SURPRISES FROM THE DEVONIAN FOREKNOBS FORMATION OF EASTERN WEST VIRGINIA

McDowell, Ronald R.[1] (mcdowell@geosrv.wvnet.edu), Avary, Katharine Lee[2], Hitzig, Jaana E.[1], Sidney, Jaen E.[1], and Case, George N.[3] - [1]West Virginia Geological and Economic Survey, 1 Mont Chateau Road, Morgantown, WV 26508, [2]Consulting Petroleum Geologist, 98 Rockley Road, Morgantown, WV 26508, [3]School of Earth and Environmental Science, James Cook University, Townsville, QLD 4811, Australia

ABSTRACT

Unusual microfossils recently recovered from the Upper Devonian Foreknobs Formation (Greenland Gap Group) of eastern West Virginia suggest that the paleoenvironmental model for the unit may need revision or refinement. In 2012, during an investigation of fresh outcrop exposures of Devonian strata along the Corridor H highway construction project in Hardy County, east of Moorefield, WV, rock samples from lowermost Foreknobs containing a large number of spherical fossil voids resembling ooids were recovered. Because the Foreknobs is a siliciclastic unit with no associated carbonate, the discovery of ooids would be of significance. Consequently, a number of thin sections were made and examined. No ooids were present. However, the spherical objects were determined to be calcispheres, identifiable as the fossilized spore bodies of algae. Two types of calcispheres were present in equal number – *Sycidium* sp., attributed to fresh to brackish water green algae and *Radiosphera* sp., attributed to planktonic marine algae. In addition, a single oncoid coated with filaments of the calcified cyanobacteria *Girvanella* sp. was observed. The remainder of the grains composing the rock consisted of echinoderm fragments, small brachiopods, and detrital quartz. Taken as a whole, this combination of sedimentary material suggests paleoenvironments ranging from fluvial to brackish water lagoon to back-reef marine to normal marine shelf. While the assemblage probably represents a storm deposit, it indicates sedimentary "sampling" of Foreknobs depositional environments that are not preserved or not yet exposed in this part of the Appalachians.

Series	Stage	Stratigraphic Units			General Lithology
Upper Devonian	Famennian	Hampshire Formation			Nonmarine, red sandstones, shales, and mudstones with occasional plant fossils.
		Greenland Gap Group	Foreknobs Formation	Red Lick Member	Fossiliferous marine siltstones and sandstones grading into nonmarine siltstones and sandstones.
	Frasnian			Pound Member	Conglomeratic medium to coarse-grained sandstone.
				Blizzard Member	Very fossiliferous, marine siltstones, sandstones, and minor shale. Several thick sand beds in the middle of the unit.
				Briery Gap Member	Conglomeratic fine to coarse-grained sandstone.
				Mallow Member	Fossiliferous marine sandstones and siltstones. Base is marked by first occurrence of medium to coarse sandstone.
			Scherr Formation		Scherr is recognized as siltstone with shale and fine sandstones, all of which weather a light olive grey.
		Brallier Formation			Marine, turbiditic, dark grey to light olive grey shales with interbedded siltstones. Rare invertebrate fossils.

Stratigraphic terminology for the Upper Devonian strata of eastern West Virginia and western Virginia. Lithologic description from Rossbach and Hall, 1998. Terminology for the Greenland Gap Group from Dennison, 1970; 1988; 1996.

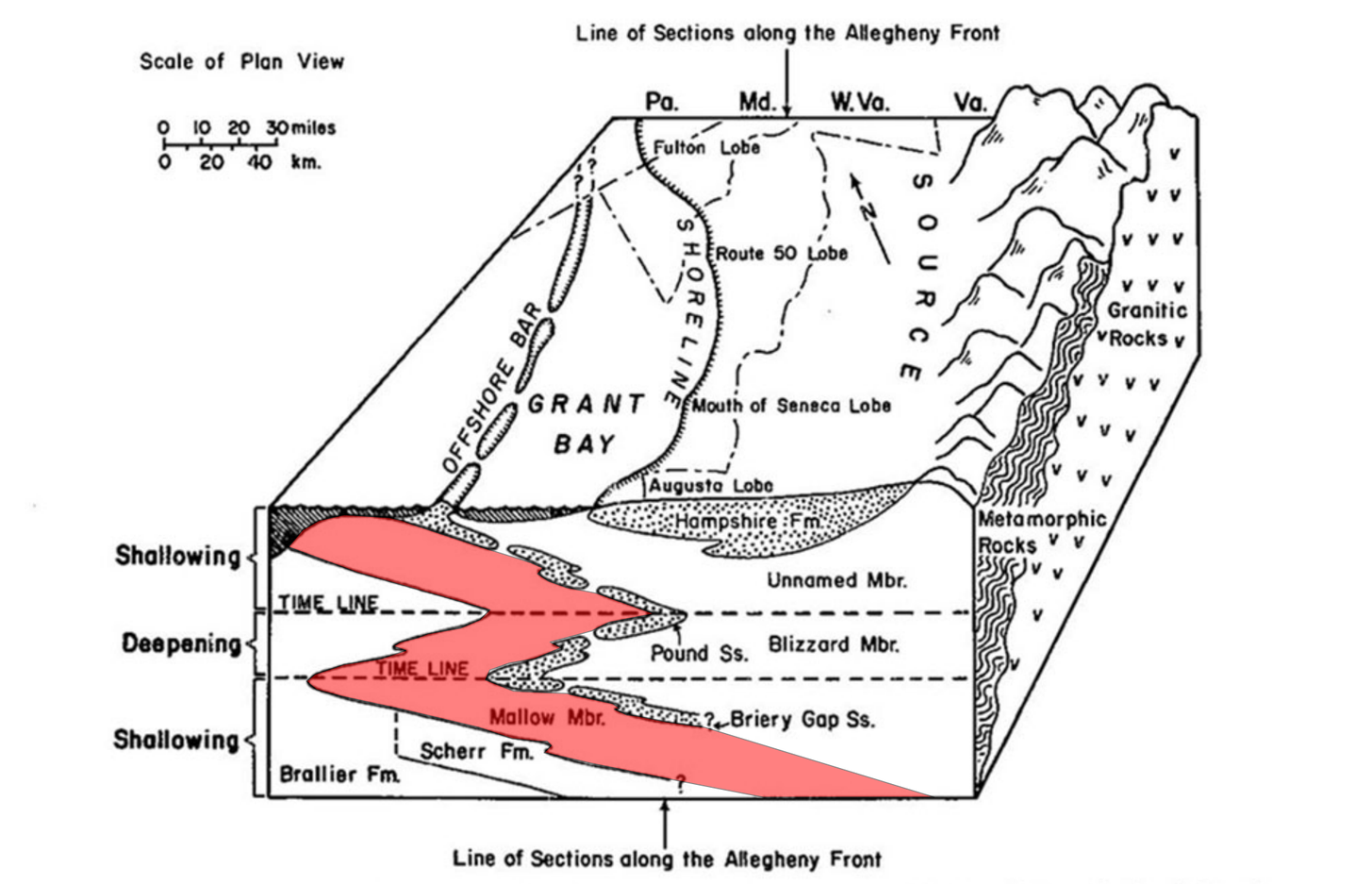


Figure 13. Preferred paleogeographic interpretation and cross-section. Late Cohocton - Early Cassadaga Age. No specific scale. *modified from* Kirchgessner, 1973, p. 58.

Kirchgessner (1973) interpreted the sediments of the Mallow Member as upper slope turbidites and shelf-margin deposits.

