# Silurian, Devonian, and Mississippian Formations of the Funeral Mountains in the Ryan Quadrangle, Death Valley Region, California

GEOLOGICAL SURVEY BULLETIN 1386

*Work done partly in cooperation with the California Division of Mines and Geology*

# Silurian, Devonian, and Mississippian Formations of the Funeral Mountains in the Ryan Quadrangle, Death Valley Region, California

*By* JAMES F. McALLISTER

GEOLOGICAL SURVEY BULLETIN 1386

*Work done partly in cooperation with the California Division of Mines and Geology*

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1974

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress Catalog-card No. 73-600357

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington, D. C. 20402 - Price $1.60 (paper cover)
Stock No. 2401-02476

# CONTENTS



# ILLUSTRATIONS

# TABLES

# SILURIAN, DEVONIAN, AND MISSISSIPPIAN FORMATIONS OF THE FUNERAL MOUNTAINS IN THE RYAN QUADRANGLE, DEATH VALLEY REGION, CALIFORNIA

By JAMES F. MCALLISTER

ABSTRACT

A composite section of the Silurian, Devonian, and Mississippian formations in the Funeral Mountains between Death Valley and Amargosa Valley is about 4,700 feet thick. The formations are in the top of a concordant, complexly faulted sequence that is about 25,000 feet thick from the highest part of the Precambrian to the Upper Mississippian. The Silurian and younger formations consist of marine dolomite and limestone that contain some regionally characteristic cherty and siliceous clastic beds as well as widely spaced fossiliferous zones.

The Hidden Valley Dolomite, overlying the Ordovician Ely Springs Dolomite, is 1,440 feet thick except in the southeast end of the area where it is 870 feet thick. Cherty dark dolomite in the lower part of the Hidden Valley contains Silurian (possibly Llandovery, clearly Wenlock, and probably Ludlow) fossils; dolomite in a somewhat argillaceous and silty uppermost part contains Lower Devonian (upper Emsian) fossils.

The Lost Burro Formation, 2,640 feet thick, has Middle Devonian (Givetian) fossils stratigraphically high in the lower part of the formation, which consists of dolomite above the basal Lippincott Member. It has Upper Devonian (Frasnian) fossils midway in the upper part, which consists predominantly of limestone.

The Tin Mountain Limestone, 315 feet thick, contains abundant Lower Mississippian (Kinderhookian and Osagean) fossils.

The Perdido Formation, which is incomplete and no more than 500 feet thick under unconformable Cenozoic continental rocks, consists mostly of limestone, chert, and siltstone. Fossils, which are scarce, include Upper Mississippian (Meramecian) microfossils 205 feet above the base of the Perdido.

## INTRODUCTION

A complexly faulted stratigraphic sequence of Precambrian to Mississippian marine sedimentary rocks is exposed for a distance of 18 miles in the Ryan quadrangle (fig. 1), in the southeastern part of the Funeral Mountains between Death Valley and Amargosa Valley in Inyo County, Calif. The whole exposed sequence is about 25,000 feet thick, of which the Paleozoic portion is about 16,500 feet,

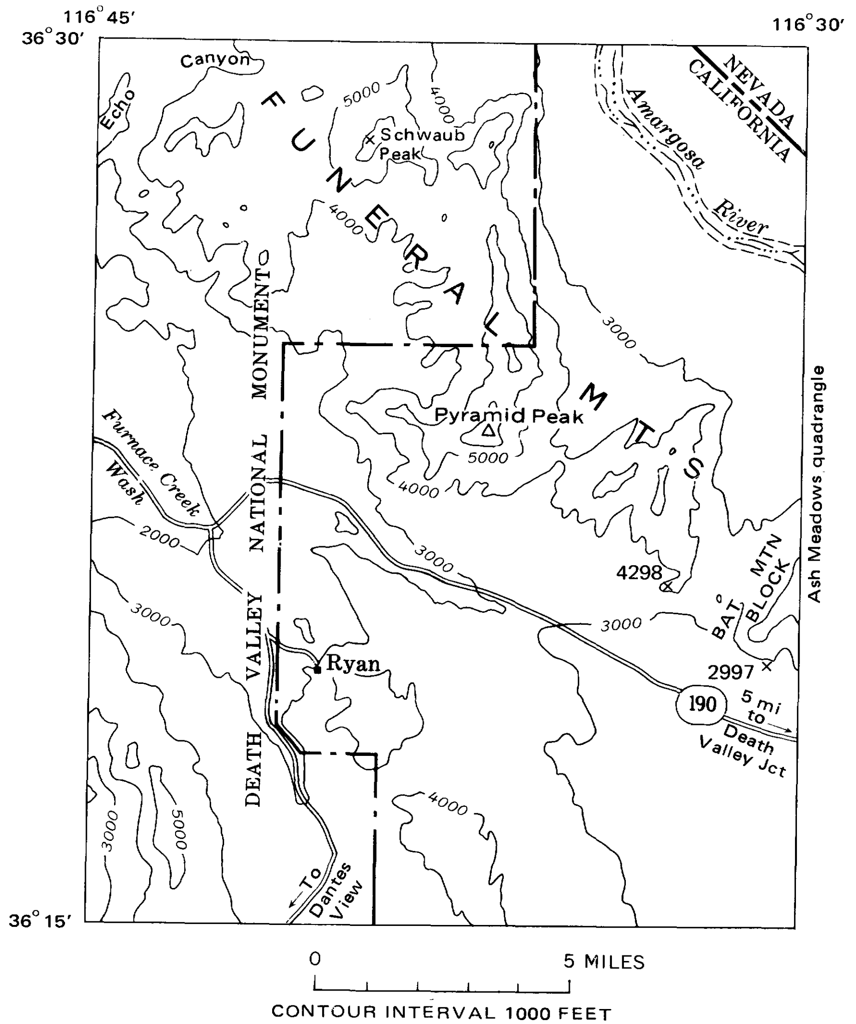


FIGURE 1.—Index map of the Ryan quadrangle. Locality information in the text is intended for plotting on the published topographic map.

and the Silurian, Devonian, and Mississippian formations together are about 4,700 feet. The sequence, as mapped in the Ryan quadrangle (McAllister, 1971), is assigned entirely to formations that have been recognized in the surrounding region (table 1) .

The Silurian through Mississippian sequence in the Ryan quadrangle consists of the Hidden Valley Dolomite of Silurian and Early Devonian age, the Lost Burro Formation of Middle and Late Devonian age, the Tin Mountain Limestone of Early Mississippian age, and the Perdido Formation of Early? and Late Mississippian age

TABLE 1.–*Precambrian and Paleozoic formations of the Funeral Mountains in the Ryan quadrangle*

| System | Series | Formation or group | Thickness[1] (feet) |
|---|---|---|---|
| Mississippian | Upper | Perdido Formation | 500 |
| | Lower | Tin Mountain Limestone | 300 |
| Devonian | Upper | Lost Burro Formation | 2,500 |
| | Middle | | |
| | Lower | Hidden Valley Dolomite | 1,400 |
| Silurian | | | |
| Ordovician | Upper | Ely Springs Dolomite | 500 |
| | Middle | Eureka Quartzite | 400 |
| | Lower | Pogonip Group | 2,200 |
| Cambrian | Upper | Nopah Formation | 1,700 |
| | Middle | Bonanza King Formation | 3,600 |
| | | Carrara Formation | 1,600 |
| | Lower | Zabriskie Quartzite | 800 |
| | | Wood Canyon Formation | [2] 4,000 |
| Precambrian | | Stirling Quartzite | [2] 4,800 |
| | | Johnnie Formation | 1,000 |

[1] Maximum measurement, rounded to nearest hundred feet
[2] Stewart (1970)

(pl. 1). A preliminary map shows the distribution of these formations in the quadrangle (McAllister, 1971). The type localities of the formations are in the Quartz Spring area or north of Ubehebe Peak (McAllister, 1952) between 50 and 65 miles west-northwest of the occurrences in the Funeral Mountains. Specialized studies of the formations at or near the type localities describe faunas and stratigraphy of the Tin Mountain and the Perdido (Langenheim and Tischler, 1960), occurrences of conodonts in uppermost Lost Burro (Youngquist and Heinrich, 1966) and the lower part of the Hidden Valley (Miller and Hanna, 1972), and petrology of the Lost Burro Formation (Zenger and Pearson, 1969).

These formations are used in the Funeral Mountains on the east side of Death Valley, in the Panamint Range (McAllister, 1952, 1956; Hall and Stephens, 1962; Hunt and Mabey, 1966; Hall, 1971) and in the Last Chance Range (Burchfiel, 1969) on the west side of Death Valley, and as far west as the Argus Range and the Inyo Mountains (McAllister, 1956; Hall and MacKevett, 1962; Hall and Stevens, 1962, 1963; Merriam, 1963a; Hall, 1971). But east of the Funeral Mountains, in Nevada, formations within the equivalent stratigraphic sequence have different names and boundaries (Burchfiel, 1964; Tschanz and Pampeyan, 1970), as established in Nevada and Utah. Published diagrams show broad correlations of the Hidden Valley Dolomite (Ross, 1966, pl. 5; Berry and Boucot, 1970, pl. 2; Tschanz and Pampeyan, 1970, fig. 13), the Lost Burro Formation (Poole and others, 1967, fig. 2b; Tschanz and Pampeyan, 1970, fig. 13), and the Tin Mountain Limestone and the Perdido Formation (Langenheim and Tischler, 1960, fig. 5). Discussion of their regional correlation is deferred to a subsequent report.

The first published reference to the post-Ordovician part of the Paleozoic sequence in the Funeral Mountains apparently is the comment by Noble (1934, p. 177) that the section is nearly as complete as in the Nopah Range and contains abundant Mississippian fossils at the southeast end of the Funeral Mountains. The pre-Mississippian stratigraphy and some faunas are treated in theses by Richards (1957) and Kesse (1963). At the southeast tip of the Funeral Mountains, Silurian to Mississippian formations extend from the Ryan quadrangle into the margin of the Ash Meadows quadrangle where they were mapped and described by Denny and Drewes (1965, pl. 1, p. L9–L11).

Formations in the pre-Silurian part of the sequence in the Ryan quadrangle (table 1) are summarized—and some are described by stratigraphic sections—in reports by Yochelson, McAllister, and Reso (1965, fig. 4), Ross (1967, p. D32–D34), Stewart (1970, pl. 1, p. 91–97), and McAllister (1970, p. 2–3).

## ACKNOWLEDGMENTS

The fieldwork, done mostly between 1960 and 1970, was part of a cooperative program of the U.S. Geological Survey and the California Division of Mines and Geology to learn more about the geologic setting of borate deposits in Tertiary rocks between Death Valley and Amargosa Valley. Donald W. Reeser ably assisted in the field during a brief period. On short field trips, Forrest G. Poole helpfully compared part of the stratigraphic sequence with his sections in southern Nevada, and I. Gregory Sohn collected Mississippian ostracodes. Professor William B. N. Berry of the University of California, Berkeley, and the following U.S. Geological Survey paleontologists, identified the fossils and commented on their stratigraphic significance: J. Thomas Dutro, Jr., Mackenzie Gordon, Jr., John W. Huddle, Charles W. Merriam, William A. Oliver, Jr., William J. Sando, Betty Skipp, I. Gregory Sohn, and Ellis L. Yochelson. It is a pleasure also to acknowledge the cordial cooperation of members of the National Park Service in Death Valley National Monument and their helpful concern about solitary work in the National Monument.

