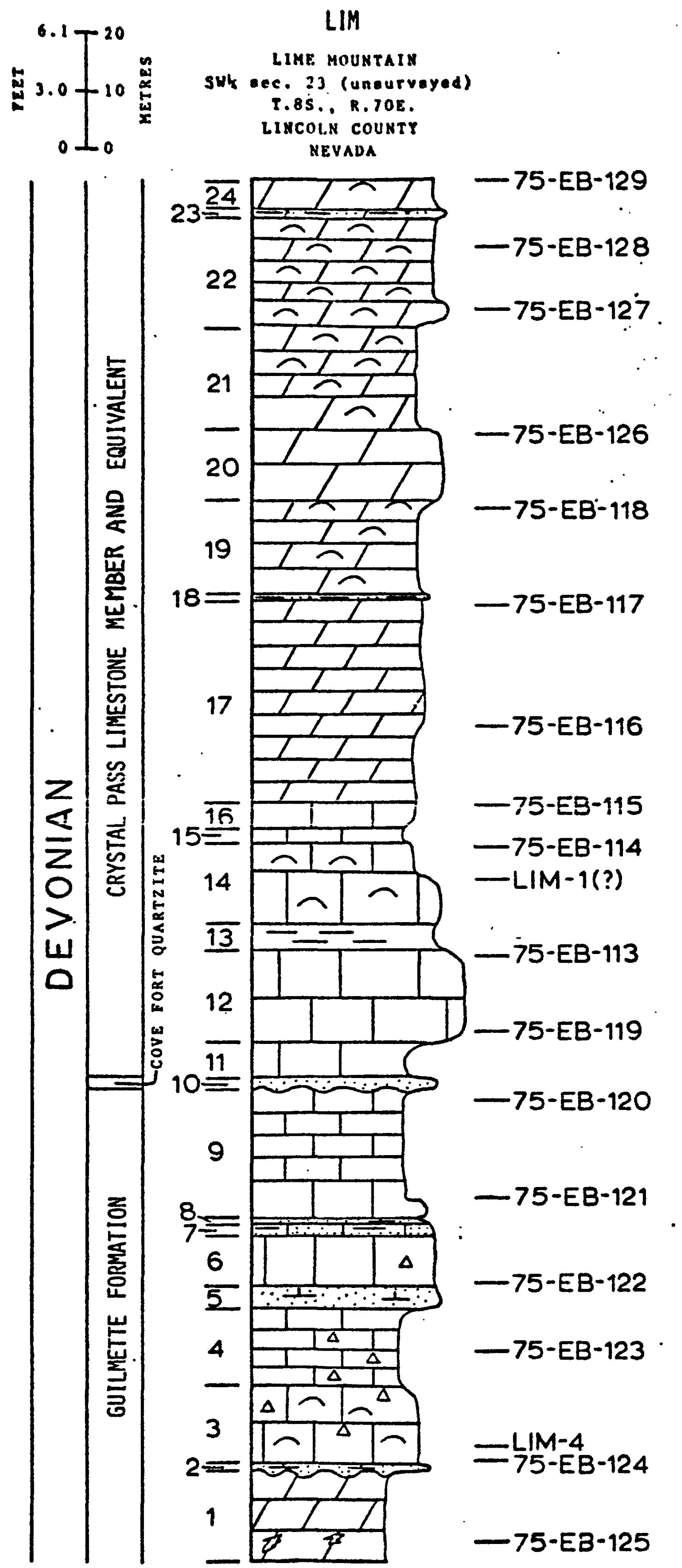

Figure 13. Measured section at Lime Mountain.

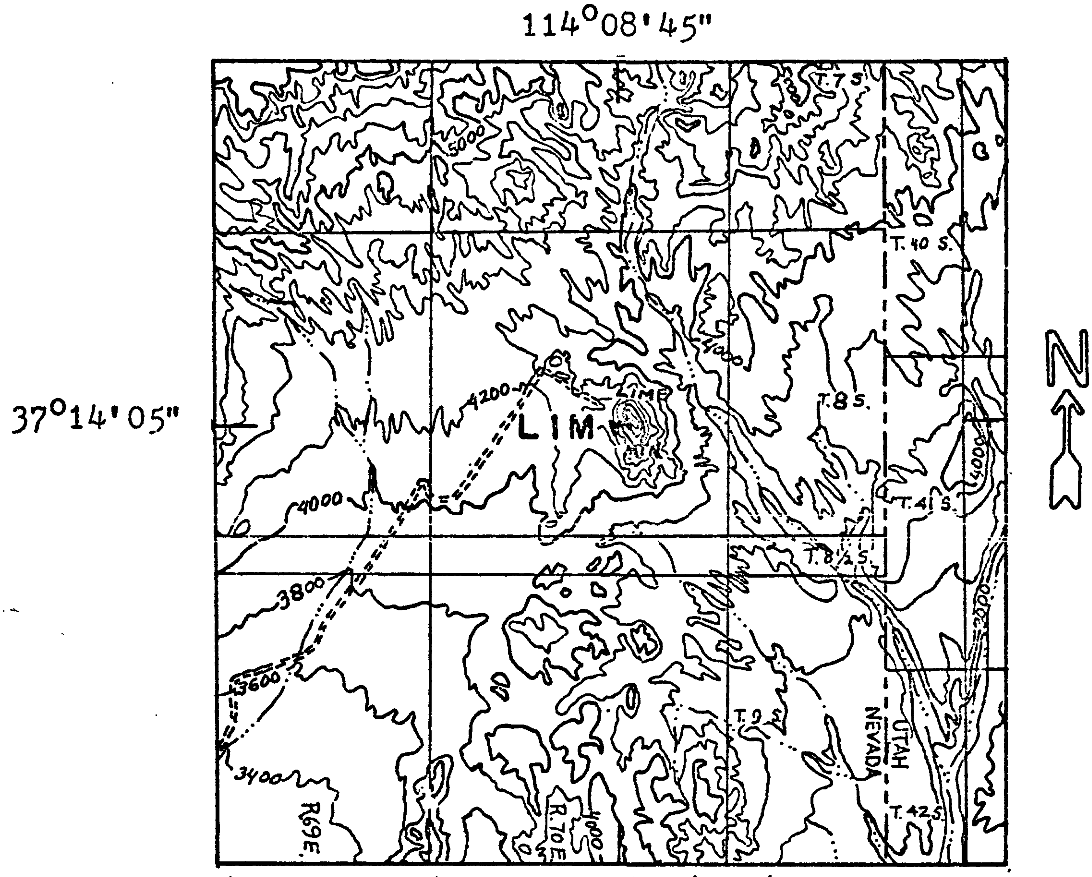

Figure 14. Lime Mountain (LIM), SW¼ sec. 23, T. 8 S., R. 70 E. (unsurveyed), Lincoln County, Nevada. Caliente Army Map Service sheet NJ 11-9. C. I. = 200 feet, scale = 1:250000.

Lime Mountain (LIM), Tule Desert, Nevada

On slope extending along the west side of Lime Mountain, SW$\frac{1}{4}$ sec. 23, T. 8 S., R. 70 E. (unsurveyed), Lincoln County, Nevada (fig. 13). Caliente Army Map Service sheet NJ 11-9, 1:250000 (scale) (fig. 14). Measurements made by a combination of tape and Jacob's staff. All thicknesses rounded to nearest tenth of a metre. Beds strike approximately N. 70° W. and dip 10° NE. Unit 1 is at southwest end of traverse.