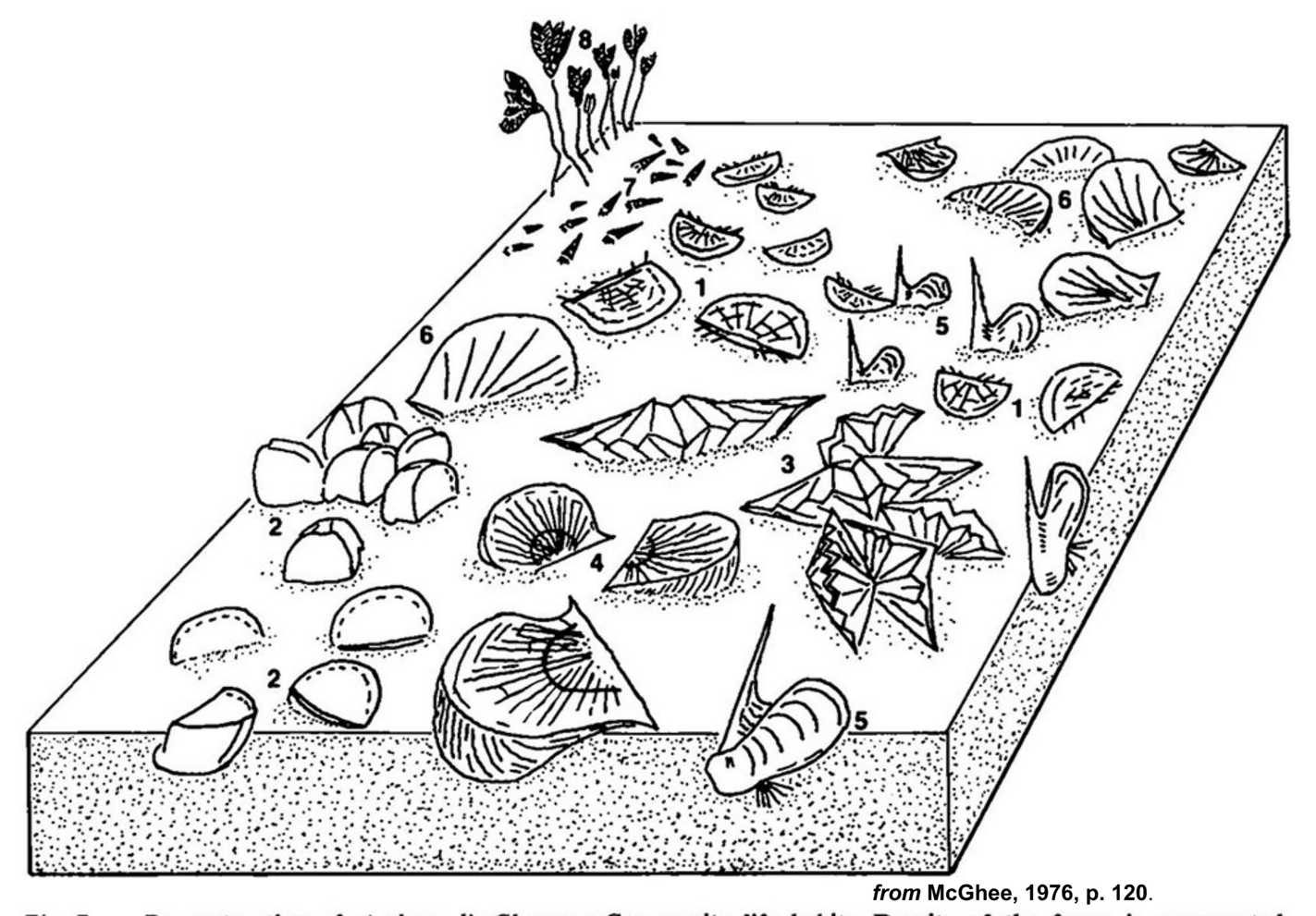


Fig. 7. Reconstruction of *Ambocoelia-Chonetes* Community life habits. Density of the fauna is exaggerated. 1, *Chonetes*; 2, *Ambocoelia*; 3, *Tylothyris*; 4, *Douvillina*; 5, *Leptodesma*; 6, *Nervostrophia*; 7, *Tentaculites*; 8, pelmatozoans.

McGhee (1976) described a brachiopod-pelmatozoan-dominated faunal assemblage for the lower Mallow Member.

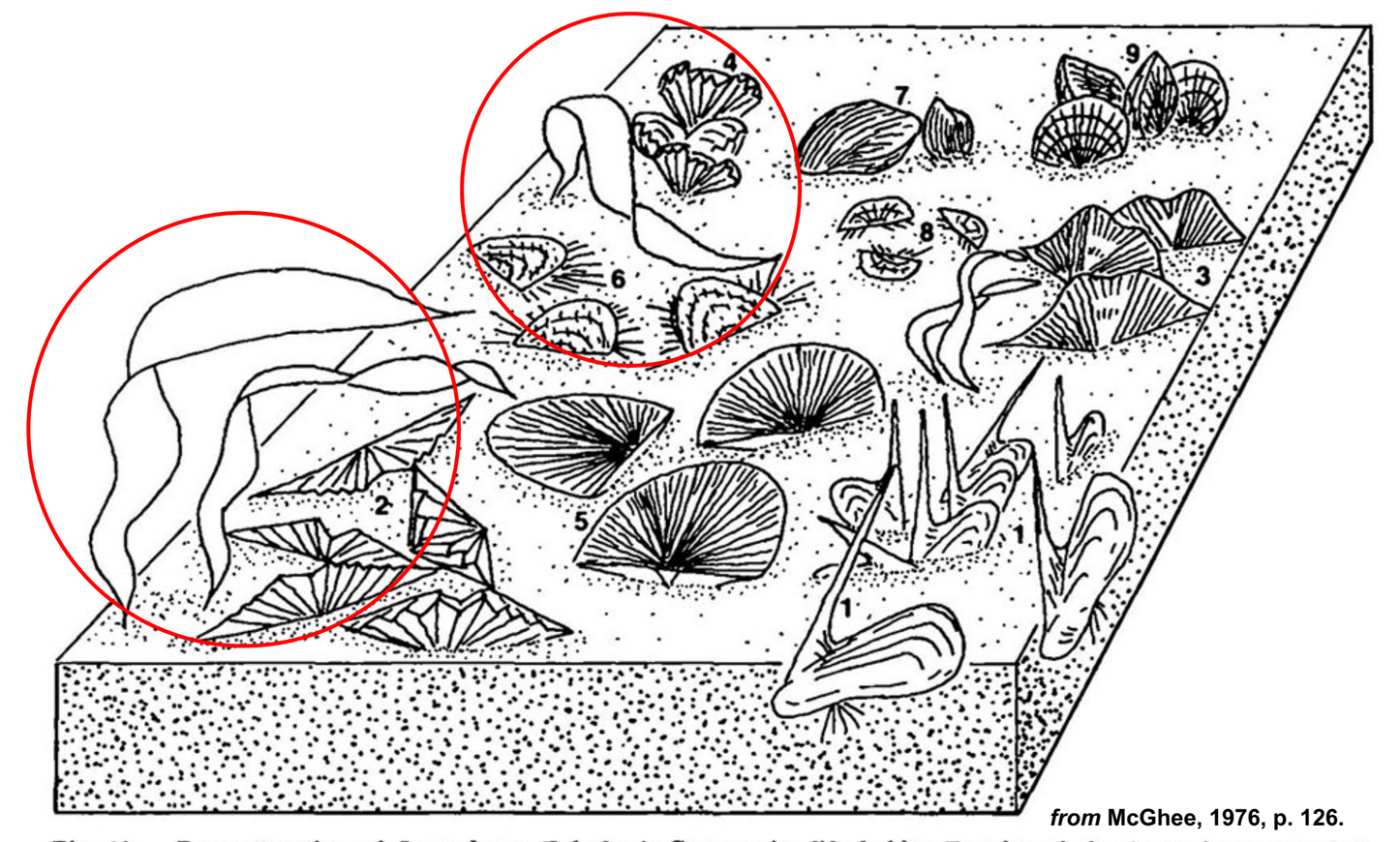


Fig. 10. Reconstruction of *Leptodesma-Tylothyris* Community life habits. Density of the fauna is exaggerated. 1, *Leptodesma*; 2, *Tylothyris*; 3, *Cyrtospirifer*; 4, *Camarotoechia*; 5, *Schuchertella*; 6, *Productella*; 7, *Schizophoria*; 8, *Chonetes*; 9, *Rhipidomella*. The presence of benthic algae is hypothetical.

McGhee (1976) noted a brachiopod-dominated faunal assemblage for the upper Mallow Member. Note the presence of benthic algae (circled).