## SILURIAN AND DEVONIAN SYSTEMS

### HIDDEN VALLEY DOLOMITE

The Hidden Valley Dolomite, of Silurian and Devonian age, lies concordantly on the Ordovician Ely Springs Dolomite and under dolomite of the Devonian Lost Burro Formation. The Hidden Valley is distinguished by marker beds at the boundaries and by rocks of a characteristic sequence of colors visible on the mostly bare mountainsides. The lower boundary is marked by a dark layer of cherty dolomite below less resistant, brown-tinged beds and above contrastingly lighter gray chertless dolomite at the top of the Ely Springs. The upper boundary is at the top of a bench-forming pinkish- and yellowish-gray dolomite and at the base of the brown-weathering Lippincott Member of the Lost Burro Formation. The Hidden Valley Dolomite is divided into a medium- to dark-gray lower member and a lighter gray much thicker upper member. The lower member consists of well-bedded dolomite containing chert and widely distributed Silurian fossils, whereas the upper member consists in general of obscurely bedded dolomite that is apparently barren except for Devonian fossils in the uppermost part. The Hidden Valley Dolomite and the underlying sequence down to the Bonanza King formation are clearly displayed along the skyline of Schwaub Peak (fig. 2) and can be easily viewed from the road to Dantes View.

A complete section of the Hidden Valley Dolomite (fig. 3) that contains the characteristic lithologic sequence of the formation in the quadrangle is designated a reference section and is used in the stratigraphic column on plate 1. The base of the section is 2.07 miles N. 51° W. of Pyramid Peak and the top is 1,500 feet S. 74° E. of the base. The Hidden Valley Dolomite in the reference section is 1,440 feet thick; the lower member is 520 feet, and the upper member is 920 feet. The stratigraphic column includes information from a supplementary measured section of the lower member (1.6 miles north of the reference section and about 3 miles northwest of Pyramid Peak) and some fossils from other localities.

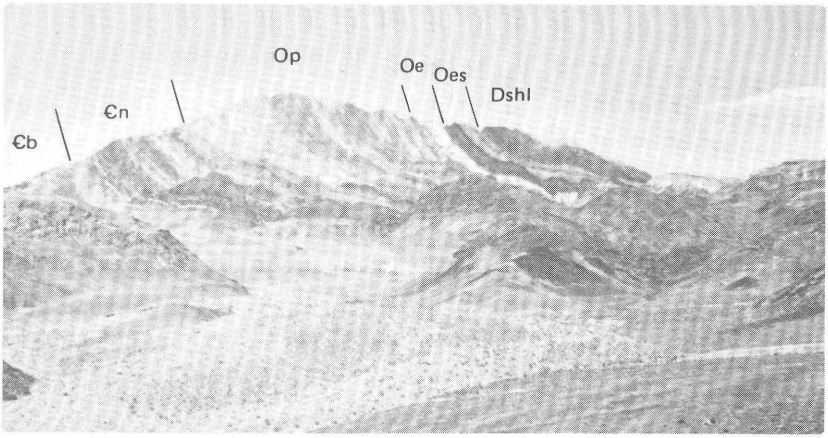


FIGURE 2.—Northward view of Schwaub Peak. Skyline profile shows stratigraphic sequence from lower part of Hidden Valley Dolomite (DShl) down through Ely Springs Dolomite (Oes), Eureka Quartzite (Oe), Pogonip Group (Op), Nopah Formation (€n), to Bonanza King Formation (€b).

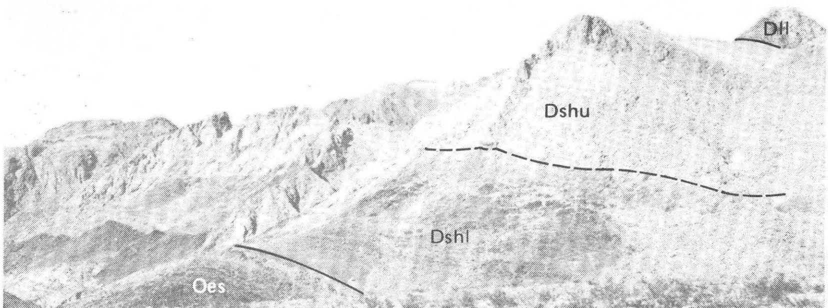


FIGURE 3.—Hidden Valley Dolomite 2 miles northwest of Pyramid Peak; reference section for the Funeral Mountains. Oes, Ely Springs Dolomite; DShl, lower member of Hidden Valley Dolomite, containing Silurian fossils; DShu, upper member of Hidden Valley Dolomite, containing Lower Devonian (upper Emsian) fossils near boundary with Lippincott Member of Lost Burro Formation (Dll) in saddle.

LOWER MEMBER (SILURIAN)

The lower member of the Hidden Valley Dolomite lies above light-gray and medium-gray chertless dolomite at the top of the Ely Springs Dolomite, which contains a sandy dolomite marker about 50 feet below the boundary. The member's basal unit (h1, pl. 1), which is about 20 feet thick, consists of medium-dark-gray dolomite that contains nodular chert. Generally the lower part of the unit is exposed as a ledge, and the upper part is concealed by rubble from overlying beds.

The middle unit (h2), about 100 feet thick, is less resistant and produces a generally concealing rubble that is a distinctive reddish brown and gray. The unit consists of thin-bedded medium- to light-gray very fine grained dolomite and subordinate interstratified chert (fig. 4). The chert characteristically is in very thin beds and in flat nodules. Argillaceous and silty material, which weathers to a distinctive reddish brown, is dispersed in some of the dolomite and it lines partings of flaggy beds. Intraformational conglomerate or sedimentary breccia in an 8-foot bed near the top of the unit consists of lithologically varied dolomite and chert fragments in a dolomite matrix. This bed contains conspicuous silicified *Favosites* and *Halysites*, characteristic fossils of the Silurian part of the Hidden Valley.

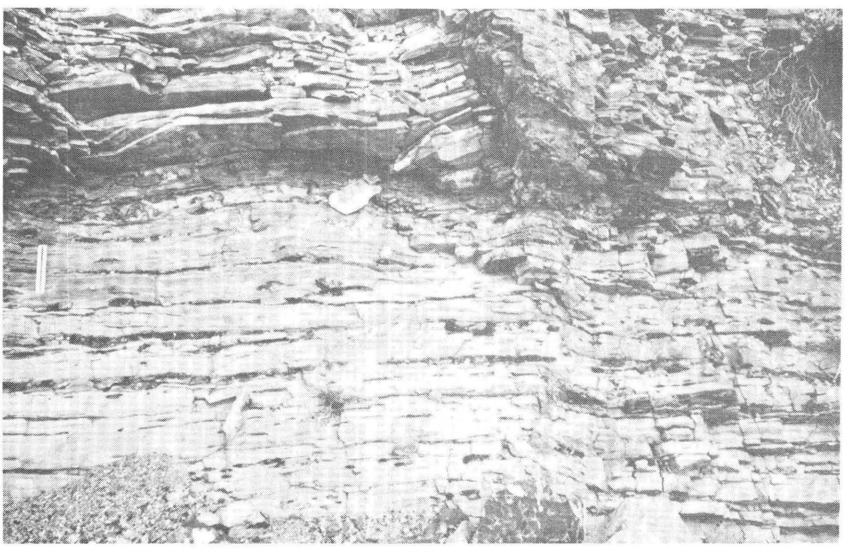

FIGURE 4.—Thin-bedded dolomite and dark-gray chert near base of Hidden Valley Dolomite. This unusually well exposed part of unit h2 is in a measured section about 1½ miles north of the reference section. Scale at left is 6 inches long.

The upper unit (h3) is by far the thickest unit of the member; it is 400 feet thick in the reference section, northwest of Pyramid Peak, and 480 feet thick in the supplementary section about 1½ miles farther north. The difference in thickness may result from the nature of the upper boundary, a gradational change in color and texture, which transects the bedding at the supplementary section.

The unit consists of medium- to dark-gray dolomite that contains nodular chert. Some of the darkest dolomite in the bottom part has vugs, clots, and networks of coarse white dolomite, resembling some dolomite in the lower part of the Ordovician Ely Springs Dolomite. Chert nodules of very irregular shape are sparse 100 feet above the base of the unit, become abundant about 80 feet higher, and disappear between 60 and 80 feet from the top. Fossils, which generally are silicified, occur throughout unit h3 but are more conspicuous in the upper part.

Collections of fossils from the lower member of the Hidden Valley Dolomite at widely scattered localities in the Funeral Mountains verify the Silurian age of the member. The collections include fossils definitely of Middle Silurian (Wenlock) age and a few that extend the range in age from possibly Early Silurian (Llandovery) into probably Late Silurian (Ludlow).

The lowest collection (JFM6659B, pl. 1), which is from thin-bedded unit h2 at a place less than 100 feet above the base of the formation southeast of Schwaub Peak, contains a diagnostic graptolite fragment. W. B. N. Berry (written commun., 1966) identifies the fragment of a rhabdosome as *Monograptus* sp. (*M. priodon* type) and comments

> The form is slender and may be a portion of the proximal region of *M. priodon* itself or it may be a part of a more slender form such as *M. parapriodon.* Age: Monograptids of the *M. priodon* type range in age from the Late Llandovery into the Wenlock. The more slender forms of this type and the thinner, shorter forms of *M. priodon* itself are essentially restricted to the Late Llandovery. Inasmuch as this specimen does appear to have come from either a slender member of the *M. priodon* group or from relatively slender form of *M. priodon* itself, I would suggest the age of the beds from which it came is Late Llandovery.

The same specimen is referred to by Berry and Boucot (1970, p. 162) as "indicative of an age in the span of Late Llandovery-Wenlock."

Higher in the same thin-bedded unit, 90–115 feet above the base of the Hidden Valley, a varied fauna that includes conspicuous *Favosites* and *Halysites* occurs in the dolomite matrix of sedimentary breccia and in closely associated silty dolomite. A collection (JFM-6354Ca) from the supplementary section about 1½ miles north of the reference section includes *Ryderophyllum, Pycnactis, Brachyelasma,* favositids, *Heliolites, Hesperorthis,* the cephalopods *Huronia* and *Huroniella,* and the large dasycladacean *Verticillopora.* Another collection (JFM661022J) from this persistently fossiliferous interval, at a locality about 3 miles east of the main section, includes *Halysites* (*Cystihalysites*) cf. *Halysites* (*Cystihalysites magnitubus*) Buehler, 1955, *Favosites* sp., *Brachyelasma* sp. B, and *Ryderophyllum* n. sp.

The fossils were identified by C. W. Merriam (written commun., 1971) who comments as follows:

This fossil assemblange is that characterizing Great Basin coral zone B of early Middle Silurian (early Wenlockian) age. In the Panamint Range reference section north of Ubehebe Peak it occurs in McAllister's [1952] Hidden Valley unit 1 about 325 feet above the base of the formation. Its most distinctive coral is the solitary lykophyllid *Ryderophyllum* n. sp. which I have given a species name in manuscript. Similar species occur in the Wenlockian of Gotland, Sweden. The *Brachyelasma* is a primitive solitary rugose coral occurring also in Late Ordovician rocks.

A varied fauna in the most fossiliferous part of unit h3 in the supplementary section is represented by a collection (JFM6354F2) from about 300 feet above the base of the Hidden Valley Dolomite. C. W. Merriam (written commun., 1971) states that this fauna, also assigned to coral zone B, is "***characterized by *Tryplasma, Halysites, Alveolites, Romingerella,* and *Cladopora.* Associated brachiopods include *Leptaena, Fardenia, Rhipidium, Atrypa, Atrypina,* and *Esopirifer* (*Striispirifer*). Lykophyllids, usually to be expected in coral zone B, were not found in this upper horizon." In the supplementary section *Halysites* is abundant in the uppermost part of the lower member.