DEVONIAN:

Crystal Pass Limestone Member and equivalent:

Unit	Description	Metres (Feet)
24	Dolomite, limonitic, medium-dark-gray, finely crystalline. Contains crinoidal debris(?). Weathers light medium gray; thin to thick bedded; resistant; ledge-forming..................................	5.1 (17)
23	Dolomite, limonitically silty, moderate-yellowish-brown, finely crystalline. Weathers medium gray; thick bedded; moderately resistant; forms one ledge.	1.6 (5)
22	Dolomite, limonitic, medium-light-gray, pelletal(?), coarsely crystalline. Contains brachiopods, crinoidal debris, rugose corals. Weathers medium light gray; thin to thick bedded; resistant; slope- and ledge-forming.......................	19.6 (64)
21	Dolomite, limonitic, medium-gray, mottled, finely crystalline. Contains brachiopods, gastropods. Weathers medium light gray; thin to thick bedded; moderately resistant; slope- and ledge-forming.	17.9 (59)
20	Dolomite, limonitic, medium-gray, mottled, finely crystalline. Contains crinoidal debris(?). Weathers medium light gray; thin to thick bedded; resistant; forms one ledge..................	12.4 (41)
19	Dolomite, limonitic, medium-dark-gray, mottled, finely crystalline. Weathers medium light gray; thin to thick bedded; irregular contact with unit 20; moderately resistant; forms minor ledges in slope.......	16.8 (55)
18	Siltstone, limonitic, dark-yellowish-orange. Weathers dark yellowish orange; very thin bedded; moderately resistant; forms one thin bed.....	0.4 (1.3)

17 Dolomite, limonitic, medium-light-gray and medium-gray, mottled in places, finely crystalline. Weathers medium light gray and medium gray; slightly laminated; massive; moderately resistant; forms a few minor ledges.......... 36.0 (118)

16 Limestone, slightly limonitic, light-gray, microcrystalline. Weathers light gray; thin to thick bedded; moderately resistant; ledge-forming.................................... 4.7 (15)

15 Limestone, slightly limonitic, medium-gray, microcrystalline. Weathers medium light gray; laminated; weakly resistant; slope-forming... 2.8 (9)

14 Limestone, fossiliferous, slightly silty, medium-light-gray, finely crystalline. Contains brachiopods, conodonts, crinoidal debris, and arenaceous foraminifer tests. Conodont sample, LIM-1, collected from this unit by C. A. Sandberg in 1972, contains fauna indicative of Upper(?) *Polygnathus styriacus* Zone (Sandberg, in press, table 1, loc. 9). Weathers grayish orange to dark yellowish orange and medium light gray; laminated to thin bedded; resistant forms four prominent ledges............................ 14.9 (49)

13 Shale, olive-green. Slightly covered; slope-forming.................................... 4.5 (15)

12 Limestone, medium light-gray, some red staining, cryptocrystalline. Weathers medium light gray; very thick bedded; massive; highly resistant; forms cliff.................................. 16.6 (54)

11 Limestone, pelloidal, silty, pale-red-purple, cryptocrystalline. Weathers light brownish gray; thick bedded; weakly resistant; slope-forming. 5.7 (19)

Total Crystal Pass Limestone Member equivalent......................... 159.0 (522)

Cove Fort Quartzite:

Unit	Description	Metres (Feet)
10	Quartz arenite, siliceous cement, grayish-pink and light-red, medium-grained, subangular, well	

sorted. Weathers grayish pink and light red; laminated; moderately resistant; forms one ledge.................................... 2.0 (6.5)

Total Cove Fort Quartzite............... 2.0 (6.5)

Disconformity

Guilmette Formation:

Unit	Description	Metres (Feet)
9	Lime grainstone, pelletal, slightly silty, secondary silicification in medium-light-gray beds, light-gray and medium-light-gray, mottled. Weathers light gray and medium light gray, mottled areas weather medium dark gray; lower 3.2 m. lacks pellets, is highly resistant, and forms one ledge; thick bedded; moderately resistant; ledge-forming..................................	23.6 (77)
8	Quartz arenite, calcareous, medium-light-gray and dark-yellowish-orange, fine-grained, rounded, well sorted. Weathers medium light gray and dark yellowish orange; thin bedded; weakly resistant, forms reentrant......................	0.3 (1)
7	Limestone, silty, 30% quartz sandy at base, medium-light-gray to dark-yellowish-orange, microcrystalline. Weathers medium light gray to dark yellowish orange; laminated and very thin bedded; moderately resistant; ledge-forming..	2.3 (7.5)
6	Limestone, silty, slightly chertified, medium-dark-gray and medium-light-gray, chert is moderate-reddish-brown, cryptocrystalline. Weathers medium dark gray and medium light gray; chert weathers reddish brown; thin to thick bedded; some laminations; highly resistant; ledge-forming....................................	9.0 (30)
5	Quartz arenite, 10-30% calcareous, very light-gray, fine- to medium-grained, rounded, well sorted. Weathers very light gray; laminated to thin bedded; isolated thin sand layers (2-4 cm. thick); highly resistant; ledge-forming......	3.6 (12)
4	Limestone, silty, chertified(?), very light-gray	

to medium-gray, cryptocrystalline. Weathers very light gray to medium gray; very thick bedded; weakly resistant; forms reentrant............ 13.3 (44)

3 Lime packstone to grainstone, pelletal, fossiliferous, slightly chertified, limonitic, hematitic, medium-light-gray. Contains brachiopods, conodonts, corals (rugose, syringoporoid), crinoidal debris, gastropods, bulbous stromatoporoids (2-15 cm.). Conodont sample, LIM-4, contains fauna indicative of Frasnian to Early Famennian. Weathers medium light gray and dark gray; very thick bedded; massive; base has nodular appearance; moderately resistant; ledge-forming.................................. 14.1 (46)

2 Quartz arenite, siliceous cement, slightly calcareous, moderate-reddish-orange, fine to medium-grained, subrounded, moderately sorted. Weathers moderate reddish orange; thin bedded; moderately resistant; ledge-forming..................... 0.6 (2)

Disconformity(?)

1 Dolomite, limonitic and hematitic , light-gray, coarsely crystalline. _Amphipora_ sp. and bulbous stromatoporoids found below base of measured section. Weathers light gray; very thick bedded; small cave development due to solution; extensive vein calcite filling fractures; base of section faulted; highly resistant; ledge-forming..... 15.4 (51)

Total measured section.................. 243.2 (798)

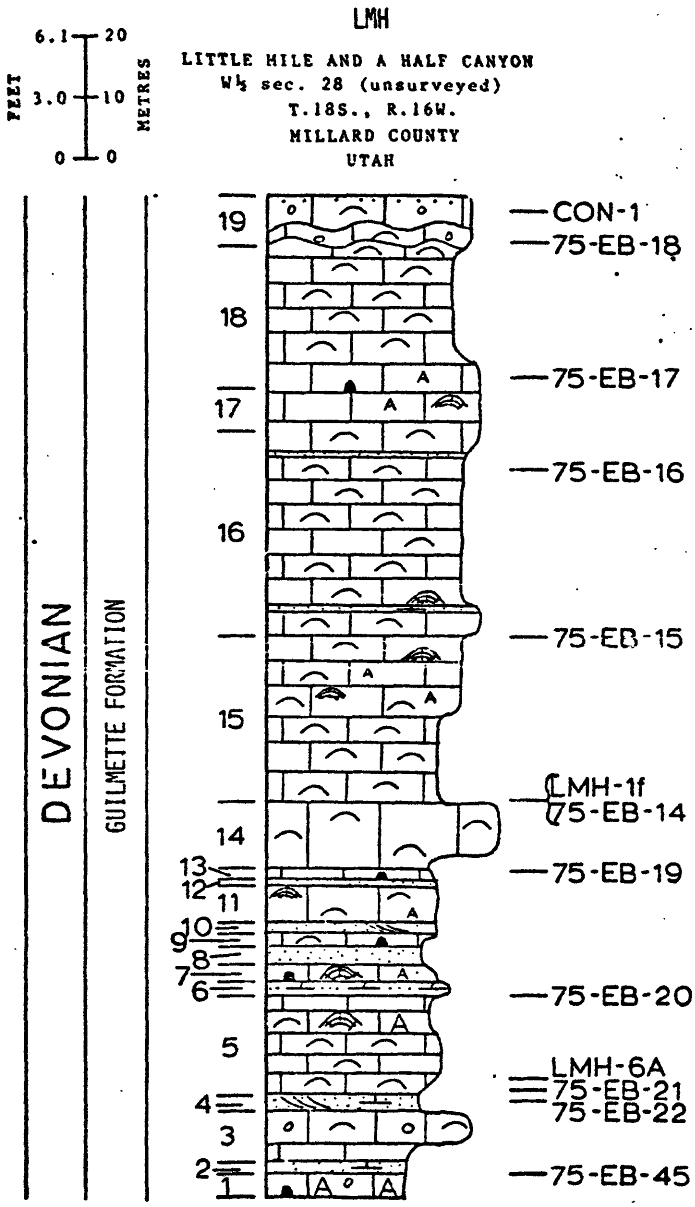

Figure 15. Measured section at Little Mile And A Half Canyon.