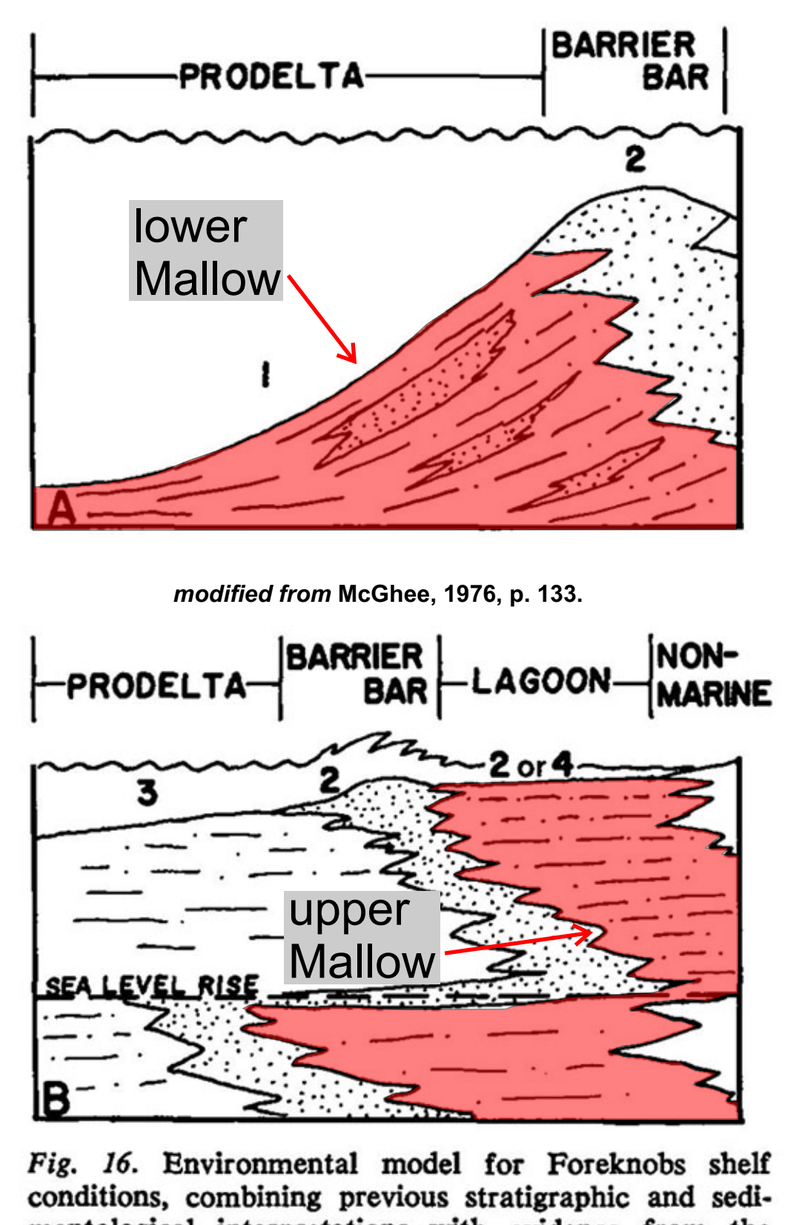
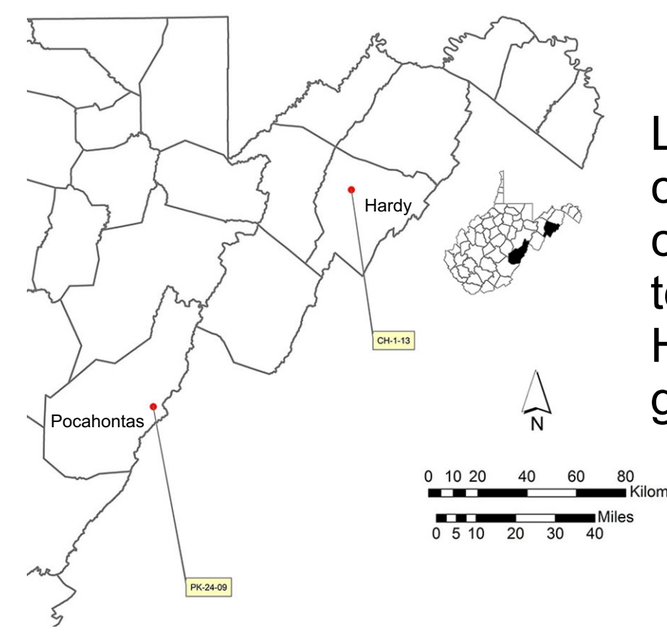
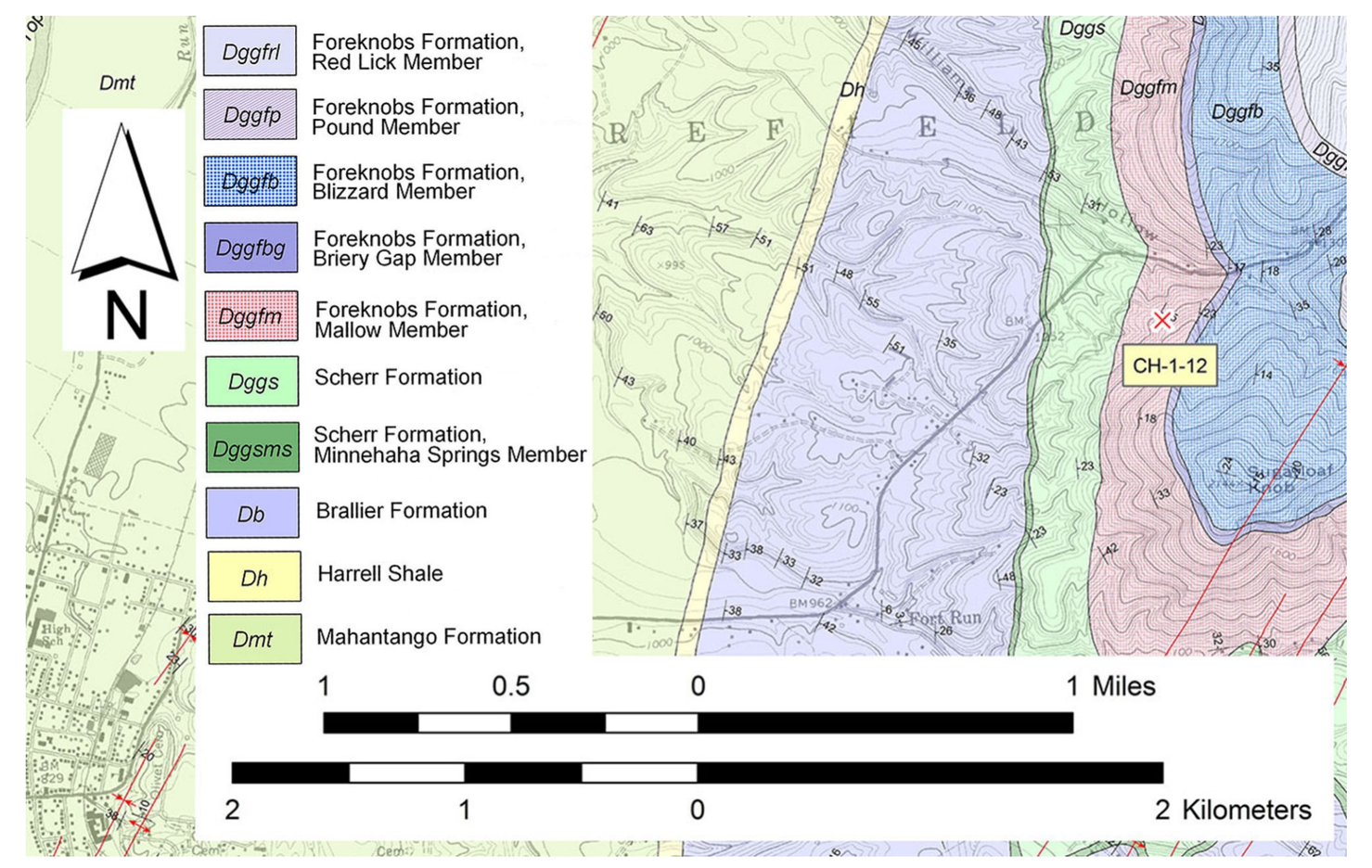


Fig. 16. Environmental model for Foreknobs shelf conditions, combining previous stratigraphic and sedimentological interpretations with evidence from the preserved fauna. Block A precedes block B in time; both sections are normal to the ancient shoreline. 1, *Ambocoelia-Chonetes* Community; 2, *Cyrtospirifer-Camarotoechia* Community; 3, *Atrypa-Cypricardella* Community; 4, *Leptodesma-Tylothyris* Community.

McGhee (1976) interpreted the lower Mallow as pro-delta deposits and the upper Mallow as back-barrier lagoonal in origin.



Lowermost Foreknobs material containing calcisphere has been recovered from two counties (Pocahontas and Hardy - see map to the left). Thus far, only the sample from Hardy County has been studied petrographically.


Dggfrl Foreknobs Formation, Red Lick Member
Dggfp Foreknobs Formation, Pound Member
Dggfb Foreknobs Formation, Blizzard Member
Dggfbg Foreknobs Formation, Briery Gap Member
Dggfm Foreknobs Formation, Mallow Member
Dggs Scherr Formation
Dggsms Scherr Formation, Minnehaha Springs Member
Db Brallier Formation
Dh Harrell Shale
Dmt Mahantango Formation
N
CH-1-12
1 Miles
2 Kilometers

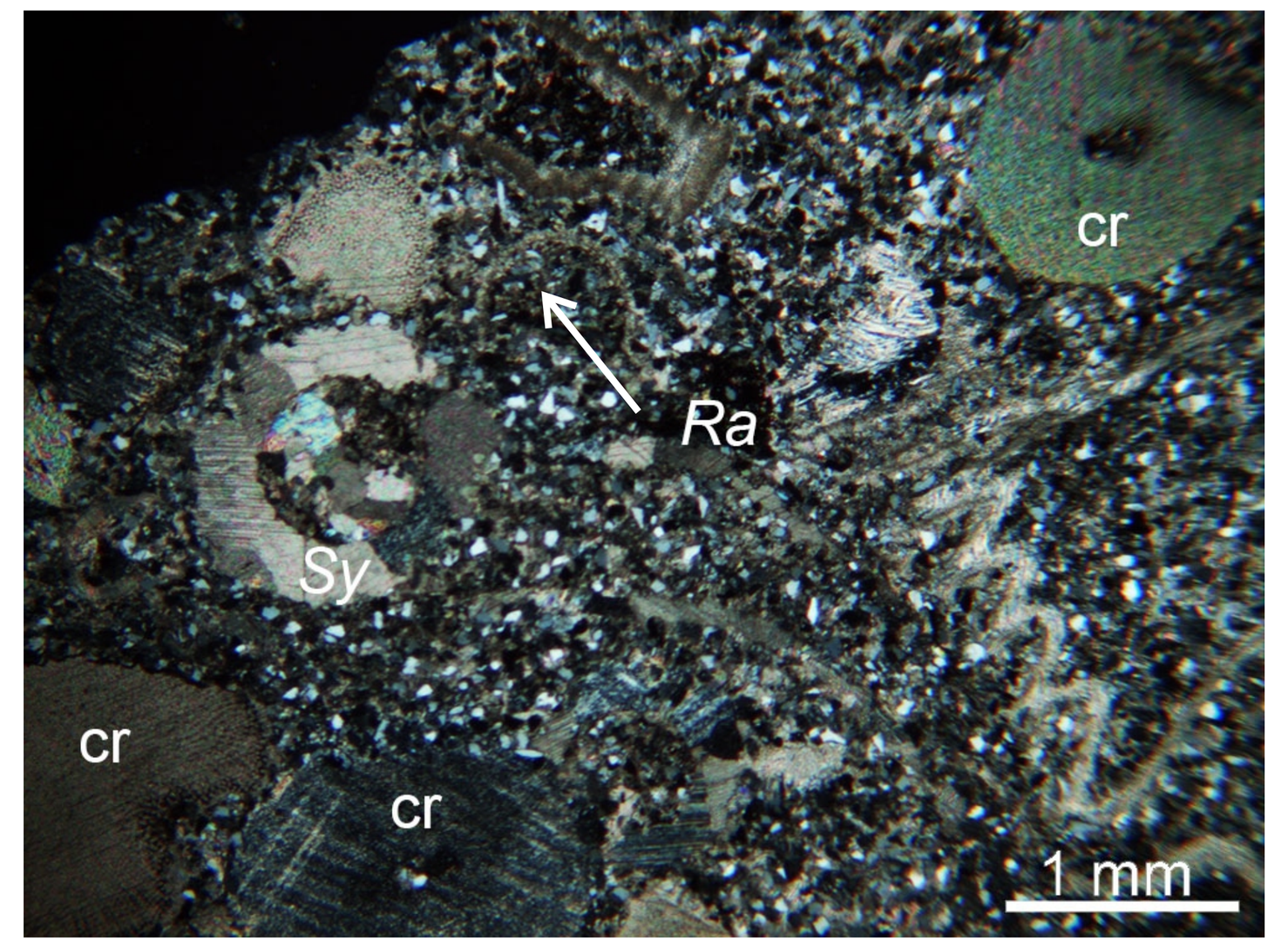
Sample CH-1-12 was recovered from the Corridor H right-of-way, east of Moorefield, WV. Location is shown plotted on a segment of the Moorefield bedrock geologic map (Dean and others, 2004).