A collection (JFM56120A) from about 450 feet above the base of the formation and near the top of the lower member in the reference section contains *Heliolites* sp., favositids, abundant ?*Syringaxon* sp., a pentameroid resembling *Cymbidium,* and abundant *Conchidium* sp. (C. W. Merriam, written commun., 1962, reviewed 1971). A. J. Boucot and J. G. Johnson (J. G. Johnson, written commun., 1965; Berry and Boucot, 1970, p. 161) report *Rhipidium* sp., indicating late Wenlock age, from an unspecified horizon at the same general locality.

Conodonts were recovered by J. W. Huddle from the matrix of megafossil collections (7299–SD, 7300–SD) from a 20-foot interval high in the lower member of the Hidden Valley Dolomite on spur 4298 (fig. 1, pl. 2). The associated, crudely silicified megafossils, as reported by W. A. Oliver, Jr. (written commun., 1964), include *Favosites* sp., *Syringopora* sp., thamnoporoid corals, horn corals, and Silurian halysitids. Huddle's report (written commun., 1965, amended 1971) giving the identification, number of specimens, and stratigraphic range of the conodonts, with comments, follows:

Collection 7300–SD:

| | | |
|---|---|---|
| *Ozarkodina* aff. *O. crassa* Walliser | 3 | Upper Silurian? |
| *Panderodus unicostatus* (Branson and Mehl) | 9 | M. Ord.-Sil., Dev.? |
| *Neoprioniodus*? sp. | 1 | Sil.-Triassic |

The *O.* aff. *O. crassa* in this collection looks like a form illustrated by Walliser, 1964, from the Ludlow of Germany. He considered it an aberrant form but included it in *O. crassa.*

Collection 7299–SD:

| | | |
|---|---|---|
| *Panderodus unicostatus* (Branson and Mehl) | 14 | M. Ord.-Sil., Dev.? |
| *Panderodus acostatus* (Branson and Mehl) | 13 | M. Ord.-Sil., Dev.? |
| *Spathognathodus primus*? (Branson and Mehl) | 1 | Silurian |
| *Ozarkodina* cf. *O. fundamentata* (Walliser) | 1 | Upper Silurian |

This collection seems to be Silurian in age and adds weight to the probable Late Silurian age of the previous collection.

The age of silicified fossils from the lower member at two other localities is reported as merely Silurian. About 2 miles east-northeast of the reference section, a collection (6843–SD) from unit h3 consists of *Cladopora* sp., *Syringaxon*? sp., and *Tryplasma*? sp., according to W. A. Oliver, Jr. (written commun., 1963). He reports *Cladopora* sp. also in a collection (6842–SD) about 55 feet stratigraphically lower, and another (colln. 6844–SD) about 100 feet higher in a biostrome of *Halysites* sp. The stratigraphically lowest of these collections was taken about 75 feet above the lower contact of thin-bedded unit h2, or an estimated 100 feet above the base of the Hidden Valley Dolomite. About 6 miles north of the reference section, a collection (JFM70518G) from an undetermined horizon in unit h3 is described by C. W. Merriam (written commun., 1970) thus:

*Halysites* sp., *Heliolites* sp., *Favosites* sp. (massive form), *Lissocoelina*? n. sp. B. This assemblage is of Silurian age, as indicated by *Heliolites* and the abundant large, smooth pentameroid brachiopod *Lissocoelina*? n. sp. B. The large brachiopod externally resembles *Pentamerus* or *Pentameroides,* but differs from each internally. It is almost identical to a species occurring abundantly at Bare Mountain near Beatty, Nevada, * * * in the dark-gray limestones in the lower part of the Silurian section below the Silurian light-gray dolomite which has been called Lone Mountain Dolomite.

### UPPER MEMBER (SILURIAN? AND DEVONIAN)

Dolomite in the upper member of the Hidden Valley Dolomite is, in general, conspicuously lighter gray and coarser grained than dolomite in the lower member. The change in color and texture is gradational and at some places transects the bedding. The upper member in the reference section is 920 feet thick; it is divided into three units (pl. 1). Although some characteristics of these lithologic units persist laterally, the boundaries between the units are difficult to trace consistently at the same stratigraphic horizons.

The bottom unit h4, which is 420 feet thick, consists rather uniformly of massive, very light gray and light-gray dolomite, tinged yellowish on the surface. The texture is diversely coarse, and the bedding is obscure if not effaced by recrystallization.

The middle unit (h5), which is 420 feet thick, consists of predominantly light-gray dolomite, tinged pale olive, and some very light gray dolomite in the middle and uppermost parts. The dolomite appears less massive and the stratification becomes progressively more distinct above the middle of the unit. Some distinctive clastic beds are in the lowest part of unit h5 in the reference section, but their lateral persistence is not known. The base of the unit is marked by a 2-foot-thick set of moderate-orange-pink to pale-reddish-brown beds, consisting of fine-grained dolomite sandstone, or dolarenite, and siltstone. About 45 feet above the base of the unit, a breccia of gray dolomite fragments in a brownish matrix is 6–12 inches thick.

The top unit (h6), which is 80 feet thick in the reference section, changes upward from medium-gray and light-gray dolomite in well-defined beds to light-gray somewhat argillaceous and silty dolomite in poorly exposed beds. Its base is a 5-foot-thick ledge-forming bed of medium-gray dolomite that contains silicified corals and a few brachiopods. Overlying fossiliferous dolomite in an interval of about 10 feet is a contrasting light gray to moderate orange pink. Muddy dolomite constituting the upper part of the unit is generally concealed by pale-red or pale-yellowish-gray rubble.

Fossils in the top unit (h6) of the Hidden Valley are late Early Devonian (late Emsian) in age, as determined by C. W. Merriam (written communs., 1965, 1971). In the reference section, a collection (JFM62611B) from the ledge-forming dark dolomite in unit h6 contains silicified *Favosites* (small form), a member of the Halliidae resembling *Odontophyllum*, and fragments of Halliidae resembling *Aulacophyllum*. Float from this, but mostly from the basal 10 feet of the overlying lighter dolomite, has, in addition, (colln. JFM 62611B1) *Favosites* (large form), *Siphonophrentis* (*Breviphrentis*) *invaginatus* (Stumm), *Papiliophyllum elegantulum* Stumm, and *Atrypa* sp. From the next spur 0.4 mile southward (colln. JFM 62427E) *Gypidula* cf. *G. loweryi* Merriam occurs with *S. invaginatus* and *Favosites* (small and large forms). Collections (7301–SD, JFM 65313D, JFM6547D) from unit h6 at the southeast end of the Funeral Mountains include an abundance of a large *Meristella* similar to *M. robertsensis* occurring with abundant *S. invaginatus* and less common *P. elegantulum*. From trimmings of collections 7301–SD, J. W. Huddle obtained 12 specimens of *Icriodus symmetricus* Branson and Mehl and a fragment of *Spathognathodus* sp.; these fossils sustain an Emsian if not a younger Devonian age (J.W. Huddle, written commun., 1965).

The fossil assemblages examined by Merriam are indicative of the lowest part of his Devonian coral zone D in the Great Basin, specifically subzone $D_1$ of late Early Devonian (late Emsian) age. He regards coral zone D as being practically equivalent to the *Eurekaspirifer pinyonensis* Zone and straddling the boundary between Lower and Middle Devonian (C. W. Merriam, written communs., 1965, 1971). His next lower coral zone C is equivalent to the *Acrospirifer kobehana* Zone (early Emsian); the *A. kobehana* Zone occurs in the uppermost unit of the Hidden Valley Dolomite at the Andy Hills locality near the type locality (McAllister, 1952, p. 17) but has not been found in the Funeral Mountains. Further collecting at the Andy Hills locality, but in sequence for comparison with occurences in the Funeral Mountains, shows that the stratigraphically highest fossils from the Hidden Valley Dolomite include *S. invaginatus* and *P. elegantulum* (C. W. Merriam, written commun., 1971) in both areas. These corals in the Andy Hills occur about 35 feet above the *A. kobehana*-bearing beds and at least 20 feet below the contact with the Lippincott Member of the Lost Burro Formation. So, according to the same evidence, the lowest part of the *E. pinyonensis* Zone (Devonian coral subzone $D_1$) is represented in the Hidden Valley Dolomite near the type locality and in the Funeral Mountains.

Some differences in lithology and thickness of the Hidden Valley Dolomite are noteworthy in its few exposures at the southeast end of the Funeral Mountains. These exposures, which are only around spur 4298 and on the northwest side of the Bat Mountain block (fig. 1), are structurally separated from the main occurences of the Hidden Valley in the quadrangle by major faults, including a thrust fault northwest of spur 4298 (McAllister, 1971). The main lithologic differences are in the lower member, where apparently much of the dolomite is recrystallized to light-gray dolomite, some of the nodular chert is recrystallized to a granular or quartzitic texture, and the basal marker beds, including the reddish-brown-weathering flaggy beds of unit h2, are lacking. Consequently, designation of the boundary with the underlying Ely Springs Dolomite on spur 4298 is tentative. The thickness of the Hidden Valley Dolomite here is no more than 870 feet, measured from the lowest possible boundary, or 800 feet, measured from the tentative boundary (pl. 2). This thickness is 570 or 640 feet less than that of the reference section (pl. 1).

The only complete exposure of the Hidden Valley Dolomite at the southeast end of the Funeral Mountains is on the west flank of spur 4298, where the base of the measured section shown on plate 2 is 4½ miles southeast of Pyramid Peak. The exposure, which is visible from California Highway 190 about 9 miles west of Death Valley Junction, includes some of the dark-gray part of the Ely Springs Dolomite at the base of the spur and the brown-weathering

Lippincott Member of the Lost Burro Formation at the top. The dark-gray dolomite of the Ely Springs contains a meagerly sampled Ordovician fauna that includes *Catenipora* sp. cf. *C. rubra* (W. A. Oliver, written commun., 1964) and a few conodonts, such as *Cordylodus* sp., *Drepanodus* sp., and *Gothodus* sp. (J. W. Huddle, written commun., 1965). The overlying lighter gray dolomite contains a sandy dolomite marker of the upper Ely Springs. The stratigraphically lowest possible place for the boundary with the Hidden Valley is about 15 feet above this marker and at the base of a 70-foot-thick unit of somewhat variegated medium-gray chertless dolomite. The tentative boundary, 70 feet higher, is at the base of a 215-foot-thick unit of light-gray dolomite that contains the lowest nodular chert and vestiges of fossils. The chert nodules are sparse, and the chert, like the dolomite, is recrystallized and bleached. Large, elongate nodules of recrystallized chert are conspicuously abundant in very light gray dolomite of the next higher, 45-foot-thick unit. The base of this unit is readily traced and was expediently used as the lower boundary of the Hidden Valley Dolomite at spur 4298 on the preliminary geologic map of the quadrangle (McAllister, 1971). The unit, which is above vestiges of fossils and 50 feet below diagnostic Silurian fossils, probably represents the chertiest beds between the horizons of collections JFM6354F2 and JFM56120A in unit h3 of the unmodified Hidden Valley (pl. 1). Silurian fossils (collns. 7299–SD, 7300–SD, p. 9, 10, pl. 2), above very light gray chertless dolomite 50 feet thick, occur along with dark chert nodules in the lowest part of generally medium-gray dolomite, which is 110 feet thick at the top of the lower member.

The upper member here is 380 feet thick and consists generally of light-gray dolomite that contains indistinctly interlayered very light gray and medium-gray dolomite. At the top of the member, a 110-foot-thick unit is lithologically characteristic of unit h6 at the top of the Hidden Valley (pl. 2), and it contains fossils (collns. 7301–SD, JFM6547D, p. 11, pl. 2) indicative of Merriam's coral subzone $D_1$ of late Early Devonian age (C. W. Merriam, written commun., 1965).

