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Conodont Faunas of the Lower *Siphonodella crenulata* Zone (Lower Mississippian) of Central and Northern Utah

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ABSTRACT

The Tournasian Lower *Siphonodella crenulata* Zone represents a time span of approximately 1.3 million years (Sandberg and Gutschick 1979). Conodont faunas collected from this zone represent a biofacies transition from carbonate bank (Joana Bank) to slope to deep basin. The conodont faunas collected have a generic composition dominated by *Siphonodella,* which was most abundant in deep basins, and *Polygnathus,* which occurs with both basin and slope faunas. *Pseudopolygnathus,* which was a nektobenthic slope dweller, and other genera occur less abundantly than *Siphonodella* and *Polygnathus* but are important as biofacies indicators.

The variation of the percentage of each genus, when compared locality to locality, shows facies control of conodont distribution. Thin-bedded basinal rocks composed mainly of micrite with some chert yield a fauna made up of *Siphonodella, Polygnathus, Pseudopolygnathus,* and lesser percentages of other genera. Slope and Joana Bank faunas found in limestone described as thick to massively bedded encrinite include *Siphonodella, Polygnathus,* and lesser percentages of other genera.

INTRODUCTION

Conodonts of the Lower *Siphonodella crenulata* Zone were collected from five (5) localities in northern and central Utah (fig. 1). These localities were selected because they represent the slope-to-basin transition within an Early Mississippian seaway. The rocks at two localities represent a starved basin setting, and those at the other three localities represent the slope-to-basin boundary. The distribution of the conodont faunas collected in this study is related to paleoecologic conditions including water depth, distance from the slope edge, and environmental energy levels. The conodont faunas collected from encrinites deposited near the shelf edge or near an offshore carbonate bank contain a lower percentage of *Siphonodella* than the micrites deposited in a starved basin. *Siphonodella* has been identified by Clark (1981) as a conodont taxa that is typical of basinal marine environments.

When the conodont faunas collected from the basinal and slope limestones of this study are compared with conodont faunas collected from rocks of similar age, deposited in shallow-marine environments such as oolitic and dolomitic facies (Austin 1976), clear differences are apparent. Conodonts faunas obtained from rocks deposited in this shallow-water facies contain few genera such as *Siphonodella* that are characteristic of deeper-water facies. Faunas collected at all localities of this study are made of similar taxa. However, differences related to the relative abundances of certain genera can be demonstrated.

The Lower *Siphonodella crenulata* Zone represents a time span of approximately 1.3 million years (Sandberg and Gutschick 1979). By studying this single zone at localities that represent slope and basin environments, differences in conodont biofacies can be related to lithofacies changes from slope to basin.

The recovery of various conodont faunas from rocks deposited in different environments of similar age illustrates facies control of conodont distributions. The matching of particular conodont faunas with specific paleoenvironments makes correlation more precise, allows description of conodont distributions, and makes facies reconstruction more accurate.

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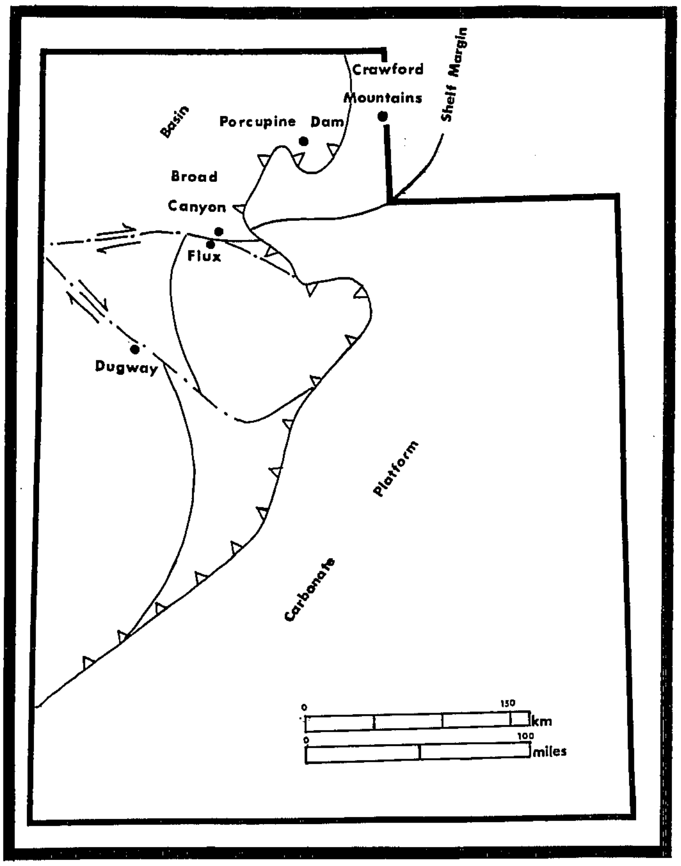


FIGURE 1.—*Index map (adapted from Gutschick and others 1980) showing the locations of sampled localities. Solid line = shelf margin.*

Sandberg and Gutschick (1984) and Hayes (1985) have suggested that Lower Mississippian starved basin rocks can be sources for hydrocarbon accumulations. Starved basin and shelf edge lithofacies are represented by the three formations chosen for this study.

Tournasian formations that contain the Lower *Siphonodella crenulata* Zone include the Lodgepole Limestone, Joana Limestone, and the Fitchville Formation. The Lodgepole Limestone occurs in Utah, Wyoming, Montana, and Idaho. The Joana Limestone is located in central and western Utah and eastern Nevada. The Fitchville Formation is restricted to central Utah.