113°39'20"

39°12'59"

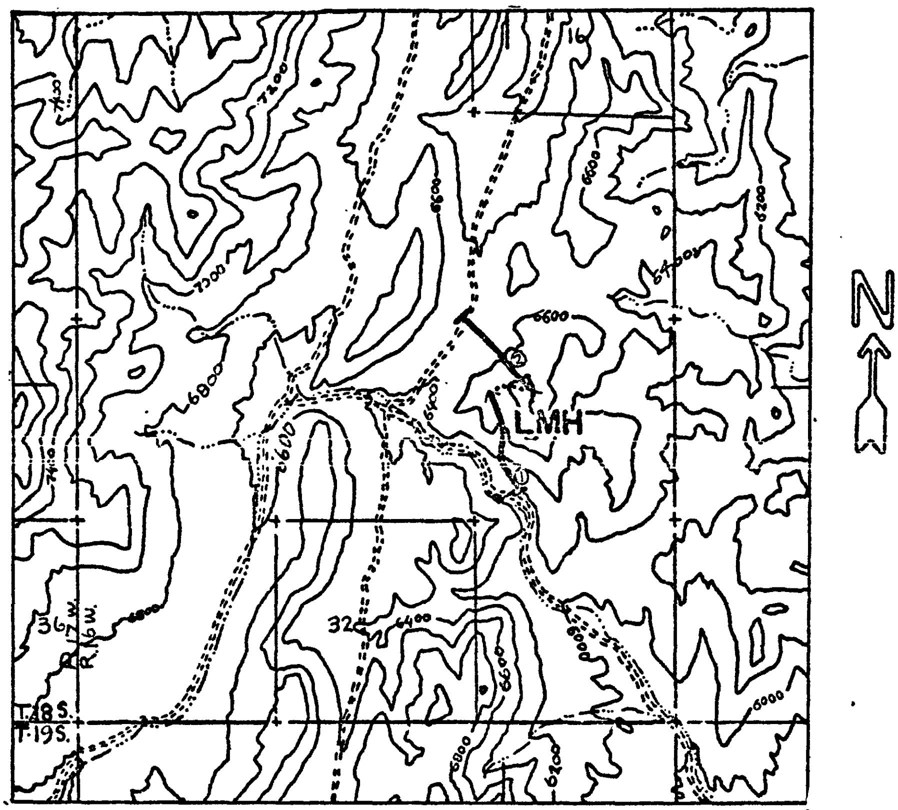

Figure 16. Little Mile And A Half Canyon (LMH), W½ sec. 28, T. 18 S., R. 16 W. (unsurveyed), Millard County, Utah. Conger Mountain 15-minute quadrangle. C. I. = 200 feet, scale = 1:62500.

Little Mile And A Half Canyon (LMH),
Confusion Range, Utah

On slopes approximately 0.8 km ($\frac{1}{2}$ mi) east-northeast of the intersection of Ledger Canyon and Little Mile And A Half Canyon, W$\frac{1}{2}$ sec. 28, T. 18 S., R. 16 W. (unsurveyed), Millard County, Utah (fig. 15). Conger Mountain 15-minute quadrangle (fig. 16). Measurements made by a combination of tape and Jacob's staff. All thicknesses rounded to nearest tenth of a metre. Beds strike approximately N. 30° E. and dip 15° NW. Unit 1 is at south end of traverse leg 1 and unit 19 is at northwest end of traverse leg 2.

DEVONIAN:

Guilmette Formation:

Unit	Description	Metres (Feet)
19	Limestone, pelletal, fossiliferous, silty, sandy phenoplast conglomeratic, olive-gray, nodular, cryptocrystalline. Contains brachiopods, crinoidal debris. Conodont sample, CON-1, collected from this unit by C. A. Sandberg in 1968, contains fauna indicative of Lower *Palmatolepis gigas* Zone. Weathers medium light gray; thin to thick bedded; moderately resistant; ledge-forming.............	7.5 (25)
18	Limestone, pelletal, fossiliferous, silty, olive-gray, mottled, cryptocrystalline. Contains *Amphipora* sp., brachiopods, bryozoa, crinoidal debris, rugose corals. Weathers medium light gray to medium gray; very thick bedded; moderately resistant; ledge-forming................................	23.3 (76)
17	Limestone, fossiliferous, pelletal, medium-light-gray, microcrystalline. Contains *Amphipora* sp., oncolites, bulbous stromatoporoids. Weathers medium gray; thick bedded; moderately resistant; ledge-forming................................	7.0 (23)
16	Limestone, pelletal, fossil fragmental, quartz sandy and silty, medium-light-gray, mottled, microcrystalline. Contains silicified brachiopods, crinoidal debris, colonial corals, gastropods, rugose corals, bulbous stromatoporoids. Weathers medium gray to dark gray; thin to thick bedded; quartz arenite beds are light brown, very fine- to coarse-grained, subrounded, moderately sorted; moderately resistant; ledge-forming......................	33.0 (108)

15 Limestone, fossiliferous, medium-dark-gray to dark-gray, mottled, cryptocrystalline. Contains *Amphipora* sp., rugose corals, syringopora corals, bulbous stromatoporoids. Brachiopod fossil collection, LMH-1f, contains fauna (*Atrypa* sp.) indicative of Lower Silurian through Upper Devonian. Weathers medium gray; thick to very thick bedded; moderately resistant; ledge-and slope-forming... 27.3 (90)

14 Limestone, limonitic, slightly silty, olive-gray, mottled, microcrystalline. Contains brachiopods, crinoidal debris, rugose corals. Weathers medium gray to medium dark gray; thin to thick bedded; massive; highly resistant; forms cliff....... 11.0 (36)

13 Limestone, algal, medium-dark-gray, microcrystalline. Contains algal structures. Weathers medium dark gray; wavy laminations; weakly resistant; slope-forming....................................... 1.6 (5.3)

12 Quartz arenite, grayish-orange to pale-brown, fine- to medium-grained, subangular, well sorted, good porosity and permeability. Weathers grayish orange to pale brown; laminated to very thin bedded; moderately resistant; ledge-forming.......... 1.1 (3.6)

11 Limestone, fossiliferous, medium-light-gray to medium-gray, nodular, microcrystalline. Contains *Amphipora* sp., *Atrypa* sp., crinoidal debris, rugose corals, bulbous stromatoporoids. Weathers medium light gray to medium gray; thin to thick bedded; moderately resistant; ledge-forming.......... 6.8 (22)

10 Quartz arenite, very pale orange, silt to very fine-grained, subangular, well sorted. Weathers very pale orange; cross laminated; moderately resistant; slope-forming.........................1.5 (5)

9 Same as unit 11..............................2.0 (7)

8 Same as unit 10.............................. 3.0 (10)

7 Same as unit 11.............................. 3.0 (10)

6 Siltstone, dolomitic, brownish-gray. Weathers brownish gray; thin bedded; fetid odor emitted when struck by hammer; moderately resistant; ledge-forming................................. 2.7 (9)

5 Limestone, pelletal, fossil fragmental, silty, medium-light-gray to brownish gray, microcrystalline. Contains Amphipora sp., Atrypa sp., gastropods, fish fragments, rugose corals, bulbous stromatoporoids. Conodont sample, LMH-6A, contains fauna (Diplododella, Hibbardella, Hindeodella, Neoprioniodus, Ozarkodina sp., Palmatodella, Polygnathus angustidiscus, Polygnathus dubius(?), Polygnathus xylus, Polygnathus webbi) indicative of Frasnian age. Weathers medium dark gray to light brown; very thin to thin bedded; some vein quartz; moderately resistant; ledge-forming.................................... 16.0 (52)

4 Quartz arenite, medium-light-gray, silt to very fine-grained, subangular, poorly sorted. Weathers medium light gray; cross laminated; weakly resistant; slope-forming...................... 2.3 (7.5)

3 Limestone, algal, pelletal, olive-gray, nodular, microcrystalline. Contains gastropods, oncolites, bulbous stromatoporoids (at top). Weathers medium light gray; very thick bedded; massive; highly resistant; forms cliff; slope-forming at base........... 8.3 (27)

2 Same as unit 4................................ 1.5 (5)

1 Limestone, dolomitic, fossiliferous, algal, medium-light-gray, nodular, microcrystalline. Contains Amphipora sp., brachiopods, gastropods, oncolites. Weathers medium light gray; thin to thick bedded; moderately resistant; ledge-forming.......... 4.0 (13)

Total measured section.................. 162.9 (534)

