ORGANIC-WALLED MICROPHYTOPLANKTON ABUNDANCE AND STRATIGRAPHIC DISTRIBUTION FROM THE MIDDLE DEVONIAN COLUMBUS AND DELAWARE LIMESTONES OF THE HAMILTON QUARRY, MARION COUNTY, OHIO

REED WICANDER, Department of Geology, Central Michigan University, Mt. Pleasant, MI 48859
ROBERT P. WRIGHT, Cities Service Company, Research Laboratory, Tulsa, OK 74102

ABSTRACT. Forty-three species representing 25 genera of organic-walled microphytoplankton were recovered from a 28.04-m thick section of the Middle Devonian Columbus and Delaware Limestones of central Ohio, USA. This assemblage compares closely with other Middle Devonian microphytoplankton assemblages from North America, indicating their potential use as biostratigraphic guides. Their stratigraphic distribution is probably related in part, to the Columbus-Delaware carbonate lithofacies. The organic-walled microfossils are neither abundant nor well-preserved in the porous dolomite near the bottom of the Columbus Limestone. This poor preservation is probably a consequence of dolomitization, while their paucity may reflect an original shallow-water environment of restricted circulation. Such an environment may not have been conducive to plankton growth. The microphytoplankton assemblage increases in numerical abundance and diversity in the overlying non-dolomitized carbonates, particularly the finer-grained limestones.

INTRODUCTION

The carbonates of the Columbus and superjacent Delaware Limestone were deposited during the Early Devonian (Emsian) with deposition continuing into the Middle Devonian (Givetian). Sediment accumulation occurred east of the Wabash Platform, a dominant paleogeographic feature of Illinois, Indiana and Ohio (Droste et al. 1975, Wright 1976, 1978, 1980). This platform, which separated the Illinois Basin from the Michigan and Appalachian Basins, was emergent in Eifelian time. Consequently, carbonate deposition in central Ohio was in proximity to carbonate flats and tidal lagoons to the west in Indiana. Planktonic algae were prolific in these sunlit waters.

Organic-walled microphytoplankton are the presumed cysts of marine planktonic algae. They can be divided into the Chlophyta (green algae) and Acritarcha (unknown affinity). They tend to be abundant, generally well preserved, and geographically widespread in distribution. As their stratigraphic ranges and areal distribution become better known, they are proving to be biostratigraphically useful in correlating Paleozoic rock units. Thus the description of the organic-walled microphytoplankton from previously studied outcrop exposures such as the Columbus and Delaware Limestones (Stauffer 1909, Conkin and Conkin 1975) is important in establishing their stratigraphic occurrence.

METHODS AND MATERIALS

For this study, 18 samples were chosen representing the various carbonate lithofacies and depositional environments of the Columbus and Delaware Limestones (fig. 1). Approximately 50 g of sample were processed using standard palynological techniques, which consisted of treatment in hydrochloric, hydrofluoric, and nitric acids; removal of the undissolved "heavy" minerals by panning; and screening through either a 38 μm or 20 μm screen. From the remaining residue, slides were then prepared. For relative abundance data, 2–5 slides were
examined, and counts were calculated on the basis of 3 slides/sample to maintain uniformity throughout the section. We counted all specimens on each slide. The number of slides varied (2—5) because the same amount of material was used per sample to maintain uniformity between samples. In some cases, only enough residue was left to make 2 slides. As is evident from fig. 2, most species exhibit low abundance throughout the section.

**STRATIGRAPHY**

At the Hamilton Quarry in Marion County, Ohio (figs. 1,2) a section of the Middle Devonian Columbus and Delaware Limestones, 28.04 m thick, was measured and sampled for organic-walled microfossils. The lower 6.10 m of the section is primarily porous recrystallized dolomite stained with hydrocarbons and containing chert lenses. The dolomite contains fossil molds of corals and is totally devoid of chitinozoans (Wright 1976), but it does contain an assemblage of 20 species of poorly preserved organic-walled microphytoplankton. The dolomitized carbonates may have been deposited in a shallow-water environment with restricted circulation just east of the Wabash Platform.

The overlying coral-stromatoporoid zone may represent a period of normal open marine conditions with good water circulation. Immediately above the coral-stromatoporoid horizon, the organic-walled microfossils increase in abundance and diversity and are better preserved. The fossiliferous limestone in this part of the section, up to the chert-bearing limestone at sample 28, represents a depositional site at or near wave base (Chapel 1975) with good water circulation.

