Pennsylvanian and Permian Stratigraphy of the Northern Argus Range and Darwin Canyon Area, California

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By PAUL STONE, CALVIN H. STEVENS, and
ROBERT T. MAGGINETTI

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CONTENTS

FIGURES

Pennsylvanian and Permian Stratigraphy of the Northern Argus Range and Darwin Canyon Area, California

By Paul Stone, Calvin H. Stevens, *and* Robert T. Magginetti

Abstract

The 2-km-thick Pennsylvanian and Permian stratal sequence in the northern Argus Range and adjacent Darwin Canyon area is herein divided into three formations: the Lower and Middle Pennsylvanian Tihvipah Limestone, originally described in the Cottonwood Mountains (northern Panamint Range) 50 km to the northeast, and the herein-named Lower Permian Osborne Canyon and Darwin Canyon Formations, both of which are herein included in the newly revised Owens Valley Group. The Darwin Canyon Formation is divided into the herein-named Millers Spring and Panamint Springs Members. The Tihvipah Limestone, which disconformably overlies the Upper Mississippian Santa Rosa Hills Limestone, is composed of cherty micritic limestone that was deposited on a deep carbonate ramp. The disconformably overlying Osborne Canyon Formation is composed of calcareous mudstone, bioclastic limestone, limestone conglomerate, and minor calcareous siltstone that were deposited in slope and basinal environments. The conformably overlying Darwin Canyon Formation is composed of very fine grained sandstone, bioclastic limestone, limestone conglomerate, and mudstone that were deposited in a basinal environment. Unnamed marine strata of Early Triassic age overlie the Darwin Canyon Formation along an angular unconformity that represents an episode of uplift and tilting during which at least 1,000 m of strata was removed in places by subaerial erosion.

INTRODUCTION

Sedimentary rocks of Pennsylvanian and Permian age are widely exposed in the northern Argus Range and the adjacent Darwin Canyon area in east-central California (fig. 1). In mapping these areas, Hall and MacKevett (1962) and Hall (1971) assigned these rocks to the Pennsylvanian and Permian Keeler Canyon Formation and the Permian Owens Valley Formation, which Merriam and Hall (1957) had defined in the nearby southern Inyo Mountains. As part of a regional stratigraphic study, we recently examined the Pennsylvanian and Permian sequence in the northern Argus Range and Darwin Canyon area in greater detail than had been done in the past. Our work has shown that this sequence consists of three units of formational rank instead of two--a basal unit of Pennsylvanian age and two units of Permian age--and that the Pennsylvanian and Permian rocks are separated by a major disconformity not previously documented. We here describe these three units and introduce new formational names for two of them. We also present a geologic map of the northern Argus Range and Darwin Canyon area, showing the locations of measured sections discussed in the text, and graphic columns of the measured sections. Written descriptions of the sections follow the main text.

OVERVIEW OF THE STRATIGRAPHY AND STRATIGRAPHIC NOMENCLATURE

Underlying Rocks

Pennsylvanian rocks in the northern Argus Range and Darwin Canyon area disconformably overlie about 200 m of massive light-gray limestone that Hall and MacKevett (1962) and Hall (1971) mapped as the Lee Flat Limestone, which they considered to be Mississippian and Pennsylvanian(?) in age. We here reassign these rocks to the Upper Mississippian Santa Rosa Hills Limestone as defined by Dunne and others (1981), with which they are both lithologically and stratigraphically equivalent, and geographically restrict the Lee Flat Limestone from the area of this report (fig. 2). This restriction follows the usage of Dunne and others (1981), who considered the Lee Flat to be a valid unit only at its type locality (fig. 1), where they demonstrated it to be a local member of the Perdido Formation (which underlies the Santa Rosa Hills Limestone) and thus not equivalent to the unit that previous workers have called the Lee Flat Limestone in the northern Argus Range and Darwin Canyon area.

Pennsylvanian Rocks

Lying disconformably above the Santa Rosa Hills Limestone in the northern Argus Range and Darwin Canyon area is a 100- to 125-m-thick sequence of dark-gray cherty limestone of Pennsylvanian age. This limestone is characterized by the abundance of small spherical chert nodules that previous workers have called golfball chert. Pennsylvanian cherty limestone sequences of similar lithology and thickness are present throughout much of the region between Owens

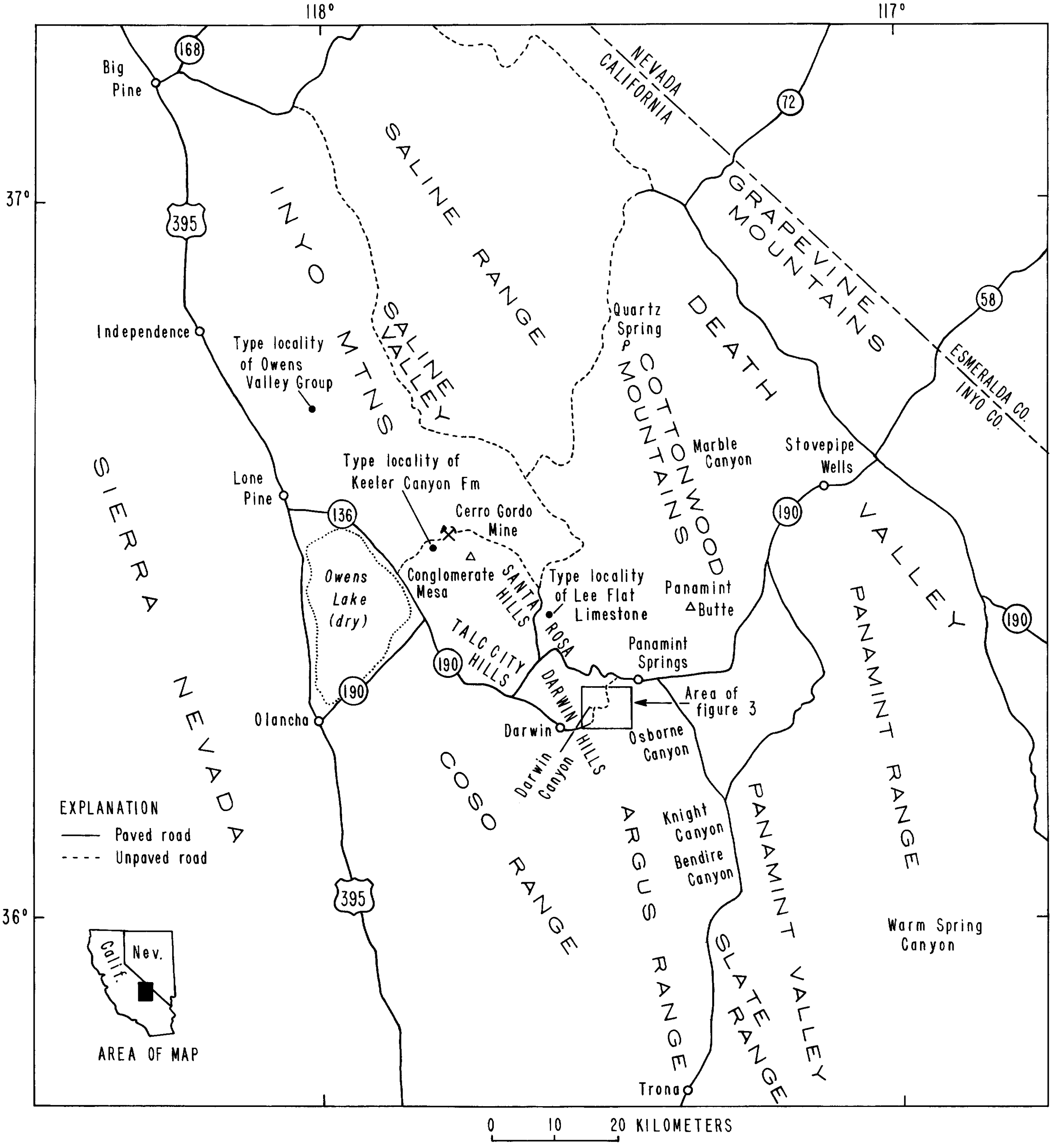
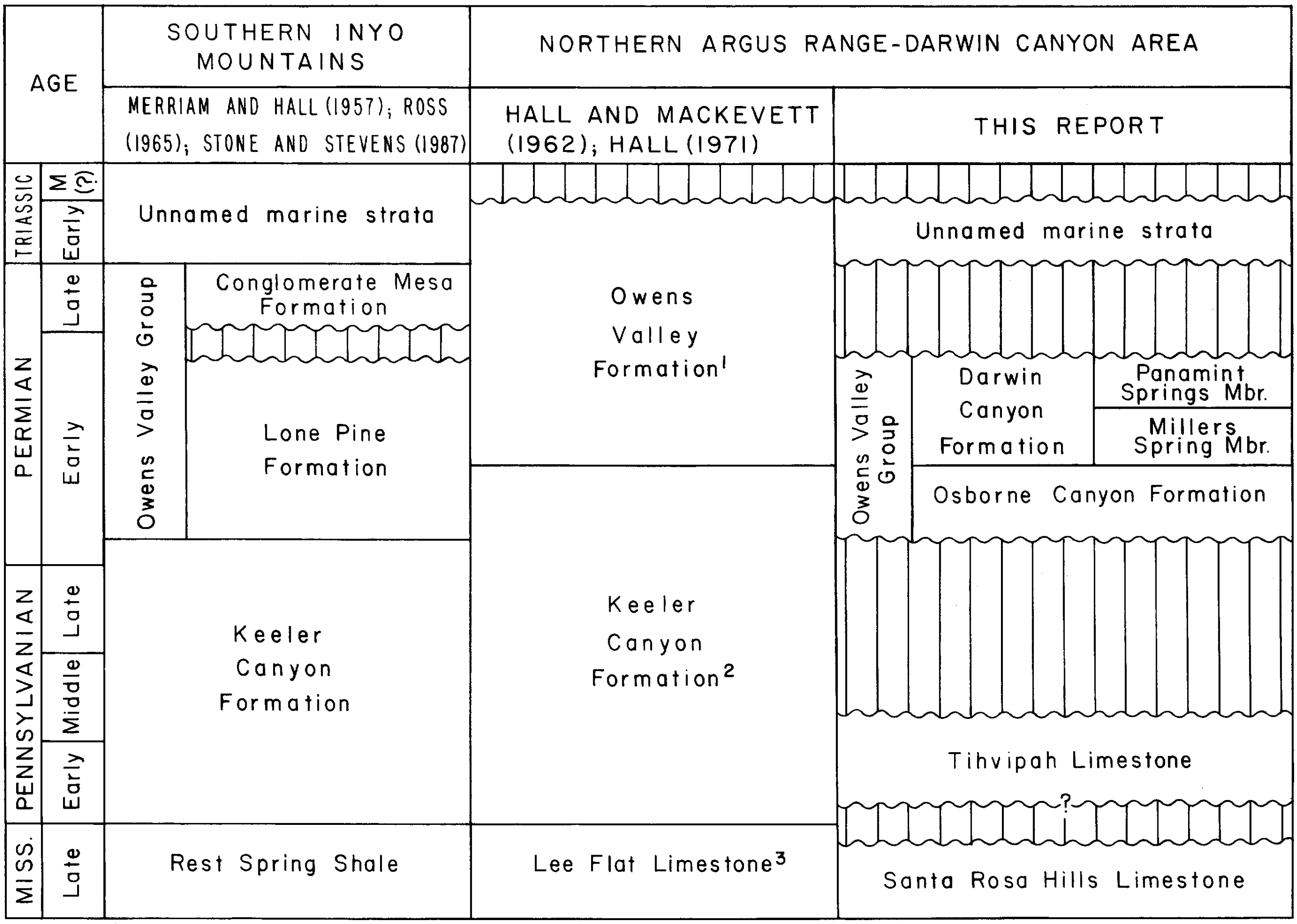


Figure 1. Region between Owens and Death Valleys, California, showing area discussed in report (see figure 3) and other localities mentioned in text.

and Death Valleys (McAllister, 1952, 1956; Merriam and Hall, 1957; Hall and MacKevett, 1962; Ross, 1965; Hall, 1971; Moore, 1976; Stone, 1984; Stone and Stevens, 1984).

The first formal name applied to a Pennsylvanian cherty limestone sequence in the Owens Valley-Death Valley region was the Tihvipah Limestone, which was used by McAllister (1952) for a sequence exposed near Quartz Spring in the Cottonwood Mountains (fig. 1). Later, Merriam and Hall (1957) considered a correlative cherty limestone sequence exposed in the southern Inyo Mountains as the informal lower member



[1]Age given as Permian in reports cited.

[2]Age given as Middle Pennsylvanian to Lower Permian in reports cited.

[3]Age given as Mississippian and Pennsylvanian(?) in reports cited.

Figure 2. Comparison of stratigraphic nomenclature used in this report with that used by previous workers in the northern Argus Range and Darwin Canyon area and southern Inyo Mountains, California.

of the Pennsylvanian and Lower Permian Keeler Canyon Formation, rather than assigning this sequence to the previously defined Tihvipah Limestone. Following Merriam and Hall (1957), Hall and MacKevett (1962) and Hall (1971) mapped the Pennsylvanian cherty limestone sequence exposed in the northern Argus Range and Darwin Canyon area as the lower part of the Keeler Canyon Formation. Our work, however, has shown that the rocks mapped by Hall and MacKevett (1962) and Hall (1971) as the upper part of the Keeler Canyon Formation in the northern Argus Range and Darwin Canyon area are not similar in either lithology or age to the upper part of the type section of that formation, and that the name Keeler Canyon is not applicable in this area. We therefore geographically restrict the Keeler Canyon Formation from the area of this report and reassign its strata in this area to the Tihvipah Limestone (thus encompassing the Pennsylvanian cherty limestone sequence exposed here within the Tihvipah) (fig. 2). This usage of the Tihvipah supersedes the nomenclature proposed by Stone (1984) and Stone and Stevens (1984), who considered the cherty limestone sequence in the northern Argus Range and Darwin Canyon area to be part of the Pennsylvanian and Lower Permian Bird Spring Formation, the type locality of which is in southern Nevada (Hewett, 1931). That assignment was based on correlation with cherty limestone of similar lithology and age ascribed by Stone (1984) and Stone and Stevens (1984) to the lower part of the Bird Spring Formation at Panamint Butte in the southern Cottonwood Mountains and at Warm Spring Canyon in the southern Panamint Range (fig. 1).

Permian Rocks

The Tihvipah Limestone in the northern Argus Range and Darwin Canyon area is disconformably overlain by rocks of Early Permian age that have a maximum thickness of about 1,900 m and comprise two units of formational rank. The lower unit, about 350 m thick, is composed of mudstone, bioclastic limestone, and limestone conglomerate; it encompasses most of the rocks previously mapped as the upper part of the Keeler Canyon Formation by Hall and MacKevett (1962) and Hall (1971). The upper unit consists of two parts: (1) a lower part about 475 to 600 m thick and composed mainly of thick-bedded, very fine grained sandstone, bioclastic limestone, and limestone conglomerate and (2) an upper part about 1,000 m in maximum thickness and composed mainly of thin-bedded, very fine grained sandstone. This unit encompasses most of the rocks previously mapped as the Owens Valley Formation by Hall and MacKevett (1962) and Hall (1971).

Our work has shown that all of the Permian rocks in the northern Argus Range and Darwin Canyon area are age correlative with parts of the Owens Valley Formation as originally defined in the southern Inyo Mountains. In contrast to previous interpretations, we believe that there are no rocks in this area that correlate in either lithology or age with the upper part of the Keeler Canyon Formation, a sequence of bioclastic limestone more than 800 m thick. It is now clear that the geologic time interval represented by the upper part of the Keeler Canyon Formation at its type locality (late Middle Pennsylvanian to earliest Permian) is spanned by the disconformity between the Tihvipah Limestone and the overlying Permian rocks in the northern Argus Range and Darwin Canyon area. The rocks mapped as the upper part of the Keeler Canyon Formation by Hall and MacKevett (1962) and Hall (1971) are not only distinctly younger than that unit, but contain proportionately more mudstone and less limestone and have more diverse and variable lithology than that unit.

