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DEVONIAN CONODONTS IN ARIZONA

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DEVONIAN STRATIGRAPHIC NOMENCLATURE

Occurrence of Devonian rocks in southern Arizona was reported by Williams (1903, p. 41), who compared fossils found along Pinal Creek north of Globe with the already well known fauna at Rockford, Iowa. The following year the same author examined brachiopods collected from the section at Bisbee by F. L. Ransome and correlated them with the Rockford fauna and fossils from the basal Chemung of New York. He interpreted *Theodossia* [*Spirifer*] *hungerfordi*, which is common at Bisbee, as having close affinities with *Spirifer anossofi*, a Russian species which was then considered to be contemporaneous with the Middle Devonian index *Stringocephalus* in central Europe. Williams therefore believed the beds at Bisbee to be of Middle Devonian age. Ransome (1923) and Stoyanow (1936) reevaluated this assignment in the light of more recent interpretations of the Russian species and decided upon an Upper Devonian age for the Arizona brachiopod fauna.

Ransome (1904, p. 33) used the name Martin Limestone for the Devonian beds of the Bisbee section. During the ensuing years, equivalent strata have been found to be widely distributed in the mountain ranges of south-central Arizona between the Mogollon Rim and the Mexican border. The Martin Formation is principally a carbonate sequence in the southern part of the state and maintains a relatively uniform thickness of the order of 375 feet in the various ranges where it is exposed. Toward central Arizona an increasingly high proportion of clastic material is admixed with the carbonate.

The brachiopod fauna, on which Upper Devonian age assignment was based, is restricted to the upper part of the formation. Stoyanow (1936) reported the occurrence of *Camarotoechia endlichi*, a characteristic fossil of the Percha Formation of New Mexico and the Ouray beds of the Four Corners region, above the strata containing *Theodossia hungerfordi* and *Cyrtospirifer whitneyi* in Peppersauce Canyon on the east side of the Santa Catalina Mountains near Tucson, and along Pinal Creek northwest of Globe. He suggested that these upper rocks be considered a separate formation which he named the Lower Ouray. Occurrence of *Spirifer iowensis* near the middle of the Devonian sequence at Superior, Arizona, has been recorded by Stoyanow. He also described abundant stromatoporoids from approximately the same horizon in the Picacho de Calera hills near Rillito, Arizona. Correlation of this lower portion of the Devonian strata of central Arizona with the Middle Devonian Cedar Valley Formation of Iowa was inferred, and Stoyanow proposed that these beds be set apart from the upper part of the section as the Picacho de Calera Formation. Most subsequent authors have rejected the Lower Ouray and Picacho de Calera of Stoyanow as formations, and instead considered them to be faunal zones within the Martin Formation.

Sabins (1957) described a carbonate and black shale sequence of Upper Devonian age which crops out along the east flank of the Chiricahua Mountains in southeastern Arizona. The black fissile shale member in the lower half of the formation is suggestive of the basal part of the Percha Formation, but, owing to the distance from the type area of the latter, the name Portal Formation was applied to the Arizona unit. Pye (1959) considered the Portal to be

a local facies of the Percha.

Devonian beds in the Swisshelm and Pedregosa Mountains between Bisbee and the Chiricahuas contain a high proportion of clastics. They were described as the Swisshelm Formation by Epis, Gilbert, and Langenheim (1957) who considered them to be equivalent to the Martin to the west, as well as to the combined Oñate, Sly Gap and Contadero of New Mexico. Absence of fossils typical of the Percha from the Arizona exposures was attributed to difference in facies. It was suggested that the Martin-Swisshelm, the Oñate-Sly Gap-Contadero sequence, and the Percha are areally distinct facies of a contemporaneous unit in which the Percha is a central basin deposit, whereas the others represent marginal phases.