## DEVONIAN SYSTEM

### LOST BURRO FORMATION

The Lost Burro Formation consists mainly of dolomite in the lower part and limestone in the upper part, both striped dark and light gray; and it includes brown-weathering sandy and quartzitic rocks that outline the boundaries of the formation. At the lower boundary, these brown-weathering rocks are in the Lippincott Member (McAllister, 1955, p. 12), and at the upper boundary they are in the Quartz Spring Sandstone Member of Langenheim and Tischler (1960, p. 92). The only complete exposure of the formation in the quadrangle, clearly visible from California Highway 190 about 7 miles west of Death Valley Junction, is in the Bat Mountain block (fig. 1) at the southeast end of the Funeral Mountains. A composite section of the Lost Burro Formation, measured from the underlying Hidden Valley Dolomite on the northwest flank of the Bat Mountain block (fig. 5) to the overlying Tin Mountain Limestone on the southwest flank (fig. 6), is 2,460 feet thick (pl. 1). Lithologic units above the Lippincott Member in the section are designated lb2 to lb5.

The Lippincott Member, at the base of the Lost Burro Formation, is characterized by sandy and silty light-gray dolomite, nodular chert, sandstone, and quartzite, interbedded with some dolomite. Much of the siliceous matter weathers brown in contrast to pinkish or yellowish tinges of the underlying argillaceous and silty dolomite in the uppermost part of the Hidden Valley. The siliceous components are generally in the following stratigraphic order, although proportions and sequences vary in detail from place to place: silt and fine-grained quartz sand dispersed in dolomite and concentrated in "fucoids" (perhaps fillings of straight, branching, and clustered burrows); nodular chert, increasingly abundant upward in dolomite interbedded with some sandstone or quartzite, partly lenticular; thick sandstone or quartzite near the middle of the member, above the highest chert;

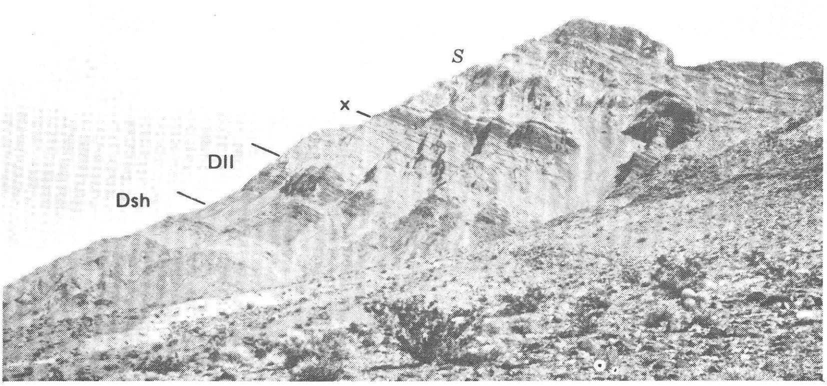


FIGURE 5.—Lost Burro Formation on Hidden Valley Dolomite, northwest side of Bat Mountain block. DSh, Hidden Valley, containing Lower Devonian (upper Emsian) fossils near top; Dll, Lippincott Member of Lost Burro; *S*, *Stringocephalus*-bearing dark dolomite. The lowest part of composite measured section of the Lost Burro extends from base of the Lippincott Member to bed at X.

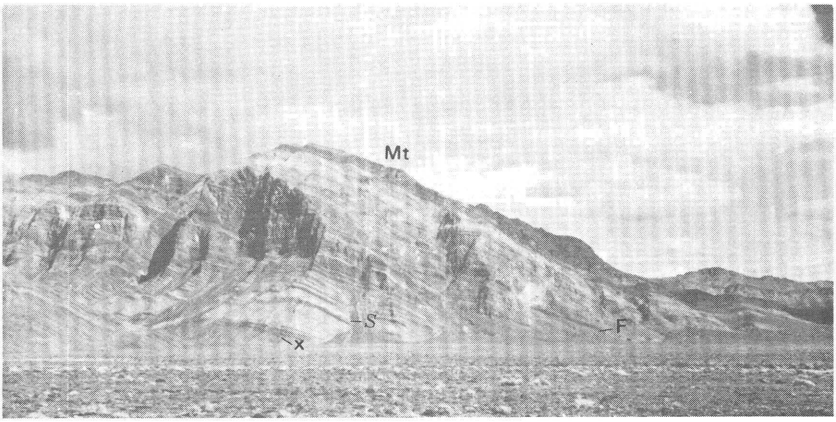


FIGURE 6.—Lost Burro Formation capped by Tin Mountain Limestone, Mt, southwest side of Bat Mountain block. *S*, *Stringocephalus*-bearing dark dolomite; F, dolomite marker containing low Upper Devonian (Frasnian) fossils. Composite measured section of the Lost Burro continues upward from bed at X.

sandstone or quartzite interbedded in dolomite up to the top. The thickness of the Lippincott Member, measured to include the uppermost sandstone or quartzite, is 260 feet on the northwest side of the Bat Mountain block (fig. 5), 295 feet on spur 4298, 290 feet in a section 1.8 miles northwest of Pyramid Peak (fig. 3), and 320 feet about 1½ miles east-southeast of Schwaub Peak. The Lippincott Member has not been dated by fossils in it, but because it lies above fossils of late Early Devonian (late Emsian) age and well below fossils of late Middle Devonian (Givetian) age, its age is considered to be Middle Devonian.

Unit lb2 above the Lippincott Member consists of light-gray and very light gray dolomite containing some poorly defined but distinctive layers of medium-gray to dark-gray dolomite. The thickness is 675 feet in the composite section on the Bat Mountain block (figs. 5, 6). Two persistent sets of darker dolomite beds are in the middle of the unit and about 45 feet from the top; below them, several dark beds generally 1–5 feet thick are widely spaced in the lighter dolomite. The lower dark set is 100 feet thick, including 10–25 feet of light-gray dolomite about 15 feet below the top. The upper dark set is about 60 feet thick. Both sets contain silicified hemispherical stromatoporoids, brachiopod fragments, and broken-spaghettilike forms that are possibly *Amphipora*?, as in collection 7278–SD (W. A. Oliver, written commun., 1964). *Stringocephalus* sp., identified by J. T. Dutro, Jr. (written commun., 1964), occurs in the upper set of dark beds (colln. 7275–SD, pl. 1), and 55 feet lower in a 3-foot-thick bed of medium-gray dolomite (colln. 7277–SD); these beds are 845 and 790 feet above the base of the formation. Merriam's *Stringocephalus* zone in the Great Basin is a widespread indicator of late Middle Devonian (Givetian) age (Merriam, 1940, p. 58–59; 1963a, p. 14–17; 1963b, 45–49; Poole and others, 1967, fig. 2a–b, p. 901–902).

The third unit (lb3, pl. 1), 300 feet thick, is a transitional sequence between underlying predominantly light-gray dolomite and overlying medium-gray limestone. The unit, which mostly consists of dolomite and limestone, is set apart by less resistant beds of silty and sandy dolomite at the bottom and platy and silty limestone at the top. Silt and fine-grained sand generally are dispersed in the lowest 50 feet but form some laminae at the base of the unit. At 190 feet above the base, three fine-grained sandstone beds, 2, 5, and 7 feet thick, are interbedded with medium-gray limestone in a zone 25 feet thick. The silty and sandy rocks weather light brown to pale orange, and some of the dolomite weathers very pale yellowish brown or yellowish gray, although most of the dolomite, like the limestone, is medium gray where weathered or fresh. A few of the limestone beds contain amphiporoids and small hemispheroidal stromatoporoids. Two beds, at 45 and 70 feet below the top of the unit, contain brachiopod sections and silicified fragments; those that were collected are indeterminate (J. T. Dutro, Jr., written commun., 1964).

The fourth unit of the Lost Burro Formation (lb4, pl. 1) is 1,130 feet thick and consists mostly of interstratified medium-gray and light-gray limestone, which is predominantly darker gray in the lower part of the unit than in the upper part. The limestone contains interbedded dolomite in two stratigraphic marker zones. Several beds of sandstone or quartzite are widely spaced in the limestone. The lowest part of the unit, extending from the base of a steep slope for 160 feet up to the lower dolomite marker zone, consists of medium-dark-gray to medium-gray limestone, which contains conspicuously abundant amphiporoids and massive stromatoporoids. In the lower dolomite marker zone, which is 35 feet thick, dolomite and dolomitic limestone beds 1–2 feet thick are lighter gray than interbedded stromatoporoidal limestone, and they weather yellowish gray to pale grayish orange, making distinctive stripes on the mountainside. About 290 feet higher, the upper dolomite marker zone (F, fig. 6), which is 80 feet thick, is less conspicuously colored than the lower one. Much of the dolomite is medium dark gray, like the interbedded limestone, although some is medium light gray, yellowish gray, or very pale orange. Dark dolomite and limestone in the lower part of the marker zone contain well-preserved fossils in a varied assemblage.

Four quartzose zones are widely spaced between the dolomite zones, and two are within 145 feet above the upper dolomite zone. The quartzose zones, which are ½–5½ feet thick, contain fine to coarse quartz sand in very sandy limestone, calcite-cemented sandstone, and quartzite. They are from medium light gray to nearly white where fresh and weather light brown or paler. The highest of these zones is the thickest, 5½ feet; it grades upward from quartzite in the lower half, through sandstone, to irregularly sandy limestone at the top. In the upper 500 feet of the unit (lb4), the limestone is generally light gray or very light gray but contains unevenly spaced darker layers lower than about 200 feet below the top.

Except for abundant poorly preserved *Amphipora*? and massive stromatoporoids, fossils have been found at only a few horizons in thick unit lb4, and none below the upper dolomite marker zone are useful for placing the boundary between Middle and Upper Devonian rocks. Stromatoporoids, including amphiporoidal forms, are conspicuous in the lowest 230 feet of the unit and occur as high as the upper marker zone. Outlines of unsilicified horn corals occur about 20 feet and about 85 feet above the lower marker. According to W. A. Oliver, Jr. (written commun., 1964), well-preserved horn corals (colln. 7272–SD) that are 140 feet above the lower marker are apparently of a single species, and they are associated with *Amphipora* sp., a form that strongly suggests a Middle or early Late Devonian age. He adds that the same species of corals is perhaps the common form in collections (7269–SD, 7270–SD) from the upper marker. Traces of high-spired gastropods are common in a 35-foot interval at approximately 10 feet below the top of the unit.

Fossils in the lower part of the upper dolomite marker zone are varied and persistent in the area of outcrop. Collections of them from several localities contain a gastropod species and a brachiopod species that merit comment. E. L. Yochelson (written commun., 1964) reports "*Orecopia*" *ambiguum* (Walcott) in collections 7268–SD and 7269–SD, which bracket fossiliferous beds in a 20-foot interval (pl. 1). He favors assigning to these collections an early Late Devonian age rather than a Middle Devonian age. He expresses this conclusion in his following comments on "*Orecopia*" *ambiguum*:

The problem with this species is somewhat complicated. Walcott described two species of '*Platyschisma*' from the Eureka area. *P. mccoyi* was obtained from Newark Mountain, and *P. ambiguum* from the 'upper horizon of the Devonian' at Devils Gate. In 1945 Knight named the genus *Orecopia* with *P. mccoyi* as type. Along with the original types Knight figured a specimen from the Goodsprings area. Ever since, essentially any small gastropod in a Devonian limestone from Nevada or Utah has been called *O. mccoyi* and dated as early Late Devonian.

* * * there are at least three different forms in the Devonian limestones. The Goodsprings form is undescribed and is almost certainly the same as two specimens which [F. J.] Kleinhampl submitted from the lower part of the Guilmette Limestone in Pancake Range of Nevada. It presumably is of Middle Devonian age in that area. So far as I know the species *ambiguum* has never been identified since Walcott's original description. It is an open question as to how many *O. mccoyi* which have been cited in past years belong to *ambiguum* or to the undescribed species. It is also an open question as to whether all three species should be assigned to *Orecopia* although they are all related.