At the Crawford Mountains, Porcupine Dam (located south of Logan, Utah), and Broad Canyon (located at the southwest end of the Great Salt Lake), the Lower *Siphonodella crenulata* Zone is contained in the Cottonwood Canyon Member and Paine Member of the Lodgepole Limestone. At Flux siding (near the north end of the Stansbury Mountains) this zone is contained in the lower middle and lower upper parts of the Fitchville Formation. At Buckhorn Canyon in the Dugway Range this zone occurs at the base of the Joana Limestone. The land grid for each collection site, weight of each sample, and the stratigraphic position of each sample are presented in the locality register (appendix).

Sloss and Hamblin (1942) divided the Lodgepole Limestone into two members: the Tournasian Paine Member and the Tournasian-Visean Woodhurst Member. The Paine Member was later subdivided by Sandberg and Klapper (1967). They separated the shaly lower part of the Paine Member from the upper Paine Member and renamed it the Cottonwood Canyon Member. The Cottonwood Canyon Member is widespread throughout Utah, Wyoming, and southern Montana and ranges in thickness from 0.1 to 18 m (Sandberg and Klapper 1967). This member is generally composed of lag limestone and sandstone beds interbedded with shales. The lower 5-m interval of the Paine Member contains abundant conodonts of the Lower *Siphonodella crenulata* Zone and is composed of encrinite and fossil fragmental limestone. Samples from both the Crawford Mountains and Broad Canyon were collected from this 5-m interval of the Paine Member. At Porcupine Dam samples were collected from both the Cottonwood Canyon Member and the lower part of the Paine Member of the Lodgepole Limestone. The upper part of the Paine Member, which ranges in thickness from 225 to 250 m, is composed of cherty slope limestone and contains few conodonts. Rocks of the upper part of the Paine Member are younger than the Lower *Siphonodella crenulata* Zone.

The Fitchville Formation was first described by Morris and Lovering (1961). The Fitchville Formation has been divided into informal lower, middle, and upper parts by Sandberg and Gutschick (1979). The lower part of the Fitchville Formation is composed of a basal sandstone marker bed that is overlain by limestone. The middle part is composed of thin-bedded argillaceous limestone. The upper part of the Fitchville Formation is composed of massive dolomite. The total thickness of the Fitchville Formation at Flux siding is 38 m (Sandberg and Gutschick 1979). The Lower *Siphonodella crenulata* Zone is contained in the lower middle and lower upper parts of the Fitchville Formation, and the samples were collected from a 15-m interval composed of cherty limestone and dolomite.

The Joana Limestone, which overlies the Pilot Shale, was first described by Spencer (1917). Sandberg and Gutschick (1979) described an occurrence of the Joana Limestone at Buckhorn Canyon in the Dugway Range. Samples used in this study were collected at the site listed above. At this site the Joana Limestone is composed of thick-bedded to massive limestone.

PREVIOUS WORK

Rose (1976) recognized that the Lower Mississippian carbonate rocks of the western United States can be divided into lower and upper depositional complexes. The lower depositional complex was described by Rose (1976) as transgressive and open marine. The rocks collected in this study are from the lower depositional complex. A paleotectonic model, proposed by Poole and Sandberg (1977), describes the paleogeographic conditions that prevailed in the western United States during the Lower Mississippian. Their diagram (fig. 2) shows a sediment-starved basin located between a flysch trough, on the west, and a carbonate platform, on the east. The flysch trough and carbonate platform effectively trapped sediments, creating the starved basin. Sandberg and Gutschick (1979) suggested that the Cottonwood Canyon Member and Paine Member of the Lodgepole Limestone and the Fitchville Formation represent basinal limestones and cherty slope limestones. Published descriptions by Newman (1980) and Sandberg and Gutschick (1979) of measured sections for many of the localities in this report provided a reference for collections to be made. Gutschick and others (1980) constructed paleogeographic maps that describe paleoenvironments and paleopositions of various rock units deposited as part of both the lower and upper depositional complexes. On the map that represents the Lower *Siphonodella crenulata* Zone, Gutschick and others (1980) show a carbonate bank known as the Joana Bank between a flysch trough and an island separating the Joana Bank from the main carbonate bank. Samples from the Dugway Range were deposited as part of the Joana Bank.

CONODONT ZONATION

Each of the Lower Mississippian conodont zones represents a time span of approximately 1.3 million years (Sandberg and Gutschick 1979). An upper Devonian and Lower Mississippian zonation based on species of the genus *Siphonodella* was proposed by Sandberg and others (1978). In the western United States the *Siphonodella crenulata* Zone and the *Anchoralis latus* Zone are two of the most widely known and best documented Early Mississippian conodont zones.

In the study area, the Lower *Siphonodella crenulata* Zone generally occurs in rocks that were deposited under conditions of slow sedimentation. These conditions resulted in samples that contain large numbers of conodonts, ranging from 1000–2000 conodonts per kilogram of rock (Sandberg and Gutschick 1979). Samples collected in this study contain as many as 1000 conodonts per kilogram of rock to as few as 100 conodonts per kilogram of rock.

Species of *Siphonodella* make up the bulk of the conodont faunas. Seven species of *Siphonodella* have been identified in this study. These seven species are contained in the Lower *Siphonodella crenulata* Zone, as described by Sandberg and others (1978). They include *Siphonodella cooperi, S. quadruplicata, S. lobata, S. sandbergi, S. crenulata, S.isosticha,* and *S. sexplicata.* Of these seven species, *S. cooperi* and *S. quadruplicata* are the most abundant.