The first example (PK-24-09) of Foreknobs material containing calcispheres was collected in Pocahontas County, WV during mapping reconnaissance in 2009. At the time, the unusual texture of the rock was attributed to an unidentified "encrusting fossil" and not examined in detail. Coin is 3 cm in diameter.

Shown above is a large piece of Foreknobs float from the Hardy County locality visited in 2012. A distinct layer marked by numerous spheroidal voids is clearly visible - the authors speculated that these might represent ooids lost by dissolution or plucking. Coin is 3 cm in diameter.

Outcrop photo of the basal Foreknobs Formation showing a thin, lenticular layer containing carbonate debris. This material has been collected and will be used for additional petrographic work. We hope to find more examples of the unusual spheroidal objects. Hammer for scale.

Sample CH-1-12 collected from the Hardy County locality was prepared into a number of thin section slices taken parallel to and at right angles to bedding. Coin is 3 cm in diameter.



Microphotograph of CH-1c-12 showing crinoids columnals (cr), a partially intact calcisphere (arrow) probably *Radiosphera* sp. (*Ra*), and an example of the *Sycidium* sp. (*Sy*) with poorly preserved scalloping on the thick outer wall. A single brachiopod valve is visible near the right of the slide. Crossed polars; transmitted, polarized light. This slide, complete with abundant quartz silt, is representative of sample CH-1-12.

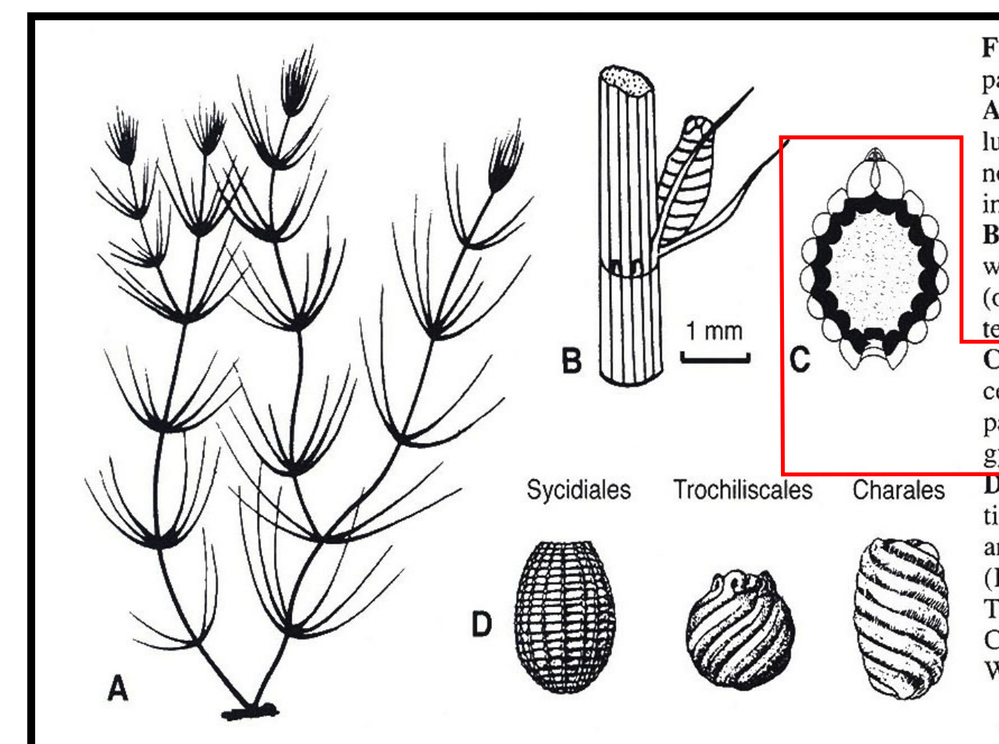
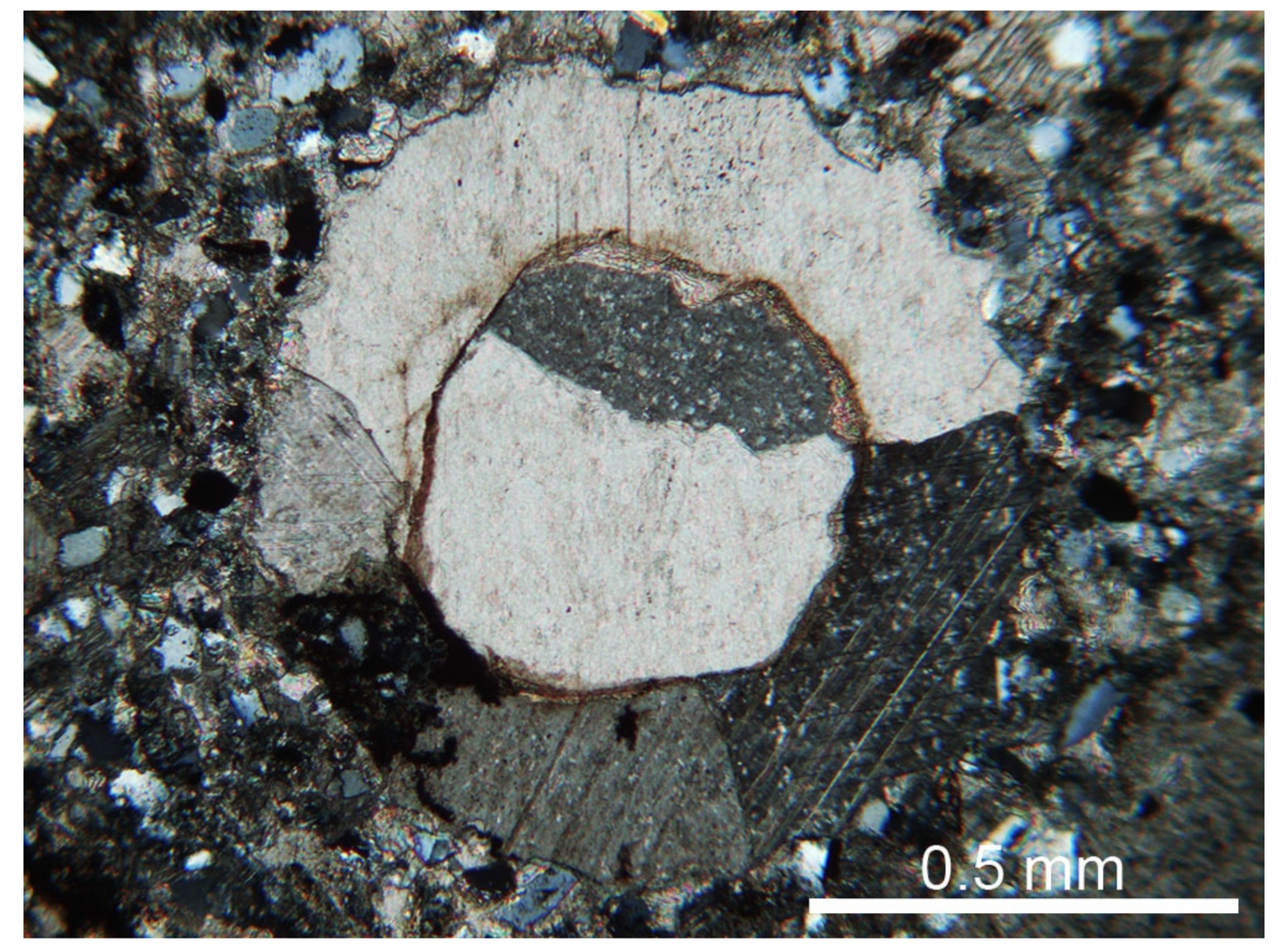
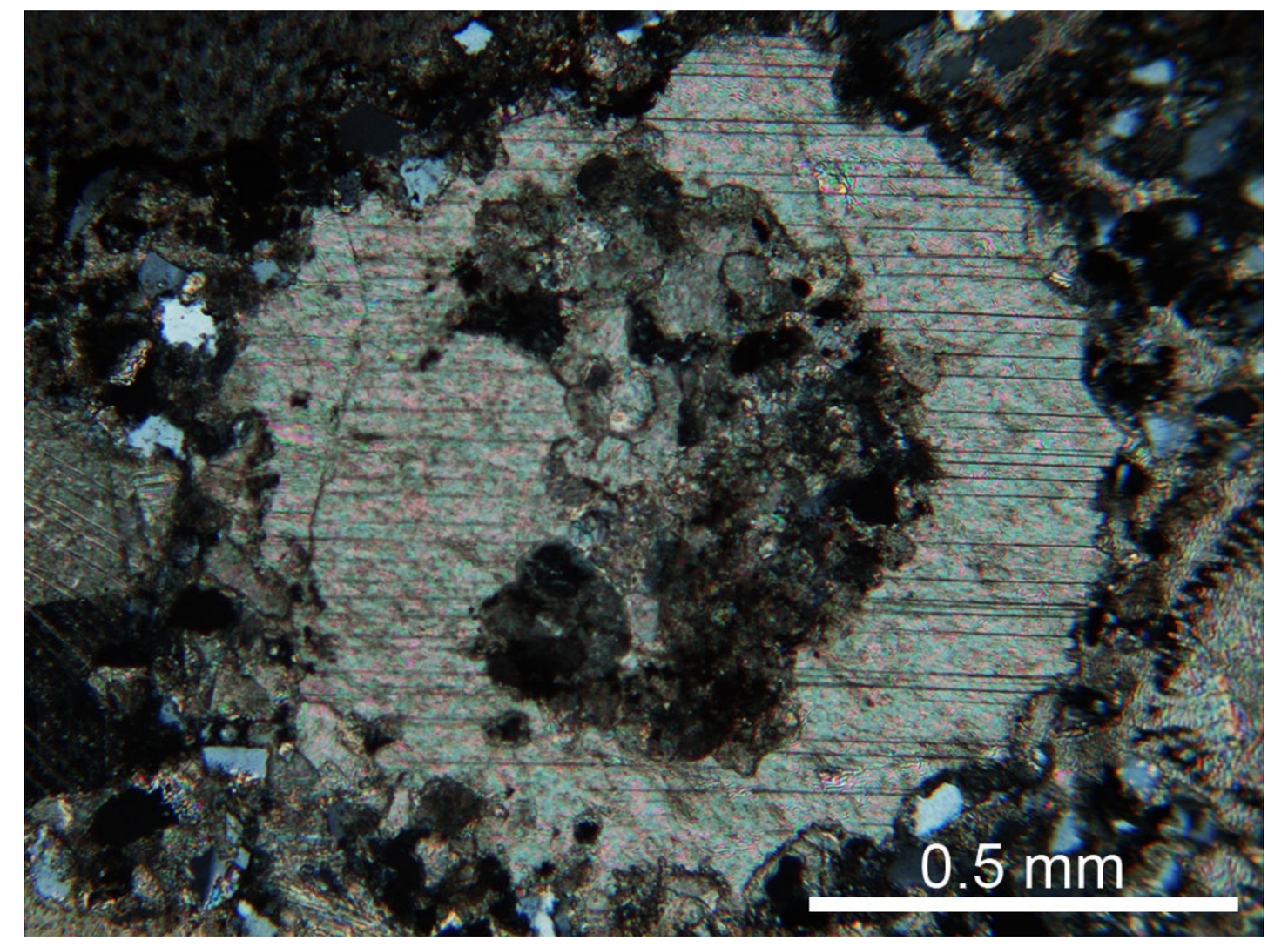