In a companion study to this one, Stone and Stevens (1987) have raised the Owens Valley Formation to group rank in the southern Inyo Mountains where it consists of two newly named formations--the Lower Permian Lone Pine Formation and the Upper Permian Conglomerate Mesa Formation--separated by an angular unconformity (fig. 2). Our work has shown that the Permian rocks exposed in the northern Argus Range and Darwin Canyon area are approximately the same age as the Lone Pine Formation, but differ markedly in lithology from that formation. The Lone Pine Formation, which has a maximum thickness of about 1,000 m, consists mainly of dark-colored, thin-bedded calcareous mudstone, lacks sandstone like that present in the northern Argus Range and Darwin Canyon area, and contains only a minor amount of bioclastic limestone. This difference in lithology precludes the use of the name Lone Pine Formation in the northern Argus Range and Darwin Canyon area and necessitates the introduction of new formational names. We herein introduce the new name Osborne Canyon Formation for the lower of the two Permian units present in this area, and the new name Darwin Canyon Formation for the upper unit (fig. 2). We also introduce the new name Millers Spring Member for the lower part of the Darwin Canyon Formation and the new name Panamint Springs Member for the upper part. Previously, Stone and Stevens (1984) used the informal names Formation B and Formation C for the units herein named the Osborne Canyon and Darwin Canyon Formations, respectively.

We include both the Osborne Canyon and Darwin Canyon Formations in the Owens Valley Group mainly as a means of establishing a formal tie between these formations and the age-equivalent Lone Pine Formation. In addition, the name Owens Valley has been established in the northern Argus Range and Darwin Canyon area for more than 20 years, and retaining the name at the group level provides continuity in stratigraphic nomenclature.

Overlying Rocks

The Darwin Canyon Formation is overlain with angular unconformity by more than 800 m of marine strata from which Lewis and others (1983) reported Early Triassic fossils. These unnamed marine strata originally were mapped as part of the Owens Valley Formation by Hall and MacKevett (1962). The angular unconformity separating the Darwin Canyon Formation and the Triassic marine strata spans the geologic time interval represented by the Conglomerate Mesa Formation, which consists of coarse-grained clastic rocks, in the southern Inyo Mountains (fig. 2).

TIHVIPAH LIMESTONE

The Tihvipah Limestone, which is here geographically extended into the northern Argus Range and Darwin Canyon area (and additional areas noted later), is a cliff-forming unit ranging in thickness from approximately 100 to 125 m. It is 121 m thick in measured section 1 in upper Osborne Canyon on the east side of the northern Argus Range (figs. 3, 4). The sharp, disconformable contact between the dark-colored well-bedded Tihvipah Limestone and the underlying light-gray massive Santa Rosa Hills Limestone is one of the most conspicuous formational boundaries in Paleozoic rocks exposed between Owens and Death Valleys.

The Tihvipah Limestone consists primarily of medium- to dark-gray micritic limestone that contains abundant nodular, lenticular, and thinly bedded dark-gray chert. Spherical chert nodules (golfball chert) are especially diagnostic of the unit. Garlow (1984) showed that much of the chert in the formation contains poorly preserved radiolarians. Tremolite produced by widespread low-grade metamorphism is common in the limestone. The cherty limestone is interbedded with light-gray to light-brown silty or argillaceous limestone commonly metamorphosed to fine-grained calc-hornfels. Typically, cherty limestone ledges 1 to 5 m thick alternate with relatively thin recessive intervals of silty or argillaceous limestone. Bedding within the cherty limestone itself is defined mainly by beds, lenses, and aligned nodules of chert that divide otherwise uniform limestone intervals into even layers 10 to 50 cm thick. A well-bedded appearance results. Also present in the Tihvipah Limestone are rare beds 40 cm to 1.5 m thick of bioclastic limestone and limestone conglomerate composed of poorly sorted echinodermal debris, coral and bryozoan fragments, and limestone clasts suspended in a micrite matrix.

The Tihvipah Limestone locally shows evidence of large-scale soft-sediment deformation. Slump features that evidently formed during or shortly after deposition are particularly well developed in upper Osborne Canyon a short distance north of measured section 1 (fig. 3).

Pennsylvanian cherty limestone sequences in the Owens Valley-Death Valley region, including the sequence here assigned to the Tihvipah Limestone in the northern Argus Range and Darwin Canyon area, have long been regarded to be of Atokan (early Middle Pennsylvanian) age based on the widespread occurrence of the fusulinid Fusulinella in their upper parts (McAllister, 1952; Merriam and Hall, 1957 Hall and MacKevett, 1962; Hall, 1971; Moore, 1976; Stone, 1984). However, Morrowan (Early Pennsylvanian) conodonts are now known to be present a few meters above the base of one such sequence exposed in the southern Darwin Hills (H.R. Lane and R.H. Miller, written commun., 1976), and also in the lower part of another such sequence exposed at Marble Canyon in the Cottonwood Mountains (J.E. Repetski, written commun. in Stone, 1984). On the basis of lithologic correlation with these sequences, we consider the Tihvipah Limestone in the northern Argus Range and Darwin Canyon area to range in age from Early into Middle Pennsylvanian. In addition, correlative cherty limestone sequences that are regarded as the lower part of the Keeler Canyon Formation in the southern Inyo Mountains (Merriam and Hall, 1957; Ross, 1965) are here considered to range into the Early Pennsylvanian, rather than being restricted to the Middle Pennsylvanian as has been previously thought (fig. 2).

We interpret the Tihvipah Limestone as having accumulated in moderately deep water on a gently sloping carbonate ramp. This interpretation is based on the fine grain size and dark color of the limestone, the abundance of chert containing radiolarians, the apparent absence of in-place benthic fossils, and the presence of slump features. The rare matrix-supported limestone conglomerates in the formation probably were deposited as debris flows.

OSBORNE CANYON FORMATION

The Osborne Canyon Formation is here named after Osborne Canyon, the northernmost major canyon on the east side of the Argus Range (fig. 1). This formation disconformably overlies the Tihvipah Limestone and is conformably overlain by the Darwin Canyon Formation. The type section of the formation is located in measured section 1 (figs. 3, 4), high on the east side of the Argus Range above Osborne Canyon (in SW 1/4 sec. 13, T. 19 S., R. 41 E., Panamint Butte 15-minute quadrangle) about 7 km south of Panamint Springs.

The Osborne Canyon Formation is composed of calcareous mudstone, bioclastic limestone, limestone conglomerate, and minor calcareous siltstone. The most characteristic features of the formation are the abundance of mudstone and the presence of coarse-grained limestone. The generally slope-forming Osborne Canyon Formation is easily distinguished at a distance from the underlying cliff-forming Tihvipah Limestone.

The type section of the Osborne Canyon Formation has a measured thickness of 346 m and consists of three locally mappable, informally designated members (in ascending order, members A, B, and C). Member A, 52 m thick, is composed primarily of light-gray to light-brown, plane-laminated calcareous siltstone; member B, 137 m thick, is composed mainly of light-gray to light-brown, massive to vaguely bedded calcareous mudstone; member C, 157 m thick, is composed mainly of light-gray to light-brown, evenly bedded and laminated calcareous mudstone. In addition to these slope-forming fine-grained rocks, all three members contain randomly spaced resistant beds of medium- to dark-gray coarsely bioclastic limestone and limestone conglomerate. The base of the formation is placed at the base of a limestone conglomerate bed that sharply overlies the highest cherty limestone bed in the Tihvipah Limestone. The low-angle truncation of beds at the top of the Tihvipah Limestone reflects erosion along this contact. The top of the formation, which also is sharp, is placed at the base of the lowest thick sequence of brown-weathering, very fine grained sandstone in the overlying Darwin Canyon Formation.

The predominantly clast-supported bioclastic limestone and limestone conglomerate beds in the Osborne Canyon Formation have sharp bases and tops and range in thickness from 10 cm to 7.5 m. Many graded beds show the Ta and Tb divisions of the Bouma sequence. Clasts as large as 10 cm in diameter consist of echinodermal debris, fusulinids, other bioclasts, and micritic limestone fragments. Coral fragments are present in a few beds near the top of the formation. Limestone beds in members A and B of the type section are highly lenticular, commonly have erosive bases, and appear to be confined to channels. In contrast, limestone beds in member C are planar, laterally extensive sheets.

Most of the calcareous mudstone in member B of the type section is massive and contains inclusions of micritic limestone that have irregular, gradational contacts with the enclosing matrix. These inclusions appear to have been incorporated into the matrix before lithification. Some of the inclusions are randomly distributed and appear to be redeposited clasts; others are aligned in wavy or convolute patterns that probably developed by soft-sediment deformation of bedding. In contrast, most of the calcareous mudstone in member C is thinly and evenly bedded. Some of the mudstone in member C contains abundant dark-gray spherical to subspherical limestone nodules or concretions that are aligned parallel to bedding.

Less than 1 km south of the type section, a lenticular body of massive limestone conglomerate about 75 m thick occurs at the base of the Osborne Canyon Formation. This conglomerate appears to replace member A of the type section along strike and evidently occupies a channel bounded laterally by beds of member A. Southward along strike, the conglomerate rapidly decreases in thickness to only a few meters.

The Osborne Canyon Formation is characterized by pronounced lateral variations in thickness and lithology. For example, a section of the formation near the eastern base of the Argus Range just outside the area of figure 3 is only about 120 m thick; it comprises about 60 m of pink to maroon calcareous mudstone overlain by about 60 m of thick-bedded limestone conglomerate. Despite such variations, the formation is easily recognized throughout and beyond the report area on the basis of its general lithology and consistent stratigraphic relations.

We have identified the following fusulinids from limestone beds at several horizons in the type section of the Osborne Canyon Formation:

Leptotriticites? sp.
Schwagerina aff. S. wellsensis Thompson and Hansen
Schwagerina spp.
Pseudofusulina? aff. P. loringi Thompson
Pseudoschwagerina uddeni Beede and Kniker
Stewartina? sp.
Eoparafusulina cf. E. linearis (Dunbar and Skinner)
Eoparafusulina sp.
Cuniculinella sp.

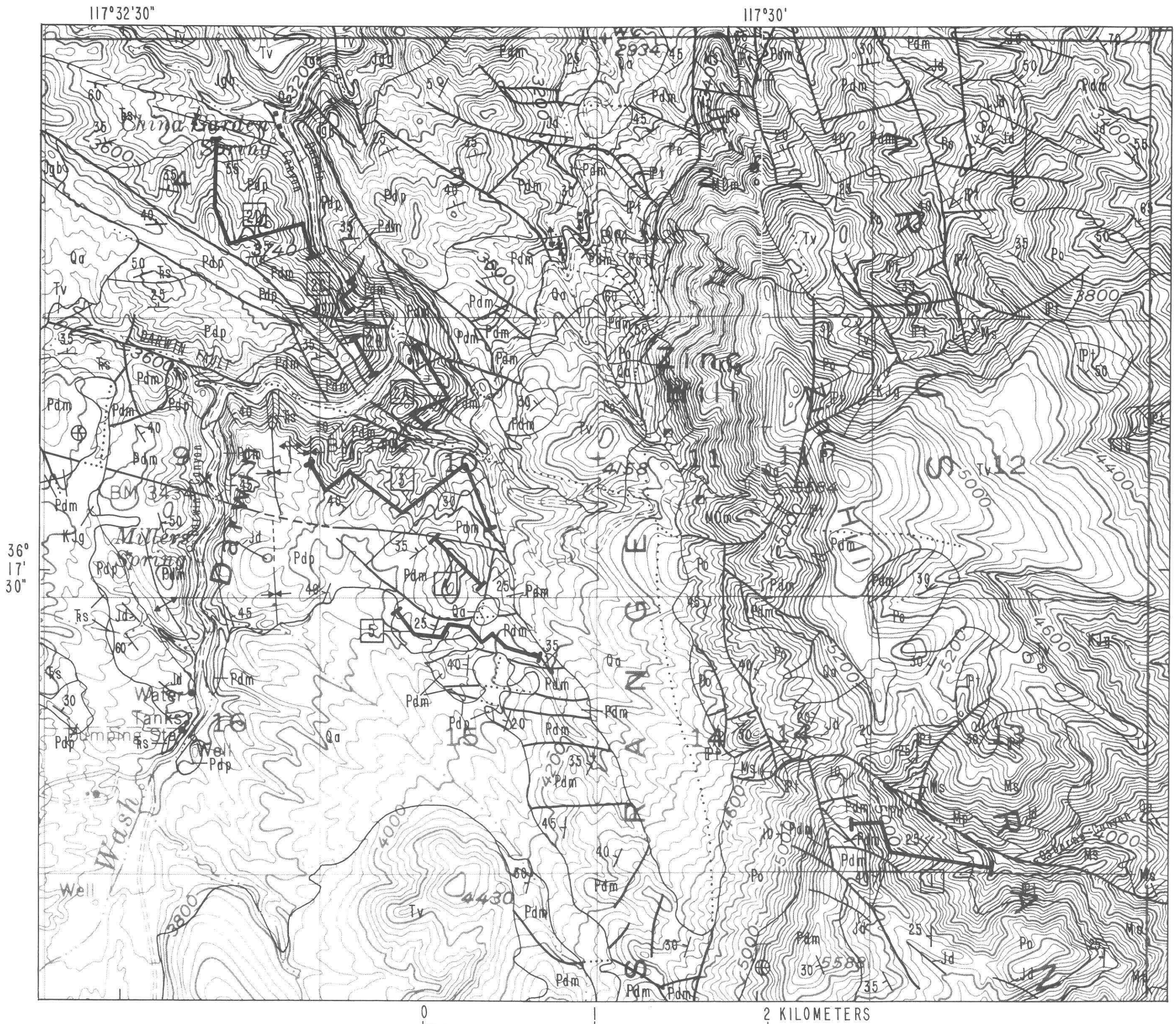


Figure 3. Geologic map of northern Argus Range and Darwin Canyon area, California, showing locations of measured sections discussed in text. See figure 1 for location of map. Base from U.S. Geological Survey, 1:62,500, Darwin, 1950; Panamint Butte, 1951 (contour interval 40 feet). Geology mapped in 1980-1981. Dikes mapped by G.C. Dunne.

This fusulinid assemblage indicates a middle Wolfcampian age (Magginetti, 1983; Stone, 1984). The presence of *Pseudoschwagerina* and *Eoparafusulina* in collection RTM-2 about 9.5 m above the base of the formation (fig. 4) indicates that no part of the formation in the type section is older than middle Wolfcampian in age. Therefore, the disconformity between the Osborne Canyon Formation and the underlying Tihvipah Limestone represents most or all of Late Pennsylvanian and earliest Permian time.

We interpret the Osborne Canyon Formation to have accumulated in deep-water marine slope and basinal environments. We consider the limestone beds in the formation to be sediment-gravity-flow deposits derived from carbonate shelves or banks upslope from the site of deposition. The abundance of soft-sediment deformation features in mudstones of the lower part of the formation (member B) strongly suggests a slope environment. The lenticular limestone beds in members A and B, including the massive lens of limestone conglomerate at the base of the formation just south of the type section, probably are slope-channel deposits. The lateral continuity of limestone beds in the upper part of the formation (member C) and the general lack of soft-sediment deformation features in the associated mudstones probably reflect a change from a channeled slope environment to an unchanneled basin-floor environment.

In light of the relatively deep-water marine origin of both the Osborne Canyon Formation and the underlying Tihvipah Limestone, we interpret the disconformity between them to have resulted from submarine erosion or nondeposition on the slope rather than from subaerial erosion. This interpretation is supported by the lack of pronounced angular discordance between the two formations and by the nearly constant thickness of the Tihvipah Limestone throughout the study area.

DARWIN CANYON FORMATION

The Darwin Canyon Formation is here named after Darwin Canyon, the major canyon between the northern Argus Range and the Darwin Hills (fig. 1). This formation conformably overlies the Osborne Canyon Formation and is unconformably overlain by unnamed marine strata of Early Triassic age.