Other conodonts of the Lower *Siphonodella crenulata* Zone that were recovered from all localities include: *Polygnathus communis communis, P. inornatus, P. triangulus, Pseudopolygnathus marginatus, Bispathodus stabilis, Bryantodus* sp., *Ligonodina* sp., *Neoprioniodus,* and *Hindeodella. Pseudopolygnathus* and *Siphonodella* are used in defining the upper and lower boundaries of the Lower *Siphonodella crenulata* Zone.

The base of the Lower *Siphonodella crenulata* Zone is defined by the first occurrence of *S. crenulata* (Sandberg and others 1978). The top of this zone is defined by the first occurrence of *Gnathodus delicatus* of the overlying Upper *Siphonodella crenulata* Zone. *Pseudopolygnathus marginatus* makes its last appearance in the Upper

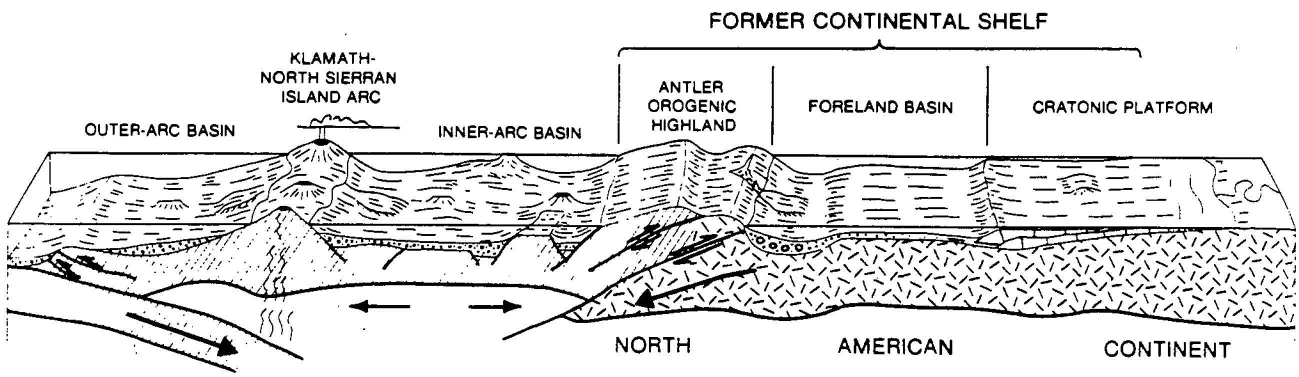


FIGURE 2.—*Block diagram representing Lower Mississippian paleogeography (from Poole and Sandberg 1977).*

Siphonodella crenulata Zone. *S. lobata* and *S. sexplicata* both make their last appearance in the Lower *Siphonodella crenulata* Zone. Samples collected in this study contain *Pseudopolygnathus marginatus*, *S. crenulata*, and *S. lobata*. No specimens of *Gnathodus delicatus* were recovered from the samples collected. Stratigraphic sections for each sampled locality are shown in figure 3.

CONODONT FAUNAS

The conodont faunas comprise 21 taxa representing 10 form genera. Examples of each taxa are shown in figures 4 and 5. Pectiniform elements, in order of decreasing abundance, comprise *Siphonodella*, *Polygnathus*, and *Pseudopolygnathus*. *Bispathodus* and *Pseudopolygnathus* occur