Fig. 10.20. Charophyta and their calcified parts.
A: Charophyte plant. The erect branched thallus is divided into a regular succession of nodes, with whorls of small branches, and internodes.
B: Calcification takes place at the nodes only with the elliptical female reproductive organ (oogonium) and near the stem nodes and internodes.
C: Oogonium consisting of the internal egg cell, surrounded by spiral cells whose inner part is calcified (black). This part, called the gyrogonite, is preserved as a fossil.
D: High-level systematic units are differentiated according to gyrogonite morphology and sculpture. From left to right: Sycidiales (Late Silurian to Early Carboniferous), Trochiliscales (Late Silurian to Permian), Charales (Devonian to Recent). A, B after Wray (1977). C, D after Schudack (1993).

Explanation and examples of calcispheres attributed to calcareous green algae (charophytes). *Sycidium* sp. is similar to "C." Modified from Flügel, 2004, p. 448.

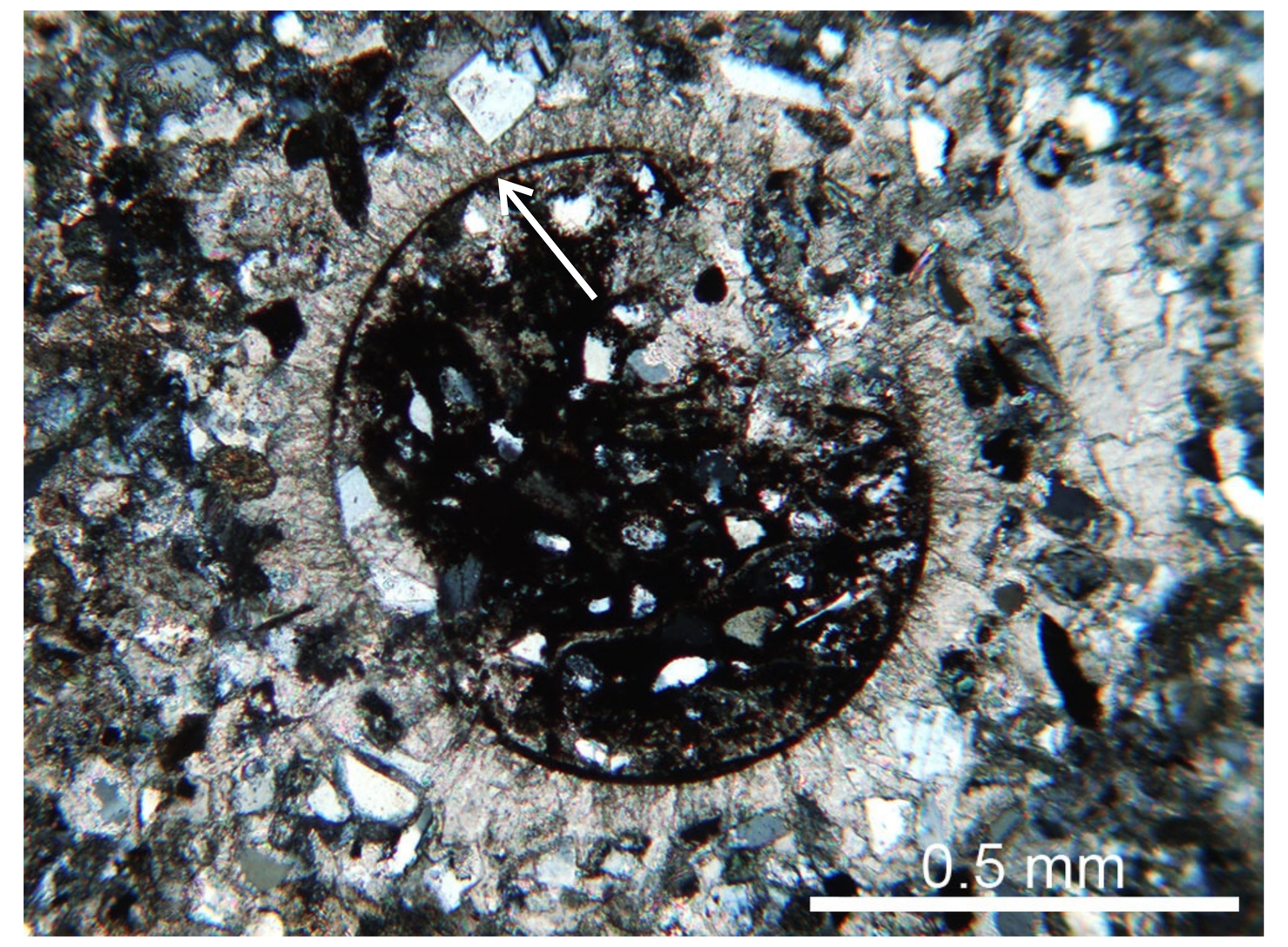


Microphotograph of CH-1d-12 showing an example of *Sycidium* sp. with good preservation of scalloping on the exterior wall. Crossed polars; transmitted, polarized light.

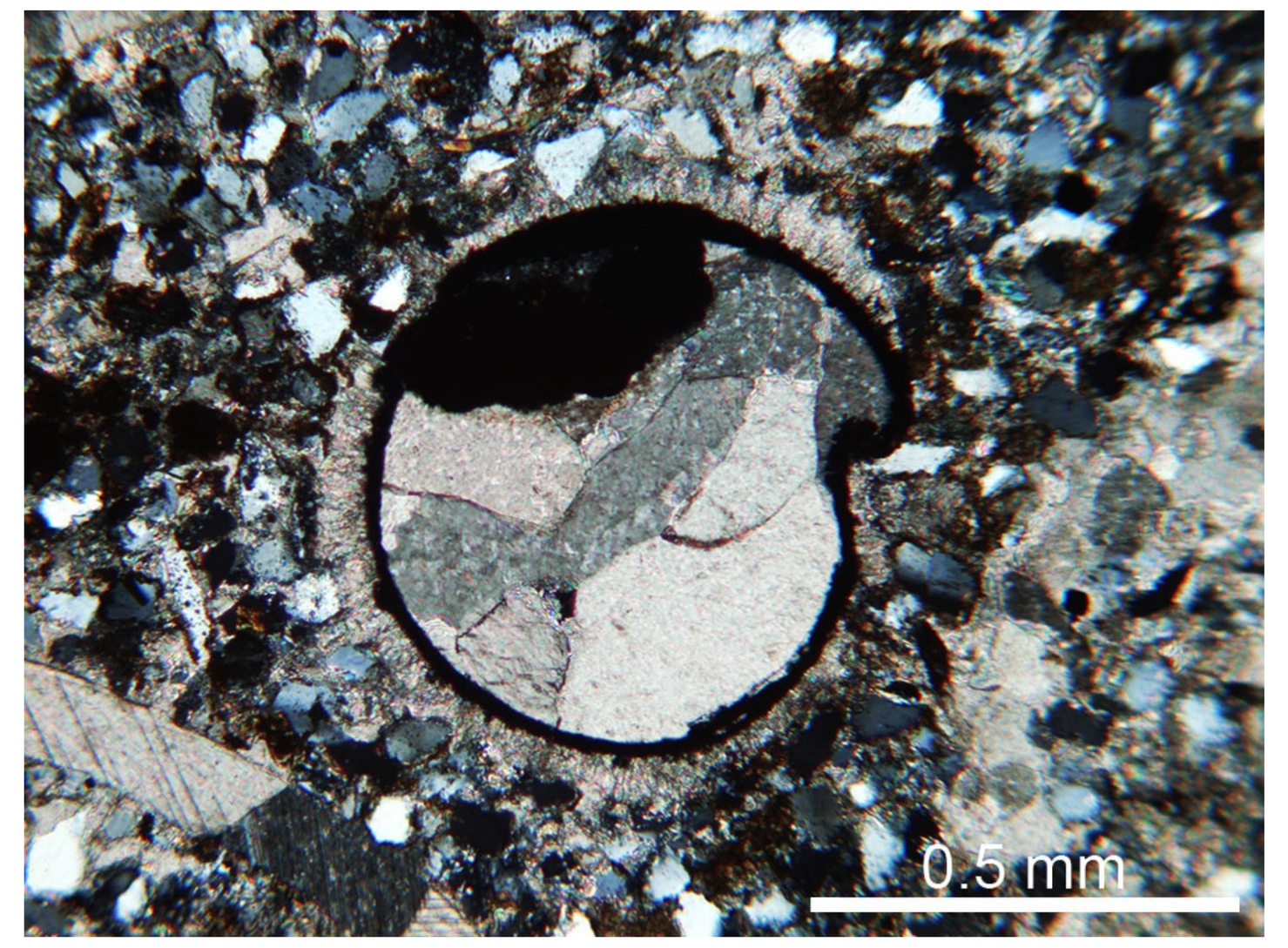


Microphotograph of CH-1c-12 showing an example of *Sycidium* sp. with a nearly intact scalloped outer wall. Notice that the thick wall of the oogonium is composed of a single sparry calcite crystal. Crossed polars; transmitted, polarized light.