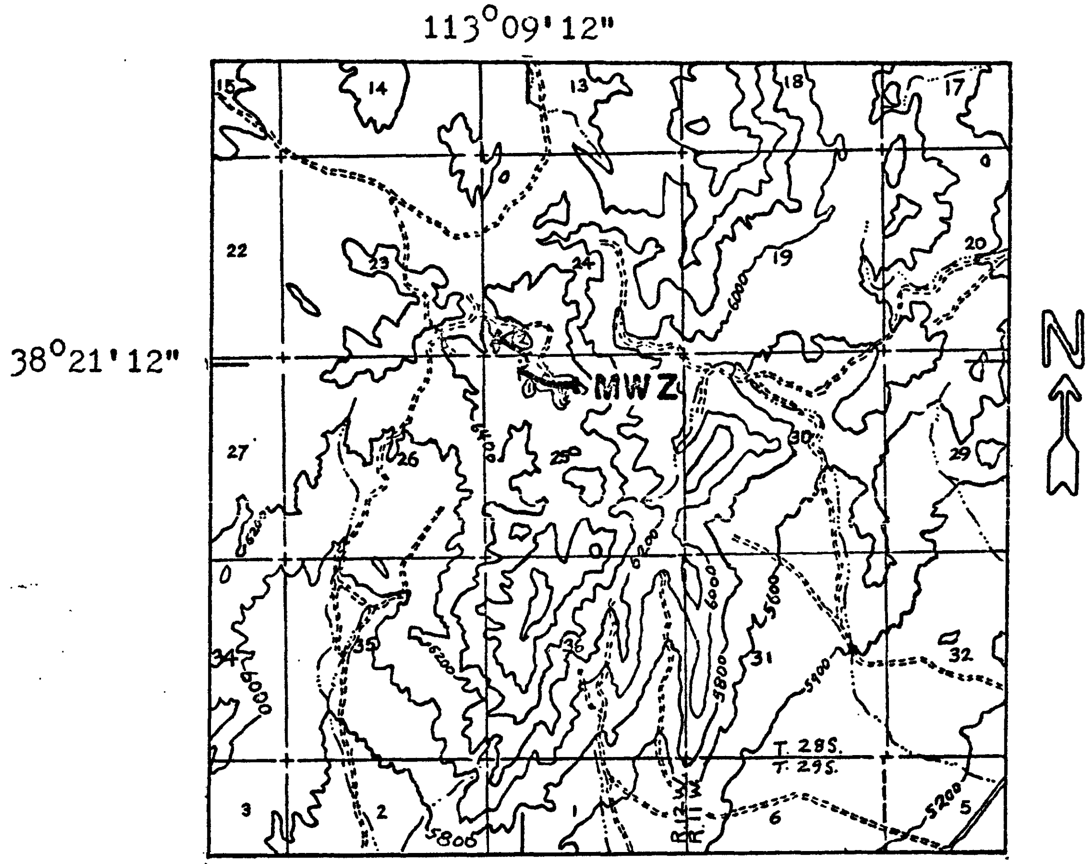

Figure 18. Mowitza Mine (MWZ), SW¼ SW¼ sec. 24 and NE¼ NW¼ sec. 25, T. 28 S., R. 12 W., Beaver County, Utah. Milford 15-minute quadrangle. C. I. = 200 feet, scale = 1:62500.

Mowitza Mine (MWZ), Star Range, Utah

On slope extending west-northwest from the Mowitza Mine, SW¼ SW¼ sec. 24 and NE¼ NW¼ sec. 25, T. 28 S., R. 12 W., Beaver County, Utah (fig. 17). Milford 15-minute quadrangle (fig. 18). Measurements made by tape. All thicknesses rounded to nearest tenth of a metre. Beds strike approximately N. 5° E. and dip 50° SE. Unit 1 is at northwest end of traverse leg 2 and unit 24 is at east end of traverse leg 1.

DEVONIAN:

Mowitza Shale:

Unit	Description	Metres (Feet)
24	Limestone, medium-light-gray and light-gray, pelloidal, cryptocrystalline. Conodont sample, MWZ-1B, collected from this unit by C. A. Sandberg in 1975, contains fauna indicative of *Polygnathus styriacus* or *Polygnathus velifer* Zone and contains silicified calcispheres. Weathers medium light gray; contains intraformational breccia which is angular and ≤2 cm.; many ferric stained stylolites; laminated to very thin bedded; moderately resistant; upper part is slightly covered, lower part forms ledges; this unit is unit #1 and #2 of Baetcke (1969)	37.4 (123)

Cove Fort Quartzite:

Unit	Description	Metres (Feet)
23	Quartz arenite, calcareous cement, medium-light-gray to medium-gray, fine- to medium-grained, rounded, moderately sorted. Weathers medium light gray to medium gray; lowest third contains subangular lithic fragments (≤2 cm.) which are composed of pelloidal limestone and are medium gray; very thick bedded; resistant; forms one ledge	1.9 (6)
22	Limestone, light-gray and medium-light-gray, pelletal, cryptocrystalline. Weathers light gray and medium light gray; laminated and thin bedded; weakly resistant; slope-forming	9.3 (31)
21	Quartz arenite, calcareous cement, light-gray, fine-grained, subrounded, moderately sorted. Weathers light brownish gray; thin bedded; weakly resistant; slope-forming	0.5 (1.5)

20	Limestone, secondary silicification, medium-dark-gray, cryptocrystalline. Weathers medium gray; thin bedded; weakly resistant; slope-forming.	2.0 (7)
19	Dolomite, medium-light-gray, coarsely crystalline. Weathers medium light gray; copper mineralization (azurite, malachite) in lower half; thin to thick bedded; moderately resistant; forms top of hill..	16.5 (54)
18	Quartz arenite, slightly calcareous, very light-gray, fine- to medium-grained, subangular, well sorted. Weathers light gray; thick bedded; moderately resistant; slope-forming.............	1.0 (3)
	Total Cove Fort Quartzite................	31.2 (102)

Disconformity

Guilmette Formation:

Unit	Description	Metres (Feet)
17	Dolomite, medium-dark-gray, finely crystalline. Contains <u>Amphipora</u> sp. (≤2.5 cm. long) which weather medium light gray. Weathers dark gray; thin to thick bedded; fetid odor emitted when struck by hammer; moderately resistant; ledge-forming.......................................	5.4 (18)
16	Dolomite, medium-light-gray, coarsely crystalline. Weathers medium gray; laminated to thin bedded; interbedding of dark and light colored layers; fractures filled with quartz crystals; moderately resistant; ledge-forming......................	12.0 (39)
15	Dolomite, fossiliferous, medium-gray and medium-light-gray, coarsely crystalline. Contains <u>Amphipora</u> sp., brachiopods, crinoidal debris, gastropods. Weathers dark gray; laminated and thin bedded; fetid odor emitted when struck by hammer; interbedding of dark and light layers; moderately resistant; ledge-forming..........	96.0 (315)
14	Dolomite, medium-light-gray, coarsely crystalline. Weathers medium light gray; thinly laminated; moderately resistant; slope-forming.............	14.0 (46)
13	Dolomite, fossiliferous, medium-dark-gray, finely	

crystalline. Contains brachiopods, gastropods. Weathers medium dark gray; thinly laminated; contains subangular breccia fragments (average size is 5 cm.); moderately resistant; slope-forming.... 6.7 (22)

12 Dolomite, fossiliferous, medium-dark-gray, finely crystalline. Contains brachiopods, colonial corals, crinoidal debris, rugose corals. Weathers medium dark gray with some interbeds of medium light gray dolomite; thin to thick bedded; moderately resistant; forms small ledges on slope........................ 16.5 (54)

11 Dolomite, fossiliferous, medium-dark-gray and medium-light-gray, finely crystalline. Intraclastic breccia fragments of units 12 and 13 in which angular fragments average 5 cm.; matrix is thinly laminated dolomite.................................... 16.5 (54)

10 Dolomite, medium-light-gray, medium crystalline. Weathers medium light gray; very thick bedded; highly resistant; forms cliff........................ 20.0 (66)

9 Dolomite, medium-light-gray, finely crystalline. Contains rugose corals. Weathers dark gray; very thin to thin bedded; some silicified fractures; moderately resistant; ledge-forming.......... 20.0 (66)

8 Dolomite, medium-light-gray, finely crystalline. Weathers dark gray; intraformational breccia (averages ≤2.5 cm.); very thin to thin bedded; moderately resistant; slope-forming...................... 22.4 (73)

7 Dolomite, fossiliferous, medium-light-gray, finely crystalline. Contains brachiopods, rugose corals. Weathers medium dark gray; thick bedded; resistant; ledge-forming.............................. 1.6 (5)