Stoyanow (1936) believed that during late Devonian time central Arizona was occupied by a northeast-trending highland area of Precambrian rocks to which he gave the name Mazatzal Land. According to his interpretation the Martin sea advanced northwestward from southern Arizona toward this barrier only as far as the general vicinity of Roosevelt Lake. Devonian deposits near Payson, some 40 miles farther to the north, were considered to be deposits laid down in another sea which transgressed from the northwest toward Mazatzal Land. These strata were correlated with the Devonian sequence near Jerome and given the name Jerome Formation. Stoyanow concluded that the Martin Limestone, which he restricted to the portion of the Devonian succession at Bisbee containing the *T. hungerfordi* fauna, was equivalent to the fossiliferous upper part of his Jerome Formation. From a locality along the Verde River about 12 miles north of Jerome, Stoyanow also described 125 feet of strata containing a molluscan fauna which was not developed in the Devonian in other areas, and applied the name Island Mesa beds to them. It seems probable that only a local faunal zone within the Devonian sequence is represented and that a distinct stratigraphic designation is not warranted.

Huddle and Dobrovolny (1952) and Anderson and Creasey (1958) rejected Stoyanow's use of a separate formation name for the Devonian rocks north of Mazatzal Land. They applied the term Martin Formation for all Devonian strata in central Arizona south of the Mogollon Rim. McNair (1951) equated the Muddy Peak Limestone of the Virgin Mountains in extreme northwestern Arizona with the Devonian of the Jerome area. He considered these rocks to be laterally gradational in a northeasterly direction into the Temple Butte Limestone of the Grand Canyon region.

DEVONIAN CORRELATIONS

Most authors have correlated the Martin Formation with the early Upper Devonian Lime Creek (Hackberry) beds of northern Iowa owing to the common occurrence of brachiopods, particularly *Theodossia hungerfordi* (Hall) and *Cyrtospirifer whitneyi* (Hall), in both units. General equivalence to at least the lower part of the Chemung of New York has been reported (Cooper, et al., 1942). Merriam (1940) correlated the Martin strata containing the brachiopod fauna with the *Cyrtospirifer* zone of the Devils Gate Formation of Nevada. However, owing to the occurrence of *Pachyphyllum* in the Martin, he considered it to be only slightly younger than the lower zone of the Devils Gate.

Correlation of the entire Martin is questionable because the *Theodossia-Cyrtospirifer* fauna is restricted to only a part of the carbonate sequence. In central Arizona, for example, it is found in only the upper fourth of the Martin strata. No fossils are known from the lower half of the unit in this area. However, as stated above, Stoyanow based a correlation of lower Martin with the Cedar Valley Formation on the reported occurrence of Middle Devonian spirifers and stromatoporoids just above the middle of the formation.

Early reports (Ransome, 1916, 1923) considered the Martin fauna to suggest equivalence to the Percha Formation of New Mexico and the Ouray Formation of southwestern Colorado. Stoyanow has demonstrated that characteristic Ouray-Percha species are present above limestones carrying the typical Martin brachiopods along Pinal Creek northwest of Globe, and in Peppersauce Canyon east of Tucson. That the Martin brachiopods are older than those of the Percha is further substantiated by Stainbrook's (1947) report of discovery of a Percha fauna above the brachiopod-bearing beds in the Martin at the type locality near Bisbee.

The Portal Formation, described by Sabins in extreme southeastern Arizona, contains a high percentage of shale, particularly in the lower half of the unit. In this respect it resembles the Percha Shale. However, G. A. Cooper (in Sabins, 1957) interpreted a sparse brachiopod fauna from near the top of the Portal as being slightly older than typical Percha forms. Sabins therefore concluded that these strata are broadly equivalent to the Martin.

DEVONIAN CONODONT LOCALITIES

Carbonate samples from Devonian rocks collected at a number of localities in Arizona have been processed in acetic or formic acid and the residues examined for conodonts. Quantity of conodonts recovered varied widely among the several localities, and at none of them could these fossils be considered to occur in abundance. In this respect, the Arizona Devonian rocks differ markedly from approximately contemporaneous formations in the mid-continent region in which abundant conodont faunas occur. However, sufficient numbers were found at three of the localities studied to provide representative conodont collections. In all cases the color of the specimens is jet black, apparently as a result of alteration. This may have accompanied the sulphide mineralization which has affected the limestones at all of the localities which were examined.