Devonian and Carboniferous calcispheres similar to *Radiosphera* sp. have been interpreted as reproductive cysts of dasyclad algae (Marszalek, 1975) or of planktonic green algae (Kazmierczak, 1975).

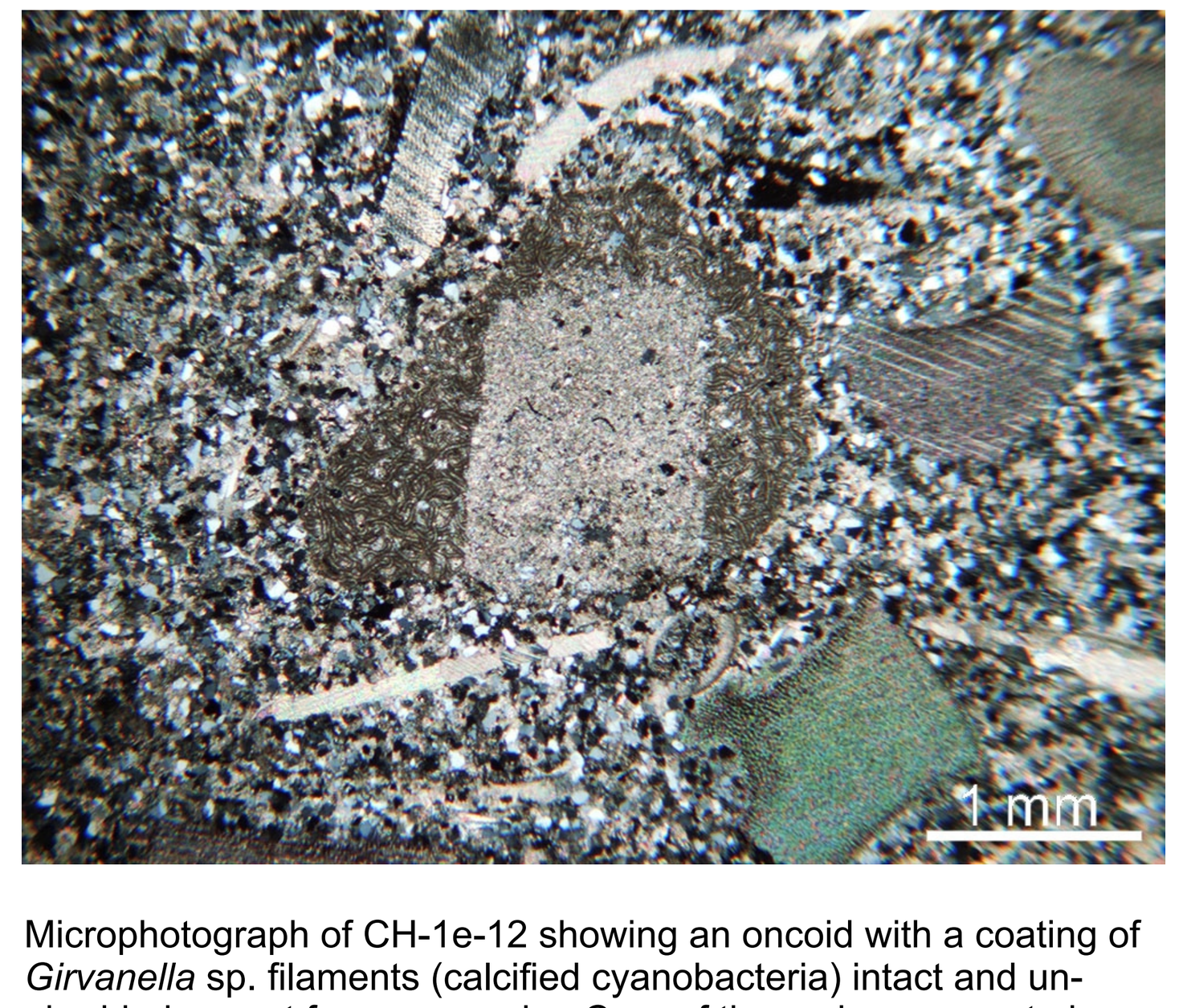


Microphotograph of CH-1a-12 showing a calcisphere identified as *Radiosphera* sp. The radially fibrous, isopachous outer wall and inner wall composed of opaque, framboidal pyrite (arrow) are typical. Crossed polars; transmitted, polarized light

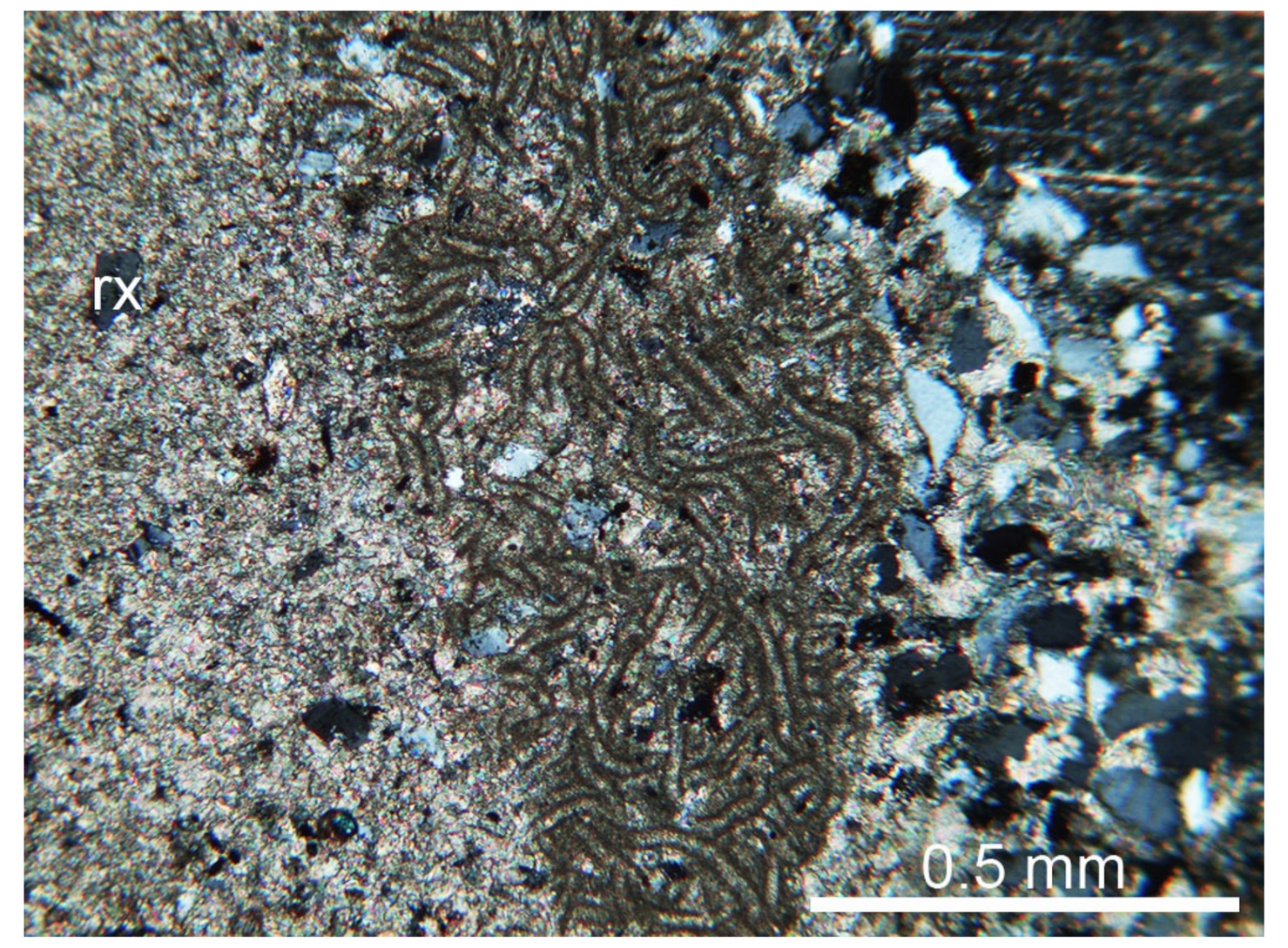


Microphotograph of CH-1b-12 showing a calcisphere similar to CH-1a-12 except that there has been distortion of the shape of the sphere during compaction. In addition, the central cavity is filled with sparry calcite crystals. Crossed polars; transmitted, polarized light.