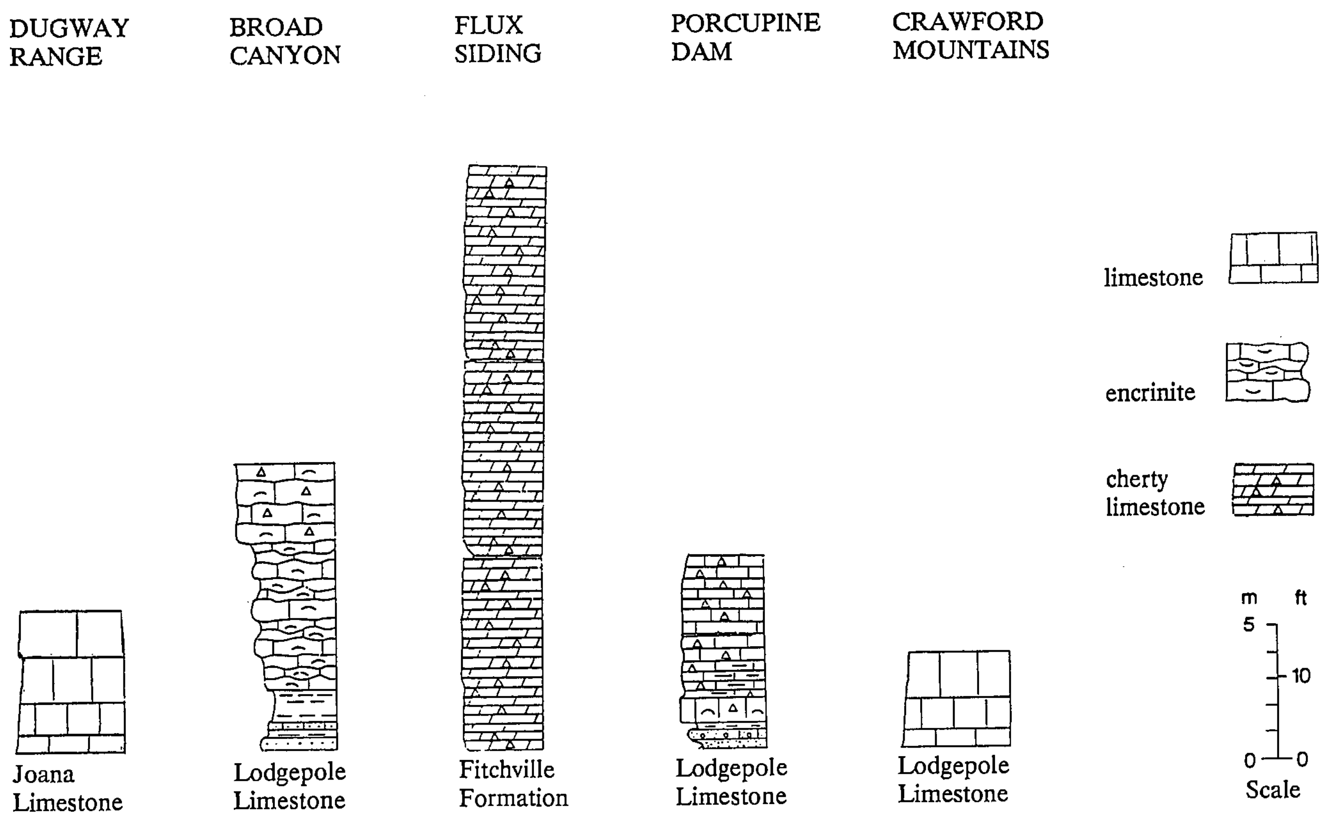
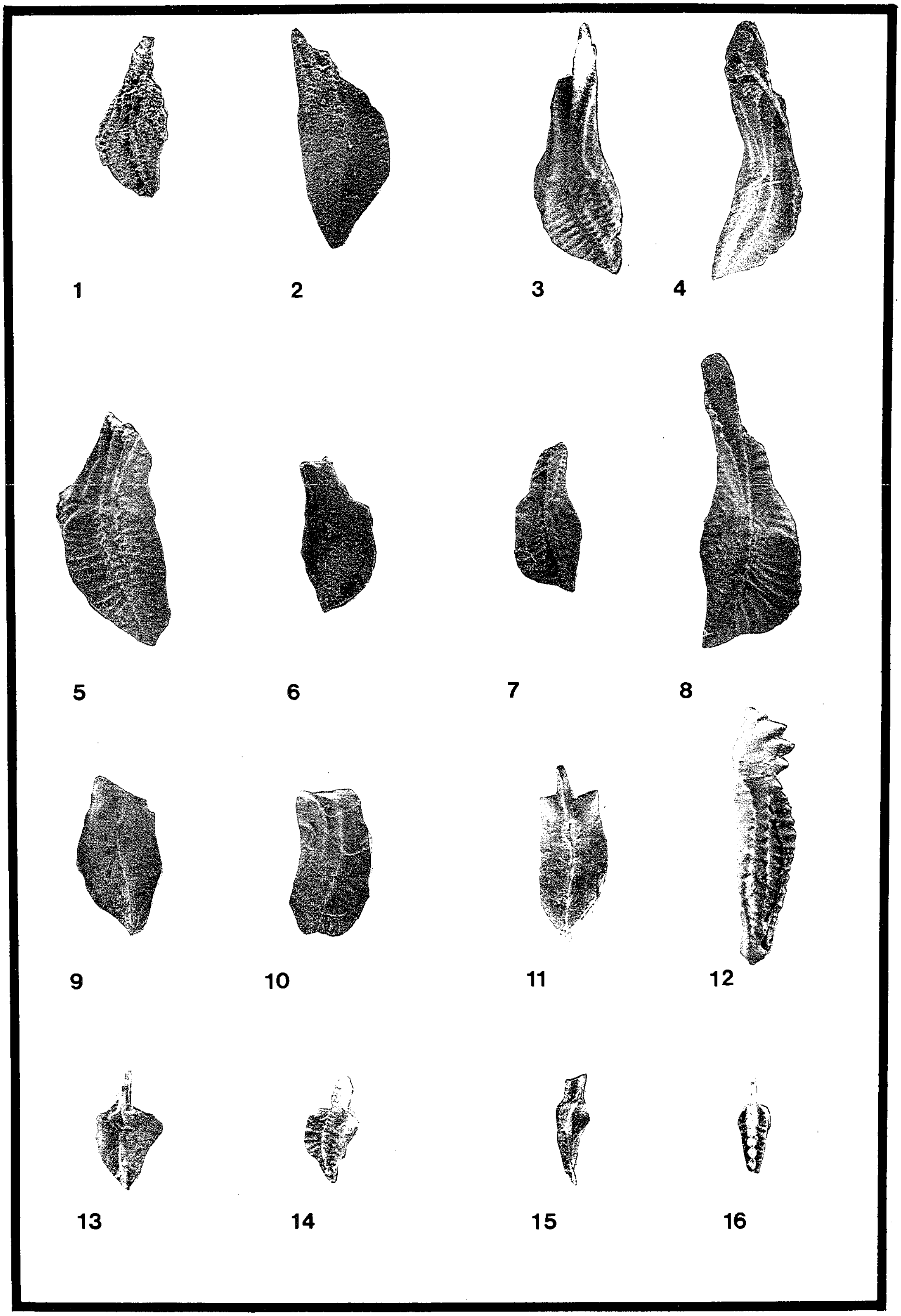


FIGURE 3.—*Stratigraphic columns from each sampled locality. Adapted from Sandberg and Gutschick (1979) and Newman (1980).*