According to Miss Jean Berdan it is probable that Walcott's locality for *ambiguum* (what an appropriate name) refers to rocks of early Late Devonian age. Thus I think that collections 7269–SD and 7268–SD are of that age rather than Middle Devonian. The situation is such that additional material from other areas might have an effect on this age determination.

On referring to the highest collection (7268–SD), which contains "*O.*" *ambiguum*, a collection (7270–SD) about 10 feet stratigraphically lower at a nearby locality, and a collection (7473–SD) from the same horizon at about 1¼ miles from the first, J. T. Dutro, Jr. (written communs. 1964 and 1968), reports "*Tenticospirifer*" *cyrtiniformis* (Hall and Whitfield). "The occurrence***indicates an early Late Devonian (Frasnian) age. This species occurs in the Mt. Hawk Formation of the Alberta Rockies and in the Hackberry beds of Iowa." He suggests correlation with some part of Merriam's *Spirifer argentarius* Zone of Late Devonian (Frasnian) age, in the middle part of the Devils Gate Limestone (Merriam, 1963b, p. 53, 54; Poole and others, 1967, fig. 2b, p. 902).

The uppermost unit of the Lost Burro Formation (lb5, pl. 1), 95 feet thick, is diversified in color and composition. Its colors include shades of gray and a more distinctive range from moderate brown, through moderate orange pink, to very pale orange. The unit is composed of limestone, dolomite, and distinctive siliceous clastic rocks. The siliceous clay, silt, and sand are dispersed in some of the carbonate rocks and form beds of mudstone, sandstone, or quartzite; these beds are thin and widely spaced in the lower part of the unit and predominant in the upper third. The lowest sandstone bed, 1½ feet thick and weathering very pale orange, marks the base of the unit. The overlying two-thirds of the unit, composed mostly of gray limestone, contains colorful beds, 1–3 feet thick, of dolomite that is light brownish gray where fresh but weathers grayish orange to very pale orange. In a 35-foot interval at the top of the unit, two thick beds of brown-weathering sandstone and quartzite that are separated by generally concealed beds correspond to the Quartz Spring Sandstone Member of Langenheim and Tischler (1960, p. 92). Calcite-cemented quartz sandstone and vitreous quartzite intergrade in various proportions in these beds. In general, the lower bed, 10–15 feet thick, consists mostly of quartzite that weathers brown; and the upper bed, 5–8 feet thick, consists mostly of sandstone that weathers a darker brown. The intervening weak beds include, along with thin-bedded shaly, silty, and sandy limestone, some thicker mudstone that is light gray tinged pink or orange. A small sample (colln. 8878–SD) from these beds, between 15 and 20 feet below the top of the formation, contains six fragmentary conodonts and a fish tooth, according to J. W. Huddle (written commun., 1964). He reports the following:

> One of the bar-type conodont fragments probably is part of an *Hindeodella* sp. The other two bar fragments are unrecognizable. Three conodont fragments seem to be parts of three specimens of *Polygnathus linguiformis*. One of these fragments represents the posterior, cross-ribbed tip of the plate, and the identification of this piece is reasonably certain. *Polygnathus linguiformis* indicates a Middle Devonian to Early Late Devonian age for the sample.

If the few fragments of conodonts in the sample were not reworked, they would indicate an age no younger than the Frasnian age of beds that are 700 feet lower in the section (p. 00). No additional conodonts were obtained by further cursory sampling of the argillaceous beds near the top of unit lb5. About 25 feet stratigraphically higher, however, Early Mississippian (Kinderhookian) conodonts (J. W. Huddle, written commun., 1964) occur in the Tin Mountain Limestone about 5 feet above the boundary with the Lost Burro.

A better indication of the age of the upper part of unit lb5 is derived by correlation. Very near the type locality of the Lost Burro Formation, in the northern Panamint Range, the uppermost unit is fossiliferous and lithologically equivalent to the upper part of unit lb5. The unit contains within 35 feet below the Tin Mountain Limestone, according to Cooper (McAllister, 1952, p. 19), a *Cyrtospirifer* fauna of Late Devonian (Cassadaga) age. Among conodonts from the interval 18–20 feet below the Tin Mountain, *Palmatolepis distorta* Branson and Mehl supports a Late Devonian (*to*II$\beta$-*to*III$\beta$, Famennian) age (Youngquist and Heinrich, 1966, p. 975).

## MISSISSIPPIAN SYSTEM

### TIN MOUNTAIN LIMESTONE

The Tin Mountain Limestone is exposed in the Funeral Mountains only at the southeast end. Here the main exposure extends continuously along the crest of the Bat Mountain block northward from hill 2997 (fig. 1). The Tin Mountain Limestone from a distance is clearly distinguished by its broad dark-gray and light-gray bands (fig. 7) above the brownish uppermost part of the Lost Burro Formation.

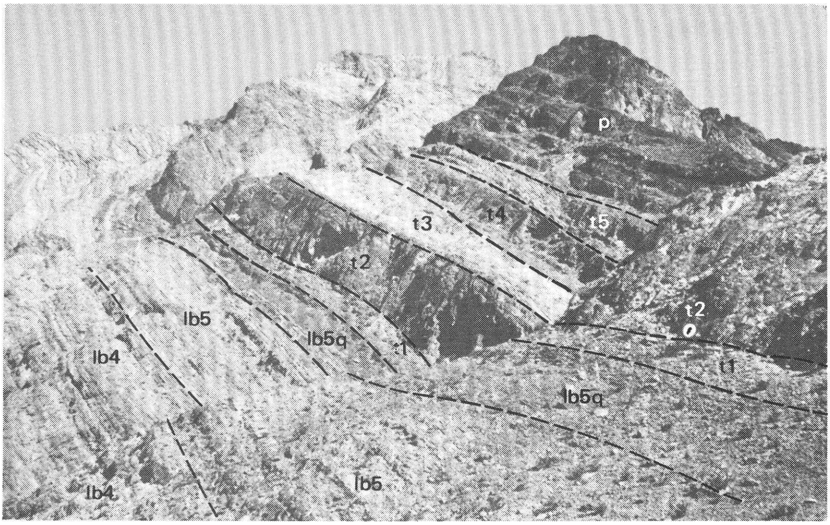


FIGURE 7.—Tin Mountain Limestone at hill 2997, southeast end of Funeral Mountains. View northward along the crest of Bat Mountain block from site of measured section on west side of hill 2997 (in foreground). Lost Burro Formation units lb4 and lb5 (includes quartzitic upper part lb5q); Tin Mountain Limestone units t1 and t5; Perdido Formation, p.

In a section measured from the underlying Lost Burro to the overlying Perdido Formation at hill 2997, the Tin Mountain Limestone is 315 feet thick.

The limestone of the Tin Mountain contains some nodular chert and thinly interstratified shale or argillaceous limestone that is a distinctive feature of some units. The texture of the limestone is conspicuously diverse within the range of very fine grained to bioclastically coarse grained. The formation is exceptionally fossiliferous in this area as well as throughout the region. The association and stratigraphic distribution of fossils collected from the measured section are shown graphically on plate 3. The most useful fossils for dating the rocks are referred to in comments on the ages of units in the Tin Mountain Limestone and Perdido Formation.

The lowest part of the Tin Mountain Limestone, a commonly concealed weak unit (t1) about 25 feet thick, consists of thinly interstratified limestone and shale or argillaceous limestone. The limestone, which is medium dark gray and weathers medium gray, is sparsely cherty and very fine grained to bioclastically coarse grained. The argillaceous thin beds and partings are tinged red or yellow. The basal bed is gradational within 1 foot upward from calcareous sandstone of the underlying Lost Burro to slightly sandy limestone in the Tin Mountain. The sandy limestone contains conspicuous *Syringopora*, which is regionally characteristic of the Tin Mountain Limestone.

Fossils in collections (21950–PC to 21953–PC) from the basal bed and higher in unit t1 (collns. 21947–PC, 21948–PC, 19772–PC, 19773–PC, pl. 3), according to reports by W. J. Sando (written communs., 1964, 1965) on the corals and by Mackenzie Gordon, Jr. (written communs., 1964, 1967) on the brachiopods, include taxa that are widely known from the Tin Mountain and are Early Mississippian in age. Conodonts in collection 24652–PC (pl. 3) from about 5 feet above the base of the formation, according to J. W. Huddle (written commun., 1965), indicate more restrictively a Kinderhookian age. Foraminifers in collection 21948–PC (pl. 3) from a few feet higher above the base, according to Betty Skipp (written commun., 1965, amended 1971), are late Kinderhookian and are common to zone 1 of the Redwall Limestone, Arizona (Skipp, 1969, p. 184–185), and to foraminiferal Zone 6 at the base of the lower Carboniferous in the type region in Belgium and France (Mamet and Skipp, 1970, fig. 7, p. 1134).

Unit t2 of the Tin Mountain Limestone, about 75 feet thick, is prominent in a dark cliff above the rubbly slope that generally conceals unit t1 and below a light-gray band in unit t3 (fig. 7). Limestone that constitutes unit t2 is medium dark gray, weathers medium gray, and is varied in texture. Near the lower boundary, which is gradational and poorly defined, beds are thin. Elongate chert nodules, 1 inch or less thick, are sparse in a 12-foot interval 30 feet above the base of the unit.

Brachiopods are common at the base of unit t2, corals are common near the top of the unit, and microfossils are associated with both. The brachiopods, none of which were collected, occur in the lowest 10 feet of the unit and extend the underlying range represented by collections 19772–PC and 19773–PC (pl. 3) at the top of unit t1. The corals near the top of unit t2 are laterally persisent in a zone 5 feet thick. Six collections (21941–PC to 21946–PC) spaced irregularly about 1,000 feet along the strike of the zone (see section on "Register of Fossil Collections") contain silicified corals identified by W. J. Sando (written commun., 1965) and given on plate 3. Their relative abundance, not shown by the chart, is suggested by the occurence of *Rylstonia* in all six collections, *Homalophyllites* in four, *Syringopora* in three, *Vesiculophyllum* in two, and *Caninia*? in one collection.

A microfossil assemblage (colln. JFM65517C, pl. 3) from beds near the base of unit t2 contains Kinderhookian foraminifers. According to Betty Skipp (written commun., 1965, amended 1971), "The fauna is that of zone 1 of the Redwall Limestone, Arizona, and is typical of Zone 6 of the foraminiferal zonation of Mamet." She reports further that collections (21941–PC and 21946–PC, pl. 3) from the coral zone, 60–65 feet higher in unit t2, significantly include *Latiendothyra* of the group *L. parakosvensis* Lipina, 1955, (*Plectogyra tumesepta* Zeller, 1957, [part]), a designation that is abbreviated in the chart, *Palaeospiroplectammina* aff. *P. parva* (Chernysheva), 1940, *Septaglomospiranella primaeva* (Chernysheva), 1940, and *S. primaeva* subsp. *noda* Skipp, 1966. She concludes, "This is a late Kinderhookian fauna similar to that of the lowest part of zone 2A of the Redwall and the lower part of Zone 7 of the foraminiferal zonation of Mamet." An inferred relationship of global foraminiferal Zone 7 with Cordilleran megafossil zones, principal European and American time-stratigraphic divisions, and Cordilleran and type Mississippian formations is show diagrammatically by Sando, Mamet, and Dutro (1969, fig. 7).