6 Dolomite, medium-light-gray and medium-dark-gray, finely crystalline. Weathers medium light gray to medium dark gray; laminated to thin bedded; moderately resistant; forms small ledges and slope...... 109.5 (359)

5 Covered....................................... 26.3 (86)

4 Limestone, medium-light-gray and light-gray, finely to medium crystalline. Weathers moderate reddish brown with interbeds of medium light gray limestone; some silicification; ferric and ferrous mineralization; thin bedded; weakly resistant; slope-forming. 95.6 (314)

3 Covered.. 12.2 (40)

Total Guilmette Formation............... 474.7 (1557)

Simonson Dolomite:

Unit	Description	Metres (Feet)
2	Dolomite, very light-gray to medium-gray, finely to coarsely crystalline. Weathers light brownish gray to very light gray; laminated to thin bedded; tends to be a mineralized marble with stringers of ferrous stain; moderately resistant except for the lower third which is very friable; slope-forming with few ledge outcrops..............................	212.5 (697)

Total measured section.................. 755.8 (2480)

Intrusive contact

1 Granite.

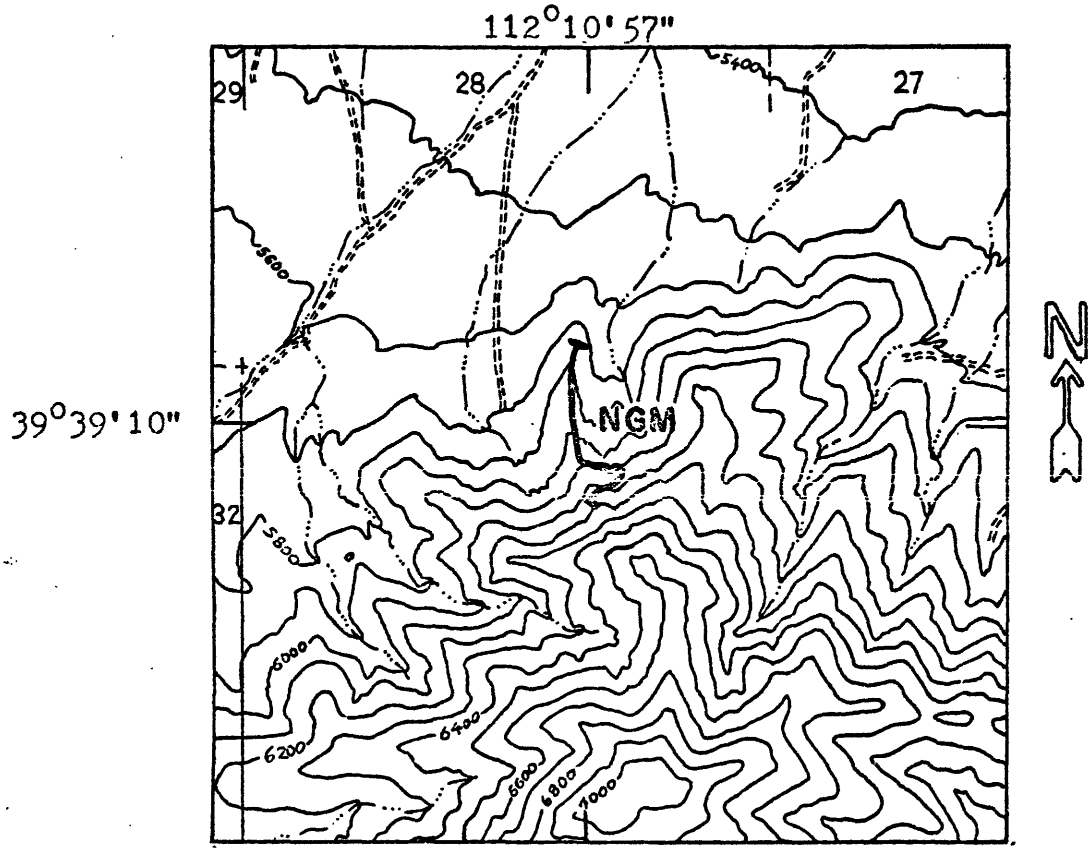

Figure 20. North Gilson Mountains (NGM), NW¼ NE¼ sec. 33, T. 13 S., R. 3 W. (unsurveyed), Juab County, Utah. Jericho 7½-minute quadrangle. C. I. = 100 feet, scale = 1:24000.

North Gilson Mountains (NGM), Gilson Mountains, Utah

On slope extending along the north side of the Gilson Mountains, NW¼ NE¼ sec. 33, T. 13 S., R. 3 W. (unsurveyed), Juab County, Utah (fig. 19). Jericho 7½-minute quadrangle (fig. 20). Measurements made by tape. All thicknesses rounded to the nearest tenth of a metre. Beds strike approximately N. 40° W. and dip 20° SW. Unit 1 is at north end of traverse.

DEVONIAN:

Lower part of the Fitchville Formation:

Unit	Description	Metres (Feet)
14	Lime grainstone, fossiliferous, pelletal, medium-dark-gray. Contains silicified brachiopods, crinoidal debris, gastropods, rugose corals (up to 5 cm. long), syringopora corals. Conodont sample, NGM-1C, collected from this unit by C. A. Sandberg in 1975, contains fauna indicative of Bispathodus costatus Zone or Protognathus Fauna. Weathers medium gray; thich bedded; fetid odor emitted when struck by hammer; moderately resistant; ledge-and slope-forming....................................	32.4 (106)
13	Limestone, fossil fragmental, pelletal, limonitic, silty, medium-dark-gray, microcrystalline. Contains silicified brachiopods, crinoidal debris, syringopora corals. Conodont sample, NGM-1, contains one broken Polygnathus communis indicative of Famennian, Kinderhookian, or Osagean age. Weathers medium light gray; thick bedded; many calcite filled fractures; moderately resistant; slope-forming....................................	3.8 (12)
12	Dolomite, light-gray, slightly chertified, fossiliferous at base, coarsely crystalline. Contains crinoidal debris(?) at base. Weathers light gray; very thick bedded; massive; highly resistant; forms cliff....................................	26.2 (86)
11	Covered....................................	1.8 (6)

Pinyon Peak Limestone:

Unit	Description	Metres (Feet)
10	Limestone, fossil fragmental, pelletal(?), silty,	

medium-light-gray, coarsely crystalline. Contains crinoidal debris. Conodont sample, NGM-2 contains fauna indicative of Upper Polygnathus styriacus Zone. Weathers medium light gray; thick bedded near top to thin bedded near base; weakly resistant; slightly covered; slope-forming........................ 52.0 (171)

Total Pinyon Peak Limestone............. 48.5 (160)

Cove Fort Quartzite:

Unit	Description	Metres (Feet)
9	Siltstone, calcareous, limonitic, light-olive-gray. Weathers grayish orange; thin bedded; flaggy; sandy at base; weakly resistant; slope-forming.....	3.5 (11)

Total Cove Fort Quartzite................. 3.5 (11)

Disconformity

Guilmette Formation:

Unit	Description	Metres (Feet)
8	Dolomite, fossil fragmental, limonitic, medium-light-gray to medium-dark-gray, finely crystalline. Contains fish remains. Conodont sample, NGM-1E, collected by C. A. Sandberg in 1975, contains Pandorinellina insita Fauna. Weathers medium dark gray; thick bedded; ledge-forming............	38.5 (126)
7	Quartz arenite, calcareous, pelletal(?), medium-light-gray, fine- to medium-grained, rounded, poorly sorted. Weathers, medium light gray; cross laminated; highly resistant; ledge-forming...	7.4 (24)

Total Guilmette Formation................ 45.9 (151)

Simonson Dolomite--Sevy Dolomite ndifferentiated:

Unit	Description	Metres (Feet)
6	Dolomite, olive-gray, cryptocrystalline. Weathers pale blue; thick bedded; moderately resistant; slope-forming................................	4.8 (16)
5	Dolomite, peloidal, silty, limonitic, very fine quartz sandy (< 4%), light-gray, sucrosic, microcrystalline. Weathers light gray, thick to very thick bedded; moderately resistant; ledge-	

forming.................................... 19.2 (63)

4 Dolomite, limonitic, pelletal(?), olive-gray, cryptocrystalline. Weathers light gray to medium light gray; laminated and thick bedded; highly fractured; weakly resistant; slope-forming....................... 29.3 (96)