FIGURE 4.—*All figures are unretouched photographs of coated specimens. 1—* Siphonodella sandbergi *Klapper, oral view, X30 (BYU 3301), Lodgepole Limestone, Broad Canyon. 2—* Siphonodella obsoleta *Hass, oral view, X20 (BYU 3302), Lodgepole Limestone, Broad Canyon. 3,4—* Siphonodella quadruplicata *Branson and Mehl, 3, oral left lateral (BYU 3303), 4, oral right lateral view (BYU 3304), both X20, Joana Limestone, Dugway Range. 5—* Siphonodella sexplicata, *oral view, X20 (BYU 3305), Lodgepole Limestone, Broad Canyon. 6,7,8—* Siphonodella crenulata Cooper, *6, aboral view (BYU 3308), all X20, Lodgepole Limestone, Porcupine Dam. 9,10—* Polygnathus inornatus *(Branson) 9, aboral view (BYU 3309), 10, oral view (BYU 3310), both X20, Joana Limestone, Dugway Range. 11,12—* Polygnathus longiposticus *(Branson and Mehl), 11, aboral view, X20, (BYU 3311), 12, oblique view X30, (BYU 3312), Broad Canyon, Lodgepole Limestone. 13,14—* Polygnathus triangulus *(Voges), 13, aboral view (BYU 3313), 14, oral view (BYU 3314), both X20, Joana Limestone, Dugway Range. 15,15—* Pseudopolygnathus marginatus *(Branson and Mehl), 15, oral view (BYU 3315), 16, aboral view (BYU 3316) both X20, Porcupine Dam, Lodgepole Limestone.*



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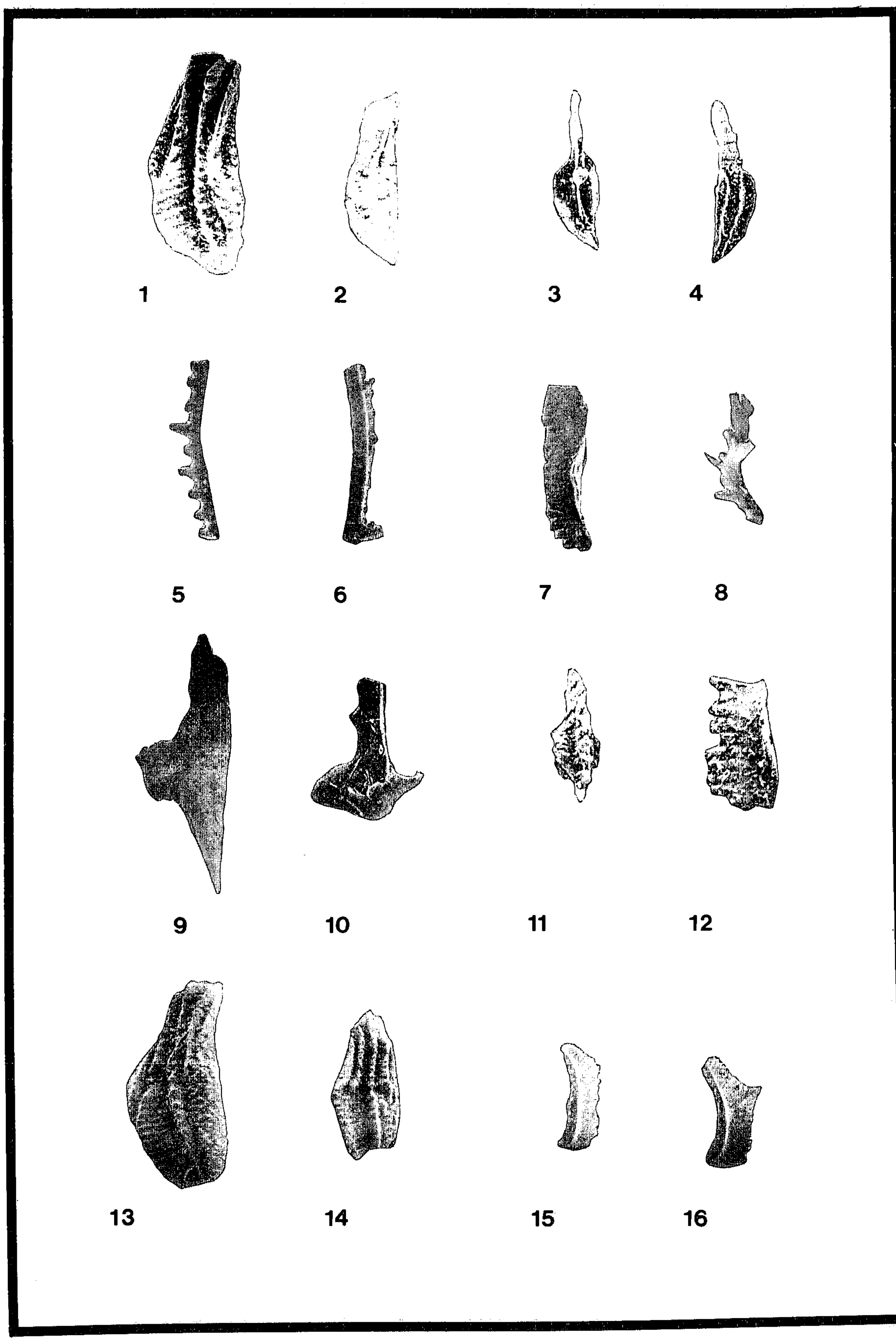
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Table 1. Conodont Alteration Index (CAI). CAI of 1 indicates temperatures that range from 30 to 80° C. CAI of 4 indicates temperatures ranging from 190 to 300° C.

LOCALITY	CONODONT ALTERATION INDEX
Flux	4
Broad Canyon	4
Dugway Range	3
Porcupine Dam	2
Crawford Mountains	1.5

with approximately equal abundance. Most of the conodont elements are individually asymmetrical and occur as right and left halves of bilaterally symmetrical pairs (Class II symmetry of Lane 1968).

Conodont Alteration Index (CAI), which indicates thermal history and is used in petroleum source rock studies, varies from locality to locality. The CAI values reported in table 1 are in agreement with those reported by Sandberg and Gutschick (1979).