Collecting areas were as follows:

1.—The Devonian section along the west side of Pinal Creek, three miles northwest of Globe, is the one from which Williams reported Devonian brachiopods in Arizona. These strata were measured and described by Stauffer (1928), who also recorded an extensive faunal list. Stauffer placed the Mississippian-Devonian boundary at the base of a yellow, splintery shale. However, Stoyanow found *Camarotoechia endlichii* in the 18 feet of yellow-gray, sugary dolomitic limestone above the shale, and correlated the shale and overlying beds with the Ouray and Percha.

The lower part of the exposure consists of buff-weathering, thick-bedded dolomitic limestones which become increasingly sandy about 100 feet above the base of the section. These beds do not contain megafossils and were not sampled at this locality. Beginning at the base of Stauffer's Unit 11, the fossiliferous portion of the out-

crop, rock specimens were taken at every lithologic change to the base of the yellow shale. Thick units were sampled at intervals to provide representative material. A total of 31 samples were collected, of which 23 contained at least some Devonian conodonts, although only four yielded any significant number.

Material collected at the top of the yellow shale was disaggregated by kerosene treatment and proved to be barren. The overlying yellow dolomitic strata were sampled at two-foot intervals and produced a few fragmented polygnathid conodonts. A thin, slabby layer, about an inch thick, at the contact between the yellow beds and the overlying gray, crinoidal limestone produced an abundance of somewhat crushed specimens of *Siphonodella*. Limestone taken six inches higher in the Mississippian rocks was barren.

2.—A complete section of the Martin Formation is well exposed on the north side of Queen Creek Canyon one-fourth mile east of Superior, Arizona. Material was collected at five-foot intervals from the top of the lowest quartzite near the middle of the formation to the base of the red fissile shale near the top of the unit. These strata comprise the Middle and Upper Members of the Martin Formation as described by Huddle and Dobrovlny. The lower portion of the sampled sequence includes the upper beds which Stoyanow believed to be of Middle Devonian age. Conodonts were found in half of the specimens collected, although none of them produced any abundance. The lower 165 feet of Devonian strata at this locality constitute the Lower Member of the Martin of Huddle and Dobrovlny, and the greater part of Stoyanow's Lower Ouray Formation. These beds consist of gray, buff-weathering, silty dolomitic limestone and are not known to contain fossils. Samples collected randomly through this part of the section proved to be totally barren of conodonts.

3.—Lithologic material collected at Black Gap, three miles southeast of Bisbee, near the type locality of the Martin, was almost all unproductive. No conodonts were found in those strata containing the abundant brachiopod and coral fauna on which correlation of the Martin strata has been based. This region has been intensely mineralized, and all of the megafossils are almost completely silicified. Possibly conodonts were destroyed in the process, if they ever were present in these rocks. A number of limestone blocks collected from exposures of fossiliferous Martin in road cuts in the Bisbee area also were totally devoid of conodonts.

4.—Sabins reported the occurrence of several conodont genera in the lower member of his Portal Formation at Blue Mountain, on the east side of the Chiricahua Mountains. Rock collected at two-foot intervals contained conodonts only in the upper 36 feet of this member. The remainder of the unit, which becomes increasingly shaly toward its base, is barren as are the other three members of the Portal Formation at this locality.

5.—Devonian corals are abundant in reddish, dolomitic limestone at the quarry a half mile north of the Diamond Point Fire Control Tower, 11 miles east of Payson, Arizona. Lithologic material from this quarry did not produce conodonts. Random collections from the Martin exposures on the slope north of Sycamore Creek, a mile west of the East Verde River bridge on the Pine-Payson highway, were also unproductive. Possibly very systematic sampling of the Devonian at the latter locality would provide a conodont fauna.

CONODONTS OF THE MARTIN AND PORTAL FORMATIONS

Occurrences of conodonts seem to be rather sporadic in the Devonian of Arizona. Only three of the collecting sites from which samples were taken produced significant numbers of specimens. Frequency of occurrence varies considerably between successive lithologies within individual outcrops, and even within individual layers. Re-sampling of the more productive horizons determined by the initial collection at the Pinal Creek locality in general failed to produce additional specimens. It therefore appears that conodonts occur only locally within the strata, rather than being uniformly distributed. Possibly local current conditions on the sea floor at the time of deposition resulted in such concentrations.