3 Covered. Float indicates: quartz arenite, calcareous, silty, moderate-reddish-orange, fine-grained. 5.8 (19)

2 Dolomite, limonitic, light-gray to medium-light-gray, sucrosic, very finely to finely crystalline. Weathers light gray to medium light gray; thick to very thick bedded; highly resistant; ledge-forming.................................... 54.7 (179)

Total Simonson Dolomite--Sevy Dolomite undifferentiated..................... 113.8 (373)

SILURIAN:

Laketown Dolomite:

Unit	Description	Metres (Feet)
1	Dolomite, limonitic, chertified, fossil fragmental, medium-light-gray, sucrosic, microcrystalline to finely crystalline. Contains silicified brachiopods, Rhynchospirina(?). Weathers medium light gray; chert weathers brownish gray; thick to very thick bedded; highly resistant; ledge-forming..............	59.0 (194)

Total measured section.................. 338.4 (1110)

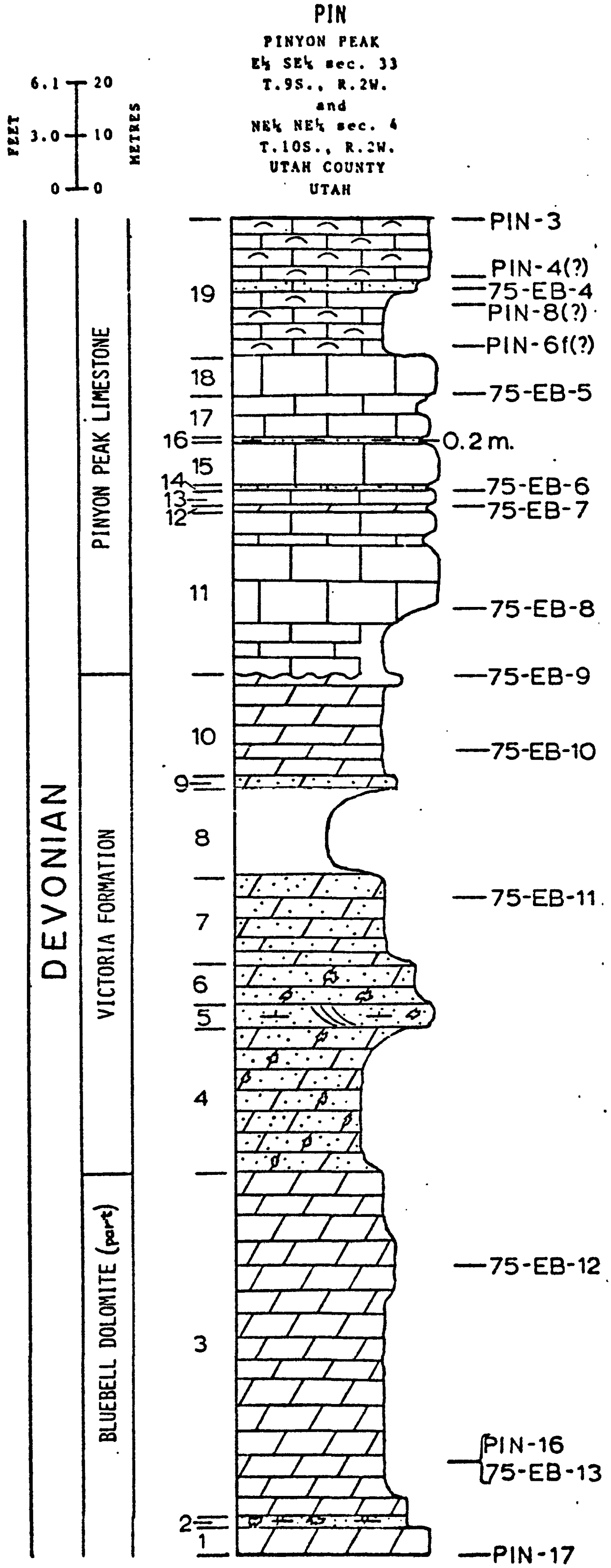

Figure 21. Measured section at Pinyon Peak.

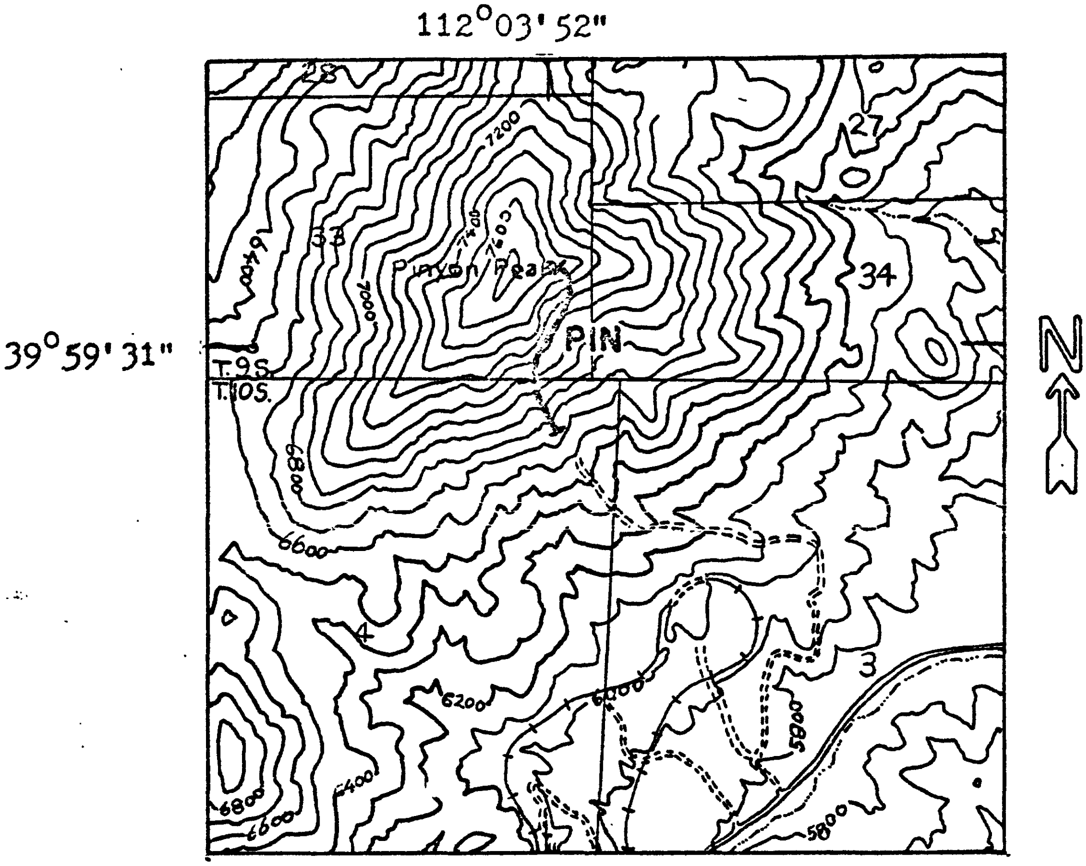

Figure 22. Pinyon Peak (PIN), E½ SE¼ sec. 33, T. 9 S., R. 2 W. and NE¼ NE¼ sec. 4, T. 10 S., R. 2 W., Utah County, Utah. Eureka 7½-minute quadrangle. C. I. = 100 feet, scale = 1:24000.

Pinyon Peak (PIN), Tintic Mining District, Utah

On slope extending along the upper part of the southeastern side of Pinyon Peak, E½ SE¼ sec. 33, T. 9 S., R. 2 W. and NE¼ NE¼ sec. 4, T. 10 S., R 2 W., Utah County, Utah (fig. 21). Eureka 7½-minute quadrangle (fig. 22). Measurements made by tape. All thicknesses rounded to nearest tenth of a metre. Beds strike approximately N. 20° W. and dip 15° SW. Unit 1 is at south end of traverse.