The 3.05 m of cherty fine-grained limestone between samples 28-34 are of interest because this interval does not contain many megafossils, has a high concentration of chitinozoans (Wright 1976), and contains 30 species of organic-walled microphytoplankton. The abundance in these samples is somewhat higher than for any other interval. Chapel (1975) considered this interval a regressive phase representing a semi-restricted deposit above wave-base, perhaps even somewhat lagoonal.

The fossiliferous limestone of the uppermost Columbus Limestone, and the 3.66 m of overlying Delaware Limestone, reflects a deepening of the water that continued into Middle Devonian time (Wright 1978). This interval contains only 17 species of organic-walled microphytoplankton from 3 samples.

Generally, then, the occurrence and the abundance of the organic-walled microphytoplankton assemblage throughout the section appear to be a reflection of the lithofacies and depositional environment. The greatest diversity and abundance of microphytoplankton occur in the calcareous mudstone (except for the Delaware Limestone). Chitinozoa are also abundant in this lithofacies (Wright 1976). However, while no chitinozoans were found in the lower dolomite facies, 20 species of organic-walled microphytoplankton were recovered. The state of preservation of the
assemblage can generally be regarded as a reflection of microphytoplankton entombment in a carbonate matrix and the subsequent alteration due to diageneric alteration of those carbonates.

**DISCUSSION**

Forty-three species of organic-walled microphytoplankton were recovered from the Columbus and Delaware Limestones. All except 2 species have been previously reported in the literature. These 2 species (Cymatosphaera sp. and Induoglobus sp.) are probably new, but only a few specimens of each were found. We felt there was an insufficient number of specimens to justify establishing new species. The range of the genus Induoglobus is now extended into the Middle Devonian, having been found previously only in the Lower Devonian Gedin-
nian of Oklahoma (Induoglobus latipenniscus Loeblich and Wicander 1976).

The organic-walled microphytoplankton assemblage shows a high degree of similarity to the younger Middle Devonian Givetian-aged Silica Formation of Ohio (Wicander and Wood 1981). Thirty of the 43 species from the Columbus and Delaware Limestones are also found in the Silica Formation. This assemblage is also similar to that of the Middle Devonian Onondaga Limestone of Ontario, Canada (Deunff 1954a, 1955, 1957, 1961, 1966a, 1971), and contains recurring species with the Middle Devonian Hamilton Formation of Ontario, Canada (Legault 1973) such as Arkonites bilixus Legault 1973, and Estiastra rhytidoa Wicander and Wood 1981, among others.

The Columbus-Delaware organic-walled microphytoplankton assemblage also has some species in common with the Late Siegenian to Givetian-aged Jaab Lake No. 1 Well in the Moose River Basin, northern Ontario, described by Playford (1977). Of particular interest is the occurrence of Goniolopadion prolixum Playford 1977. This species has been reported by Playford (1977) only from the Williams Island Formation (Givetian) in the Jaab Lake No. 1 Well, northern Ontario. In that formation, it is recovered from a limestone unit (as it is here) and not from a calcareous shale interval within either the Williams Island Formation or the Silica Formation. Perhaps this species is lithofacies restricted. Obviously more work needs to be done in this regard, but species/lithofacies relationships is an area of promising research as more is learned about the temporal and spatial distribution of organic-walled microphytoplankton.

As noted by Wicander and Wood (1981) only a few North American Middle Devonian organic-walled microphytoplankton assemblages have been described, and of these, most only list a few species. Hence, the comparisons to other Middle Devonian formations that Wright (1976) was able to make for the chitinozoans, is not yet possible with any real precision for the organic-walled microphytoplankton.

It is precisely because so few Middle Devonian organic-walled microphytoplankton assemblages have been reported that we are describing this assemblage from the Columbus and Delaware Limestones. We hope that greater biostratigraphic refinement will ensue from such studies.

**SYSTEMATIC PALEONTOLOGY**

We list here only the valid name and North American geologic range (Early, Middle, Late) for the species recovered from the Columbus and Delaware Limestones at the Hamilton Quarry, Marion County, Ohio. For a complete synonymy with world-wide geologic range and geographic distribution, the reader is referred to Wicander and Wood (1981) and Wicander (in press).

All figured specimens are deposited in the Museum of Paleontology, Department of Geology, Central Michigan University, Mount Pleasant, MI 48859. Numbers given as CMUMP#5160, #43 > 20 μm 1,116.7; 16.1 refer to Central Michigan University Museum of Paleontology depository number (CMUMP#5160), sample number (#43), size fraction and slide number of that size fraction (>20 μm), and microscope coordinates (116.7; 16.1) on Central Michigan University Department of Geology Olympus Microscope #64387.