Conodonts are abundant and varied in one of the collections (21946–PC) from the coral zone and in a collection (21940–PC) from 5 feet higher, at the top of unit t2. The fauna listed (pl. 3) by J. W. Huddle (written commun., 1965, amended 1971) is similar to that from the base of the formation; both assemblages contain predominantly *Siphonodella cooperi* Hass, but the assemblage from unit t2 contains in addition *S. obsoleta* Hass, *Polygnathus symmetricus* E. R. Branson, and *P. inornatus* E. R. Branson. The conodont fauna is Early Mississippian in age and is probably equivalent in age to late but not the latest Kinderhookian of southwestern Missouri and adjacent areas as reported by Thompson and Fellows (1969, table 1).

Coarsely bioclastic crinoidal limestone characterizes unit t3, which is 75 feet thick in the section at hill 2997. Much of the unit makes a light-gray band on the mountain spur (fig. 7), in contrast to darker gray beds in the base of the unit and in underlying unit t2. The darker gray basal beds contain sparse, large chert nodules in a 15-foot interval where the section was measured. A thousand feet northward, the cherty interval is 25 feet thick, and the chert is abundant in its lower part. The nodules that occur together abundantly are commonly 8–10 inches long and 3–4 inches thick. They consist of dark-gray to olive-black chert that weathers brownish black. The light-gray main part of the unit consists of broad crinoid columnals and some long segments of crinoid stems.

A few corals and brachiopods were collected near the base and near the top of unit t3 (collns. 21938–PC, 21939–PC, pl. 3). The higher collection (21938–PC), 160–165 feet above the base of the

Tin Mountain Limestone contains *Dimegelasma* sp., identified by Mackenzie Gordon, Jr. (written commun., 1967). He states that *Dimegelasma* is considered to be a post-Kinderhookian brachiopod genus. Judging from this and from the distribution of corals listed by Sando (pl. 3), he believes that this and the overlying part of the Tin Mountain are Osagean in age.

Unit t4, which is 50 feet thick, forms a rubbly bench below a steeper slope or cliff. In the less resistant, lower part of the unit, thin limestone beds are interstratified with pale-red or pinkish-gray argillaceous beds. Reddish argillaceous material forms partings in the upper part. The limestone, which is medium gray or darker and weathers somewhat lighter gray is fine- to coarse-grained biocalcarenite that consists of fragmented mixed fossils. Unbroken fossils are conspicuous and varied. Elongate chert nodules, which almost coalesce in some beds, are abundant in the upper part of the unit.

Specialists who identified the corals, brachiopods, conodonts, and ostracodes in collections from unit t4 (tabulated on pl. 3) agree that the faunas are Early Mississippian but they do not agree whether they indicate an Osagean or a Kinderhookian age. The corals that were identified by W. J. Sando (written commun., 1965) are not diagnostic as to which of these ages. He states that the coral zones established for the Madison Group in the northern Cordillera region (Sando and others, 1969) and the coral zones established for the Redwall Limestone in Arizona (Sando, 1969, p. 268–271) are not clearly evident in the Funeral Mountains section. The seven genera of brachiopods that Mackenzie Gordon, Jr. (written commun., 1967), identified from unit t4 (pl. 3) do not by themselves indicate Osagean age, but they occur above the *Dimegelasma*-bearing bed that he believes is Osagean in age.

A goniatite that is associated with brachiopods in collection 21936–PC is a *Protocanites* or young *Merocanites* sp. indet., according to Mackenzie Gordon, Jr. (written commun., 1967), who comments, "The young goniatite***is neither large enough nor well enough preserved to enable us to distinguish between Kinderhook and Osage in this bed. It is, however, certainly a Lower Mississippian form."

A conodont fauna in this collection (21936–PC) from the middle of unit t4 has predominantly *Gnathodus punctatus* (Cooper) and *Polygnathus communis* Branson and Mehl (pl. 3), according to J. W. Huddle (written commun., 1965). He notes, "*Gnathodus punctatus* has been found in the upper part of the Joana Limestone of Nevada, in the Chappel Limestone of central Texas, and the Welden Limestone of Oklahoma. The age of this part of the Tin Mountain is Early Mississippian, probably late Kinderhookian." *G. punctatus* characterizes but is not restricted to the uppermost part of the Kinderhookian Series in the southern midcontinent where its name has been used for an upper Kinderhookian–lower Osagean zone in Texas (Hass, 1959, p. 369; Thompson and Fellows, 1969, p. 60) and for a subzone limited to the uppermost Kinderhookian of southwestern Missouri (Thompson and Fellows, 1969, p. 56–57). In southwestern Missouri and adjacent areas *G. punctatus* occurs also in overlying beds of Osagean conodont zones (Thompson and Fellows, 1969, for example, see distribution charts 2, 13, 19).

An abundant silicified ostracode assemblage, which contains more than 40 species, mostly new, was recovered by I. G. Sohn from a collection (12858–PC) within the basal 15 feet of unit t4. The following is from his report on the assemblage (I. G. Sohn, written commun., 1966, reviewed 1971):

The etched residue consists of thousands of specimens in various stages of preservation. Some of the specimens, though intact, show bending and lines of breakage, indicating that postdepositional and presilicification movement took place. Many of the taxa are represented by growth stages, an indication the ostracodes were not transported. Although most of the specimens are single valves and only rare complete carapaces are recovered, I consider this to be the result of the laboratory process because an acetate peel of an etched surface has a few cross-sections of carapaces.

* * * This assemblage consists of practically all new species and several genera that I do not recognize. * * * One of the problems is that few silicified faunas have been described.* * *

The ostracodes have an aspect that is similar to etched forms from the middle and upper members of the type Banff Formation (Green, 1963) and from the *Gattendorfia* Beds of Thüringia (Gründel, 1961; 1962). As indicated above, however, this may be due more to the fact that the two assemblages listed are also etched from limestone than to age similarity.

Ranges in age of 14 ostracode species that are close relatives of those in collection 12858–PC are shown in table 2 by Sohn (written commun., 1966, reviewed 1971). Seven of the related species are Osagean in age, such as *Kirkbyella* (*Berdanella*) *reticulata* Green, 1963, and *Rectobairdia confragosa* Green, 1963; two are Kinderhookian, *Psilokirkbyella ozarkensis* (Morey, 1936) and *Monoceratina*? *elongata* Benson and Collinson, 1958; and the other five species are both Osagean and Kinderhookian. Sohn comments that the comparison made in the table suggests an Osagean age for the assemblage.

Later Sohn collected in sequence through the same stratigraphic interval in the lowest part of unit t4. He recovered abundant silicified ostracodes from samples taken from 11–15.9 feet above the base. In reporting on his collections (written commun., 1971), he states that in addition to *Shivaella macallisteri* Sohn, 1972 (p. 5, pl. 3, figs. 1–38), 14 species are either identical or closely related, on the species level,

TABLE 2.–*Ostracodes in collection 12858-PC, Tin Mountain Limestone, listed by I. G. Sohn, showing range in age of close relatives*

| | Tournaisian Stage | |
|---|---|---|
| | Kinderhookian Series | Osagean Series |
| *Tetrasacculus* sp. aff. *T. stewartae* Benson and Collinson, 1958 | — | — |
| *Amphissites* n. sp. aff. *A. similaris* Morey. Green, 1963 | | — |
| *Roundyella* n. sp. aff. *Scrobicula crestiformis* Zanina, 1956 | ?— | —? |
| *Kummerowia*? n. sp. aff. *Kirkbya fernglennensis* Benson, 1955 | — | — |
| *Kummerowia*? n. sp. aff. *Kirkbya keiferi* Benson, 1955 | | — |
| *Kirkbyella* (*Berdanella*) n. sp. aff. *Kirkbyella annensis* Benson and Collinson, 1968 | — | — |
| *K.* (*B.*) n. sp. aff. *K.* (*B.*) *recticulata* Green, 1963 | | — |
| *Psilokirkbyella ozarkensis*? (Morey, 1936) | — | |
| *Rectobairdia* sp. cf. *R. confragosa* Green. 1963 | | — |
| *Acratia* (*Cooperuna*) n. sp. aff. *A.* (*C.*) *similaris* Morey. Green, 1963 | | — |
| *Bohlenatia*? n. sp. aff. *Acanthoscapha*? *banffensis* Green, 1963 | | — |
| *Monoceratina* n. sp. aff. *M. virgata* Green, 1963 | | — |
| *Monoceratina*? n. sp. aff. *M.*? *elongata* Benson and Collinson, 1958 | — | |
| *Graphiadactylloides* n. sp. aff. *Graphiadactyllis moridgei* Benson, 1955 | — | — |

to ostracodes from the Narrow Canyon Limestone and lower part of the Mercury Limestone in the Nevada Test Site, about 45 miles east-northeast of the Funeral Mountains.

Unit t5 at the top of the Tin Mountain Limestone is more uniform in composition and bedding than the underlying units but is variable in thickness. Limestone in the unit is commonly very fine grained and medium dark gray that becomes medium light gray through weathering. A few chert nodules mark a zone 5–10 feet thick about 50 feet from the base of the unit. Unit t5 is at least 90 feet thick to alluvial cover at the top of the Tin Mountain in the continuous measured section across hill 2997, and 90 feet thick to the exposed contact with the Perdido Formation in a supplementary section 250 feet northward. It is only 55 feet thick about 250 feet farther north and 65 feet thick in the next ridge about 1,000 feet eastward, where the cherty zone is also about 50 feet above the base of the unit. The change in thickness occurring between the cherty zone and distinctive mudstone at the base of the Perdido implies that the upper contact of the Tin Mountain in the vicinity of hill 2997 is a disconformity if it is not an obscure bedding fault of local extent.

Fossils are scarce in unit t5. The only fossils found, except for a poorly preserved brachiopod (colln. 21934–PC, pl. 3) at the base, are a few brachiopods and poorly preserved horn corals (colln. 21933–PC) from the interval between 70 and 75 feet above the base of the unit. Betty Skipp examined two samples taken for possible foraminifers from lower beds in the unit and only found calcareous sponge spicules and fragments of bryozoans and algae. The brachiopod assemblage from the uppermost part of the formation (colln. 21933–PC) contains *Brachythyris* cf. *B. suborbicularis* (Hall) and *Imbrexia* sp., according to Mackenzie Gordon, Jr. (written commun., 1967). He comments "The *Brachythyris* indicates an Osagean, rather than Kinderhookian, age for this bed. This species, however, ranges into rocks of early Meramecian age."

In summary, the age of the Tin Mountain Limestone here is Early Mississippian. The lowest part of the formation is Kinderhookian in age on the basis of conodonts and is restricted to late Kinderhookian on the basis of foraminifers. The upper part above unit t3, on the basis of brachiopods and tentative support of ostracodes, is Osagean.

## PERDIDO FORMATION

In the Funeral Mountains the Perdido Formation is exposed only on the Bat Mountain block (fig. 1), where it is the youngest Paleozoic formation under Cenozoic continental rocks. The Perdido here is incomplete, for it lacks the distinctive uppermost limestone and shale beds that contain Chesterian fossils in the type area, northern Panamint Range. It is distinguished at a distance by a moderate-brown upper part overlying a generally more resistant, brownish-gray lower part, which together contrast with light-gray limestone at the top of the Tin Mountain Limestone. The boundary between the formations is drawn at the base of a thin mudstone unit. The lithology of the Perdido Formation, which is characteristically diverse, is predominantly medium-dark-gray limestone containing interbedded chert in the lower part, and it is mostly siltstone in the upper part. Much of the limestone is bioclastic, of varied grain size, and it contains irregularly interbedded calcareous quartz siltstone and much less sandstone. Uncomminuted fossils are rare. Abundant dark-gray chert, thinly interbedded in limestone, and brown-weathering calcareous siltstone are diagnostic features of the formation. At the top of the mountain 1.5 miles north of hill 2997, the thickness of the Perdido Formation is about 500 feet where the lower and upper parts of the formation are nearly equal. The lower 215 feet of the Perdido Formation, which is described below and shown on plate 3, was measured on the low ridge that is about 1,000 feet east of hill 2997.