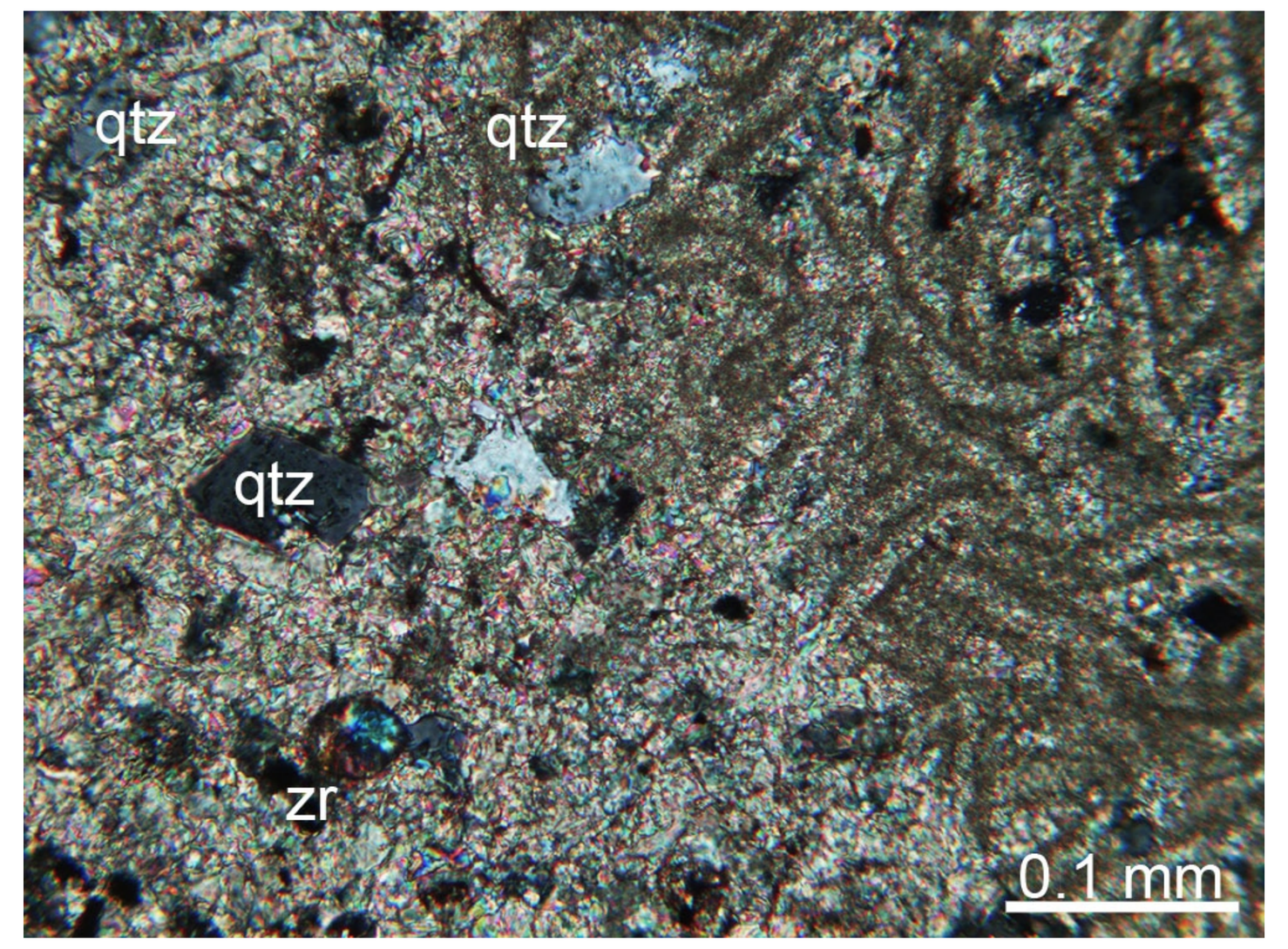
Calcified cyanobacteria like *Girvanella* sp. in Paleozoic deposits are associated with tidal and subtidal deposition in reef and carbonate platform settings (Flügel, 2004, p. 410).



Microphotograph of CH-1e-12 showing an oncoid with a coating of *Girvanella* sp. filaments (calcified cyanobacteria) intact and unabraided except for one margin. Core of the grain appears to be primarily recrystallized micrite with inclusions of siliciclastic and other detritus. Crossed polars; transmitted, polarized light.



Microphotograph of CH-1e-12 – enlargement of the core of the oncoid showing angular quartz silt. The calcite-cemented, siliciclastic matrix of the rock is visible along the right margin. *Girvanella* sp. filaments do not appear abraded from transport of the oncoid prior to deposition. Crossed polars; transmitted, polarized light.



Microphotograph of CH-1e-12 – further enlargement of the core of the oncoid showing angular quartz silt (qtz) and a single detrital zircon (zr) grain. *Girvanella* sp. filaments are not notably micritized along their margins, suggesting relatively rapid burial. Crossed polars; transmitted, polarized light.

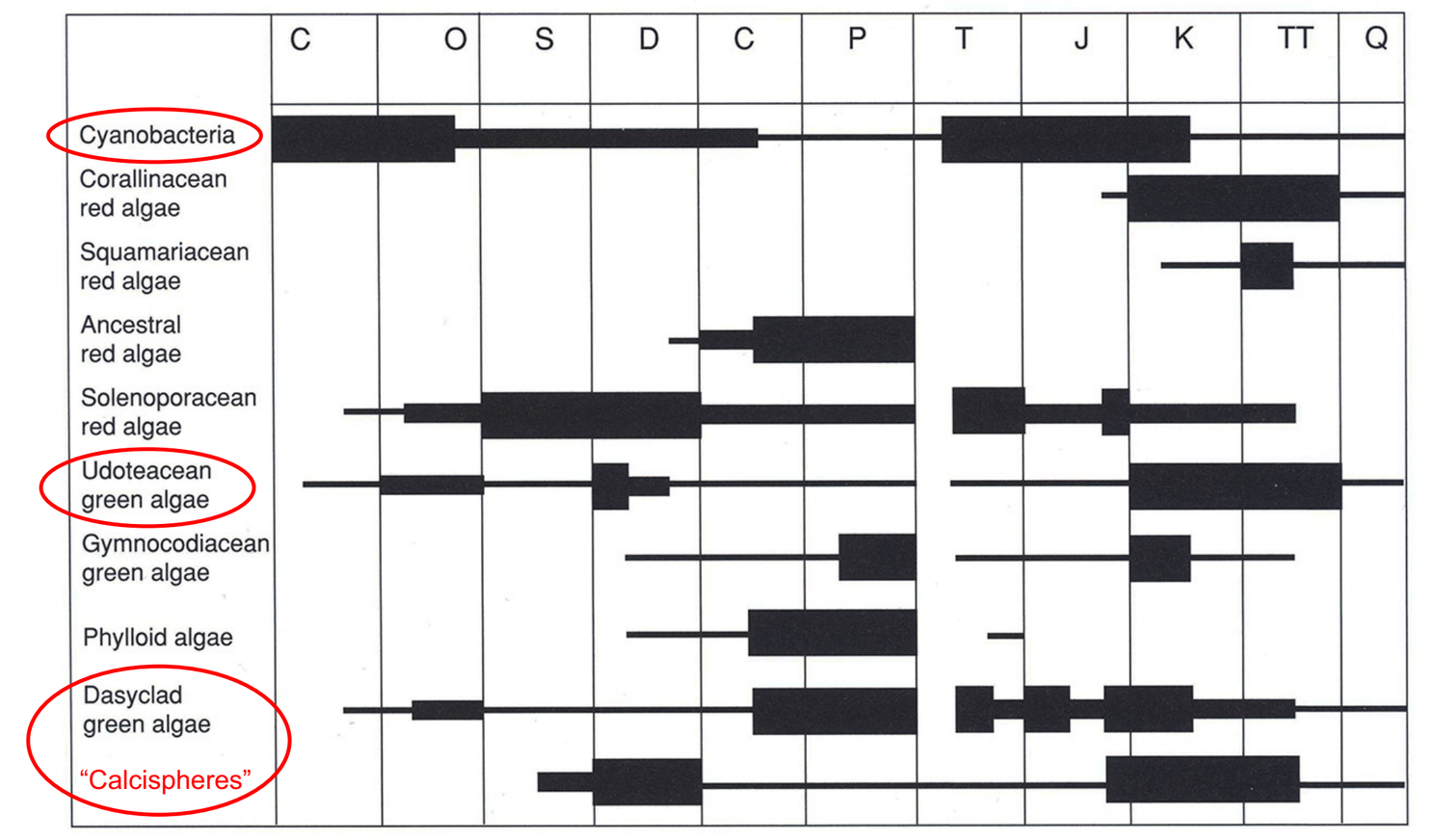


Fig. 10.4. *Distribution of Phanerozoic calcimicrobes and major calcareous algal groups.* Note that the thickness of the bars does not reflect taxonomic diversity, but instead indicates the relative frequency in thin sections.

Distribution of algal components in thin sections of Phanerozoic rocks. Types of material encountered in the lower Foreknobs Formation are circled. Modified from Flügel, 2004, p. 405.