DEVONIAN:

Pinyon Peak Limestone:

Unit	Description	Metres (Feet)
19	Limestone, fossiliferous, limonitic, medium-dark-gray, microcrystalline. Contains crinoidal debris, rugose corals, sponge spicules. Brachiopod sample, PIN-6f, from float contains Paurorhyncha sp. which is indicative of Upper Devonian. Conodont samples, PIN-3, 4, 8, collected from this unit by C. A. Sandberg in 1969, contain fauna indicative of Upper Polygnathus styriacus Zone (Sandberg, in press, table 1, loc. 11). Weathers light gray; thick bedded; mottled at base; moderately resistant; ledge-forming..........	25.9 (85)
18	Lime grainstone, pelletal, olive-gray. Weathers light gray; thick to very thick bedded; massive; highly resistant; forms cliff................	8.5 (28)
17	Lime grainstone, pelletal, limonitic, olive-gray. Weathers light gray to medium dark gray; thick to very thick bedded; nodular appearance; calcite filled fractures; moderately resistant; ledge-forming....................................	7.0 (23)
16	Siltstone, calcareous, light-reddish-brown Weathers olive gray; laminated; weakly resistant; slope-forming............................	0.2 (0.7)
15	Lime grainstone, pelletal, light-gray. Weathers light gray; thick to very thick bedded; massive; highly resistant; forms cliff................	7.2 (23.6)
14	Lime mudstone, quartz sandy (approximately 40-50%), olive-gray. Weathers olive gray; thin bedded; weakly resistant; slope-forming.............	0.5 (1.6)
13	Same as unit 18. Forms reentrant at base....	3.1 (10)

12	Dolomite, limonitic, medium-dark-gray, very finely crystalline. Weathers medium gray; very thin bedded; weakly resistant; forms reentrant..................................	0.6 (2)
11	Same as unit 18. Generally forms cliffs; re-entrant approximately 5.5 m. below top; slope forming as base which is slightly covered....	31.0 (102)
	Total Pinyon Peak Limestone.............	84.0 (276)

Disconformity

Victoria Formation:

Unit	Description	Metres (Feet)
10	Dolomite, silty, light-gray to medium-dark-gray, sucrosic, finely crystalline. Weathers light gray to medium dark gray; laminated to thin bedded; intraformational breccia in lower 18 m.; weakly resistant; slope-forming.....................	20.6 (67)
9	Dolomite, quartz sandy (approaches 60%), light-gray to medium-dark-gray, cryptocrystalline. Weathers light gray to medium dark gray; laminated; cross laminated; middle part of this unit contains a thin moderate reddish brown shale (0.05 m. thick) and a medium to coarse grained, subrounded, well sorted, grayish brown quartz arenite (0.2 m. thick) moderately resistant; ledge-forming..........	2.3 (7.5)
8	Covered..	16.7 (55)
7	Dolomite, quartz sandy (40-50%), light-gray to medium-dark-gray, finely crystalline. Weathers light gray and medium dark gray; thin to thick bedded; moderately resistant; slope-forming..	15.1 (50)
6	Same as unit 7. Intraformational brecciation; ledge-forming................................	8.0 (26)
5	Quartz arenite, calcareous, light-moderate-red and yellowish-orange, very fine-grained, subrounded, well sorted. Weathers light moderate red and yellowish orange; cross laminated; large angular breccia fragments similar in lithology to the matrix; highly resistant; ledge-forming.............	3.4 (11)
4	Same as unit 6................................	27.2 (89)

Total Victoria Formation................ 93.3 (306)

Bluebell Dolomite (upper beds):

Unit	Description	Metres (Feet)
3	Dolomite, limonitic, micritic(?), light-gray to medium-light-gray, cryptocrystalline. Conodont sample, PIN-16, contains fauna (*Diplododella* sp., *Hindeodella* sp., *Icriodus* cf. *I. alternatus*, *Neoprioniodus* sp., *Ozarkodina* sp., *Polygnathus webbi*, *Scutula* sp., ramiform elements) indicative of Frasnian age. Weathers light gray to medium light gray; laminated to thin bedded; slope-forming....................................	65.0 (215)
2	Sublithic arenite, calcareous, light-brown and light-gray, very fine-grained, subrounded, poorly sorted. Weathers light brown and light gray; thick to very thick bedded; contains dolomite breccia fragments; moderately resistant; slope-forming...	2.4 (8)
1	Dolomite, limonitic, medium-gray, sucrosic, very finely crystalline. Contains fish remains. Conodont sample, PIN-17, contains fauna (*Diplododella* sp., *Hibbardella*, *Hindeodella* sp., *Icriodus*, *Neoprioniodus* sp., *Nothognathella*, *Ozarkodina* sp., *Polygnathus angustidiscus*, *Polygnathus dubius*, *Polygnathus xylus*) indicative of Frasnian age. Weathers medium gray; thick to very thick bedded; highly resistant; ledge-forming....................................	6.0 (20)

Total measured section.................. 250.7 (822)

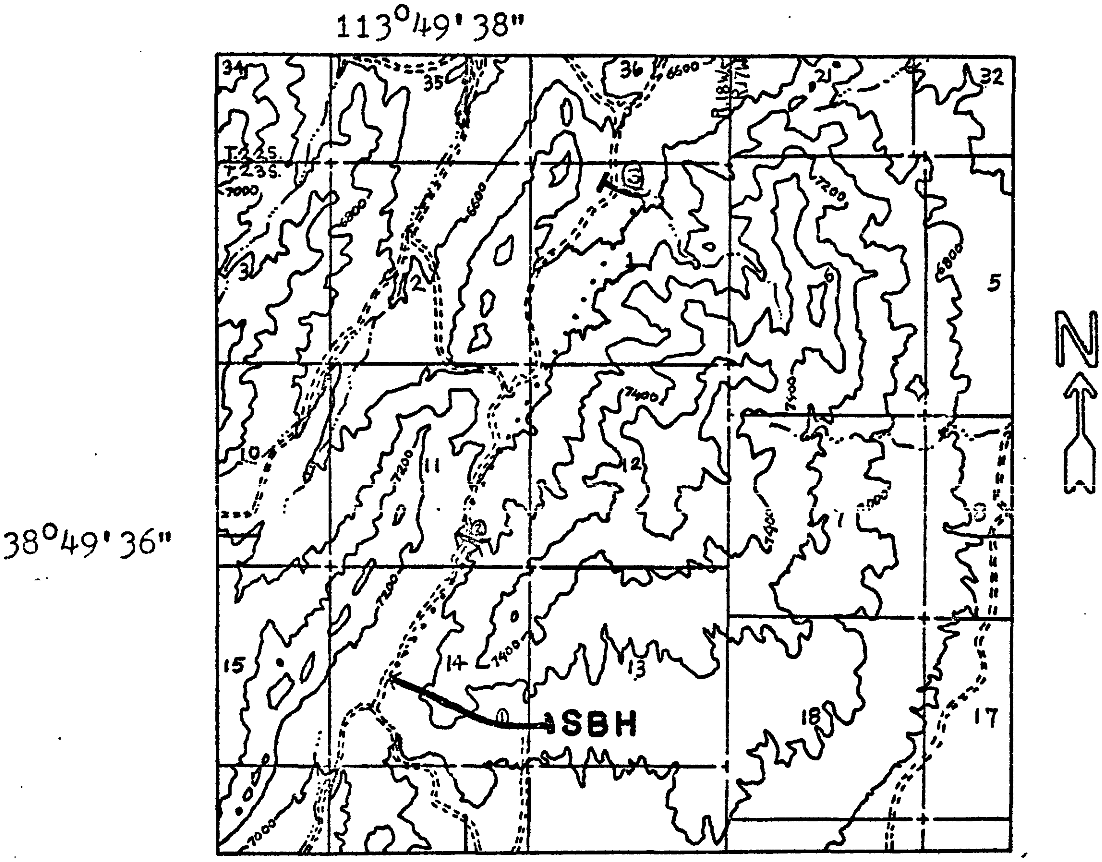

Figure 24. South Burbank Hills (SBH), N½ sec. 1 and SW¼ SE¼ sec. 11 and SW¼ SW¼ sec. 13 and S½ sec. 14, T. 23 S., R. 18 W., Millard County, Utah. Burbank Hills 15-minute quadrangle. C. I. = 200 feet scale = 1:62500.

South Burbank Hills (SBH), Burbank Hills, Utah

On slopes generally parallel and southeast of Big Jensen Pass road, N½ sec. 1 and SW¼ SE¼ sec. 11 and SW¼ SW¼ sec. 13 and S½ sec. 14, T. 23 S., R. 18 W., Millard County, Utah (fig. 23). Burbank Hills 15-minute quadrangle (fig. 24). Measurements made by a combination of tape and Jacob's staff. All thicknesses rounded to nearest tenth of a metre. Beds strike approximately N. 25° E. and dip 30° NW. Unit 1 is at east end of traverse leg 1, unit 18 at east end of traverse leg 2, and unit 21 at west end of traverse leg 3.