Faunal lists for the Martin and Portal Formations are shown below. At each of the localities, species of *Polygnathus* exceed all other faunal elements combined in number of specimens.

Martin Formation Along Pinal Creek North of Globe

Ancyrodella aff. *A. buckeyensis* Stauffer
Apatognathus aff. *A. varians* Branson & Mehl
Bryantodus camurus Huddle
B. multidentis Ulrich & Bassler
Ctenopolygnathus brevilamina (Branson & Mehl)
C. iowaensis (Youngquist & Peterson)
Falcodus secundus (Youngquist)
Hindeodella acuta Branson & Mehl
H. cf. H. subtilis Ulrich & Bassler
Icriodus alternatus Branson & Mehl
Ligonodina falciformis Branson & Mehl
Lonchodina projecta Ulrich & Bassler
L. aff. L. discreta Ulrich & Bassler
Neoprioniodus sp.
Ozarkodina cf. *O. regularis* Branson & Mehl
Palmatolepis sp.
Polygnathus linguiformis Hinde
P. normalis Miller & Youngquist
P. procera Sannemann
P. subserrata Branson & Mehl
P. unicornis Muller & Muller
P. sp.
Polygnathus? *angulosa* Stauffer
Prioniodina prona (Huddle)
Roundya aurita Sannemann
R. robusta (Branson & Mehl)
R. tumida (Branson & Mehl)

Martin Formation at Superior

Hindeodella acuta Branson & Mehl
H. subtilis Ulrich & Bassler
Icriodus sp.
Lonchodina sp.
Neoprioniodus alatus (Hinde)
Ozarkodina regularis Branson & Mehl
Palmatolepis subrecta Miller & Youngquist
Polygnathus normalis Miller & Youngquist
P. procera Sannemann
P. aff. P. semicostata Branson & Mehl
Prioniodina prona (Huddle)
Roundya aurita Sannemann
R. laminata (Branson & Mehl)
Spathognathodus sp.

Portal Formation at Blue Mountain

Ancyrodella aff. *A. buckeyensis* Stauffer
Ancyrognathus amana Muller & Muller
Avignathus? sp.

Bryantodus sp.
Hindeodella sp.
Icriodus symmetricus Branson & Mehl
I. aff. I. cornutus Sannemann
Ligonodina delicata Branson & Mehl
L. flexuosa Branson & Mehl
Lonchodina robusta Branson & Mehl
Neoprioniodus sp.
Ozarkodina aff. *O. plana* (Huddle)
O. sp.
Palmatolepis sp.
Palmatolepis flabelliformis Stauffer
Polygnathus aff. *P. normalis* Miller & Youngquist
Prioniodina powellensis (Stauffer)
P. sp.
Scutula? sp.

STRATIGRAPHIC EVALUATION OF THE CONODONTS

The conodonts of the Martin Formation are best developed in the Pinal Creek exposure, both in abundance of specimens and total number of species. Although frequency of occurrence is much less and fewer forms are present, the same fauna is represented at Superior. At both of these localities conodonts were found only in the upper half of the formation, and any inferences concerning age and correlation can be made only for those upper strata. No positive evidence was found for a Middle Devonian age for the lower Martin, as has been suggested by Stoyanow. The fossiliferous beds (Middle Martin of Huddle and Dobrovolsky) at Superior, on which he based this interpretation, yielded only a few conodont specimens, all of which occur higher in the section associated with species of unquestionable Upper Devonian age.

The total collection indicates that at least the upper Martin beds were deposited during early Upper Devonian time, and represent part of the *Manticoceras* Stufe of the standard European Devonian section. Many species are long-ranging forms and have little stratigraphic value. Several forms are sufficiently restricted in their stratigraphic ranges to permit comparison with conodonts collected from other localities.

The conodonts from Blue Mountain are very similar to those from the Superior-Pinal Creek area, although only a few species occur at all localities. In particular, the occurrence of *Palmatolepis subrecta* in upper Martin at Superior, and the closely related *Palmatolepis flabelliformis* in the basal member of the Portal at Blue Mountain, together with the common presence of *Ancyrognathus buckeyensis*, supports the correlation of these strata.