**DIVISION CHLOROPHYTA CLASS PRASINOPHYCEAE**

Order Halosphaerales Family Pterospermataceae

Genus Cymatiosphaera O. Wetzel ex Deflandre 1954


Cymatiosphaera sp. fig. 3, (3) DESCRIPTION: Vesicle circular in outline, 20 μm in diameter; vesicle surface divided into 12, laevigate, polygonal fields, 6 per hemisphere, 12–14 μm in diameter; fields separated by membranous, laevigate, round-topped ridges; 6 μm high; overall diameter 34–36 μm; no method of excystment observed. REMARKS: Only a few specimens of this distinctive species were recovered and it was decided not to name species on such a limited number of specimens.

Genus Dictyotidium Eisenack emend. Staplin 1961


Genus Duvernavysphaera Staplin 1961

FIGURE 3
FIGURE 4
FIGURE 5
FIGURE 6
FIGURE 3. (1) Cymatiosphaera canadensis Deunff 1961. CMUMP #5160, #16 > 38 μm 3, 146.0; 14.0. 500X. (2) Cymatiosphaera cornifera Deunff 1955. CMUMP #5161, #16 > 38 μm 3, 123.3; 3.7 500X. (3) Cymatiosphaera sp., CMUMP #5162, #41 < 38 μm 1, 132.3; 21.5. 500X. (4) Diatrysidium obora Wicander and Wood 1981. CMUMP #5163, #41 > 38 μm 2, 129.6; 7.7. 500X. (5) Diatrysidium cf. variatum Playford 1977. CMUMP #5164, #22 < 38 μm 2, 123.5; 11.5. 500X. (6) Devonaysphaera angularis Deunff 1964. CMUMP #5165, #31 > 38 μm 2, 122.7; 18.5. 500X. (7) Devonaysphaera tentacularata Staplin 1961. CMUMP #5166, #31 < 38 μm 2, 126.6; 23.0. 500X. (8) Muraticavea munificus Wicander and Wood 1981. CMUMP #5167, #17 > 38 μm 1, 131.8; 17.5. 500X. (9) Polyedryxium cf. ambitum Wicander and Wood 1981. CMUMP #5168, #25 > 20 μm 3, 128.5; 16.7. 500X. (10) Polyedryxium bathyster Deunff 1961. CMUMP #5169, #31 > 38 μm 3, 146.4; 13.3. 500X. (11) Polyedryxium cf. diabolicum Deunff 1961. CMUMP #5170, #16 > 38 μm 3, 132.5; 19.6. 500X. (12) Polyedryxium embudum? Cramer 1964. CMUMP #5171, #31 > 38 μm 3, 146.0; 21.3. 500X.

FIGURE 4. (1, Polyedryxium fragosulum Playford 1977. CMUMP #5172, #41 < 38 μm 2, 150.9; 5.4. 500X. (2) Pterospermella cf. hermosita (Cramer) Eisenack and Cramer 1973. CMUMP #5173, #17 > 30 μm 2, 126.0; 13.8. 500X. (3) Polyedryxium pharaonis Deunff 1961. CMUMP #5174, #31 > 38 μm 3, 150.4; 15.5. 500X. (4) Pterospermella reticulata Loeblich and Wicander 1976. CMUMP #5175, #31 > 38 μm 3, 150.4; 15.5. 500X. (5) Pterospermella sp., CMUMP #5176, #16 > 38 μm 1, 121.8; 17.6. 500X. (6) Arkonites bilixus Legault 1973. CMUMP #5177, #43 > 20 μm 1, 116.7; 16.1. 500X. (7) Baltisphaeridium disentarium Playford 1977. CMUMP #5178, #16 > 38 μm 1, 142.8; 13.7. 500X. (8) Diexallophasis simplex Wicander and Wood 1981. CMUMP #5179, #30 > 20 μm 1, 112.7; 14.4. 500X. (9) Dasyispula sp., CMUMP #5180, #24 > 30 μm 1, 123.4; 8.9. 500X. (10) Estiastra rhytidos Wicander and Wood 1981. CMUMP #5181, #43 > 20 μm 3, 137.4; 13.4. 500X. (11) Exochothermera arcia Wicander and Wood 1981. CMUMP #5182, #31 > 38 μm 3, 120.9; 6.6. 500X.