We here divide the Darwin Canyon Formation into two formally named members, the Millers Spring

EXPLANATION

Qa — Alluvium and talus (Quaternary)

Tv — Volcanic rocks (Tertiary)

KJg — Leucocratic granitoid rocks (Cretaceous? and Jurassic)--Quartz monzonite and granite

Jd — Mafic to intermediate dikes (Jurassic)--Correlated with Independence dike swarm

Jgb — Gabbro, granodiorite, and minor quartz monzonite (Jurassic?)

TRs — Marine sedimentary rocks (Lower Triassic)--Light-brown calc-hornfels and gray marble; minor siltstone and shale; sandy limestone and calcareous sandstone in lowermost part

Owens Valley Group (Lower Permian)--In this area, consists of:

Darwin Canyon Formation--Divided into:

Pdp — Panamint Springs Member--Brown, thin-bedded siltstone and very fine grained sandstone; medium- to dark-gray limestone in lowermost part

Pdm — Millers Spring Member--Brown, thick-bedded, very fine grained sandstone and medium- to dark-gray, thin- to thick-bedded bioclastic to conglomeratic limestone

Po — Osborne Canyon Formation--Light-gray to light-brown, thin-bedded to massive calcareous mudstone and medium- to dark-gray, thin- to thick-bedded bioclastic to conglomeratic limestone; minor calcareous siltstone

IPt — Tihvipah Limestone (Middle and Lower Pennsylvanian)--Medium- to dark-gray, thin- to thick-bedded micritic limestone with abundant nodular, lenticular, and bedded chert; subordinate light-gray to light-brown silty or argillaceous limestone

Ms — Santa Rosa Hills Limestone (Upper Mississippian)--Light-gray massive limestone

Mp — Perdido Formation (Mississippian)--Dark-gray limestone and thin-bedded chert

MDm — Marble (Mississippian and (or) Devonian)--Presumably correlative with the Devonian Lost Burro Formation and (or) the Mississippian Tin Mountain Limestone, Perdido Formation, and Santa Rosa Hills Limestone

Contact

Fault--Dashed where approximately located, dotted where concealed. Arrows show relative movement direction

Anticline

Syncline--dashed where approximately located

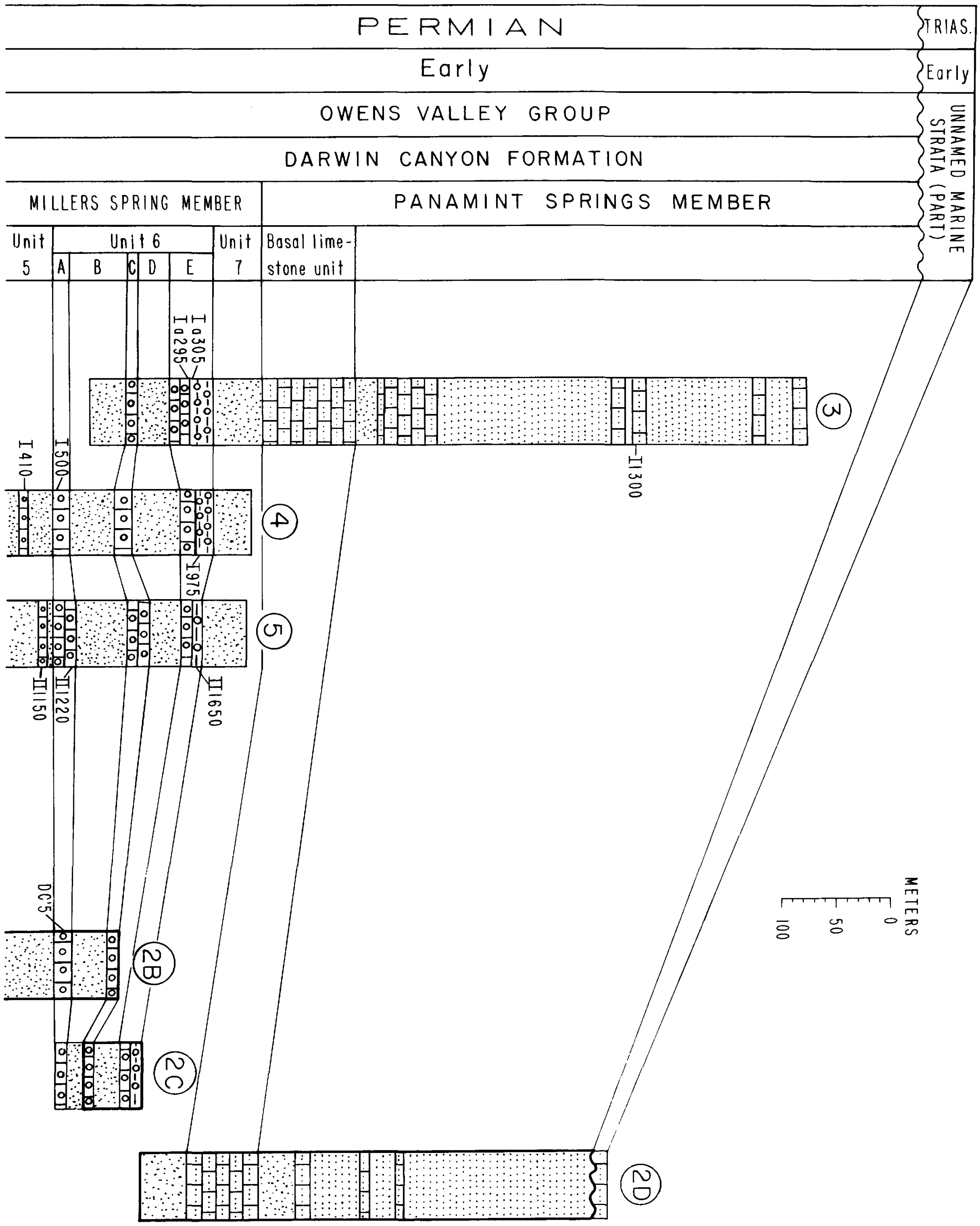
Strike and dip of beds

60 Inclined

Horizontal

3 Line of measured section

Figure 3. Continued.


PERMIAN
TRIAS.
Early
Early
OWENS VALLEY GROUP
DARWIN CANYON FORMATION
UNNAMED MARINE STRATA (PART)
MILLERS SPRING MEMBER
PANAMINT SPRINGS MEMBER
Unit 5
Unit 6
A
B
C
D
E
Unit 7
Basal limestone unit
Ia305
Ia295
I500
I410
II300
I975
II150
II220
II650
DC'5
3
4
5
2B
2C
2D
METERS
0
50
100

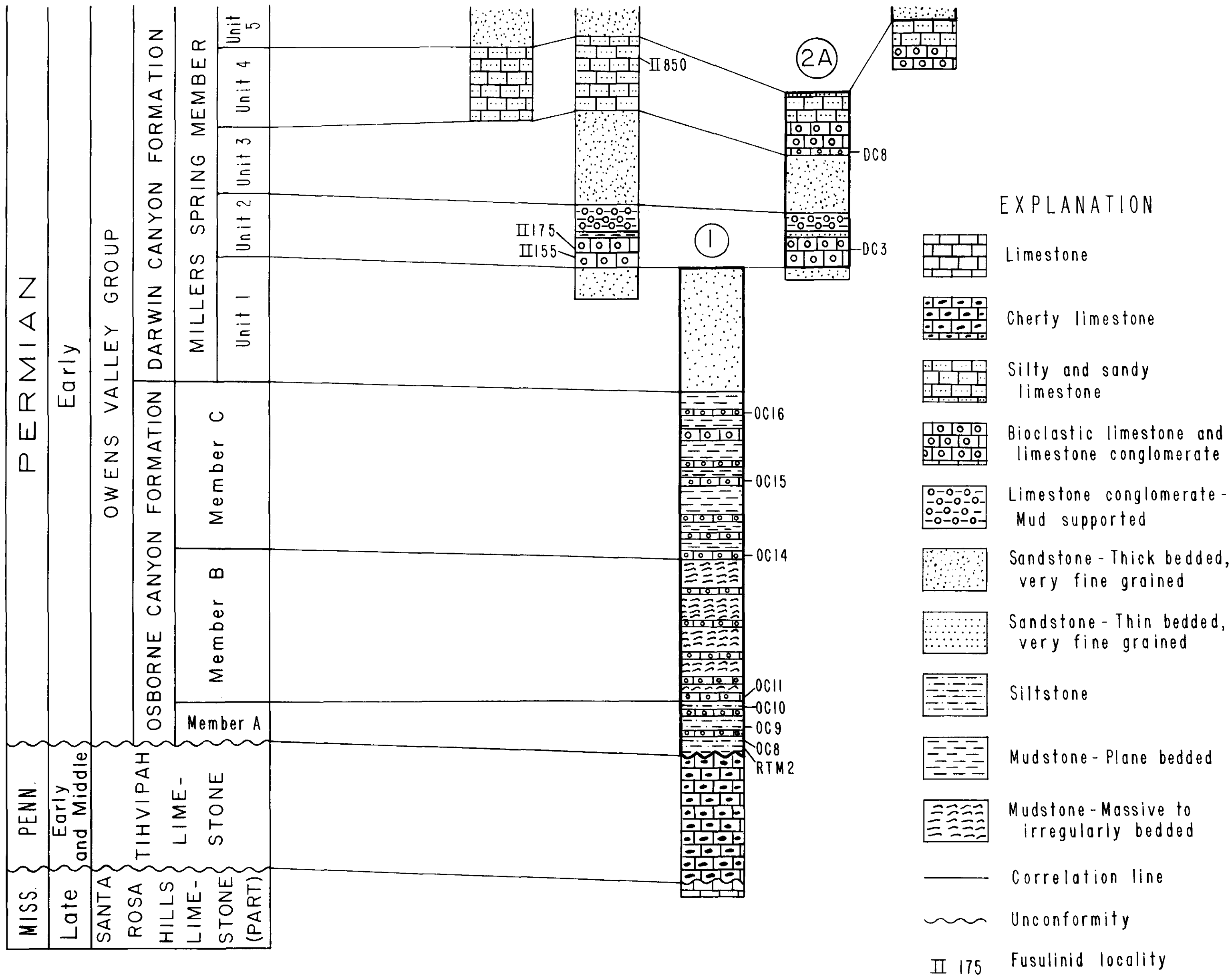


Figure 4. Generalized graphic columns of measured sections 1-5. Type sections of Osborne Canyon Formation and Darwin Canyon Formation in measured sections 1, 2A, 2B, 2C, and 2D denoted by heavy outline. Stratigraphic positions of fusulinid collections shown to right of columns. Locations of measured sections shown on figure 3.

Member and the overlying Panamint Springs Member (figs. 2, 4). These units are named after Millers Spring, which is located near the head of Darwin Canyon, and Panamint Springs, which is situated on California State Highway 190 at the northeast base of the Argus Range. The type section of the Millers Spring Member is a composite section measured in five segments correlated by marker beds (fig. 4). The lowest segment overlies the type section of the Osborne Canyon Formation in measured section 1, high on the east slope of the Argus Range (in SW 1/4 sec. 13 and SE 1/4 sec. 14, T. 19 S., R. 41 E., Panamint Butte 15-minute quadrangle); the other segments (measured sections 2A, 2B, 2C and 2D) are in Darwin Canyon north of the Darwin fault (in NW 1/4 sec. 10, SW 1/4 sec. 3, and SE 1/4 sec. 4, T. 19 S., R. 41 E., Darwin 15-minute quadrangle) (figs. 3, 4). The type section of the Panamint Springs Member overlies that of the Millers Spring Member in measured section 2D (in E 1/2 sec. 4, T. 19 S., R. 41 E., Darwin 15-minute quadrangle). The type section of the Darwin Canyon Formation is defined as the composite of the type sections of its two members. We have also measured reference sections through parts of the Millers Spring Member and Panamint Springs Member in the hills south of the Darwin fault: Millers Spring Member--in S 1/2 sec. 10 (measured sections 3 and 4, figs. 3, 4) and N 1/2 sec. 15 (measured section 5, figs. 3, 4), T. 19 S., R. 41 E., Darwin 15-minute quadrangle; Panamint Springs Member--in S 1/2 sec. 10, T. 19 S., R. 41 E., Darwin 15-minute quadrangle (measured section 3, figs. 3, 4).

The Darwin Canyon Formation is composed mainly of well-bedded, brown-weathering, very fine grained sandstone and calcarenitic sandstone; the Millers Spring Member additionally contains abundant medium- to dark-gray, calcarenitic, coarsely bioclastic limestone and limestone conglomerate and subordinate gray to pink calcareous mudstone and silty mudstone. The formation is distinguished from the underlying Osborne Canyon Formation primarily by the dominance of sandstone over mudstone. The brown ledgy slopes typically formed by the Darwin Canyon Formation contrast strongly with the generally smooth, gray slopes formed by the Osborne Canyon Formation. Near intrusive bodies, parts of the Darwin Canyon Formation have been metamorphosed to quartzite, calc-hornfels, and marble.

Millers Spring Member

The Millers Spring Member ranges in thickness from about 475 to 600 m in the area of this report and averages about 550 m thick. In its composite type section, the member has a measured thickness of 487 m.

The Millers Spring Member has a distinctive internal stratigraphy. Four units composed chiefly of medium- to thick-bedded, very fine grained sandstone and calcarenitic sandstone (units 1, 3, 5, and 7) are separated by three units composed largely of limestone (units 2, 4, and 6) (fig. 4). All seven units can be mapped throughout the northern Argus Range and Darwin Canyon area with only minor changes in thickness and lithology.

Sandstone of the Millers Spring Member is quartzitic to subarkosic (and variably calcareous) in composition and arenitic in texture. Thin sections show that the sandstone typically is composed of 70 to 80 percent framework grains and 20 to 30 percent calcite cement. The detrital fraction generally consists of about 60 to 80 percent quartz, 5 to 25 percent feldspar, 10 to 15 percent calcite (echinodermal debris and peloids), and trace amounts of muscovite and heavy minerals. Some beds contain as much as 50 percent detrital calcite. Grains are subangular to subrounded and are very well sorted in the coarse silt to very fine sand range. Grains smaller than 0.05 mm and larger than 0.1 mm are rare. Neither terrigenous nor calcareous mud is present in the sandstone.

Sandstone beds in the Millers Spring Member are planar and laterally extensive; they range in thickness from 10 cm to 3.5 m and have an average thickness of about 50 cm. These beds alternate with recessive, generally poorly exposed intervals of mudstone that range in thickness from less than 1 cm to about 2 m. The average ratio of sandstone to mudstone is between 1.5:1 and 2:1. Sandstone beds have sharp lower and upper contacts and range from apparently massive to pervasively plane laminated, crosslaminated, and convolute laminated. Calcarenitic beds are more conspicuously laminated than the more purely siliciclastic beds. With rare exceptions, the sandstone beds are not visibly graded, although thin sections show that many beds are weakly graded. Flute and groove casts are rare.

The three limestone units of the Millers Spring Member consist mainly of clast-supported, coarsely bioclastic limestone and limestone conglomerate beds ranging in thickness from 1 to 5 m. These beds are composed of tightly packed echinodermal debris, fusulinids, massive and fasciculate coral fragments, other bioclasts, and micritic limestone clasts in a micritic limestone matrix. Maximum clast size in most beds is about 5 cm. Many graded beds display the Ta and Tb divisions of the Bouma sequence. A few thick beds of mud-supported limestone conglomerate (conglomeratic mudstone) are present in addition to the clast-supported beds.