As has been demonstrated by Stoyanow, upper Martin of central Arizona is overlain by a thin unit which is the correlative of the Percha Shale of New Mexico. The few conodonts found in these layers north of Globe are fragmented polygnathids. Although not sufficiently diagnostic to permit precise temporal evaluation, these specimens appear to be typical of long-ranging Devonian species. Lack of abundance of conodonts is a character that seems to be common to the Percha equivalents throughout the southwest. Material examined by the writer from the Chaffee Formation of central Colorado, and from the Ouray Formation of the Four Corners region, both of which contain a Percha brachiopod fauna, yielded no conodonts. Additional collections from the Box Member of the Percha Formation at a locality 17 miles east of Silver City, New Mexico, produced only several polygnathids including *P. linguiformis*, a *Spathognathodus*, a *Prioniodina* and *Hindeodella*.

No conodonts were found above the lower member of the Portal Formation at Blue Mountain. However the lithologies involved, a black fissile shale overlain by a carbonate section, suggest that these units are continuous with the Percha which is typically developed 100 miles to the northeast in New Mexico. Although much thinner, the same sequence of rock types is widespread at the top of the Devonian in central Arizona. Correlation of these strata is indicated in Figure 1. Although the characteristic shale is lacking in the Devonian at Bisbee, Stainbrook (1947, p. 298) reported the occurrence near the top of the section of brachiopods which characterize the Percha. Stainbrook concluded that the Percha brachiopods indicate Mississippian age. However, two specimens of *Palmatolepis rugosus*, an Upper Devonian conodont which is indicative of somewhat younger age than *Palmatolepis subrecta* which characterizes the Martin conodonts, were found a short distance below the base of the Escabrosa Formation at Black Gap near Bisbee. This is approximately the same horizon from which Stainbrook reported the Percha brachiopods. The few conodonts recovered from the Percha and its equivalents near Globe do not suggest Mississippian age for these strata. Furthermore, along Pinal Creek the Percha equivalent is immediately overlain by a thin layer rich in *Siphonodella*, a genus which Mehl (1960) considered to

indicate the base of the Mississippian.

Clark and Becker (1960) have established a conodont zonation which they propose as a standard for the Great Basin. Presence of *Palmatolepis subrecta*, *Ancyrodella* and *Ctenopolygnathus* among the upper Martin-lower Portal conodonts indicates that these strata can be correlated with their Zone A which includes the lower Pilot Shale of western Utah, as well as part of the *Cyrtospirifer* Zone of the Devils Gate Formation in Nevada. *Palmatolepis* constitutes nearly 60 percent of the Devils Gate conodonts, whereas it is only sparingly represented among the forms at hand. No conodonts characteristic of Zone B of Clark and Becker were found in any of the Arizona collections. However, the presence of *Palmatolepis rugosus* near the top of the Devonian at Bisbee, and in the upper Pinyon Peak Limestone of Utah (Clark and Becker, footnote, p. 1667) suggests that the Percha and its correlatives are equivalent to their Zone C.

Since it was first described, the megafauna of the Martin Formation has been compared with the Upper Devonian fossils of the *Cyrtospirifer whitneyi* Zone in the Lime Creek beds at Rockford, Iowa. Conodonts from the Iowa unit have been described by Bjoraker (1955). His report, together with collections made at Rockford by the author, indicates that conodonts are considerably more