FIGURE 5. (1) Goniosphaeridium proflexum Playford 1977. CMUMP #5183, #41 > 38 μm 3, 139.5; 18.6. 700X. (2) Gorgoniosphaeridium inflatum Wicander and Wood 1981. CMUMP #5184, #16 < 39 μm 1, 143.9; 20.0. 500X. (3) Haplospatella cebra Wicander and Wood 1981. CMUMP #5185, #13 > 38 μm 2, 136.0; 10.7. 500X. (4) Haplospatella cernata (Deunff) Playford 1977. CMUMP #5186, #13 > 38 μm 1, 143.2; 14.6. 500X. (5) Indoglobus sp., CMUMP #5187, #16 > 38 μm 3, 128.8; 11.4. 500X. (6) "Micbystridiurn pactispinum" Deunff 1961. CMUMP #5188, #24 > 38 μm 3, 130.6; 14.5. 500X. (7) Micbystridiurn sp. A., CMUMP #5189, #17 > 38 μm 3, 149.4; 17.3. 500X. (8) Micbystridiurn sp. B., CMUMP #5190, #31 < 38 μm 2, 150.3; 8.2. 500X. (9) Multispicastra ramosculum (Deflandre) Lister 1970. CMUMP #5191, #31 > 38 μm 2, 121.2; 15.7. 500X. (10) Ozostrachion furcillatus (Deunff) Playford 1977 CMUMP #5192, #17 > 38 μm 2, 150.0; 13.0. 500X. (11) Ozostrachion dactylos Loeblich and Drugg 1968. CMUMP #5193, #13 < 38 μm 1, 142.4; 5.9. 500X. (12) Verybachium lairdi (Deflandre) ex Deunff 1959. CMUMP #5194, #13 < 38 μm 1, 145.2; 21.0. 500X. (13) Navifusa bisulcum (Deunff) Playford 1977. CMUMP #5195, #17 > 38 μm 2, 121.3; 15.6. 500X. (14) Palanotus ledeboeri (Deunff) Playford 1977. CMUMP #5196, #13 < 38 μm 1, 129.0; 4.7. 500X. (15) Sollinium octoaster (Staplin) Jardine, Combaz, Magloire, Peniguel, and Vachey, 1972. CMUMP #5197, #16 > 38 μm 3, 121.6; 5.4. 500X. (16) Verybachium trispina (Eisenack) Deunff 1954. CMUMP #5198, #31 < 38 μm 1, 133.2; 12.4. 500X.


Genus Muraticavea Wicander 1974

Genus Polyedryxium Deunff 1961

Petrosperma reticulata Loeblich and Wicander 1976

Petrosperma sp. fig. 4, (5) REMARKS: This species is similar to the Petrosperma sp. figured by Wicander and Wood (1981) from the Silica Formation.

Group Acritarcha Evitt 1963

Genus Arkonites Legault 1973


Genus Baltisphaeridium Eisenack 1958


Genus Dasyillula Loeblich and Wicander 1976

Dasyillula sp. fig. 4, (9) REMARKS: This species is similar to Dasyillula sp. figured by Wicander and Wood (1981) from the Silica Formation.

Genus Diexallophasis Loeblich 1970


Genus Estiastria Eisenack 1959


Genus Exochoderna Wicander 1974


Genus Goniotrachelus Playford 1977


Genus Gorgonisphaeridium Staplin, Jansonius and Pocock 1965


Genus Hapsidopalla Playford emend. Wicander and Wood 1981


Genus Induoglobus Loeblich and Wicander 1976

Induoglobus sp. fig. 5, (5) DESCRIPTION: Vesicle circular in outline, 18 μm in diameter; wall laevigate; 7–8 processes, 16 μm long, bordered by a thin diaphanous list that extends to adjacent processes; processes appear to communicate with vesicle; no method of excystment observed. REMARKS: Only a few specimens of this distinctive species were found, and it was decided not to establish a new species based on the limited number found. The occurrence of this genus extends its geologic range from the Late Gedinnian to the Givetian.

Genus Micrhystridium Deutilandre 1937


Micrhystridium sp. A fig. 5, (7) REMARKS: This is the same species reported by Wicander and Wood (1981) from the Silica Formation.

Genus Multiplicisphaeridium Staplin emend.

Staplin, Jansonius and Pocock 1965


Genus Navifusa Combaz, Lange and Pansart 1967


Genus Ozotobrachion Loeblich and Druge 1968


Genus Palacanthus Wicander 1974


Genus Stellinium Jardiné, Combaz, Magloire, Peniguel and Vachey 1972


Genus Tunisphaeridium Deunff and Evitt 1968


Genus Tylignatoma Playford 1977


Genus Verybachium Deunff ex Downie 1959


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