Each of the limestone units of the Millers Spring Member has a characteristic stratigraphy. Unit 2 typically consists of two thick clast-supported limestone beds overlain by a thick matrix-supported bed. Lico (1983) studied unit 2 in detail and demonstrated the substantial lateral continuity of the individual beds within it. Unit 4 consists of a basal zone of several thick, clast-supported, coarse-grained limestone beds overlain by a zone of thinner, finer grained limestone beds. Unit 6 consists of three discrete zones of thick, coarse-grained limestone beds (units 6A, 6C, and 6E) separated by intervals of thick-bedded sandstone (units 6B and 6D). Unit 6E is capped by a distinctive pink, mud-supported conglomerate bed 10 m thick. All three limestone units maintain their lithologic identity throughout and beyond the study area and make excellent stratigraphic markers.

We have identified fusulinids from units 2, 4, 5, and 6 of the Millers Spring Member in the type section and in the reference sections south of the Darwin fault. Collections from units 2 and 4 yielded the following taxa:

Schwagerina aculeata Thompson and Hazzard
Schwagerina elkoensis? Thompson and Hansen
Schwagerina aff. S. eolata Thompson
Schwagerina aff. S. thompsoni Needham
Schwagerina spp.
Pseudofusulina? aff. P.? loringi Thompson
Chusenella compacta (White)
Paraschwagerina sp.
Pseudoschwagerina sp.
Stewartina moranensis (Thompson)
Stewartina sp.
Stewartina? spp.
Eoparafusulina cf. E. linearis (Dunbar and Skinner)
Cuniculinella spp.

Collections from units 5 and 6 yielded the following taxa:

Schwagerina aculeata Thompson and Hazzard
Schwagerina cf. S. crebrisepta Ross
Schwagerina diversiformis Dunbar and Skinner
Schwagerina elkoensis Thompson and Hansen
Schwagerina cf. S. eolata Thompson
Schwagerina aff. S. thompsoni Needham
Schwagerina cf. S. wellsensis Thompson and Hansen
Schwagerina spp.
Chusenella sp.
Pseudoschwagerina uddeni (Beede and Kniker)
Pseudoschwagerina convexa Thompson
Pseudoschwagerina sp.
Stewartina sp.
Chalaroschwagerina sp.
Parafusulina sp.

These fusulinid assemblages indicate a middle to late Wolfcampian age. Fusulinid assemblages from units 2 and 4 lack typical late Wolfcampian taxa and are considered middle Wolfcampian in age. The assemblages from units 5 and 6 contain the typical late Wolfcampian fusulinids Schwagerina cf. S. crebrisepta, Schwagerina diversiformis, and Chalaroschwagerina sp. (Magginetti, 1983; Stone, 1984). We interpret the presence of Parafusulina, a typical Leonardian genus, in one collection (I410, unit 5, measured section 4) as an unusually early occurrence of this genus; the fusulinids in this collection, although redeposited, do not appear to have been significantly reworked.

We interpret the Millers Spring Member to represent deposition in a deep-water marine basinal environment, primarily because of the presence of Bouma sequences in the clast-supported limestone beds. These beds evidently are turbidites that were derived from carbonate banks or shelves upslope from the site of deposition. We interpret the thick, matrix-supported beds such as those in units 2 and 6E as submarine debris-flow deposits that resulted from collapse of large segments of the shelf and slope adjacent to the basin. The lateral continuity of the limestone units, and of many individual beds, strongly suggests that deposition took place on a generally featureless basin floor.

Sandstone beds in the Millers Spring Member probably are sediment-gravity-flow deposits akin to turbidites, as indicated by their lateral continuity and their association with limestone turbidites and debris-flow deposits. However, these beds differ from typical turbidites in at least three important respects: they lack a muddy matrix and Bouma sequences, they generally lack flute and groove casts, and they are much more strongly and pervasively crosslaminated than typical turbidites of comparable thickness. Their exact mechanism of deposition is unclear.

Panamint Springs Member

The Panamint Springs Member of the Darwin Canyon Formation is a lithologically homogeneous unit composed mainly of light-brown, thin-bedded, very fine grained sandstone and siltstone. It is distinguished from the underlying Millers Spring Member by its consistently thin bedding and by its general lack of coarse-grained limestone.

The Panamint Springs Member, where not covered at the top by alluvium or Tertiary volcanic rocks, is overlain with angular unconformity by unnamed Triassic marine strata (fig. 3). The best exposure of this unconformity is on a cliff face in Darwin Canyon immediately south of the Darwin fault, where thick-bedded sandy limestone and calcareous sandstone of Early Triassic age overlie the Panamint Springs Member with an angular discordance of about 15°. Owing to this angular relationship with the overlying rocks, the Panamint Springs Member ranges in thickness from zero in the western part of the report area to about 1,000 m a short distance east of the area. The type section of the member in Darwin Canyon (measured section 2D) is 372 m thick.

Although the stratigraphic relations of the Panamint Springs Member are clearly revealed in the type section, the lithologic features of the member are somewhat obscure there as a result of metamorphism. The original lithology of the member is better displayed in the vicinity of measured section 3 south of the Darwin fault (fig. 3). There, the member is composed mainly of very fine grained sandstone and siltstone in laterally extensive, graded, laminated and crosslaminated beds 2 to 15 cm thick. Many of these beds show the Ta, Tb, and Tc divisions of the Bouma sequence. Beds are either amalgamated or are separated by mudstone partings that are generally less than 1 cm thick. Bedding is very even and planar, although the basal surfaces of some beds show evidence of scour. Most beds are composed of about 50 percent detrital quartz and feldspar and about 50 percent detrital and recrystallized calcite. Locally interbedded with the thin-bedded sandstone and siltstone are relatively thick (20 cm to 1 m) beds of coarse-grained sandstone containing chert pebbles and silicified reworked fusulinids. Such beds, most of which are graded, are particularly common in the lower part of the member.

The lowermost part of the Panamint Springs Member is a distinctive unit of medium- to dark-gray, generally fine-grained calcarenitic limestone and light-gray, brown, and pink mudstone. This unit, which has a measured thickness of 65 m in the type section of the Panamint Springs Member, sharply overlies the highest thick-bedded sandstone unit in the Millers Spring Member. Locally, as in Darwin Canyon south of the Darwin fault, the basal limestone unit is deformed by conspicuous folds that do not extend into the enclosing sandstone beds. Although the lithology of this limestone unit is atypical of the Panamint Springs Member, its base is the most objective horizon on which to define the base of the member. The basal limestone unit grades upsection into the thin-bedded siltstone and sandstone that composes the rest of the member.

Within the immediate report area (fig. 3), the only fossils we have obtained from the Panamint Springs Member are reworked fusulinids from a pebbly sandstone bed 336 m above the base of the member in measured section 3 (collection I1300). This collection contains a typical late Wolfcampian fusulinid assemblage that includes Schwagerina diversiformis Dunbar and Skinner, Schwagerina cf. S. crebrisepta Ross, Chalaroschwagerina sp., and Pseudoschwagerina convexa Thompson. A short distance west of the report area, in the northern Darwin Hills, a similar pebbly sandstone bed somewhat lower in the member contains Parafusulina in addition to late Wolfcampian species of Schwagerina and Pseudoschwagerina. This bed evidently is late Wolfcampian in age with an unusually early occurrence of Parafusulina. At least part of the thick sequence of unfossiliferous siltstone and sandstone in the Panamint Springs Member above our fusulinid collections probably is Leonardian in age.

The Panamint Springs Member represents deposition in a deep-water marine basinal environment, as indicated by the dominance of thin graded sandstone and siltstone beds of apparent turbidite origin. The absence of coarse-grained limestone like that in the Millers Spring Member indicates that the basin was no longer flanked by carbonate shelves and banks. This change in the shelf margin probably also resulted in the pronounced decrease in average sandstone-bed thickness in the Panamint Springs Member relative to that in the Millers Spring Member. During deposition of the Millers Spring Member, basin-rimming carbonate buildups may have ponded sand prior to its discharge into the basin, resulting in high-volume sand flows and thick beds. The lack of such buildups during deposition of the Panamint Springs Member would have prevented the ponding of sand, resulting in smaller sand flows and thinner beds.

REGIONAL EXTENT OF THE TIHVIPAH LIMESTONE, OSBORNE CANYON FORMATION, AND DARWIN CANYON FORMATION

The Tihvipah Limestone and numerous correlative cherty limestone sequences can be recognized throughout the region between Owens and Death Valleys (Stone, 1984; Stone and Stevens, 1984). Sections that we here regard as belonging to the Tihvipah and which are nearly identical in lithology and thickness to that occurring in the area of this report are present at Knight and Bendire Canyons in the central Argus Range, the southern Darwin Hills, and the Santa Rosa Hills (fig. 1). Hall and MacKevett (1962) and Moore (1976) assigned these sections to the Keeler Canyon Formation, while Stone and Stevens (1984) alternatively assigned them to the Bird Spring Formation. At Knight and Bendire Canyons, as in the report area, the Tihvipah Limestone rests directly on the Santa Rosa Hills Limestone; in the southern Darwin Hills and the Santa Rosa Hills, a thin sequence of Upper Mississippian sandstone and shale lies between the Tihvipah and Santa Rosa Hills Limestones. At Marble Canyon in the southern Cottonwood Mountains, cherty limestone similar in lithology to that of the Tihvipah Limestone forms the major part of a Pennsylvanian section more than 600 m thick. This section, which Stone and Stevens (1984) assigned to the Bird Spring Formation, overlies a thin sequence of Upper Mississippian sandstone and shale like that in the Santa Rosa Hills and southern Darwin Hills. As previously noted, cherty limestone lithologically similar to the Tihvipah Limestone forms the lower part of the Bird Spring Formation in the southern Cottonwood Mountains and the southern Panamint Range, and the lower part of the Keeler Canyon Formation in the southern Inyo Mountains.

The Osborne Canyon and Darwin Canyon Formations can be recognized at Knight and Bendire Canyons in the central Argus Range, in the Darwin Hills, and at Marble Canyon in the central Cottonwood Mountains (fig. 1), where they encompass some of the rocks heretofore mapped as the Keeler Canyon and Owens Valley Formations by Hall and MacKevett (1962), Stadler (1968), Johnson (1971), and Moore (1976). Rocks similar in general lithology and age to the Osborne Canyon and Darwin Canyon Formations are present in the northern Santa Rosa Hills and the Conglomerate Mesa area in the southeastern Inyo Mountains (Stone and Stevens, 1984). However, the stratigraphy of the rocks in the northern Santa Rosa Hills and Conglomerate Mesa area differs sufficiently from that of the Permian section in the northern Argus Range and Darwin Canyon area that, in our opinion, the names Osborne Canyon and Darwin Canyon should not be extended there. Rocks similar in lithology and age to the Osborne Canyon Formation overlie the Bird Spring Formation at Panamint Butte in the southern Cottonwood Mountains, and rocks that may correlate with the Osborne Canyon Formation overlie the Bird Spring Formation at Warm Spring Canyon in the southern Panamint Range (Stone and Stevens, 1984).

DEPOSITIONAL HISTORY

During the Late Mississippian, the report area was part of a broad, shallow carbonate shelf upon which the Santa Rosa Hills Limestone accumulated (Dunne and others, 1981). In Early and Middle Pennsylvanian time, a substantial rise in relative sea level resulted in the deposition of the Tihvipah Limestone in moderately deep, quiet water. This sea-level rise probably was caused, at least in part, by tectonic subsidence of the shelf. Increased subsidence in Late Pennsylvanian and earliest Permian time led to the development of an unstable slope upon which no net sedimentation took place. Sediment accumulation resumed in middle Wolfcampian time with deposition of the Osborne Canyon Formation disconformably on the Tihvipah Limestone and continued through late Wolfcampian and probably into Leonardian time with deposition of the Darwin Canyon Formation. Channeled slope environments prevalent in the report area during the early phases of Permian sedimentation were replaced by unchanneled basin-floor environments as the depositional system matured. The area subsequently was uplifted, tilted, and subjected to an episode of subaerial erosion during which at least 1,000 m of strata (the maximum thickness of the Panamint Springs Member) was stripped away in places. Regional studies (Stone, 1984; Stone and Stevens, 1984) suggest that uplift occurred primarily in late Early or early Late Permian time, prior to the deposition of the Upper Permian Conglomerate Mesa Formation outside the boundaries of the report area. In response to renewed subsidence beginning in the Early Triassic, marine sediments were deposited unconformably on the tilted and erosionally truncated Lower Permian rocks.

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MEASURED SECTIONS (LOCATIONS SHOWN ON FIG. 3)

Section 1. Tihvipah Limestone; type sections of the Osborne Canyon Formation and unit 1 of the Millers Spring Member of the Darwin Canyon Formation. Measured on the east side of the Argus Range above Osborne Canyon in July 1981.

	Thickness meters
Darwin Canyon Formation (Lower Permian) (incomplete):	
Millers Spring Member (incomplete):	
Unit 2 (basal bed; not measured): Limestone conglomerate, bioclastic, medium gray	---
Unit 1:	
9. Sandstone (25 percent) and cover (75 percent). Sandstone, quartzose, variably calcareous and calcarenitic, gray to brown on weathered surface, very fine grained; in beds 15 to 80 cm thick; commonly plane laminated, less commonly crosslaminated and convolute laminated. Covered intervals 60 cm to 1.8 m thick.....	5.6
8. Limestone; one bed (Bouma Tab); grades from coarse-grained echinodermal calcarenite at base to silty calcisiltite at top..................	1.8
7. Sandstone (50 percent) and cover (50 percent), as in 9. Sandstone, in beds 30 cm to 1.7 m thick; mean bed thickness about 1.0 m. Covered intervals 10 cm to 2.0 m thick......	20.2
6. Interval occupied by cross-cutting dike................................	3.5
5. Sandstone (45 percent) and cover (55 percent), as in 9. Sandstone, generally highly calcareous and calcarenitic; in beds 10 cm to 1.0 m thick; mean bed thickness about 50 cm. Covered intervals 20 cm to 1 m thick..................	14.3
4. Interval occupied by cross-cutting dike................................	3.0
3. Sandstone (60 percent), mudstone (5 percent), and cover (35 percent), as in 9 except for mudstone. Sandstone in beds 15 cm to 1.5 m thick; mean bed thickness about 60 cm. Mudstone, gray, pink, and brown; in beds 1 to 70 cm thick between sandstone beds. Covered intervals 20 cm to 1.0 m thick.........................	60.9
2. Interval occupied by cross-cutting dike................................	3.5
1. Sandstone (65 percent), mudstone (20 percent), and cover (15 percent), as in 3. Sandstone in beds 20 to 70 cm thick; mean bed thickness about 40 cm. Mudstone in beds 5 to 50 cm thick. Covered intervals 10 to 40 cm thick......................	9.1
Total thickness unit 1.....................	121.9
Incomplete thickness Millers Spring Member..................................	121.9

Section 1: Lower Permian--Continued
Darwin Canyon Formation--Continued

	Thickness meters
Incomplete thickness Darwin Canyon Formation..............................	121.9
Conformable contact.	
Osborne Canyon Formation (Lower Permian):	
Member C:	
62. Mudstone, calcareous, light gray; poorly exposed......................	5.0
61. Limestone, dark gray; one bed (Bouma Ta); grades from bioclastic limestone conglomerate at base to light-gray calcisiltite at top; contains limestone clasts to 3 cm in diameter, broken fasciculate rugose corals to 5 cm in diameter, and fusulinids.......................	4.2
60. Mudstone, calcareous, light gray; limestone beds (fine-grained calcarenite; Bouma Tb) 14 and 40 cm thick present 4.0 and 5.4 m above base of interval...............	6.6
59. Limestone; one bed (Bouma Ta); grades from dark-gray bioclastic limestone conglomerate at base to light-gray calcareous mudstone at top; contains limestone clasts to 4 cm in diameter, coarse echinodermal debris, and fusulinids; upper part of bed contains micritic limestone clasts. Fusulinid collection OC16: *Stewartina*? sp., *Cuniculinella* sp....................	1.7
58. Covered interval; light-gray calcareous mudstone scree...........	2.5
57. Limestone; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to laminated fine-grained calcarenite at top; contains fusulinids....	0.6
56. Covered interval.....................	3.5
55. Mudstone, calcareous, light gray, massive; small dark-gray limestone clasts present in basal 80 cm........	4.5
54. Limestone, dark gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to fine-grained calcarenite at top; contains fusulinids..........	0.3
53. Mudstone, calcareous, light gray; poorly exposed......................	3.0
52. Limestone (calcarenite), dark gray, fine grained; one bed (Bouma Tbc)....	0.6
51. Covered interval.....................	0.2
50. Limestone (calcarenite), dark gray, fine grained; one bed (Bouma Tb).....	0.1
49. Mudstone, calcareous.................	0.1
48. Limestone (calcarenite), dark gray; one bed (Bouma Tab); grades from medium grained at base to fine grained at top......................	0.1