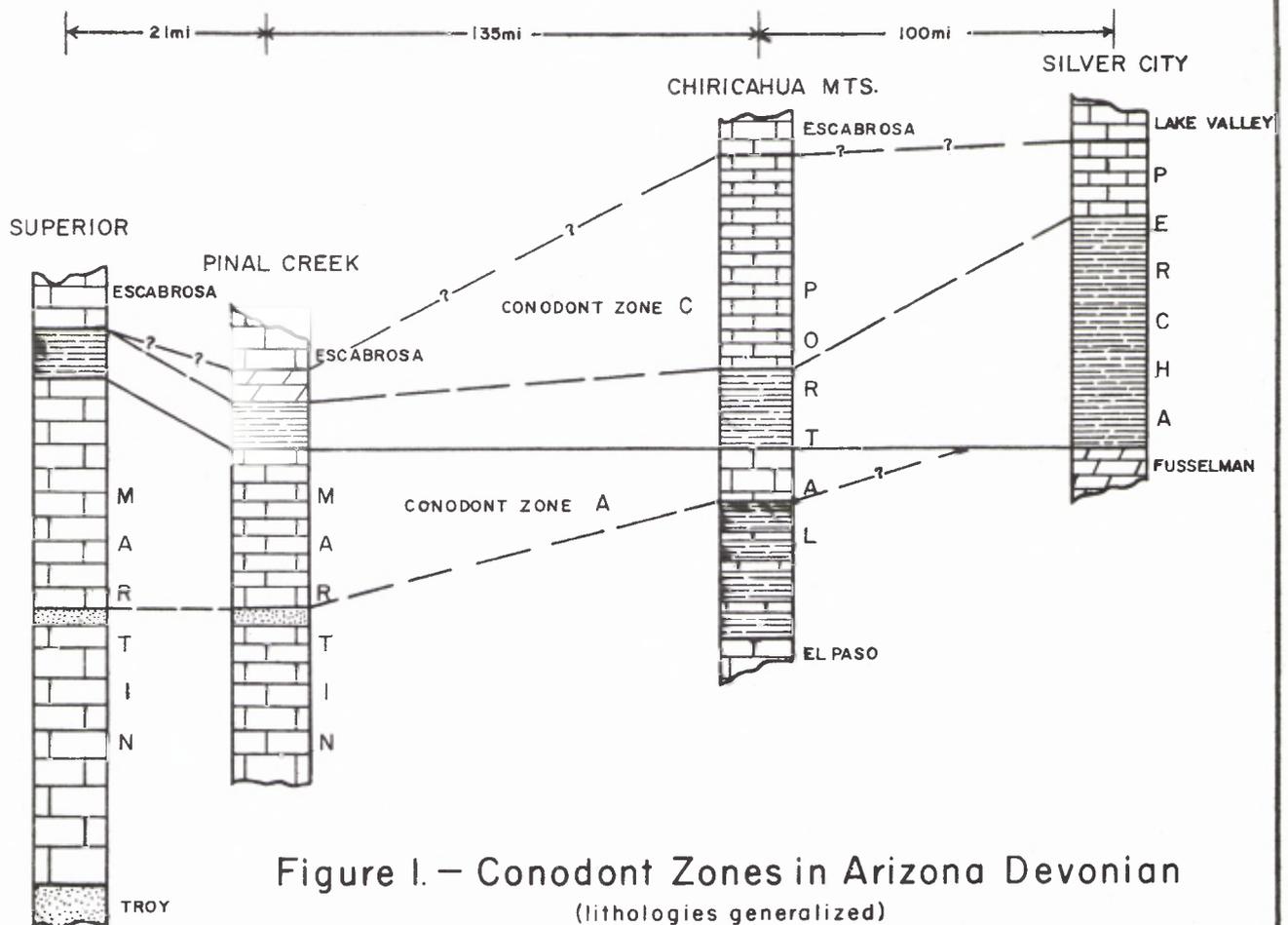


Figure 1. - Conodont Zones in Arizona Devonian (lithologies generalized)

abundant in the shaly Lime Creek beds than they are in the Arizona carbonates. Furthermore, the average size of individuals in the Iowa fauna is larger than that of their Arizona counterparts. Nevertheless the conodonts from the two regions are quite similar and serve to reinforce the long-standing correlation of the brachiopod-bearing part of the Martin and the Lime Creek.

A conodont zonation for the Devonian section of New York was described by Hass (1959). He reported *Palmatolepis subrecta* to be a zonal index for the Chemung. Its occurrence in the Martin at Superior constitutes further evidence for a Chemung age for this portion of the Arizona Devonian.