The samples from all localities yield faunas that are similar in composition (dominated by species of *Siphonodella;* see table 2). However, not only does the number of conodonts collected from each locality vary (depending on sample size and environmental conditions), but relative abundances of each taxon also change from locality to locality (table 3).

CONODONT PALEOECOLOGY

Conodonts lived in a wide variety of ancient marine environments. Some species of conodont animals were more abundant in particular marine environments (Austin and Davies 1984, Clark 1974, Sandberg and Gutschick 1979). To explain differences in the distribution of conodont faunas, several models have been proposed. These models describe where the conodont animal lived (fig. 6). Seddon and Sweet (1971) proposed a model based on depth stratification. Fahraeus and Barnes (1975) offered an alternate model based on a presumed nektobenthic habitat. Sandberg and Gutschick (1979) demonstrated that the distribution of some conodont faunas can be described by a combination of the depth stratification and nektobenthic models. Interpreting paleoecologic conditions such as energy levels, salinity, and food supply from outcrop characteristics provides additional information that can be applied to the interpretation of conodont distributions. Both the depth stratification and nektobenthic models can be used to describe the distribution of the conodont faunas collected for this study.

INTERPRETATION

The close association of specific conodont faunas with particular paleoenvironments provides information about conodont distributions. Species of the genus *Siphonodella, Polygnathus,* and *Pseudopolygnathus,* all of which are present in samples of this study, have been associated with particular environments by various authors. The interpretation of conodont distributions in this study has been based on *Siphonodella, Polygnathus,* and *Pseudopolygnathus.*

Clark (1974) and Austin (1976) proposed that conodont distribution and conodont morphology are related. They suggested that conodonts with large platforms and small basal cavities lived in deeper waters, and conodonts with small blades and high carinas favored shallow waters. The majority of the conodonts found in the slope and basinal rocks of this study have large platforms and small basal cavities, in agreement with Clark's and Austin's observations.

Siphonodella is thought to occur in basin environments far from shore (Gutschick and Sandberg 1983). This genus is represented by the greatest number of species and

FIGURE 5.—*All figures are unretouched photographs of coated specimens. 1,2*— Siphonodella cooperi *Hass, 1, oral view (BYU 3317), 2, aboral view (BYU 3318), both X40, Flux Siding, Fitchville Formation. 3,4*— Polygnathus communis communis *Branson and Mehl, 3, aboral view (BYU 3319), 4, oral view (BYU 3320), both X30, Broad Canyon, Lodgepole Limestone. 5,6*— Hindeodella *sp., both right lateral views (BYU 3321, 3322), both X45, Broad Canyon, Lodgepole Limestone. 7*— Bispathodus *sp., oblique view, X30 (BYU 3323), Flux Siding, Fitchville Formation. 8,9*—Neoprioniodus *sp., left lateral views (BYU 3324, 3325), both X20, Porcupine Dam, Lodgepole Limestone. 10*—Ligonodina *sp., oblique lateral view, X30 (BYU 3326), Dugway Range, Joana Limestone. 11,12*— Bispathodus stabilis *Branson and Mehl. 13,14*— Siphonodella isosticha, *13, right lateral view (BYU 3329), 14, left lateral view (BYU 3330), both X20, Broad Canyon, Lodgepole Limestone. 15,16*— Elictognathus laceratus *Branson and Mehl, both right lateral views (BYU 3331, 3332), both X45, Porcupine Dam, Lodgepole Limestone.*

Table 2. Abundances of conodonts recovered from this study.

Species/Area	Broad Canyon	Flux	Dugway Range	Porcupine Dam	Crawford Mountains
Siphonodella crenulatae	Canyon	Flux	Dugway	Porcupine	Mountains
Siphonodella crenulata	2	3	1	36	26
S. quadruplicata	9	0	8	8	2
S. sandbergi	1	0	0	0	0
S. sexplicata	1	0	0	0	0
S. isosticha	10	1	5	11	22
S. cooperi	149	9	61	42	57
S. lobata	1	0	1	0	0
S. sp.	177	133	391	123	350
Polygnathus inornatus	2	1	0	3	4
P. triangulus	23	2	25	2	2
P. communis communis	138	45	72	4	25
P. longiposticus	52	8	57	20	20
Pseudopolygnathus marginatus	1	2	7	14	7
Ligonodina sp.	13	2	10	2	2
Neopioniodus	3	4	4	3	4
Ozarkodina sp.	5	0	0	0	2
Hindeodella sp.	7	23	5	5	32
Bryantodus sp.	0	1	1	0	2
Bispathodus	43	20	10	7	8
Synprioniodina	0	0	0	0	1
Total	*647*	*254*	*658*	*279*	*564*
SAMPLE SIZE	2.75 kg	1.3 kg	6.6 kg	24.2 kg	0.5 kg

Table 3. Diagram showing relative abundances of various genera. The number of each genus is normalized to a 0.5 kilogram sample weight. The conodonts from the Crawford Mountains were obtained from a 0.5 kilogram sample. BC = Broad Canyon, DG = Dugway, FX = Flux, PRC = Porcupine Dam, CF = Crawford Mountains.