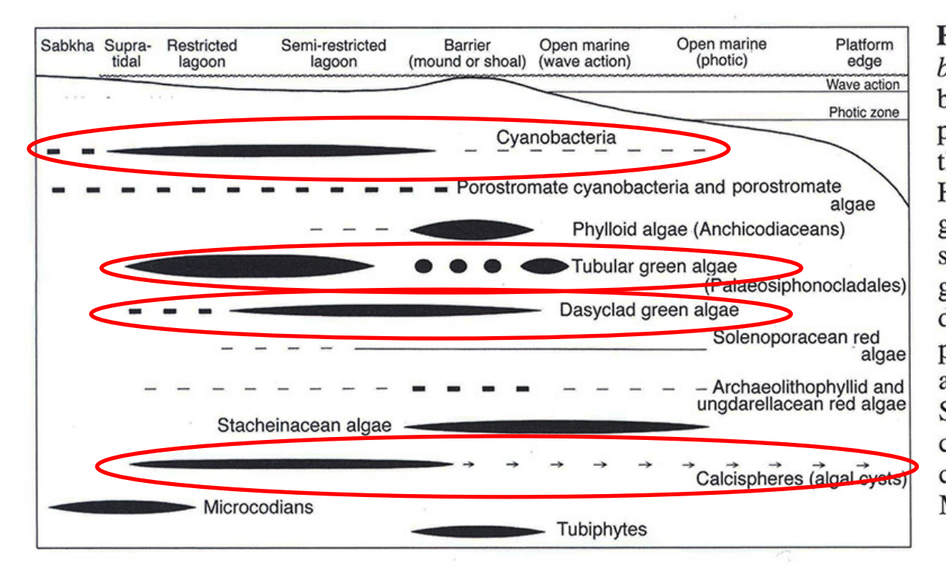
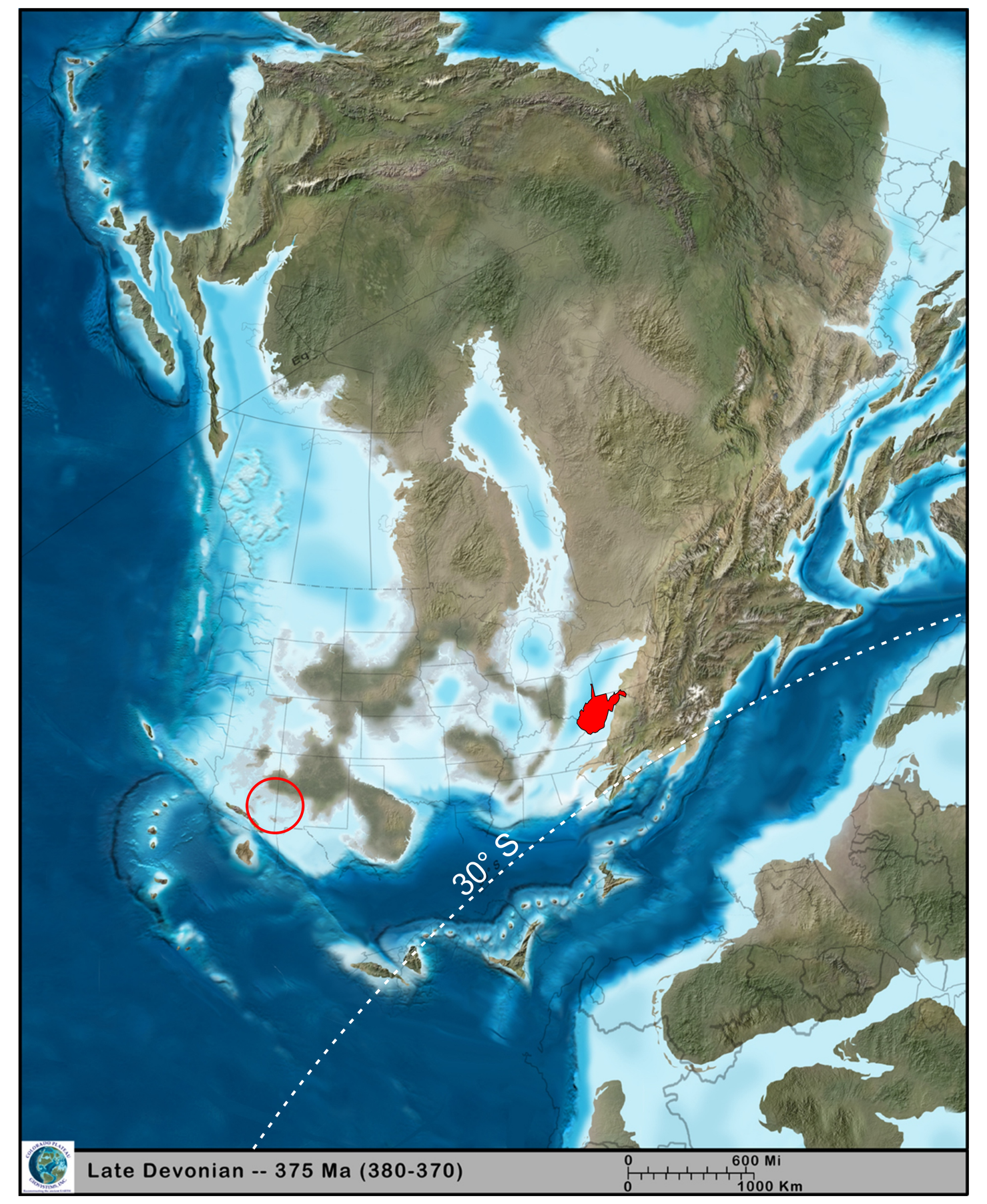

Sabkha
Supra-tidal
Restricted lagoon
Semi-restricted lagoon
Barrier (mound or shoal)
Open marine (wave action)
Open marine (photic)
Platform edge
Wave action
Photic zone
Cyanobacteria
Porostromate cyanobacteria and porostromate algae
Phylloid algae (Anchicodiaceans)
Tubular green algae (Palaeosiphonocladales)
Dasyclad green algae
Solenoporacean red algae
Archaeolithophyllid and ungdarellacean red algae
Stacheinacean algae
Calcispheres (algal cysts)
Microcodians
Tubiphytes

Fig. 10.17. *Distribution of algae and cyanobacteria* on an idealized Carboniferous carbonate platform. Stacheinacean and solenoporacean algae (Pl. 55 and Pl. 56) indicate the deepest habitats in the photic zone. Higher up in open-marine settings red algae occur together with tubular palaeosiphonoclad algae. Shallow shoals and lagoonal environments are indicated by abundant dasyclads. Dasyclads associated with palaeosiphonoclads and cyanobacteria mark a semi-restricted very shallow environment. Similar associations occur in restricted near-coastal environments together with algal cysts (calcispheres, see Sect. 10.2.1.9). Modified from Mamet (1991).

Environmental distribution of algal components encountered in the lower Foreknobs Formation (circled). Although this figure was prepared for Carboniferous strata, the components of interest are believed to have had a similar origin in Upper Devonian deposits. Modified from Flügel, 2004, p. 436. NOTE: these environments are associated with a carbonate platform setting.

The algal materials seen in thin sections of the sample from the lower Foreknobs are clearly allochthonous based on their presence in predominantly siliciclastic rocks. However, their origin appears to have been in a carbonate-producing environmental setting.



Paleogeographic reconstruction by Blakey (2013) places West Virginia at 20-25° south latitude in the Late Devonian. Examination of various COSUNA charts for states along this paleolatitude indicates that the only significant carbonate accumulations of this age are in AZ and NM (circled).

DISCUSSION

The discovery of a suite of unusual calcareous microfossils in siliciclastic strata of the Upper Devonian Foreknobs Formation in eastern West Virginia, raises questions regarding the existing interpretation of depositional and paleoecological settings for the formation. Carbonate strata are not a "typical" component of any portion of the Foreknobs and examination of the unit in eastern West Virginia would suggest that siliciclastic input during deposition of the Foreknobs should have precluded primary carbonate deposition.

During the Late Devonian, the paleogeographical position of West Virginia at 20-25° S was not too dissimilar to that of Arizona and New Mexico where carbonate deposits of that age are present. Upper Devonian carbonates are lacking in eastern North America probably due to the proximity of a major source of siliciclastics in the highlands directly to east.

The calcareous microfossils encountered in the Foreknobs appear to have originated in a carbonate-producing environment. Although ultimately deposited in a siliciclastic setting, the lack of abrasion and transport damage to relatively fragile carbonate materials suggests that the duration or intensity of transport was not great. More importantly, the presence of these fossils raises the questions of where the suspected carbonate environments were situated and why there are not more examples or even indications of their presence preserved in the rock record.

REFERENCES

Blakey, R., 2013, Key Time slices of North American Geologic History, Colorado Plateau Geosystems, Arizona USA., URL: http://cpgeosystems.com

Dean, S. L., Kulander, B. R., McColloch, G. H., McColloch, J. S., Kulander, C. S., and Lessing, P., 2004, Bedrock Geologic Map of the Moorefield 7.5' Quadrangle, West Virginia: West Virginia Geological and Economic Survey Map WV-38, 1 sheet.

Dennison, J. M., 1970, Stratigraphic divisions of Upper Devonian Greenland Gap Group ("Chemung Formation") along Allegheny Front in West Virginia, Maryland, and Highland County, Virginia: Southeastern Geology, v. 12, no. 1, p. 53-82.

Dennison, J. M. (ed.), 1988, Geologic Field Guide, Devonian delta, east-central West Virginia and adjacent Virginia: American Association of Petroleum Geologists, Eastern Section Meeting - 1988, 169 p.

Dennison, J. M. (ed.), 1996, Geologic Guide to Devonian Hydrocarbon Stratigraphy of Southeastern West Virgina and Adjacent Virginia: American Association of Petroleum Geologists Eastern Section Meeting - 1996, 160 p.

Kirchgessner, D. A., 1973, Sedimentology and Petrology of the Upper Devonian Greenland Gap Group along the Allegheny Front, Virginia, West Virginia, and Maryland: unpublished PhD Dissertation, University of North Carolina - Chapel Hill, 93 p.

Flügel, E., 2004, Microfacies of Carbonate Rocks, Springer, Berlin, 976 p.

Kazmierczak, J., 1975, Colonial Volvocales (Chlorophyta) from the Upper Devonian of Poland and their paleogeographical significance: Acta Palaeontologica Polonica, v. 29, p 73-75.

Marszalek, D. S., 1975, Calcisphere ultrastructure and skeletal aragonite from the alga *Acetabularia antillana*: Journal of Sedimentary Petrology, v. 45, p. 266-271.

McGhee, G., 1976, Late Devonian benthic marine communities of the central Appalachian Allegheny Front: Lethaia, v. 9, p. 111-136.

Rossbach, T. J. and Hall, J. C., 1998, The Late Devonian (Frasnian-Famennian) Extinction Event in the Catskill delta of Virginia and West Virginia: Field Trip Guidebook, Southeastern Section, Geological Society of America, 35 p.

ACKNOWLEDGEMENTS

The authors acknowledge the U. S. G. S. STATEMAP Program (contract #'s G09AC00168 and G12AC20163) for financial support while mapping in eastern West Virginia.

WVGES
West Virginia Geological and Economic Survey