Section 1: Lower Permian--Continued
Osborne Canyon Formation--Continued
Member C--Continued

	Thickness meters
47. Covered interval	1.7
46. Limestone, dark gray; one bed (Bouma Ta); grades from coarse-grained bioclastic (largely echinodermal) calcarenite at base to medium-grained calcarenite at top; contains broken fasciculate rugose corals	2.0
45. Mudstone, calcareous, light gray to light brown; poorly exposed	3.0
44. Limestone, dark gray; one bed (Bouma Tab); grades from bioclastic limestone conglomerate at base to laminated fine-grained calcarenite at top; contains limestone clasts to 12 cm in diameter, coarse echinodermal debris, and broken fasciculate rugose corals; spherical limestone cobbles in lower part of bed may be reworked concretions	2.0
43. Mudstone, calcareous, light brown; contains limestone concretions; poorly exposed; one bed of laminated calcisiltite 8 cm thick present 11.5 m above base of interval	23.6
42. Limestone; one bed (Bouma Tab); grades from coarse-grained bioclastic (largely echinodermal) calcarenite at base to laminated calcisiltite at top; contains broken fasciculate rugose corals and fusulinids	2.5
41. Mudstone, siliceous, brown; contains gray limestone concretions; subordinate light-gray calcareous mudstone	1.2
40. Mudstone, calcareous, light gray; contains rare limestone concretions in lower 6.5 m; poorly exposed; one bed of laminated calcisiltite 40 cm thick 6.5 m above base of interval	10.2
39. Limestone, dark gray; one bed (Bouma Tab); grades from bioclastic limestone conglomerate at base to laminated calcisiltite at top; contains limestone clasts to 2 cm in diameter and fusulinids. Fusulinid collection OC15: *Schwagerina* spp., *Stewartina*? sp., *Leptotriticites*? sp., *Eoparafusulina* cf. *E. linearis*	3.5
38. Mudstone, calcareous; poorly exposed	2.0
37. Limestone (calcarenite), medium gray, medium grained; one bed	0.4
36. Mudstone, calcareous, light gray	0.8
35. Limestone, dark gray; one bed (Bouma Tab); grades from bioclastic limestone conglomerate at base to laminated calcisiltite at top; contains limestone clasts to 5 cm in diameter, coarse echinodermal debris, and fusulinids	2.4
34. Mudstone, calcareous, light gray; poorly exposed	2.3
33. Limestone, dark gray; one bed (Bouma Tabc); grades from coarse-grained echinodermal calcarenite at base to fine-grained calcarenite at top; upper part of bed convolute laminated	0.9
32. Mudstone, calcareous, light gray; poorly exposed	2.0
31. Limestone, dark gray; one bed (Bouma Tb); grades from fine-grained calcarenite at base to calcisiltite at top	0.2
30. Mudstone, calcareous, light gray; poorly exposed	2.5
29. Limestone (calcisiltite), light gray; one bed	0.6
28. Mudstone, calcareous, light gray; interbedded with brown siliceous mudstone; poorly exposed	1.4
27. Limestone, dark gray; one bed (Bouma Tab); grades from coarse-grained bioclastic (largely echinodermal) calcarenite at base to calcisiltite at top; contains fusulinids	0.9
26. Limestone (calcarenite), bioclastic (largely echinodermal), coarse-grained; one ungraded bed (Bouma Ta); contains fusulinids; capped by 2 cm of mudstone	0.8
25. Covered interval	3.0
24. Limestone; one bed (Bouma Tab); grades from dark-gray, coarse-grained echinodermal calcarenite at base to light-gray calcisiltite at top	0.8
23. Covered interval	1.3
22. Limestone; one bed (Bouma Tab); grades from dark-gray coarse-grained bioclastic calcarenite at base to light-gray laminated calcisiltite at top; capped by 5 cm of siliceous mudstone	0.6
21. Mudstone	0.1
20. Limestone, dark gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to laminated medium-grained calcarenite at top; contains fusulinids	0.4
19. Covered interval	1.0
18. Mudstone, calcareous, plane laminated; contains dark-gray limestone concretions	0.6

Section 1: Lower Permian--Continued
Osborne Canyon Formation--Continued
Member C--Continued

	Thickness meters
17. Mudstone, siliceous, brown, thin bedded; contains dark-gray limestone concretions to 5 cm in diameter; poorly exposed	1.7
16. Limestone, medium gray; one bed (Bouma Tab); grades from coarse-grained bioclastic (largely echinodermal) calcarenite at base to laminated calcisiltite at top; contains fusulinids	0.2
15. Mudstone, siliceous, as in 17; poorly exposed	2.3
14. Limestone (calcarenite), dark gray, fine grained; one bed	0.1
13. Covered interval; loose limestone concretions in scree	2.5
12. Mudstone, calcareous, light gray, massive; may grade up from underlying limestone	3.0
11. Limestone, dark gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to light-gray, laminated calcisiltite at top; contains fusulinids	2.1
10. Mudstone, calcareous, light brown; poorly exposed	2.3
9. Limestone, medium gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to fine-grained calcarenite at top; contains fusulinids	0.4
8. Interval largely covered; few outcrops of dark-gray micritic limestone in beds 10 to 25 cm thick and light-gray calcareous mudstone; one bed of coarse-grained bioclastic limestone 13 cm thick present 1.0 m above base of interval	10.6
7. Mudstone, calcareous, light gray, massive; may grade up from underlying limestone	1.5
6. Limestone, medium gray; one bed (Bouma Tab); grades from medium-grained echinodermal calcarenite at base to laminated calcisiltite at top	1.0
5. Mudstone, calcareous, light brown, massive; about 50 percent covered	7.2
4. Limestone, medium gray; one bed (Bouma Tab); grades from coarse-grained echinodermal calcarenite at base to laminated calcisiltite at top	1.8
3. Covered interval	8.5
2. Mudstone, calcareous, light brown; poorly exposed	2.0
1. Limestone, medium gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to laminated fine-grained calcarenite at top; contains fusulinids. Fusulinid collection OC14: _Schwagerina_ aff. _S. wellsensis_, _Schwagerina_ sp	2.0
Total thickness member C	156.9

Section 1: Lower Permian--Continued
Osborne Canyon Formation--Continued
Member C--Continued

	Thickness meters
Member B:	
33. Covered interval; light-gray calcareous mudstone scree	7.5
32. Mudstone, calcareous, light gray to light brown; faintly laminated in irregular, convolute patterns; laminations defined by aligned small clasts of medium- to dark-gray micritic limestone; lenticular beds of dark-gray limestone (fine-grained calcarenite; Bouma Tb) 15 to 35 cm thick present at base of interval and 3.2, 8.8, 10.9, 16.3, 30.9, 32.9, 33.3, and 39.7 m above base of interval. A 1.5-m-thick dike present 1.3 m below top of interval. Upper 20 m of interval poorly exposed	43.6
31. Covered interval	2.0
30. Mudstone, calcareous, light gray to light brown, massive; contains scattered large irregularly shaped clasts of medium- to dark-gray micritic limestone; in part covered; one lenticular bed of dark-gray, fusulinid-bearing bioclastic limestone 15 cm thick present 2.4 m above base of interval	9.1
29. Limestone, dark gray; one bed Bouma Tab); grades from limestone-pebble conglomerate at base to laminated calcisiltite at top	0.5
28. Mudstone, calcareous, as in 30; upper part poorly exposed	8.3
27. Limestone, dark gray; one bed (Bouma Tab); grades from limestone conglomerate at base to fine-grained calcarenite at top; contains limestone clasts to 2 cm in diameter	0.5
26. Covered interval	0.9
25. Limestone, dark gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to laminated calcisiltite at top	0.5
24. Mudstone, calcareous, as in 30; thin lenticular beds of bioclastic limestone conglomerate present 0.8 and 2.5 m above base of interval	4.8
23. Siltstone, calcareous, light gray to light brown, laminated	0.6

Section 1: Lower Permian--Continued
Osborne Canyon Formation--Continued
Member B--Continued

	Thickness meters
22. Limestone, (calcarenite), bioclastic, dark gray, coarse grained; one ungraded bed (Ta)	0.3
21. Mudstone, calcareous, as in 30; poorly exposed	2.0
20. Limestone, dark gray; one bed (Bouma Tab); grades from limestone conglomerate at base to laminated calcisiltite at top; contains limestone clasts to 6 cm in diameter	1.0
19. Covered interval	0.8
18. Limestone, dark gray; one bed (Bouma Tab); grades from limestone conglomerate at base to laminated calcisiltite at top; contains limestone clasts to 3 cm in diameter	0.5
17. Covered interval	0.7
16. Limestone, dark gray; one bed (Bouma Tab); grades from limestone conglomerate at base to laminated calcisiltite at top; contains limestone clasts to 15 cm in diameter; clasts tightly packed	1.0
15. Mudstone, calcareous, as in 30, poorly exposed; one lenticular bed of bioclastic limestone 15 cm thick 3.5 m above base of interval	4.5
14. Limestone, dark gray; one bed (Bouma Tab); grades from bioclastic limestone conglomerate at base to laminated calcisiltite in upper 5 cm; contains limestone clasts to 5 cm in diameter	1.5
13. Siltstone, calcareous, as in 23	1.3
12. Limestone, dark gray; one bed (Bouma Tab); grades from bioclastic limestone conglomerate at base to fine-grained calcarenite at top; poorly sorted; contains limestone clasts to 30 cm in diameter; clasts tightly packed	1.8
11. Siltstone, calcareous, as in 23	2.0
10. Covered interval	2.0
9. Mudstone, calcareous, as in 30	5.0
8. Covered interval	5.0
7. Mudstone, calcareous, light gray, laminated; interbedded with black-weathering calcareous chert	3.0
6. Limestone-pebble conglomerate; lenticular	0.2
5. Mudstone, calcareous, as in 30	1.5
4. Limestone conglomerate, bioclastic, dark gray, poorly sorted; one bed (Bouma Tab); contains limestone clasts to 10 cm in diameter and abundant coarse echinodermal debris; clasts tightly packed; upper 20 cm is laminated calcisiltite	7.5
3. Covered interval; calcareous mudstone scree	4.0
2. Mudstone, calcareous, light gray, massive	6.0
1. Limestone, medium gray; one bed (Bouma Tab); grades from bioclastic limestone conglomerate at base to laminated, fine-grained calcarenite at top; contains limestone clasts to 2 cm in diameter and fusulinids. Fusulinid collection OC11: _Leptotriticites_? sp., _Schwagerina_ sp.	7.0
Total thickness member B	136.9

Member A:

	Thickness meters
30. Covered interval	1.0
29. Limestone, dark gray; one bed (Bouma Tab); grades from very coarse grained bioclastic (largely echinodermal) calcarenite at base to laminated calcisiltite at top; contains fusulinids. Fusulinid collection OC10: _Schwagerina_ sp	0.3
28. Covered interval	2.0
27. Siltstone, calcareous, light gray to light brown, laminated; a 2-m-thick dike cuts interval 4.0 m above base	8.0
26. Limestone conglomerate, bioclastic, dark gray; one ungraded bed (Bouma Ta); poorly sorted; contains limestone clasts, echinodermal debris, and fragmented bryozoa to 5 cm in diameter; clasts tightly packed	1.0
25. Covered interval; calcareous siltstone and mudstone scree	12.0
24. Limestone (calcarenite), bioclastic (largely echinodermal), dark gray, coarse grained; one ungraded bed (Bouma Ta); contains fusulinids. Fusulinid collection OC9: _Schwagerina_ sp., _Pseudofusulina_? aff. _P.? loringi_	0.5
23. Covered interval; calcareous siltstone scree	3.5
22. Limestone conglomerate, dark gray; one ungraded bed (Bouma Ta); contains limestone clasts	

Section 1: Lower Permian--Continued
Osborne Canyon Formation--Continued
Member A--Continued

	Thickness meters
to 2 cm in diameter; clasts tightly packed	0.3
21. Limestone (calcarenite), bioclastic; thinly interbedded with calcareous siltstone; poorly exposed	1.0
20. Limestone (calcarenite), bioclastic, medium gray; in lenticular beds 5 to 10 cm thick; contains fusulinids; interbedded with calcareous siltstone. Fusulinid collection OC8: Pseudofusulina? aff. P.? loringi	0.3
19. Siltstone, calcareous, as in 27; poorly exposed	3.0
18. Limestone conglomerate, medium gray; one ungraded bed (Bouma Ta); contains limestone clasts to 4 cm in diameter; clasts tightly packed	0.5
17. Siltstone, calcareous, as in 27; poorly exposed	3.0
16. Limestone (calcarenite), echinodermal, medium gray, coarse grained; one bed	0.1
15. Covered interval	0.2
14. Limestone (calcarenite), medium gray, fine grained; one bed (Bouma Tb)	0.3
13. Covered interval	0.4
12. Siltstone, calcareous, as in 27	1.0
11. Covered interval	4.0
10. Limestone conglomerate, bioclastic, medium gray; one ungraded bed (Bouma Ta); contains limestone clasts and echinodermal debris to 3 cm in diameter and fusulinids. Fusulinid collection RTM2: Schwagerina sp., Pseudofusulina? aff. P. loringi, Pseudoschwagerina uddeni, Eoparafusulina sp	0.4
9. Covered interval	0.2
8. Siltstone, calcareous, as in 27	2.2
7. Limestone (calcarenite), echinodermal, medium gray, coarse grained; in two lenticular graded beds (Bouma Ta) 25 and 30 cm thick; both beds wedge out within 10 m along strike	0.5
6. Siltstone, calcareous, as in 27; poorly exposed	3.3
5. Limestone (calcarenite), echinodermal, medium gray; one bed (Bouma Ta); grades from coarse grained at base to fine grained at top	0.3
4. Siltstone, calcareous, as in 27	1.1
3. Limestone (calcarenite), echinodermal, medium gray; one bed containing internal size-sorted layers 2 to 10 cm thick	0.6
2. Covered interval	0.2
1. Limestone (calcarenite), echinodermal, medium gray; one bed (Bouma Ta); grades from coarse grained at base to fine grained at top	0.9
Total thickness member A	52.1
Total thickness Osborne Canyon Formation	345.9

Disconformable contact.
Tihvipah Limestone (Lower and Middle Pennsylvanian):

	Thickness meters
23. Limestone (micrite), medium gray; contains abundant nodular, lenticular, and bedded chert; tremolite abundant	20.0
22. Covered interval	1.0
21. Limestone (micrite), medium gray; contains abundant nodular chert in basal 4 m and mostly lenticular and bedded chert above that; chert layers in upper part of interval are 1 to 5 cm thick and spaced 5 to to 20 cm apart; bedding well defined	19.5
20. Limestone (micrite), cherty, as in 23; forms ledges	11.0
19. Limestone, bioclastic and conglomeratic, light gray; contains echinodermal debris, fragmented bryozoans, and limestone clasts suspended in a micrite matrix	0.4
18. Limestone (micrite), cherty, as in 23; forms ledges	15.5
17. Limestone (micrite), variably silty or argillaceous, light to medium gray; contains abundant nodular, lenticular, and bedded chert; beds 10 to 20 cm thick defined by variations in silt or clay content and by chert layering	8.7
16. Covered interval	1.0
15. Limestone (micrite), medium to dark gray, massive; contains sparse nodular chert; forms ledges	7.5
14. Limestone (micrite), medium gray; contains abundant nodular, lenticular, and bedded chert; spherical chert nodules common; bedding defined by chert layers spaced 20 to 50 cm apart; tremolite abundant	7.5
13. Limestone (micrite), variably silty or argillaceous, as in 17; beds 10 to 30 cm thick	1.8
12. Limestone (micrite), dark gray, with rare chert; tremolite abundant	2.0
11. Covered interval	3.0

Section 1: Lower and Middle Pennsylvanian—Continued
Tihvipah Limestone--Continued

	Thickness meters
10. Limestone (micrite), variably silty or argillaceous, as in 17............	3.5
9. Covered interval......................	2.0
8. Limestone (micrite), silty or argillaceous, light gray; tremolite abundant............................	1.0
7. Limestone, bioclastic and conglomeratic; contains coarse-grained echinodermal debris, rare rugose coral fragments, and limestone clasts to 6 cm in diameter suspended in a micrite matrix; tremolite abundant...................	1.5
6. Covered interval......................	1.0
5. Limestone (micrite), medium gray; nodular chert uncommon; minor light-gray silty or argillaceous limestone; coarse echinodermal debris present locally...............	5.0
4. Covered interval......................	1.5
3. Limestone (micrite), silty or argillaceous, light gray; contains rare spherical chert nodules.........	2.0
2. Covered interval......................	1.5
1. Limestone (micrite), medium gray; contains nodular, lenticular, and bedded chert; small spherical chert nodules common; tremolite abundant...	2.8
Total thickness Tihvipah Limestone.......	120.7

Disconformable contact.
Santa Rosa Hills Limestone (Mississippian) (not measured):

Marble, white to light gray, massive, coarse grained; forms cliffs.........	---

Section 2. Type sections of the Millers Spring Member (units 2 through 7) and of the Panamint Springs Member of the Darwin Canyon Formation. Measured in four segments (2A, 2B, 2C, 2D,) in Darwin Canyon north of the Darwin fault in July 1981 and September 1985. Section 2A includes units 2, 3, and 4 of the Millers Spring Member; section 2B includes units 5, 6A, and 6B of the Millers Spring Member; section 2C includes units 6C, 6D, and 6E of the Millers Spring Member and the Panamint Springs Member; section 2D includes unit 7 of the Millers Spring Member and the Panamint Spring Member.