Basal unit p1 of the Perdido is 18 feet thick in the measured section where it is concealed by slope rubble on a bench. In a good exposure a few hundred feet north of hill 2997, unit p1 consists of light-gray partly shaly mudstone that has some thinly interbedded limestone, especially in the upper part. The unit, although thin, extends to the farthest exposure of the base of the Perdido in the Bat Mountain block. Other units in the measured section (pl. 3) may not be as extensive, but they are characteristic of the general sequence in the lower part of the Perdido Formation.

Unit p2, which is 87 feet thick, contains evenly bedded medium-dark-gray limestone that weathers medium gray, medium light gray, and light olive gray. Some of the limestone is bioclastic. Abundant dark-gray chert forms beds that are less than an inch to 3 inches thick and commonly about 2 inches thick. Exposed surfaces of the chert are brownish gray, contributing to the color of the unit.

Unit p3, which is 20 feet thick, is the lower of two units that are browner than others in the lower part of the Perdido. Chert, siltstone, silty limestone, and subordinate limestone are generally in discontinuous beds less than 1 foot thick. Fine-grained sandstone, gray where fresh, occurs in irregular pods and in beds that pinch and swell. The quartzrose rocks weather brown.

Unit p4, which is 25 feet thick, consists mostly of medium-gray limestone in beds that are commonly about 1 foot thick but range in thickness from a few inches to 1½ feet. Coarse crinoidal debris forms beds that pinch and swell, and individual lenses that are as much as 4 feet thick. Quartzose rocks ranging from silty fine-grained limestone to calcareous sandstone are interbedded with the limestone.

Unit p5, which is 15 feet thick, is the upper brown-weathering unit. It is lithologically similar to unit p3, the lower brown unit.

Unit p6 measures 50 feet thick to a fault of undetermined displacement. Beyond the fault similar beds are probably less than a hundred feet thick below alluvial cover. Fine- to coarse-grained limestone, which constitutes about half the unit, is medium dark gray, weathers the same gray or somewhat lighter, and occurs in beds about 1 foot thick or less. Chert and siltstone occur in beds that are generally a fraction of an inch to several inches thick and of local continuity.

Very few fossils were obtained from the Perdido Formation, except for microfossils of Late Mississippian (Meramecian) age in the collection at the top of the section (24651–PC, pl. 3). Fossils in lower collections (21931–PC, 21932–PC, pl. 3), as evaluated in the following comments, are inadequate to distinguish an Osagean from a Meramecian age. The corals in collection 21932–PC (pl. 3) only indicate a Mississippian age (W. J. Sando, written commun., 1965) and the associated conodonts are not diagnostic (J. W. Huddle, written commun., 1965). Mackenzie Gordon, Jr. (written commun., 1967), comments on a moderately large form of productoid in collection 21931–PC (pl. 3), as follows: "This productoid suggests by its fine ribbing either of two genera: *Setigerites* and *Striatifera.* These have very distinctive shapes but this one specimen is not sufficiently complete to allow us to distinguish which genus is represented. Both occur in rocks of Meramecian (Late Mississippian) age. *Setigerites* also occurs in rocks of Osagean (Early Mississippian) age." Concerning one of the conodonts from the same collection, J. W. Huddle (written commun., 1965) points out, "*Gnathodus texanus* ranges from Early to Late Mississippian. It has been found in the Mississippi Valley in rocks as old as the Burlington Limestone [in the middle part of the Osagean Series] and as young as the Bethel sandstone in the lower part of the Chesterian Series. It is abundant in the Keokûk, Warsaw, Salem, and lower St. Louis Limestones."

The sample at the top of the section (colln. 24651–PC, pl. 3), which was collected only for possible microfossils 205 feet above the base of the Perdido Formation, yielded diagnostic foraminifers and conodonts among those listed on the chart (pl. 3). The following designations of foraminifers as reported by Betty Skipp (written commun., 1965, amended 1971) are abbreviated on the chart:

*Endothyra* of the group *E. prisca* Rauser-Chernousova and Reitlinger, 1936
*Endothyra* of the group *E. bowmani* Brady, 1876, emend. ICZN 1965
*Globoendothyra* of the group *G. tomiliensis* Grozdilova, 1954
*Tetrataxis* of the group *T. eominima* Rauser-Chernousova, 1948

Although *Calcisphaera pachysphaerica* Pronina, 1963, and *Stacheia* Brady, 1876, are listed as foraminifers, Skipp adds the following comment:

*Calcisphaera* and *Stacheia* are considered algae by both Mamet and me. *Calcisphaera* suggests a very shallow water environment. This assemblage is definitely

Late Mississippian (middle Viséan to early Namurian) in age. All of the forms are common in rocks of Meramecian age. But the age is not earliest Meramecian because both *G. tomiliensis* and *E. bowmani* appear in early St. Louis time. Also, *G. tomiliensis* is very scarce in late Chesterian faunas. Therefore, a middle Meramecian to early Chesterian age range fits best.

Concerning the conodonts recovered from the sample, J. W. Huddle (written commun., 1965) reports, "This fauna is early Late Mississippian in age. *Taphrognathus varians* is abundant in the Keokuk, Warsaw, Salem, and lower St. Louis Limestones in the Mississippi Valley."

The age of this bed in the Perdido, based on the foraminifers and conodont occurring together, is Late Mississippian. Furthermore, the lowest occurence of *G. tomiliensis* and *E. bowmani* and the highest occurence of abundant *T. varians* in the provincial series of the Mississippi Valley indicate that its age is comparable with that of the lower part of the St. Louis Limestone, about middle Meramecian. Systematic sampling for microfossils is necessary in order to determine whether beds of Osagean age are limited to the upper part of the Tin Mountain Limestone or whether they continue into the lower part of the Perdido Formation.

## REGISTER OF FOSSIL COLLECTIONS CITED

Field numbers have the prefix JFM and show date of collecting by first two digits for year, next for month, and last for day. Localities are defined by distances and bearings measured on the U.S. Geological Survey topographic map of the Ryan quadrangle, enlarged to scale of 1:31,680, referred to features designated on the 1952 edition. Hill 2997, reference point for many of the collections, is 0.85 mile from the east boundary at longitude 116°30′ W. and 5.2 miles from the south boundary at latitude 36°15′ N.

| *USGS number* | |
|---|---|
| 6842–SD | (JFM6344A). Hidden Valley Dolomite, lower member, about 100 ft above base of formation; 1.93 miles N. 12° E. of Pyramid Peak. |
| 6843–SD | (JFM6344B). Hidden Valley Dolomite, lower member, about 55 ft above 6842–SD. |
| 6844–SD | (JFM6344C). Hidden Valley Dolomitie, lower member, about 155 ft above 6842–SD. |
| 7268–SD | (JFM64526C). Lost Burro Formation, 20 ft above 7269–SD. |
| 7269–SD | (JFM64526B). Lost Burro Formation, about 1,735 above base in measured composite section, southeast end of Funeral Mountains; 2,000 ft N. 47° W. of hill 2997. |
| 7270–SD | (JFM64525D). Lost Burro Formation, 170 ft above 7272–SD. |
| 7272–SD | (JFM64525B2). Lost Burro Formation, about 1,575 ft above base in measured composite section, southeast end of Funeral Mountains; 2,750 ft N. 34° W. of hill 2997. |
| 7275–SD | (JFM64321C). Lost Burro Formation, 240 ft above 7278–SD. |

*USGS number*

7277–SD (JFM64523D). Lost Burro Formation, 185 ft above 7278–SD.

7278–SD (JFM64321B). Lost Burro Formation, about 605 ft above base in measured composite section, southeast end of Funeral Mountains; 4,000 ft N. 38° W. of hill 2997.

7299–SD (JFM64519B). Hidden Valley Dolomite, lower member, within interval about 380–400 ft above base of formation, west side of spur 4298, southeast end of Funeral Mountains; 4.48 miles S. 46½ E. of Pyramid Peak.

7300–SD (JFM64520B). Hidden Valley Dolomite, lower member, interval 380–400 ft above base of formation in measured section, west side of spur 4298, southeast end of Funeral Mountains; 4.49 miles S. 47° E. of Pyramid Peak.

7301–SD (JFM64520C). Hidden Valley Dolomite, upper member, interval 35–50 ft below top of formation in measured section, west side of spur 4298, southeast end of Funeral Mountains; 4.56 miles S. 47° E. of Pyramid Peak.

7473–SD (JFM65316B). Lost Burro Formation, equivalent to stratigraphic position about 1,750 ft above base of formation in measured composite section, southeast end of Funeral Mountains; 1.63 miles N. 25° W. of hill 2997.

8878–SD (JFM631214B+80). Lost Burro Formation, within interval 15–20 ft below top of formation, in supplementary section measured into overlying Tin Mountain, 1,100 ft N. 24° W. of hill 2997, southeast end of Funeral Mountains.

12858–PC (JFM65517E). Tin Mountain Limestone, within interval 175–190 ft above base, along line of measured section across hill 2997, southeast end of Funeral Mountains.

19772–PC (JFM631214D). Tin Mountain Limestone, 20 ft above base, collected from same 1-foot stratigraphic interval for about 200 ft along strike from measured supplementary section at 1,100 ft N. 24° W. of hill 2997, southeast end of Funeral Mountains.

19773–PC (JFM631214D1). Tin Mountain Limestone, 20 ft above base in measured supplementary section, 1,100 ft N. 24° W. of hill 2997, southeast end of Funeral Mountains.

21931–PC (JFM64319F). Perdido Formation, 150 ft above base in measured section at 1,400 ft N. 65° E. of hill 2997, southeast end of Funeral Mountains.

21932–PC (JFM64319E). Perdido Formation, 20 ft above base in measured section at 1,400 ft N. 65° E. of hill 2997, southeast end of Funeral Mountains.

21933–PC (JFM64319A). Tin Mountain Limestone, about 295–300 ft above base, about 250 ft north along strike from measured section across hill 2997, southeast end of Funeral Mountains.

21934–PC (JFM64317G). Tin Mountain Limestone, about 225 ft above base, about 300 ft south along strike from measured section across hill 2997, southeast end of Funeral Mountains.