CONCLUSIONS

Early Upper Devonian conodonts characterized by *Palmatolepis subrecta*, *Ancyrodella*, and an abundance of *Polygnathus* occur in the upper part of the Martin Formation in central Arizona, and near the base of the Portal Formation of the southeastern part of the state. Collectively these conodonts indicate that this is the same fauna which Clark and Becker designated as representing Zone A in the Upper Devonian of eastern Great Basin. The upper Martin-lower Portal strata are overlain by a shale and carbonate sequence which contains few conodonts, but which can be correlated with the Percha Formation of New Mexico on the basis of megafossils and similar lithologies. Occurrence of the basal Mississippian index *Siphonodella* immediately above these beds at Globe confirms their Upper Devonian age. No conodonts are known to occur in the lower half of the Devonian sequence of central Arizona. Whether these rocks should be considered to also be of Upper Devonian age, or assigned to the Middle Devonian as has been suggested, cannot be determined. The long-standing correlations of the Martin megafossils with brachiopods from the Lime Creek beds of Iowa and the Chemung of New York are supported by comparison of the respective conodonts.

REFERENCES

- Anderson, C. A. and Creasey, S. C., 1958, Geology and ore deposits of the Jerome area, Yavapai County, Arizona: U. S. Geol. Survey Prof. Paper 308, 185 p., 13 pls.
- Bjorkaker, R. W., 1955, Upper Devonian conodonts from the Lime Creek Formation of northern Iowa: State Univ. Iowa, Unpub. M. S. Thesis, 67 p., 5 pls.
- Clark, D. L. and Becker, J. H., 1960, Upper Devonian correlations in western Utah and eastern Nevada: Geol. Soc. America Bull., v. 71, p. 1661-1674, 2 pls.
- Cooper, G. A., et al., 1942, Correlation of the Devonian sedimentary formations of North America: Geol. Soc. America Bull., v. 53, p. 1729-1794, 1 pl.
- Epis, R. C., Gilbert, C. M. and Langenheim, R. L., 1957, Upper Devonian Swisshelm Formation of southeastern Arizona: Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2243-2256.
- Hass, W. H., 1959, Conodont faunas of the Devonian of New York and Pennsylvania (Abstract): Geol. Soc. American Bull., v. 70, p. 1615.
- Huddle, J. W. and Dobrovolsky, Ernest, 1952, Devonian and Mississippian rocks of central Arizona: U. S. Geol. Survey Prof. Paper 233, p. 67-112, pls. 11-13.
- McNair, A. H., 1951, Paleozoic stratigraphy of part of northwestern Arizona: Am. Assoc. Petroleum Geologists Bull., v. 35, p. 503-541.
- Mehl, M. G., 1960, The relationships of the base of the Mississippian System in Missouri: Denison Univ. Jour. Sci. Labs., v. 45, p. 57-107.
- Merriam, C. W., 1940, Devonian stratigraphy and paleontology of the Roberts Mountain region, Nevada: Geol. Soc. America Spec. Paper 25, 114 p., 16 pls.
- Pye, W. D., 1959, Silurian and Devonian stratigraphy, southeastern Arizona and southwestern New Mexico: Arizona Geol. Soc. Southern Arizona Guidebook II, p. 25-30.
- Ransome, F. L., 1904, The Geology and ore deposits of the Bisbee Quadrangle, Arizona: U. S. Geol. Survey Prof. Paper 21, 168 p., 29 pls.
-, 1916, Some Paleozoic sections in Arizona and their correlation: U. S. Geol. Survey Prof. Paper 98, p. 133-166, pls. 24-31.
-, 1923, Description of the Ray Quadrangle: U. S. Geol. Survey Geologic Atlas of the U. S., Folio 217, 24 p., 5 pls.
- Sabins, F. F., Jr., 1957, Stratigraphic relations in Chiricahua and Dos Cabezas mountains, Arizona: Am. Assoc. Petroleum Geologists Bull., v. 41, p. 466-510.
- Stainbrook, M. A., 1947, Brachiopoda of the Percha Shale of New Mexico and Arizona: Jour. Paleontology, v. 21, p. 297-328, pls. 44-47.
- Stauffer, C. R., 1928, The Devonian section on Pinal Creek, Arizona: Ohio Jour. Sci., v. 28, p. 253-260.
- Stoyanow, A. A., 1936, Correlation of Arizona Paleozoic formations: Geol. Soc. America Bull., v. 47, p. 459-540, 1 pl.
- Williams, H. S., 1903, Devonian fossils of the Globe Quadrangle, Arizona: in Ransome, F. L., Geology of the Globe Copper District, Arizona: U. S. Geol. Survey Prof. Paper 12, p. 40-42.