Section 2D. Type sections of the Panamint Springs Member and unit 7 of the Millers Spring Member.

	Thickness meters
Unnamed marine strata (Lower Triassic) (not measured):	
Limestone and marble, sandy, light gray to brown; contains planar to gently undulating, silty and sandy laminations; forms resistant ledges averaging about 1 m thick............	---

Section 2—Continued

Unconformable contact (poorly exposed).
Darwin Canyon Formation (Lower Permian) (incomplete):
Panamint Springs Member:

	Thickness meters
75. Covered interval; scree of siltstone and very fine grained sandstone......	4.0
74. Limestone (calcisiltite), silty, light gray, laminated................	2.0
73. Siltstone and very fine grained sandstone, quartzose, calcareous, brown to reddish brown on weathered surface; in planar beds 2 to 10 cm thick; most beds plane laminated to gently crosslaminated................	70.0
72. Limestone, silty, as in 74...........	2.0
71. Siltstone and very fine grained sandstone, as in 73..................	10.5
70. Limestone, silty, as in 74...........	1.0
69. Siltstone and very fine grained sandstone, as in 73..................	4.5
68. Limestone, silty, as in 74...........	0.5
67. Siltstone and very fine grained sandstone, as in 73..................	22.5
66. Limestone (calcisiltite), silty, light gray; contains irregular brown silty layers 5 to 10 cm thick........	3.0
65. Siltstone and very fine grained sandstone, as in 73..................	2.0
64. Limestone (calcarenite), medium gray, fine grained; one graded bed.........	0.5
63. Siltstone and very fine grained sandstone, as in 73..................	2.0
62. Limestone, silty, as in 74...........	1.5
61. Siltstone and very fine grained sandstone, as in 73..................	1.5
60. Limestone (calcisiltite), medium gray; one bed.........................	0.5
59. Siltstone and very fine grained sandstone, as in 73..................	22.5
58. Limestone (calcarenite), pebbly; contains fusulinids; poorly exposed.	0.2
57. Limestone (calcisiltite), medium gray; poorly exposed..........	3.0
56. Siltstone and very fine grained sandstone, as in 73..................	12.0
55. Sandstone, calcareous, coarse grained, plane laminated; one graded bed; contains bioclastic debris..............................	0.3
54. Limestone, as in 57..................	1.0
53. Siltstone and very fine grained sandstone, as in 73; some beds have spherical medium-gray limestone concretions 2 to 4 cm in diameter....	72.0
52. Limestone, as in 57..................	0.5

Section 2: Lower Permian—Continued
Darwin Canyon Formation—Continued
Panamint Springs Member—Continued

	Thickness meters
51. Siltstone and very fine grained sandstone, as in 73	4.5
50. Limestone (calcisiltite), silty, light gray; one bed	0.3
49. Siltstone and very fine grained sandstone, as in 73	9.0
48. Limestone (calcisiltite), silty, light brown; one bed; laminated	1.5
47. Covered interval; silty limestone scree	2.5
46. Limestone (calcisiltite), silty, medium gray; one bed; plane laminated	0.8
45. Siltstone or very fine grained sandstone, brown	0.2
44. Limestone, silty, as in 46; one bed	0.7
43. Siltstone or very fine grained sandstone, as in 45	0.3
42. Limestone, silty, as in 46; one bed	0.5
41. Siltstone or very fine grained sandstone, as in 45	0.3
40. Limestone, silty, as in 46; one bed	0.6
39. Limestone (calcisiltite), silty, light gray, laminated; poorly exposed	5.5
38. Limestone (calcisiltite), silty, medium gray, laminated; contains irregular brown-weathering layers 5 to 10 cm thick; small limestone concretions at top of interval; forms a massive ledge	6.5
37. Covered interval	1.2
36. Sandstone, as in 24; one bed	0.3
35. Limestone (calcisiltite), light gray; one bed; dark-gray limestone concretions on upper bedding surface	0.1
34. Sandstone, as in 24; one bed	3.5
33. Mudstone, as in 24	0.1
32. Sandstone, as in 24; one bed	0.4
31. Mudstone, as in 24	0.2
30. Covered interval	3.5
29. Sandstone, as in 24; one bed	0.5
28. Mudstone, as in 24	0.2
27. Sandstone, as in 24; one bed	0.4
26. Mudstone, as in 24	0.1
25. Limestone (calcisiltite), light gray, laminated; locally contains dark-gray limestone concretions; silty layers 2 to 5 cm thick in upper part	2.0
24. Sandstone (65 percent) and mudstone (35 percent); in alternating beds. Sandstone, quartzose, variably calcareous and calcarenitic, gray to brown on weathered surface, very fine grained; in beds 20 cm to 2.8 m thick; mean bed thickness about 80 cm; generally plane laminated; commonly gently cross-laminated and convolute laminated; bedding surfaces sharp. Mudstone, siliceous to calcareous, light brown to light gray; in beds 2 cm to 1.1 m thick; mean bed thickness about 40 cm	10.2
23. Limestone (calcarenite), silty, light gray, fine grained; one bed	0.4
22. Sandstone (75 percent) and mudstone (25 percent), as in 24. Sandstone in beds 15 cm to 2.3 m thick; mean bed thickness about 75 cm. Mudstone in beds 10 to 75 cm thick; mean bed thickness about 25 cm; locally contains dark-gray limestone concretions	11.2
Total thickness Panamint Springs Member not including basal limestone unit	307.0

Basal limestone unit:

	Thickness meters
21. Limestone (calcisiltite) and siltstone; in irregular beds 5 to 20 cm thick. Limestone, variably silty, light to medium gray; siltstone, light brown, calcareous	7.0
20. Covered interval	2.0
19. Limestone (fine-grained calcarenite and calcisiltite), silty, light to medium gray; one graded bed	2.0
18. Mudstone (60 percent) and limestone (fine-grained calcarenite and calcisiltite) (40 percent); in alternating beds. Mudstone, siliceous to calcareous, light brown to light gray; in beds 10 to 80 cm thick; mean bed thickness about 55 cm. Limestone, silty and sandy, light to medium gray; in beds 15 to 80 cm thick; mean bed thickness about 40 cm; unlaminated to plane laminated, crosslaminated, and convolute laminated; bedding surfaces sharp	7.3
17. Limestone (fine-grained calcarenite or calcisiltite), medium gray, indistinctly bedded; forms flaggy outcrops	3.5
16. Mudstone (80 percent) and sandstone (20 percent); in alternating beds. Mudstone, siliceous, gray, brown, and reddish gray, generally in beds	

Section 2: Lower Permian--Continued
Darwin Canyon Formation--Continued
Panamint Springs Member--Continued
Basal limestone unit--Continued

	Thickness meters
1 to 2 m thick. Sandstone, quartzose, strongly calcarenitic, gray to brown on weathered surface, very fine grained; in beds 15 to 80 cm thick; mean bed thickness about 35 cm; commonly plane laminated, less commonly ripple cross-laminated and convolute laminated; bedding surfaces sharp...............	15.5
15. Covered interval.....................	0.9
14. Sandstone (80 percent) and mudstone (20 percent), as in 16. Sandstone in beds 20 cm to 1.0 m thick, mudstone in beds 2 to 50 cm thick................	3.6
13. Covered interval.....................	1.0
12. Limestone (calcarenite), silty, light gray to light brown, fine grained; in irregular beds 5 to 10 cm thick defined by variations in silt content; plane laminated.....	4.5
11. Covered interval.....................	1.0
10. Sandstone, as in 16; two beds 33 and 55 cm thick separated by 20 cm of mudstone....................	1.1
9. Mudstone, as in 16...................	0.5
8. Limestone (calcarenite), medium gray, fine grained; plane laminated but indistinctly bedded; contains thin lenticular partings of brown siliceous mudstone.............................	3.0
7. Mudstone, siliceous, brown; contains a 7-cm-thick bed of medium-gray, fine-grained limestone 1.0 m above base....................	1.4
6. Sandstone, as in 16; two beds 45 and 33 cm thick separated by 10 cm of light-gray calcareous mudstone....	0.9
5. Covered interval.....................	0.8
4. Sandstone, as in 16; one bed; laminated............................	0.6
3. Mudstone, siliceous, brown; weathers to small chips..............	2.0
2. Limestone (calcarenite and calcisiltite) (35 percent) and mudstone (65 percent); in alternating beds. Limestone, variably silty, light to medium gray; generally fine grained but rarely medium to coarse grained at bases of beds; in graded and ungraded beds 10 to 40 cm thick; mean bed thickness about 20 cm; faintly laminated; has a strong tectonic cleavage. Mudstone, siliceous, brown; in beds 10 cm to 1.1 m thick; mean bed thickness about 50 cm................	5.8
1. Covered interval.....................	0.8
Total thickness basal limestone unit.......	65.2
Total thickness Panamint Springs Member....	372.2

Millers Spring Member (incomplete):
Unit 7:

	Thickness meters
7. Sandstone (80 percent) and mudstone (20 percent); in alternating beds. Sandstone, quartzose, variably calcareous and calcarenitic, gray to brown on weathered surface; in beds 40 cm to 1.9 m thick; generally plane laminated, less commonly crosslaminated and convolute laminated; bedding surfaces sharp. Mudstone, light gray, light brown, and purplish gray; in beds 10 to 40 cm thick..........................	5.5
6. Interval occupied by crosscutting dike................................	4.0
5. Sandstone (70 percent) and mudstone (30 percent), as in 7. Sandstone in beds 20 to 50 cm thick. Mudstone in beds 10 to 40 cm thick..........................	2.9
4. Interval occupied by crosscutting dike................................	1.0
3. Sandstone, as in 7; two amalgamated beds 26 and 30 cm thick..............	0.6
2. Limestone (calcarenite), echinodermal, medium gray, coarse grained; one graded bed (Bouma Ta); base erosional.......	0.5
1. Sandstone (55 percent) and mudstone (45 percent), as in 7. Sandstone in beds 5 cm to 2.7 m thick; mean bed thickness about 60 cm. Mudstone in beds 2 cm to 2.3 m thick; mean bed thickness about 50 cm................	24.9
Total thickness unit 7.....................	39.4
Unit 6E (uppermost bed, not measured): Mudstone, calcareous, conglomeratic, pink, massive; contains scattered fusulinids, echinodermal debris, and limestone clasts.................	---
Incomplete thickness Millers Spring Member...................................	39.4
Incomplete thickness Darwin Canyon Formation.................................	411.6

Section 2: Lower Permian—Continued

Section 2C. Units 6A, 6B (incomplete due to faulting); type section of units 6C-6E, Millers Spring Member.

	Thickness meters
Darwin Canyon Formation (Lower Permian) (incomplete):	
Millers Spring Member (incomplete):	
Unit 7 (not measured):	
Sandstone, quartzose, gray to brown, very fine grained, thick bedded; interbedded with light-gray to light-brown calcareous mudstone..................	---
Unit 6E:	
4. Mudstone, calcareous, conglomeratic, pink, massive; contains limestone clasts and bioclasts averaging 1 cm in diameter; echinodermal debris and fusulinids abundant; crude normal grading defined by upward decrease in abundance of clasts (clasts rare in upper 5 m of bed)....	10.0
3. Limestone, medium gray; one bed (Bouma Tab); grades from limestone conglomerate at base to laminated calcisiltite at top; contains limestone clasts to 5 cm in diameter..........................	3.6
2. Covered interval; pink mudstone scree................................	2.0
1. Limestone, medium gray; one bed (Bouma Ta); grades from limestone conglomerate at base to medium-grained echinodermal calcarenite at top except for uppermost 25 cm which is inversely graded to coarse-grained calcarenite; contains limestone clasts to 10 cm in diameter; dark-gray spherical limestone clasts 2 to 5 cm in diameter abundant at base of bed.................................	3.7
Total thickness unit 6E...................	19.3
Unit 6D:	
Sandstone (35 percent) and mudstone (65 percent); in alternating beds. Sandstone, quartzose, variably calcareous and calcarenitic, very fine grained; in planar beds 10 cm to 1.0 m thick; mean bed thickness about 40 cm; generally plane laminated, less commonly crosslaminated and convolute laminated. Mudstone, light gray to pinkish gray; in beds 5 cm to 2.5 m thick (mean bed thickness about 70 cm)..........	25.5
Total thickness unit 6D...................	25.5
Unit 6C:	
6. Limestone, medium gray; one bed (Bouma Tabc); grades from limestone-pebble conglomerate at base to laminated calcisiltite at top; upper 20 cm is ripple laminated............................	2.3

Section 2: Lower Permian—Continued
Darwin Canyon Formation—Continued
Millers Spring Member—Continued
Unit 6C—Continued

	Thickness meters
5. Mudstone..............................	0.3
4. Limestone-cobble conglomerate; one ungraded bed (Bouma Ta); contains tectonically stretched clasts...............................	1.5
3. Covered interval.....................	0.5
2. Limestone (calcarenite), silty, fine grained; one bed................	0.1
1. Limestone, medium gray; one bed (Bouma Tabc); grades from limestone conglomerate at base to laminated calcisiltite at top; contains tectonically stretched limestone clasts to 15 cm long; clasts tightly packed; upper 15 cm of bed is ripple laminated; capped by 2 cm of mudstone...........	1.6
Total thickness unit 6C....................	6.3
Unit 6B:	
2. Mudstone; thin sandstone bed present 0.8 m above base.............	1.3
Fault; small but indeterminate amount of section missing.	
1. Sandstone (75 percent) and mudstone (25 percent), as in unit 6D. Sandstone in beds 10 cm to 1.1 m thick; mean bed thickness about 50 cm. Mudstone in beds 1 to 75 cm thick; mean bed thickness about 20 cm...........	16.7
Total thickness unit 6B (incomplete due to faulting).........................	18.0
Unit 6A:	
4. Mudstone, calcareous, massive; may grade up from underlying limestone............................	3.5
3. Limestone, medium gray; one bed (Bouma Tab), grades from limestone conglomerate at base (mean clast size 1 cm) to laminated calcisiltite at top; contains fusulinids..........	3.7
2. Covered interval.....................	1.5
1. Limestone conglomerate; one bed (Bouma Ta); contains dark-gray micritic limestone clasts averaging 1 cm in diameter; matrix is light gray to pinkish gray; clasts loosely packed..	1.5
Total thickness unit 6A....................	10.2
Unit 5 (not measured):	
Sandstone and mudstone, as in unit 6D.............................	---
Incomplete thickness Millers Spring Member..................................	79.3
Incomplete thickness Darwin Canyon Formation...............................	79.3

Section 2B. Unit 4 (incomplete), type section of units 5, 6A and 6B; unit 6C (incomplete), Millers Spring Member.