Genus/Locality	Broad Canyon		Flux		Dugway Range		Porcupine Dam		Crawford Mountains	
	total	%	total	%	total	%	total	%	total	%
Siphonodella	308	58	54	64	146	73	23	80	457	87
Polygnathus	169	31	21	24	41	20	3	10	52	10
Pseudopolygnathus	21	4	2	2	10	5	2	7	9	2
Bispathodus	38	7	8	10	3	2	1	3	2	1
Total	536		85		200		29		526	

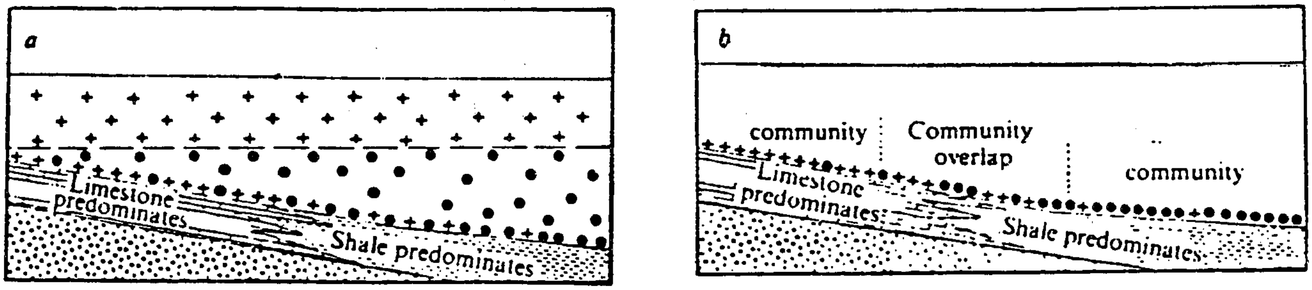

FIGURE 6.—*Diagrammatic cross sections showing the depth stratification (a) and nektobenthic (b) models of conodont paleoecology. Reprinted from Fahreaus and Barnes (1975).*

largest number of conodont elements in this study. The limestones collected have sedimentologic characteristics that indicate deposition in environments ranging from slope to basin. The character of the rocks and the character of the conodont faunas together indicate water depths of 200 m or greater.

In a study by Sandberg and Gutschick (1979), middle Mississippian conodont faunas collected from rocks deposited on the slope contained 65% *Polygnathus communis communis*. Austin and Davies (1984) have proposed that *Polygnathus inornatus* is generally found in rocks that were deposited in open-marine environments. *Polygnathus communis communis* has a wide distribution in rocks of both shallow- and deep-water facies and is thought to have inhabited shallow depths offshore (Sandberg in Lane and others 1980). Austin and Davies (1984) suggested that *Polygnathus inornatus,* like *Polygnathus communis communis,* also lived in the upper layers of the sea. One difference between these two species as noted by Austin and Davies is the absence of *Polygnathus inornatus* from rocks deposited in low-energy environments with possibly raised salinities. Due to its absence from the conditions described above, *Polygnathus inornatus* may indicate open-marine conditions. As indicated in table 2, many specimens of *P. communis communis* and a few specimens of *P. inornatus* were collected at each locality of this study.

Because *Polygnathus* is generally found in deep marine environments and has a large platform and a small basal cavity, it has been suggested by Clark (1981) that it is typical of a deep marine environment. In this study, more specimens of *Polygnathus* are present in the encrinites, deposited near the slope-basin boundary, and collected from the Dugway Range and Broad Canyon than are present in the micritic limestones collected at the other three localities.

Many species of *Pseudopolygnathus* are thought to have been slope dwellers (Sandberg and Gutschick 1979). Due to its nektobenthic habit, the occurrence of *Pseudopolygnathus* can indicate either proximity to the slope or mixing of slope faunas with deeper water faunas. A few specimens (table 2) of *Pseudopolygnathus* were collected at each locality.

PALEOENVIRONMENTS

Outcrops, thin sections, and conodont faunas were studied to aid in determining environmental factors such as water depth, distance from shore, salinity, and environmental energy levels that may have influenced the distribution of conodont faunas. Gutschick and Sandberg (1983) have shown that the color of Lower Mississippian carbonate rocks can be used as an indicator of water depth. The rocks collected match the color classification of Gutschick and Sandberg (1983) in that encrinites (Dugway Range) deposited in shallower waters are lighter in color than the rocks collected from localities that represent deeper water environments (Flux siding, Porcupine Dam, and the Crawford Mountains). Samples ranged from medium gray to brownish black. Flugel (1982) defined and gave criteria for the recognition of pelagic carbonate rocks. Flugel suggested that carbonate rocks deposited in deep water are generally dark colored, thin bedded, and contain chert and abundant lime mud. The samples collected from the Crawford Mountains, Porcupine Dam, and Flux siding fit Flugels description. It should be noted that the conodont faunas and the specific taxa that the faunas contain were also considered in determining paleoenvironments and conodont distributions.

The texture and composition of the rock, which at all localities is composed of lime mud with varying amounts of poorly sorted crinoidal debris, indicates deposition in a low-energy environment (table 4). Rock collected from the Dugway Range and Broad Canyon contains less lime mud and more crinoidal debris than the rock samples collected from the other three localities. Rock samples from all localities contain very small amounts of insoluble residues. Insoluble materials are composed of limonite, hematite, conodonts, phosphatized gastropods, and fish debris. All samples (except those collected from the Joana

Table 4. Description and environmental classification of rocks collected. Descriptions are based on thin sections and insoluble residues. BC = Broad Canyon, DG = Dugway, FX = Flux, PRC = Porcupine Dam, CF = Crawford Mountains, wckstn = wackestone, pckstn = packstone, lmdstn = lime mudstone.

Thin Section Characteristic	Locality				
	BC	DG	FX	PRC	CF
% Carbonate grains	50	30–40	20–30	3	1
% Micrite	50	60–70	70–80	97	99
Texture	wackestone	packstone	lmdstn	lmdstn	lmdstn
Environment	****margin/slope****			basin	basin
Organisms	samples from all localities contain conodonts, fish debris, gastropods, and crinoidal debris.				

Limestone at the Dugway Range) were collected from thin-bedded units.