DEVONIAN:

Lower part of West Range Limestone:

Unit	Description	Metres (Feet)
21	Limestone, fossiliferous, limonitically silty, hematitic, sandy, medium-light-gray to medium-dark-gray, phenoplast conglomeratic, medium crystalline. Contains brachiopods, phosphatic fossil hash. Conodont sample, SBH-12, collected from this unit by C. A. Sandberg in 1975, contains fauna indicative of Middle _Palmatolepis crepida_ Zone. Conodont sample, SBH-13, contains fauna (_Apatognathus varians_, _Hindeodella_, _Palmatolepis minuta minuta_, _Palmatolepis quadrantinodosalobata_, _Pelekysgnathus planus_) indicative of Lower _Palmatolepis crepida_ Zone. Weathers medium light gray to medium dark gray; thin bedded; the lower part contains a thin, medium light gray, very fine- to fine-grained, subrounded, quartz sandy (50-60%) limestone; moderately resistant; generally forms slopes but also is ledge-forming.............	104.0 (341)
20	Shale, calcareous, hematitic, medium-light-gray. Weathers medium light gray; laminated; fissile; weakly resistant; forms slope................	14.0 (46)
	Total lower part of West Range Limestone.	118.0 (387)

Guilmette Formation:

Unit	Description	Metres (Feet)
19	Quartz arenite, calcareous, limonitic, light-red and light-brownish-gray, very fine-to medium-grained, subangular, well sorted, good porosity and permeability. Weathers light red and light brownish gray; very thick bedded; massive; highly resistant; ledge-forming......................	14.0 (46)

18 Limestone, silty, slightly quartz sandy, medium-dark-gray, phenoplast conglomeratic, very finely crystalline. Contains silicified brachiopods, fish remains. Conodont sample, SBH-14, contains fauna (Angulodus, Palmatolepis delicatula, Palmatolepis gigas, Palmatolepis subrecta, Polygnathus angustidiscus, Polygnathus brevis, Polygnathus cf. dubius, Polygnathus xylus(?), Polygnathus webbi) indicative of Upper Palmatolepis gigas Zone. Weathers medium light gray; thin to thick bedded; moderately resistant slope-forming.. 47.0 (154)

17 Quartz arenite, calcareous, light-red and light-brownish-gray, fine- to medium-grained, subangular to subrounded, well sorted, good porosity and permeability. Contains subhorizontal boring tubes at the top of the unit. Weathers light red and light brownish gray; very thick bedded; massive; highly resistant; ledge-forming.............. 25.0 (82)

16 Limestone, fossiliferous, quartz sandy, medium-light-gray to medium-dark-gray, slightly mottled, microcrystalline. Conodont sample, SBH-15A, contains silicified gastropods, silicified anthozoans (Alveolites sp.) indicative of Silurian or Devonian age, silicified brachiopods (Tenticospirifer sp.) indicative of Upper Devonian age, conodont fauna (Ancyrodella nodosa, Elsonella sp., Ozarkodina sp., Palmatolepis delicatula(?), Palmatolepis foliacea transitional to Palmatolepis linguiformis, Palmatolepis gigas, Palmatolepis subrecta, Palmatolepis unicornis, Polygnathus brevis, Polygnathus webbi, Polygnathus xylus(?), Scutula bipennatus) indicative of Upper Palmatolepis gigas Zone. Brachiopod fossil collection, SBH-4f, contains fauna (Calvinaria albertensis albertensis (Warren), Calvinaria albertensis opima(?)) indicative of Frasnian age; SBH-3f, contains fauna (Calvinaria albertensis feni(?)) indicative of Frasnian age; SBH-18f, contains fauna (Tenticospirifer sp.) indicative of Upper Devonian age. Ammonoid fossil collection, SBH-16bf, contains fauna (Manticoceras sp.) indicative of Devonian age. Conodont sample, SBH-17A, contains fauna (Palmatolepis foliacea) indicative of Lower Palmatolepis gigas Zone. Conodont sample, SBH-18, contains fauna indicative of Lower Palmatolepis gigas Zone. Weathers light medium gray to medium dark gray; thin to thick bedded; quartz sand is bimodal (silt to very fine-grained, angular and medium- to coarse-grained, rounded, frosted); nodular at base; moderately resistant; ledge- and slope-forming.......... 145.0 (476)

15 Dolomite, fossiliferous, limonitic, medium-gray and brownish-gray; microcrystalline. Contains algal heads and oncolites, Amphipora sp. Weathers medium gray to brownish gray; thin to thick bedded; many alternating light and dark layers; moderately resistant; ledge-forming........................ 71.0 (233)

14 Dolomite, fossiliferous, limonitic, medium-dark-gray, microcrystalline. Contains Amphipora sp., brachiopods, rugose corals. Weathers brownish gray; thin to thick bedded; moderately resistant; ledge-forming................................ 30.5 (100)

13 Dolomite, medium-dark-gray, microcrystalline. Weathers medium light gray; thin to thick bedded; moderately resistant; slope-forming.......... 16.5 (54)

12 Quartz arenite similar to unit 19; **dolomitic.** Dolomite same as unit 14..................... 20.0 (66)

11 Dolomite, fossiliferous, very light gray to brownish-gray, microcrystalline. Contains Amphipora sp., brachiopods. oncolites, rugose corals. Weathers very light gray to brownish gray; thin to thick bedded; moderately resistant; ledge- and slope-forming. 81.0 (266)

10 Limestone, fossil fragmental, medium-gray, microcrystalline. Contains brachiopods, crinoidal debris, echinodermal debris. Weathers medium light gray; thin to thick bedded; moderately resistant; ledge-forming................................ 15.0 (49)

9 Dolomite, fossiliferous, limonitic, medium-gray, cryptocrystalline. Contains brachiopods. Weathers brownish gray; laminated to thin bedded; moderately resistant; slope-forming.................... 16.5 (54)

8 Limestone, fossil fragmental, olive-gray to medium-gray, slightly mottled, cryptocrystalline. Contains Amphipora sp., Alveolites sp., gastropods, oncolites, rugose corals. Weathers brownish gray to medium dark gray; thin to thick bedded; many calcite filled fractures; moderately resistant; ledge- and slope-forming.................................... 67.0 (220)

7 Limestone, dolomitic, fossiliferous, medium-light-gray, microcrystalline. Contains Amphipora sp., crinoidal debris, oncolites (1 cm. diameter), rugose corals. Weathers medium light gray; laminated to very thin bedded; fetid odor emitted when struck by hammer;

much calcification of fossil debris; moderately resistant; slope-forming.................... 19.5 (64)

6 Limestone, fossiliferous, medium-light-gray to medium-gray, nodular, microcrystalline. Contains *Alveolites* sp., brachiopods, crinoidal debris, limonitic and hematitic calcispheres, oncolites. Weathers medium light gray to medium gray; laminated to thin bedded; moderately resistant; slope-forming.................................... 20.2 (66)

5 Limestone, pelletal, silty, olive-gray, cryptocrystalline. Contains oncolites. Weathers medium light gray; thin bedded; moderately resistant; slope-forming.................................... 25.0 (82)

4 Limestone, fossiliferous, limonitic, micritic, olive-gray to medium-dark-gray, microcrystalline. Contains brachiopods, oncolites. Conodont sample, SBH-20, contains fauna (*Hindeodella* sp., *Icriodus expansus*, *Ozarkodina* sp., *Pandorinellina insita*, *Synprioniodina* sp.) indicative of *Pandorinellina insita* Fauna. Weathers medium light gray to medium gray; laminated to thin bedded; some silicification; moderately resistant; slope-forming.......... 32.5 (107)

3 Limestone, algal, fossil fragmental, silty, olive-gray, slightly mottled, microcrystalline. Contains silicified algal heads, *Alveolites* sp., oncolites, ostracods (at base). Weathers medium light gray; thinly laminated to thin bedded; moderately resistant; ledge- and slope-forming............. 85.0 (279)

2 Dolomite, brecciated, slightly calcitic, fossiliferous, medium-dark-gray to olive-gray, microcrystalline. Contains *Atrypa* sp., biserial gastropods. Weathers medium light gray to brownish gray; thin to thick bedded; many fractures filled with calcite; weakly to moderately resistant; slope-forming....... 62.3 (204)

1 Limestone, fossiliferous, silty, medium-dark-gray, nodular, cryptocrystalline at base. Contains brachiopods, gastropods. Weathers brownish gray; thin to thick bedded; many fractures filled with calcite; brecciated at base due to folding(?); weakly to moderately resistant; ledge- and slope-forming.................................... 78.0 (256)

Total measured section.................. 989.0 (3244)