	Thickness meters
Top of section faulted.	
Darwin Canyon Formation (Lower Permian) (incomplete):	
Millers Spring Member (incomplete):	
Unit 6C (incomplete):	
8. Limestone conglomerate, medium gray; one graded bed; median clast size 2 cm at base and 5 mm at top; top of bed faulted	1.0
7. Covered interval	1.0
6. Limestone (calcarenite), silty, medium gray, fine grained; one bed; laminated	0.5
5. Limestone (calcarenite), echinodermal, medium gray, medium to fine grained; one graded bed (Bouma Tab)	0.5
4. Covered interval	3.0
3. Limestone conglomerate, bioclastic, medium gray; one graded bed (Bouma Ta); contains limestone clasts to 10 cm in diameter and broken fasciculate rugose corals; median clast diameter at top of bed 1 cm; clasts tightly packed	2.0
2. Covered interval	0.8
1. Limestone, medium gray; one bed (Bouma Ta); grades from limestone conglomerate at base to fine-grained calcarenite at top; contains limestone clasts to 5 cm in diameter; clasts strongly imbricated (possibly a tectonic fabric)	2.0
Incomplete thickness unit 6C	10.8
Unit 6B:	
Sandstone, quartzose; gray to brown on weathered surface; very fine grained; in beds 10 cm to 1.5 m thick; poorly exposed	32.7
Total thickness unit 6B	32.7
Unit 6A:	
7. Mudstone, calcareous, purplish gray, massive; may grade up from underlying limestone	3.0
6. Limestone, medium gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to laminated calcisiltite at top; contains fusulinids. Fusulinid collection DC′5: *Schwagerina* aff. *S. thompsoni*, *Pseudoschwagerina convexa*	3.7
5. Covered interval	0.8

	Thickness meters
4. Limestone conglomerate; one ungraded bed (Bouma Ta); composed of micritic limestone clasts and bioclasts (maximum diameter 2 cm) in a light-gray to pinkish-gray micritic matrix	2.0
3. Limestone, medium gray; one bed (Bouma Ta); grades from coarse-grained bioclastic calcarenite at base to medium-grained calcarenite at top	0.8
2. Sandstone, quartzose, brown, very fine grained	1.5
1. Limestone conglomerate, bioclastic; one ungraded bed (Bouma Ta); composed of medium-gray micritic limestone clasts (maximum diameter 2 cm, median diameter 1 cm) and subordinate bioclasts, including fusulinids and broken fasciculate rugose corals, in a light-gray micritic matrix; clasts loosely packed	3.5
Total thickness unit 6A	15.3
Unit 5:	
16. Covered interval	0.2
15. Sandstone, quartzose, strongly calcarenitic, brown, very fine grained; one bed	1.2
14. Covered interval	2.0
13. Sandstone, as in 15; one bed	1.7
12. Mudstone	0.1
11. Limestone, medium gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to laminated calcisiltite at top; contains fusulinids	1.2
10. Sandstone (50 percent) and mudstone (50 percent); in alternating beds. Sandstone, quartzose, strongly calcarenitic, light gray; in beds 10 cm to 1.5 m thick, generally plane laminated and crosslaminated, commonly convolute laminated; bedding surfaces sharp. Mudstone, calcareous, purplish gray; in beds 5 cm to 1.0 m thick; mean bed thickness about 50 cm	7.4
9. Mudstone, purplish gray, massive; contains spherical to subspherical dark-gray limestone concretions 2 to 5 cm in diameter	0.7
8. Limestone, medium gray; one bed (Bouma Tabc); grades from medium-grained echinodermal calcarenite at base to laminated calcisiltite at top	0.7
7. Mudstone, purplish gray	0.3

Section 2: Lower Permian—Continued
Darwin Canyon Formation—Continued
Millers Spring Member—Continued
Unit 5—Continued

	Thickness meters
6. Sandstone, quartzose, in part weakly calcareous and calcarenitic; generally brown on weathered surface; very fine grained; thick bedded; poorly exposed	13.7
5. Sandstone (45 percent) and mudstone (55 percent), as in 10. Sandstone, strongly calcarenitic; in beds 25 cm to 1.5 m thick; mean bed thickness about 50 cm. Mudstone, in beds 5 cm to 1.0 m thick; mean bed thickness about 60 cm	10.9
4. Covered interval	3.0
3. Interval occupied by crosscutting dike	2.0
2. Limestone, medium gray; one bed (Bouma Tab); grades from fine-grained calcarenite at base to calcisiltite at top	2.0
1. Sandstone (45 percent) and mudstone (55 percent), as in 10. Sandstone, strongly calcarenitic; in beds 10 cm to 1.0 m thick; mean bed thickness about 40 cm. Mudstone, in beds 10 cm to 1.0 m thick; mean bed thickness about 50 cm	11.9
Total thickness unit 5	59.0

Unit 4 (incomplete):

	Thickness meters
25. Limestone, dark gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to laminated fine-grained calcarenite at top; contains fusulinids	1.2
24. Mudstone, calcareous	0.8
23. Limestone (fine-grained calcarenite or calcisiltite), silty; one bed	0.2
22. Mudstone, calcareous; thin limestone interbeds	3.0
21. Limestone (fine-grained calcarenite or calcisiltite) silty; one bed	0.3
20. Mudstone, calcareous	0.8
19. Limestone, medium gray; one bed (Bouma Tab); grades from coarse-grained echinodermal calcarenite at base to laminated calcisiltite at top; well sorted	1.5
18. Covered interval	1.0
17. Limestone (fine-grained calcarenite and calcisiltite) (60 percent) and mudstone (40 percent); in alternating beds. Limestone, silty, medium to dark gray, very fine to fine grained; in beds 10 to 55 cm thick; mean bed thickness about 30 cm; generally plane laminated and commonly convolute laminated; some beds may contain more than 50 percent quartz silt and very fine sand. Mudstone, calcareous, gray to purplish gray; in beds 5 to 60 cm thick; mean bed thickness about 25 cm	6.3
16. Mudstone, calcareous, purplish gray, massive; contains scattered diffuse clasts of medium-gray limestone	3.0
15. Limestone (fine-grained calcarenite or calcisiltite); one bed	0.9
14. Mudstone	0.1
13. Limestone, medium gray; one bed (Bouma Tab); grades from limestone conglomerate at base to silty fine-grained calcarenite at top; contains limestone clasts to 5 cm in diameter	1.0
12. Limestone and calcareous mudstone; one massive bed, graded from well-sorted echinodermal calcarenite in lower 3 m to pinkish-gray calcareous mudstone in upper 11 m; mudstone contains large rounded limestone clasts with diffuse borders	14.0
11. Mudstone	0.1
10. Limestone-pebble conglomerate, bioclastic; one ungraded bed (Bouma Ta); clasts loosely packed; fusulinids present at base	0.5
9. Mudstone	0.1
8. Limestone-pebble conglomerate, bioclastic; one crudely graded bed (Bouma Ta); fusulinids abundant	4.0
7. Mudstone, calcareous, purplish gray	0.4
6. Limestone (fine-grained calcarenite or calcisiltite); one bed	0.1
5. Mudstone, calcareous, grayish orange, massive; contains indistinct limestone clasts	2.5
4. Limestone (fine-grained calcarenite or calcisiltite); one bed	0.4
3. Mudstone, calcareous, purplish gray	0.7
2. Limestone conglomerate, bioclastic, medium gray; one ungraded bed (Bouma Ta); contains micritic limestone clasts to 6 cm in diameter and broken fasciculate rugose corals; clasts tightly packed and strongly imbricated	0.6
1. Limestone (40 percent) and mudstone (60 percent), as in 17. Limestone, in beds 10 to 60 cm thick. Mudstone, in beds 10 to 70 cm thick	4.1

Section 2: Lower Permian—Continued
Darwin Canyon Formation—Continued
Millers Spring Member—Continued
Unit 4—Continued

	Thickness meters
Incomplete thickness unit 4................	47.6
Incomplete thickness Millers Spring Member................................	165.4
Incomplete thickness Darwin Canyon Formation................................	165.4

Base of section covered.

Section 2A. Unit 1 (incomplete); type section of units 2-4, Millers Spring Member.

	Thickness meters
Top of section faulted.	
Darwin Canyon Formation (Lower Permian) (incomplete):	
Millers Spring Member (incomplete):	
Unit 4:	
16. Limestone, dark gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to laminated fine-grained calcarenite at top; contains fusulinids. Section faulted immediately above this bed, which is correlated with the uppermost bed in unit 4 of the Millers Spring Member in section 2B..........................	1.1
15. Limestone (fine-grained calcarenite and calcisiltite) (50 percent) and mudstone (50 percent); in alternating beds. Limestone, medium gray, silty; in beds 15 to 40 cm thick, all with pervasive plane lamination and many with convolute lamination; bedding surfaces sharp. Mudstone, calcareous, yellowish brown; in beds 5 to 50 cm thick................	4.2
14. Mudstone, calcareous, yellowish brown, light gray, and pinkish gray; indistinctly bedded....	1.4
13. Limestone (fine-grained calcarenite or calcisiltite); one bed; crosslaminated and convolute laminated..................	0.4
12. Mudstone, calcareous.................	1.0
11. Limestone, medium gray; one bed (Bouma Tab); grades from coarse-grained echinodermal calcarenite at base to laminated calcisiltite at top..................	1.0
10. Limestone (fine-grained calcarenite and calcisiltite), silty, medium to dark gray; in beds 25 to 50 cm thick; plane laminated and crosslaminated; poorly exposed; subordinate gray to brown calcareous mudstone occurs mainly as float......	11.9

Section 2: Lower Permian—Continued
Darwin Canyon Formation—Continued
Millers Spring Member—Continued
Unit 4—Continued

	Thickness meters
9. Limestone, medium gray; one bed (Bouma Tab); grades from coarse-grained echinodermal calcarenite at base to laminated fine-grained calcarenite at top................................	1.0
8. Mudstone, calcareous.................	0.2
7. Limestone (calcarenite), echinodermal, fine grained; one ungraded bed (Bouma Ta).............	0.1
6. Limestone and calcareous mudstone; one massive bed, grades from well-sorted echinodermal calcarenite in lower 3 m to pinkish-gray calcareous mudstone in upper 11 m; mudstone contains scattered diffuse rounded clasts of medium-gray micritic limestone..................	14.0
5. Mudstone, calcareous, pink, massive; lenticular..................	10.0
4. Limestone conglomerate, bioclastic; one crudely graded bed (Bouma Ta); contains micritic limestone clasts that decrease in maximum diameter from 5 cm at base to less than 1 cm at top, broken fasciculate rugose corals, and fusulinids; clasts loosely to tightly packed...........	6.0
Minor fault; small amount of section probably missing.	
3. Limestone (fine-grained calcarenite and calcisiltite) (70 percent) and cover (30 percent). Limestone, silty; in beds 10 to 40 cm thick; plane and convolute lamination common..................	1.4
2. Mudstone, calcareous, pink, massive; contains scattered clasts of medium-gray micritic limestone; clast borders diffuse, blending with matrix; may grade up from underlying limestone................	4.5
1. Limestone, medium gray; one bed (Bouma Ta); grades from coarse-grained bioclastic calcarenite at base to medium-grained echinodermal calcarenite at top; contains fusulinids. Fusulinid collection DC8: *Schwagerina* spp., *Eoparafusulina* cf. *E. linearis*...........................	2.7
Total thickness unit 4....................	60.9
Unit 3:	
14. Sandstone (65 percent) and mudstone (35 percent); in alternating beds. Sandstone, quartzose, variably calcareous and calcarenitic, gray to brown on weathered surface, very fine grained; in beds 15 cm to 2.1 m	

Section 2: Lower Permian—Continued
Darwin Canyon Formation—Continued
Millers Spring Member—Continued
Unit 3—Continued

	Thickness meters
thick; mean bed thickness about 60 cm; commonly plane laminated and crosslaminated, less commonly convolute laminated; bedding surfaces sharp. Mudstone, light gray, in beds 10 to 90 cm thick; mean bed thickness about 35 cm..........................	7.4
13. Mudstone and siltstone, calcareous, light gray, thin bedded.............	2.5
12. Sandstone (55 percent) and mudstone (45 percent), as in 14. Sandstone, strongly calcarenitic; in beds 20 to 55 cm thick; contains well-developed convolute lamination. Mudstone in beds 40 to 45 cm thick......................	2.9
11. Covered interval.....................	2.0
10. Sandstone (65 percent) and mudstone (35 percent), as in 14. Sandstone in beds 10 cm to 2.5 m thick; mean bed thickness about 70 cm. Mudstone in beds 5 cm to 1 m thick; mean bed thickness about 35 cm..........................	14.6
9. Limestone, medium gray; one bed (Bouma Tab), grades from coarse-grained bioclastic calcarenite at base to laminated fine-grained calcarenite at top; contains fusulinids..................	0.3
8. Sandstone (45 percent) and mudstone (55 percent), as in 14. Sandstone in beds 5 to 85 cm thick; mean bed thickness about 20 cm. Mudstone in beds 2 to 40 cm thick; mean bed thickness about 25 cm..........................	10.4
7. Limestone, medium gray; one bed (Bouma Tabe); grades from coarse-grained bioclastic calcarenite at base to micrite at top..............................	0.7
6. Mudstone, calcareous, light gray.....	0.5
5. Covered interval.....................	2.5
4. Sandstone, quartzose, brown, very fine grained (lower 50 cm); grades upward into light-gray calcareous siltstone and mudstone (upper 1.6 m).......................	2.1
3. Limestone, medium gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to laminated calcisiltite at top..................	0.8
2. Mudstone, calcareous, light gray; contains scattered unsorted dark-gray limestone clasts to 30 cm in diameter; largest clasts are in upper part of bed...........	3.0
1. Sandstone (40 percent) and mudstone (60 percent), as in 14. Sandstone in beds 10 to 70 cm thick; mean bed thickness about 30 cm. Mudstone in beds 5 cm to 1.4 m thick, poorly exposed.......	6.0
Total thickness unit 3....................	55.7

Unit 2:

	Thickness meters
9. Mudstone, calcareous, conglomeratic, light gray, grayish orange, and grayish pink; one massive bed; contains abundant matrix-supported clasts that include micritic limestone clasts to 50 cm in diameter, broken fasciculate rugose corals, fusulinids, echinodermal debris, and other bioclasts; limestone clasts have sharp borders........................	17.0
8. Sandstone, very fine grained, and calcareous siltstone; thin bedded and laminated; poorly exposed.......................	3.0
7. Mudstone, calcareous, light gray to grayish pink, massive; contains large rounded micritic limestone clasts with diffuse borders; may grade up from underlying limestone...	12.0
6. Limestone (calcarenite), bioclastic, medium gray; one graded bed (Bouma Ta); contains fusulinids. Fusulinid collection DC3: _Schwagerina_ spp., _Pseudoschwagerina_ sp.................	3.5
5. Mudstone, calcareous, light gray; one massive bed; contains medium-gray micritic limestone clasts with diffuse borders in basal 1.0 m; lenticular...	7.0
4. Limestone; one bed (Bouma Tab); grades from medium-gray limestone-granule conglomerate at base to laminated light-gray calcisiltite at top..................	1.2
3. Limestone-pebble conglomerate, medium gray; one graded bed (Bouma Ta); clasts strongly imbricated......	0.8
2. Limestone, medium gray; one bed (Bouma Ta); grades from bioclastic limestone conglomerate at base to echinodermal calcarenite at top; contains micritic limestone clasts to 4 cm in diameter and broken fasciculate rugose corals............	1.2
1. Mudstone, calcareous, yellowish brown; one massive bed; contains large fragments of medium-gray bioclastic limestone and limestone conglomerate...........	5.0
Total thickness unit 2....................	50.7

Section 2: Lower Permian—Continued
Darwin Canyon Formation—Continued
Millers Spring Member—Continued

	Thickness meters
Unit 1 (incomplete):	
3. Sandstone (55 percent) and mudstone (45 percent); in alternating beds. Sandstone, quartzose, variably calcareous and calcarenitic, brown to reddish brown on weathered surface; in beds 10 cm to 1.5 m thick, generally plane laminated and and crosslaminated, less commonly convolute laminated. Mudstone, gray to purplish gray; in beds 10 to 60 cm thick............	5.8
2. Limestone, medium gray; one bed (Bouma Tab); grades from coarse-grained bioclastic calcarenite at base to laminated calcisiltite at top; contains fusulinids..	0.9
1. Sandstone (60 percent) and mudstone (10 percent), as in 3; covered intervals (30 percent) probably represent unexposed mudstone intervals. Sandstone in beds 40 cm to 1.4 m thick. Mudstone in beds 10 to 30 cm thick..........................	5.8
Incomplete thickness unit 1................	12.5
Incomplete thickness Millers Spring Member..................................	179.8
Incomplete thickness Darwin Canyon Formation...............................	179.8

Base of section covered.