21935–PC (JFM64317F). Tin Mountain Limestone, about 215–220 ft above base, about 300 ft south along strike from measured section across hill 2997, southeast end of Funeral Mountains.

| *USGS number* | |
|---|---|
| 21936–PC | (JFM64317E). Tin Mountain Limestone, about 205 ft above base, about 300 ft south along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21937–PC | (JFM64319C). Tin Mountain Limestone, about 175–190 ft above base, float virtually in place, about 700–1,000 ft north along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21938–PC | (JFM64317D). Tin Mountain Limestone, about 160–165 ft above base, about 300 ft south along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21939–PC | (JFM64317C). Tin Mountain Limestone, about 105–110 ft above base, about 300 ft south along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21940–PC | (JFM64317B). Tin Mountain Limestone, 100 ft above base, in measured section across hill 2997, southeast end of Funeral Mountains. |
| 21941–PC | (JFM64317A6). Tin Mountain Limestone, 90–95 ft above base, about 700 ft north along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21942–PC | (JFM64317A5). Tin Mountain Limestone, 90–95 ft above base, about 300 ft south along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21943–PC | (JFM64317A4). Tin Mountain Limestone, 90–95 ft above base, about 250 ft north along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21944–PC | (JFM64317A3). Tin Mountain Limestone, 90–95 ft above base, about 150 ft north along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21945–PC | (JFM64317A2). Tin Mountain Limestone, 90–95 ft above base, about 55 ft north along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21946–PC | (JFM64317A1). Tin Mountain Limestone, 90–95 ft above base, about 15 ft north along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21947–PC | (JFM64316E). Tin Mountain Limestone, 7–8 ft above base, about 40–75 ft south along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21948–PC | (JFM64316E float). Tin Mountain Limestone, float virtually in place, same as 21947–PC. |
| 21950–PC | (JFM64316D4). Tin Mountain Limestone, basal bed less than 1 ft thick, lithologically transitional from calcareous sandstone of underlying Lost Burro Formation to sparsely sandy limestone, about 140 ft south along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| 21951–PC | (JFM64316D3). Tin Mountain Limestone, basal bed, same as 21950–PC except about 110 ft south along strike from measured section. |
| 21952–PC | (JFM64316D2). Tin Mountain Limestone, basal bed, same as 21950–PC except about 95 ft south along strike from measured section. |

| *USGS number* | |
|---|---|
| 21953–PC | (JFM64316D1). Tin Mountain Limestone, basal bed, same as 21950–PC except about 60 ft south along strike from measured section. |
| 24651–PC | (JFM64319G). Perdido Formation, 205 ft above base in measured section at 1,400 ft N. 65° E. of hill 2997, southeast end of Funeral Mountains. |
| 24652–PC | (JFM64316F). Tin Mountain Limestone, about 5 ft above base, about 170 ft south along strike from measured section across hill 2997, southeast end of Funeral Mountains. |
| JFM56120A | Hidden Valley Dolomite, lower member, about 450 ft above base of formation, several hundred feet south of measured section; 1.95 miles N. 51° W. of Pyramid Peak. M1097* |
| JFM62427E | Hidden Valley Dolomite, upper member, unmeasured distance within 80 ft below top of formation; 1.56 miles N. 57½° W. of Pyramid Peak. M1060* |
| JFM62611B | Hidden Valley Dolomite, upper member, interval 75–80 ft below top of formation, measured section; 1.84 miles N. 47° W. of Pyramid Peak. M1059* |
| JFM62611B1 | Hidden Valley Dolomite, upper member, float virtually in place in 10-ft interval stratigraphically above but downslope from JFM62611B. |
| JFM6354Ca | Hidden Valley Dolomite, lower member, about 100 ft above base of formation, 3 miles S. 22° E. of Schwaub Peak. M1098* |
| JFM6354F2 | Hidden Valley Dolomite, lower member, 200 ft above JFM 6354Ca. |
| JFM65313D | Hidden Valley Dolomite, upper member, 45 ft below top of formation, southeast end of Funeral Mountains; 6.23 miles S. 72° E. of Pyramid Peak. M1064* |
| JFM6547D | Hidden Valley Dolomite, upper member, unmeasured distance within 50 ft below top of formation, north side of spur 4298; 4.68 miles S. 51° E. of Pyramid Peak. M1063* |
| JFM65517C | Tin Mountain Limestone, about 30 ft above base, approximately in line of measured section across hill 2997, southeast end of Funeral Mountains. |
| JFM6659B | Hidden Valley Dolomite, lower member, within 100 ft above base of formation; 0.82 mile S. 62° E. of Schwaub Peak. D210–SD† |
| JFM661022J | Hidden Valley Dolomite, lower member, same horizon as JFM 6354Ca that is about 100 ft above base of formation; 1.9 miles N. 59° E. of Pyramid Peak. M1127* |
| JFM70518G | Hidden Valley Dolomite, lower member; 1.8 miles N. 25° E. of Schwaub Peak. |

*USGS Paleozoic number, Menlo Park, Calif.
†USGS number, Denver, Colo.

## REFERENCES CITED

Berry, W. B. N., and Boucot, A. J., 1970, Correlation of the North American Silurian rocks: Geol. Soc. America Spec. Paper 102, 289 p.

Burchfiel, B. C., 1964, Precambrian and Paleozoic stratigraphy of Specter Range quadrangle, Nye County, Nevada: Am. Assoc. Petroleum Geologists Bull., v. 48, no. 1, p. 40–56.

———1969, Geology of the Dry Mountain quadrangle, Inyo County, California: California Div. Mines and Geology Spec. Rept. 99, 19 p.

Denny, C. S., and Drewes, Harald, 1965, Geology of the Ash Meadows quadrangle, Nevada-California: U.S. Geol. Survey Bull. 1181–L, p. L1–L56.

Green, Robert, 1963, Lower Mississippian ostracodes from the Banff Formation, Alberta: Research Council Alberta Bull. 11, 237 p.

Gründel, Joachim, 1961, Zur Biostratigraphie und Fazies der *Gattendorfia*-Stufe in Mitteldeutschland unter besonderer Berücksichtingung der Ostracoden: Freiberger Forschungshefte, Heft C 111, p. 53–173.

———1962, Zur Taxionomie der Ostracoden der *Gattendorfia*-Stufe Thüringens: Freiberger Forschungshefte, Heft C 151, p. 51–105.

Hall, W. E., 1971, Geology of the Panamint Butte quadrangle, Inyo County, California: U.S. Geol. Survey Bull. 1299, 67 p.

Hall, W. E., and MacKevett, E. M., Jr., 1962, Geology and ore deposits of the Darwin quadrangle, Inyo County, California: U.S. Geol. Survey Prof. Paper 368, 87 p.

Hall, W. E., and Stephens, H. G., 1962, Preliminary geologic map of the Panamint Butte quadrangle, Inyo County, California: U.S. Geol. Survey Mineral Inv. Field Studies Map MF–251, scale 1:48,000.

———1963, Economic geology of the Panamint Butte quadrangle and Modoc district, Inyo County, California: California Div. Mines and Geology Spec. Rept. 73, 39 p.

Hass, W. H., 1959, Conodonts from the Chappel limestone of Texas: U.S. Geol. Survey Prof. Paper 294–J, p. 365–399.

Hunt, C. B., and Mabey, D. R., 1966, Stratigraphy and structure, Death Valley, California: U.S. Geol. Survey Prof. Paper 494–A, p. A1–A162.

Kesse, G. O., 1963, Fauna of the Hidden Valley Dolomite (Silurian), Death Valley, California: Univ. Southern California, Los Angeles, M. S. thesis, 107 p.

Langenheim, R. L., Jr., and Tischler, Herbert, 1960, Mississippian and Devonian paleontology and stratigraphy, Quartz Spring area, Inyo County, California: California Univ. Pubs. Geol. Sci., v. 38, no. 2, p. 89–150.

McAllister, J. F., 1952, Rocks and structure of the Quartz Spring area, northern Panamint Range, California: California Div. Mines Spec. Rept. 25, 38 p.

———1955, Geology of mineral deposits in the Ubehebe Peak quadrangle, Inyo County, California: California Div. Mines Spec. Rept. 42, 63 p.

———1956, Geology of the Ubehebe Peak quadrangle, California: U. S. Geol. Survey Geol. Quad. Map GQ–95, scale 1:62,500.

———1970, Geology of the Furnace Creek borate area, Death Valley, Inyo County, California: California Div. Mines and Geology Map Sheet 14, with text, 9 p.

———1971, Preliminary geologic map of the Funeral Mountains in the Ryan quadrangle, Death Valley region, Inyo County, California: U.S. Geol. Survey open file report, scale 1:31,680.

Mamet, B. L., and Skipp, Betty, 1970, Lower Carboniferous calcareous Foraminifera: preliminary zonation and stratigraphic implications for the Mississippian of North America: Internat. Cong. on Carboniferous Stratigraphy and Geology, 6th, Sheffield, England, 1967, Compte rendu, v. 3, p. 1129–1146.

Merriam, C. W., 1940, Devonian stratigraphy and paleontology of the Roberts Mountains region, Nevada: Geol. Soc. America Spec. Paper 25, 114 p.

———1963a, Geology of the Cerro Gordo mining district, Inyo County, California: U.S. Geol. Survey Prof. Paper 408, 83 p.

———1963b, Paleozoic rocks of Antelope Valley, Eureka and Nye Counties, Nevada: U.S. Geol. Survey Prof. Paper 423, 67 p.

Miller, R. H., and Hanna, F. M., 1972, Silurian conodonts from Death Valley, California: preliminary report: Jour. Paleontology, v. 46, no. 6, p. 922–924.

Noble, L. F., 1934, Rock formations of Death Valley, California: Science, v. 80, no. 2069, p. 173–178.

Poole, F. G., Baars, D. L., Drewes, H., Hayes, P. T., Ketner, K. B., McKee, E. D., Teichert, C., and Williams, J. S., 1967, Devonian of the southwestern United States, *in* Internat. Symposium on the Devonian System, Calgary, 1967 [Proc.], v. 1: Calgary, Alberta, Alberta Soc. Petroleum Geologists, p. 879–912 [1968].

Richards, C. A., 1957, Geology of a part of the Funeral Mountains, Death Valley National Monument, California: Univ. Southern California, Los Angeles, M. S. thesis, 124 p.

Ross, D. C., 1966, Stratigraphy of some Paleozoic formations in the Independence quadrangle, Inyo County, California: U.S. Geol. Survey Prof. Paper 396, 64 p.

Ross, R. J., Jr., 1967, Some Middle Ordovician brachiopods and trilobites from the Basin Ranges, western United States, *with stratigraphic sections* A, north of Pyramid Peak, Calif., by R. J. Ross, Jr., *and* B, in Specter Range, Nev., by Harley Barnes: U.S. Geol. Survey Prof. Paper 523–D, 43 p.

Sando, W. J., 1969, Corals, *in* McKee, E. D., and Gutschick, R. C., History of the Redwall Limestone of northern Arizona: Geol. Soc. America Mem. 114, p. 257–343.

Sando, W. J., Mamet, B. L., and Dutro, J. T., Jr., 1969, Carboniferous megafaunal and microfaunal zonation in the northern Cordillera of the United States: U.S. Geol. Survey Prof. Paper 613–E, 29 p.

Skipp, Betty, 1969, Foraminifera, *in* McKee, E. D., and Gutschick, R. C., History of the Redwall Limestone of northern Arizona: Geol. Soc. America Mem. 114, p. 173–255.

Sohn, I. G., 1972, Late Paleozoic ostracode species from the conterminous United States: U.S. Geol. Survey Prof. Paper 711–B, p. B1–B13.

Stewart, J. H., 1970, Upper Precambrian and Lower Cambrian strata in the southern Great Basin, California and Nevada: U.S. Geol. Survey Prof. Paper 620, 206 p.

Thompson, T. L., and Fellows, L. D., 1969, Stratigraphy and conodont biostratigraphy of Kinderhookian and Osagean (Lower Mississippian) rocks of southwestern Missouri and adjacent areas: Missouri Div. Geol. Survey and Water Resources Rept. 45, 263 p.

Tschanz, C. M., and Pampeyan, E. H., 1970, Geology and mineral deposits of Lincoln County, Nevada: Nevada Bur. Mines Bull. 73, 187 p.

Yochelson, E. L., McAllister, J. F., and Reso, Anthony, 1965, Stratigraphic distribution of the Late Cambrian mollusk *Matthevia* Walcott, 1885, *in* Geological Survey research 1965: U.S. Geol. Survey Prof. Paper 525–B, p. B73–B78.

Youngquist, Walter, and Heinrich, M. A., 1966, Late Devonian conodonts from the Lost Burro Formation of California: Jour. Paleontology, v. 40, no. 4, p. 974–975.

Zenger, D. H., and Pearson, E. F., 1969, Stratigraphy and petrology of the Lost Burro Formation, Panamint Range, California, *in* Short contributions to California geology: California Div. Mines and Geology Spec. Rept. 100, p. 45–65.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1974——543–584/82