The characteristics of the rocks (table 4) described above provide evidence that the rocks collected at all localities were deposited in environments ranging from slope to basin. Rocks collected from Broad Canyon and the Dugway Range contain enough crinoidal debris to be classified as encrinites. Rocks from the other three localities contain less crinoidal material and bioclastic material and are designated as lime mudstones.

Encrinites from Broad Canyon contain about 50% bioclastic material. Encrinites from the Dugway Range contain less crinoidal material than those from Broad Canyon. Texturally, rocks from the Dugway Range can be described as packstones, and the rocks from Broad Canyon can be described as wackestones. Encrinites from Broad Canyon represent slope deposits, and those from the Dugway Range represent carbonate bank deposits.

Rocks collected from Porcupine Dam, Flux siding, and the Crawford Mountains are lime mudstones. At Porcupine Dam and Flux siding the rocks contain chert. The sample from the Crawford Mountains contained very little, if any, bioclastic material. The rocks collected at Flux siding contained about 20% bioclastic material.

The large amounts of lime mud in the rock, the presence of chert, dark color, and thin bedding were interpreted as an indication of a deep marine environment. Even though lime mudstones may occur in environments other than deep basins, the large numbers of conodonts that are typical of deep marine environments indicate that these rocks were deposited in waters 200 m or deeper.

CONCLUSION

Conodont faunas composed primarily of species of *Siphonodella* and *Polygnathus* have been collected from rocks representing basin, slope, and carbonate bank environments. Study of this zone, which spans about 1.3 million years of Early Mississippian history (Sandberg and Gutschick 1979), in areas representing a variety of paleogeographic locations has shown that variation in biofacies can be related to variation in lithofacies. Table 3 shows the percentages of various taxa in each fauna. Figure 7 is a model (adapted from Sandberg and Gutschick 1979) illustrating the relationship of conodont faunas and sampled localities to environment.

Encrinites containing large conodont faunas that are similar in composition were collected at the Dugway Range and Broad Canyon. At the Dugway Range the encrinites are thick bedded, dark gray, and represent deposition in the carbonate bank environment discussed earlier in the section on previous work. At Broad Canyon the encrinites are dark gray, thin bedded, and represent slope deposits. *Polygnathus* makes up a larger percentage of the fauna at these two localities than at the other three localities that represent basin deposits.

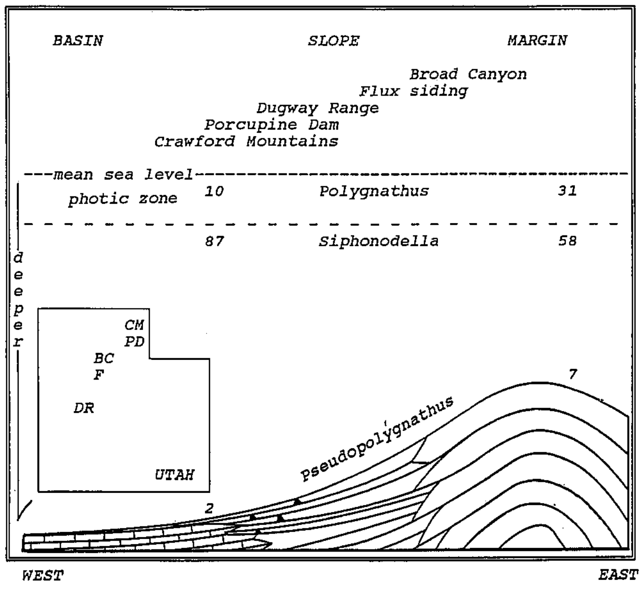

FIGURE 7.—*Model illustrating the relationship of conodont faunas to environment. Adapted from Sandberg and Gutschick (1979).*

Lime mudstones were collected at the Crawford Mountains, Flux siding, and Porcupine Dam. These lime mudstones represent basin environments and contain abundant micrite with little bioclastic material. These rocks are thin bedded and generally darker in color than the rocks collected from the Dugway Range and Broad Canyon. Higher percentages of *Siphonodella* are present in the lime mudstones than in the encrinites described above.

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APPENDIX

LOCALITY REGISTER

Stansbury Island Broad Canyon	BC	SE 1/4, NW 1/4, NW 1/4, section 23, T. 1 N, R. 6 W, Tooele County, Utah. One sample (2.75 kilograms), 3 m above the top of the Cottonwood Canyon Member, Lodgepole Limestone. Sandberg and Gutschick (1979), p. 121.
Dugway Range Buckhorn Canyon	DG	SE 1/4, NW 1/4, NW 1/4, section 1, T. 10 S, R. 21 W, Tooele County, Utah. Composite sample (7.7 kilograms), lower 3 m of the Joana Limestone.
Flux siding	FX	Center, section 31, T. 1 S, R. 6 W, Tooele County, Utah. Composite sample (6.6 kilograms), lower 15 m of the middle part of the Fitchville Formation. Sandberg and Gutschick (1979), p. 119.
Porcupine Dam	PRC	SW 1/4, NW 1/4, NE 1/4, section 17, T. 9 N, R. 2 E, Cache County, Utah. Composite sample (24.2 kilograms) 3-m interval above the base of the Cottonwood Canyon Member. Sandberg and Gutschick (1979), p. 120.
Crawford Mountains	CF	NE 1/4, NE 1/4, NW 1/4, section 32, T. 11 N, R. 8 E, Rich County, Utah. One sample (2.4 kilograms), lower part of the Lodgepole Limestone. The sample was provided by Charles A. Sandberg. Sando, W. J., Dutro, T. J., and Gere, W. C. (1959), p. 2741–69.

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