Section 3. Unit 6B (incomplete) and units 6C-7, Millers Spring Member, and Panamint Springs Member (incomplete) of the Darwin Canyon Formation. Measured in the hills south of Darwin Canyon in June 1981.

	Thickness meters
Section ends at axis of syncline.	
Darwin Canyon Formation (Lower Permian) (incomplete):	
Panamint Springs Member (incomplete):	
13. Limestone, medium gray, and light-brown siltstone................	9.1
12. Siltstone and very fine grained sandstone, light brown; in thin graded beds that commonly have parallel and convolute lamination....	35.1
11. Limestone, medium gray, and light-brown siltstone; subordinate pink shale..........................	13.7
10. Siltstone and very fine grained sandstone, as in 12.................	93.0
9. Limestone, light gray, and light-brown siltstone. Limestone in graded beds as thick as 30 cm; contains fusulinids, coarse echinodermal debris, and chert clasts to 3 mm in diameter. Fusulinid collection I1300 from 25 m above base of interval: *Schwagerina* cf. *S. crebrisepta*, *Schwagerina diversiformis*, *Pseudoschwagerina convexa*, *Chalaroschwagerina* sp...	29.0

Section 3: Lower Permian—Continued
Darwin Canyon Formation—Continued
Panamint Springs Member—Continued

	Thickness meters
8. Shale, moderate pink.................	3.0
7. Siltstone and very fine grained sandstone, as in 12; a few thick graded calcareous beds contain fusulinids, echinodermal debris, chert clasts, and occasional limestone clasts to 6 mm in diameter............................	143.3
6. Siltstone, calcareous, moderate orange to grayish orange pink; contains nodules of medium-gray limestone 15 to 25 cm long......	9.1
5. Limestone, medium light gray, fine grained; contains about 40 percent dark-gray elongate to spherical limestone nodules..........	21.3
4. Siltstone, medium light gray and grayish orange.......................	3.0
3. Limestone, medium gray, massive; contains dark-brown siliceous layers and nodules.........................	29.0
2. Sandstone, quartzose, calcareous, medium light gray to grayish orange, very fine grained; in beds 50 cm to 1 m thick...........................	16.8
Incomplete thickness Panamint Springs Member not including basal limestone unit.	405.4
Basal limestone unit:	
1. Limestone, medium dark gray; pink shale; and grayish-orange to moderate-yellowish-brown silty limestone; in beds 30 cm to 1 m thick; felsic dike 1 m thick present 6 m below top of interval....	86.9
Total thickness basal limestone unit.......	86.9
Incomplete thickness Panamint Springs Member..........................	492.3
Millers Spring Member (incomplete):	
Unit 7:	
Sandstone, quartzose, calcareous, medium gray to moderate brown, very fine grained; in beds 15 to 60 cm thick..........................	44.2
Total thickness unit 7.....................	44.2
Unit 6E:	
2. Mudstone, mottled grayish pink to moderate pink and medium light gray; contains limestone clasts and fusulinids. Fusulinid collection Ia-305 from 1 m above base of	

Section 3: Lower Permian--Continued
Darwin Canyon Formation--Continued
Millers Spring Member--Continued
Unit 6E--Continued

	Thickness meters
interval: Schwagerina aculeata, Schwagerina aff. S. thompsoni, Schwagerina sp, Chusenella sp.	21.4
1. Limestone, light to medium gray; in beds 60 cm to 1.5 m thick; some beds contain fusulinids and some contain clasts of fine- to medium-grained limestone to 15 cm in diameter. Fusulinid collection Ia-295 from 2 m below top of interval: Schwagerina elkoensis, Chalaroschwagerina sp., Pseudoschwagerina uddeni............	18.3
Total thickness unit 6E....................	39.7
Unit 6D:	
Sandstone, as in unit 7..............	29.0
Total thickness unit 6D....................	29.0
Unit 6C:	
Limestone, light to medium gray; in graded beds 60 cm to 1.5 m thick; some beds contain clasts of fine- to medium-grained limestone to 15 cm in diameter............................	9.2
Total thickness unit 6C....................	9.2
Unit 6B (incomplete):	
Sandstone, as in unit 7..............	35.1
Incomplete thickness unit 6B...............	35.1
Incomplete thickness Millers Spring Member..................................	157.2
Incomplete thickness Darwin Canyon Formation...............................	649.5

Base of section covered.

Section 4. Unit 4 (incomplete), units 5-6, and unit 7 (incomplete), Millers Spring Member of the Darwin Canyon Formation. Measured in the hills south of Darwin Canyon in June 1981.

	Thickness meters
Top of section faulted.	
Darwin Canyon Formation (Lower Permian) (incomplete):	
Millers Spring Member (incomplete):	
Unit 7 (incomplete):	
Sandstone, quartzose, calcareous, medium light gray to grayish orange, very fine grained, thick bedded; convolute lamination common..........	36.6
Incomplete thickness unit 7................	36.6
Unit 6E:	
2. Mudstone, moderate pink, massive; contains medium-light-gray limestone clasts to 5 cm in diameter, coral fragments, and fusulinids. Fusulinid collection I975 from 4 m above base	

Section 4: Lower Permian--Continued
Darwin Canyon Formation--Continued
Millers Spring Member--Continued
Unit 6E--Continued

	Thickness meters
of interval: Schwagerina cf. S. eolata, Pseudoschwagerina convexa............................	15.3
1. Limestone, medium light gray; in graded beds averaging about 3 m thick; contains medium-light-gray limestone clasts to 5 cm in diameter and coral fragments......................	15.3
Total thickness unit 6E....................	30.6
Unit 6D:	
Sandstone, quartzose, calcareous, very fine grained; and dusky-brown, medium-light-gray, and grayish-orange silty limestone; in beds as much as 1.5 m thick; convolute lamination common.....................	44.2
Total thickness unit 6D.....................	44.2
Unit 6C:	
2. Limestone, medium gray; in thick graded beds; contains rounded medium-gray limestone clasts to 8 cm in diameter; one bed contains imbricated clasts and coral fragments...........................	10.7
1. Limestone, medium light gray; one graded bed; contains fusulinids and coarse echinodermal debris at base...	4.8
Total thickness unit 6C....................	15.5
Unit 6B:	
3. Limestone, silty, grayish orange, dusky brown, and light gray; convolute lamination common..........	9.2
2. Sandstone, quartzose, calcareous, very fine grained; in beds 1 to 1.5 m thick; forms ridge.............	16.8
1. Sandstone, quartzose, calcareous, very fine grained; and grayish-orange, dusky-brown, and light-gray silty limestone; in beds 30 cm to 1.5 m thick; convolute lamination common; outcrops resistant with blocky fracture.....................	16.8
Total thickness unit 6B....................	42.8
Unit 6A:	
Limestone, medium gray; one bed; grades upward into laminated, medium-light-gray silty limestone; contains rounded limestone clasts to 1 cm in diameter and abundant fusulinids and echinodermal debris. Fusulinid collection I500 from base of interval: Schwagerina cf. S. crebrisepta, Schwagerina elkoensis, Schwagerina cf. S. wellsensis, Stewartina sp.	13.7
Total thickness unit 6A....................	13.7

	Thickness meters
Total thickness units 6A-6E	146.8
Unit 5:	
3. Sandstone, quartzose, calcareous, grayish orange, dusky brown, and light gray, very fine grained; and medium-dark-gray, fine-grained limestone; in graded beds 1 to 1.5 m thick; some beds contain fusulinids. Fusulinid collection I1410 from 14 m above base of interval: *Schwagerina aculeata*, *Schwagerina diversiformis*, *Pseudoschwagerina uddeni*, *Pseudoschwagerina* sp., *Parafusulina* sp.	41.2
2. Sandstone, quartzose, grayish red to dusky red, very fine grained, massive; forms resistant outcrops with blocky fracture	12.2
1. Sandstone, quartzose, calcareous, very fine grained; and grayish-orange, dusky-brown, and light-gray silty limestone; in beds 30 to 60 cm thick; parallel and convolute lamination common	30.5
Total thickness unit 5	83.9
Unit 4 (incomplete):	
3. Limestone, medium to dark gray, in graded beds as much as 60 cm thick; consists mainly of fine-grained echinodermal debris; fusulinids present in some beds; parallel and convolute lamination present in some beds	30.5
2. Limestone, silty, grayish pink and medium light gray; grayish-pink beds have convolute lamination and contain spherical nodules of medium-light-gray, fine-grained limestone to 15 cm in diameter; medium-light-gray beds are graded, average about 30 cm thick, and have convolute lamination	29.0
1. Limestone, medium light gray; in graded beds 45 cm to 1 m thick; contains rounded limestone clasts to 5 cm in diameter, echinodermal debris, fusulinids, and corals	9.2
Incomplete thickness unit 4	68.7
Incomplete thickness Millers Spring Member	336.0
Incomplete thickness Darwin Canyon Formation	336.0

Base of section faulted.

Section 5. Unit 1 (incomplete), units 2-6, and unit 7 (incomplete), Millers Spring Member of the Darwin Canyon Formation. Measured in the hills south of Darwin Canyon in June 1981.

	Thickness meters
Top of section covered.	
Darwin Canyon Formation (Lower Permian) (incomplete):	
Millers Spring Member (incomplete):	
Unit 7 (incomplete):	
Sandstone, quartzose, calcareous, light gray, grayish orange, and grayish brown on weathered surface, very fine grained; thick bedded, laminated; convolute lamination common	40.0
Incomplete thickness unit 7	40.0
Unit 6E:	
2. Mudstone, calcareous, moderate pink; contains fusulinids, coral fragments, and rounded medium-gray limestone clasts to 2 cm in diameter. Fusulinid collection I11605 from 1 m below top of interval: *Schwagerina* spp	7.6
1. Limestone, medium gray; in thick, graded beds; contains rounded medium-gray limestone clasts to 5 cm in diameter and abundant coral fragments; tops of beds fine grained and plane laminated	12.2
Total thickness unit 6E	19.8
Unit 6D:	
Sandstone, as in unit 7	27.4
Total thickness unit 6D	27.4
Unit 6C:	
Limestone, medium gray; in graded beds 1 to 3 m thick; contains fusulinids, coral fragments, and gray limestone clasts to 5 cm in diameter; clasts strongly imbricated in some beds	19.8
Total thickness unit 6C	19.8
Unit 6B:	
Sandstone, as in unit 7	47.3
Total thickness unit 6B	47.3
Unit 6A:	
Limestone, medium gray; in thick graded beds; contains rounded, medium-gray limestone clasts to 1 cm in diameter, fusulinids, coral fragments, and coarse echinodermal debris. Fusulinid collection I11220 from 4 m below top of interval: *Schwagerina aculeata*, *Schwagerina* sp	19.8
Total thickness unit 6A	19.8
Total thickness units 6A-6E	134.1

Section 5: Lower Permian--Continued
Darwin Canyon Formation--Continued
Millers Spring Member--Continued

	Thickness meters
Unit 5:	
5. Siltstone, grayish brown to brownish black; contains nodules and lenses of fine-grained gray limestone 8 to 30 cm long; subordinate medium-gray limestone in graded beds containing fusulinids (2 beds present). Fusulinid collection II150 from base of interval: *Schwagerina* cf. *S. crebrisepta*, *Schwagerina elkoensis*............................	6.1
4. Sandstone, quartzose, brownish gray, brownish black, and pale reddish brown on weathered surface, very fine grained; in beds as much as 1.5 m thick; forms ridges; crosscutting dike present 15 m below top of interval................	45.7
3. Covered interval.....................	10.7
2. Limestone, medium gray, fine grained, thin to medium bedded; plane and convolute laminated; some graded beds contain coarse echinodermal debris and fusulinids.......................	4.6
1. Sandstone, as in 4...................	6.1
Total thickness unit 5.....................	73.2
Unit 4:	
Limestone, medium gray, fine grained, thin to medium bedded; beds commonly graded. One 2-m-thick graded bed 46 m above base of interval contains medium-gray limestone clasts to 1 cm in diameter, fusulinids, and coral fragments. Fusulinid collection II850 from this bed: *Schwagerina aculeata*, *Chusenella compacta*, *Pseudofusulina*? aff. *P. loringi*, *Cuniculinella* spp.	70.1
Total thickness unit 4.....................	70.1
Unit 3:	
2. Sandstone, quartzose, calcareous, very fine grained, and yellowish-brown- to grayish-orange-weathering silty limestone; in laminated beds as much as 1 m thick; convolute lamination common...	67.1
1. Limestone, silty limestone, and quartzose sandstone. Limestone, medium gray, medium grained; in graded beds 25 cm to 1 m thick. Sandstone and silty limestone, yellowish brown to grayish orange on weathered surface; in laminated beds to 1 m thick; convolute lamination common....................	21.3
Total thickness unit 3.....................	88.4
Unit 2:	
3. Mudstone, calcareous, moderate pink; one massive bed; contains rounded to subangular, light- to medium-gray limestone clasts to 75 cm in diameter and fusulinids, corals, and echinodermal debris..............	25.0
2. Limestone, shaly, moderate pink......	4.6
1. Limestone, medium gray; in thick graded beds; contains rounded, medium-gray limestone clasts, fusulinids, and coral fragments; clasts imbricated. Fusulinid collection II155 from 12 m above base of interval: *Schwagerina elkoensis*?, *Chusenella compacta*, *Paraschwagerina* sp., *Pseudoschwagerina uddeni*, *Pseudoschwagerina* sp., *Stewartina*? spp.; fusulinid collection II175 from 18 m above base of interval: *Schwagerina* cf. *S. eolata*, *Schwagerina* aff. *S. thompsoni*, *Chusenella compacta*, *Stewartina moranensis*, *Stewartina* sp......................	32.0
Total thickness unit 2.....................	61.6
Unit 1 (incomplete):	
Sandstone, quartzose, calcareous, very fine grained, and pale-yellowish-orange-weathering silty limestone; in laminated beds as much as 75 cm thick; convolute lamination common...................	35.1
Incomplete thickness unit 1................	35.1
Incomplete thickness Millers Spring Member..................................	502.5
Incomplete thickness Darwin Canyon Formation................................	502.5

Base of section covered.

GPO 785-048/48043