OHIO GEOLOGY

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OHIO DEPARTMENT OF NATURAL RESOURCES • DIVISION OF GEOLOGICAL SURVEY

TINY HIDDEN TREASURES—THE MICROFOSSILS OF OHIO

Many people associate paleontology (the study of ancient life) with dinosaurs and other large and spectacular fossils. Although dinosaurs get a lot of attention, and deservedly so, there are many fields of paleontological research that are virtually unknown to the general public but of great importance to geologists. One such field is micropaleontology, the study of microscopic fossils, or microfossils, which are small, fossilized remains that can best be studied using a microscope. Seemingly lifeless pieces of rocks can contain thousands of entombed miniature fossils that are very important for the understanding of our changing planet.

Microfossils include a wide variety of minute organisms, including single-celled plants and animals, small pieces of larger organisms such as teeth and scales, and pollen and spores. The juvenile forms of many larger animals also may be preserved as microfossils.

The sedimentary rocks of Ohio contain an abundance of microfossils. These hidden treasures are not only fascinating and beautiful but also can be used to solve a wide range of geological problems. Because most microfossils require good laboratory facilities to be extracted from the rocks and specialized equipment to be studied, it is only during the past 50 years or so that micropaleontology has become an important research field and, as discussed below, a highly applicable science.

MICROFOSSIL EXTRACTION AND PREPARATION

Microfossils are prepared using several different techniques depending on the origin and composition of the fossil and on the chemistry and hardness of the enclosing rock (matrix). Microfossil preparation basically consists of the following steps: breaking up (disaggregating) the sample, removing fine sediment through sieving, drying the residue, and hand-picking under a microscope.

A general rule is that the harder the sample, the harsher the treatment. For soft and porous sediments, wet or dry sieving is generally the simplest and most efficient method and is inexpensive. If the specimens are embedded in harder rock, such as limestone, sieving will not be of much use, at least not initially. Instead, the rock must be dissolved or crushed without damaging the fossils. "Semi-hard" rock, such as shale, can be saturated with water and then put into a freezer. The formation of ice breaks up the rock. This freeze-thaw method can be repeated several times until the rock is disaggregated. Shale also can be soaked in kerosene. (Note: kerosene is highly flammable and must be used with great care and only in a well-ventilated location.) After soaking for a few hours, the kerosene is poured off and the sample is covered with water. The water forces the kerosene out of the pores in the rock and in the process disaggregates it. Although some of the fossils may be damaged during these processes, rocks generally break at their weakest points, which are the contacts between the fossils and the matrix.

Many microfossils are insoluble in acids. If they are embedded in a carbonate-rich rock such as limestone, an acid solution (commonly acetic acid) can be used to dissolve the rock without damaging the fossils. The residue of acid-resistant minerals and fossils is generally free of adhering sediment particles. When studying the sieved and dried residue for the first time under a regular reflected-light microscope, a whole new exciting world of minute fossils appears. If greater magnification is required, a scanning electron microscope (SEM) commonly is used. SEM produces beautiful and highly detailed images of the fossils.

USEFULNESS OF MICROFOSSILS

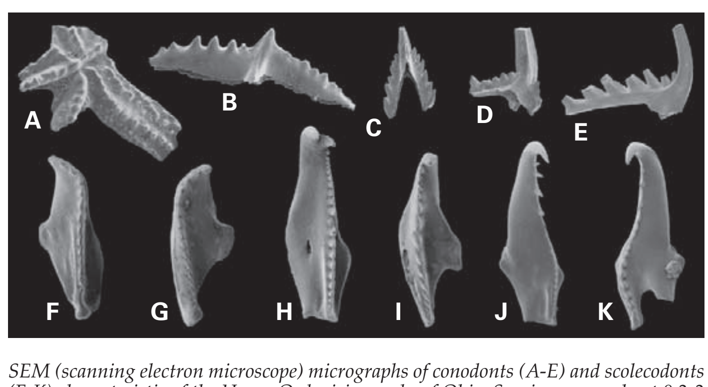
Microfossils are very useful in many geological investigations. Their size and abundance make them invaluable tools for determining the age of sedimentary rocks, and they are commonly used as index fossils (fossils that are diagnostic of a certain age or rock unit). Microfossils can be used for correlations within and between continents in order to show whether or not a body of rock was deposited at the same time in different regions. Such information allows reconstructions of the history of the Earth. Rocks that lack larger fossils may, and commonly do, have abundant microfossils. The microfossils may be the only tool available for determining the environmental origin and age of a rock. Microfossils are particularly useful in examining drill cores, which have obvious sample size limitations.

The composition of the microfossil also may have advantages. Some groups, such as conodonts (see discussion below), show variations in color when exposed to different temperatures and can be used as a "paleothermometer." Because oil and gas are formed within a specific temperature range, it is of great importance to know to what degree a rock has been heated during its geologic history in order to determine whether or not it may be a source rock, and, as such, if it is worth exploring further. Thus, microfossils not only have great scientific value but are also of crucial economic importance.

HIGHLIGHTS OF SOME MICROFOSSIL GROUPS

Some of the more common microfossil groups found in the sedimentary rocks of Ohio are discussed here. With the exception of most pollen and spores, these groups were selected because they represent fossils that may be observed in the field with the naked eye or with a hand lens. Other types of microfossils include tentaculitoids (a cone-shaped fossil, probably belonging to the mollusks), acritarchs (algal-like, planktonic organisms), dinoflagellates (single-celled algae), foraminiferans (single-celled, shell-bearing organisms), and radiolarians (single-celled organisms with a siliceous skeleton). All microfossils discussed below, except for ostracodes, are acid resistant and are easily extracted from carbonate-rich rocks using the acid-dissolution technique.

Conodonts are one of the best known and most widely used groups of microfossils. They consist of calcium phosphate and are the jaw elements of an extinct wormlike marine animal, which is considered to have been a chordate. The animal had a jaw apparatus consisting of 12 or 14 individual elements, which were the only hard parts in the body. Although a few conodont elements are known that reach a centimeter or more in size, the majority are between 0.1 and 2 mm long. The conodont animal appeared in the Cambrian Period (*c.* 530 million years ago) and became extinct at the end of the Triassic Period (*c.* 208 million years ago). Conodonts are abundant in most sedimentary rocks of marine origin and are very useful for determining the age of rocks, especially rocks of early to middle



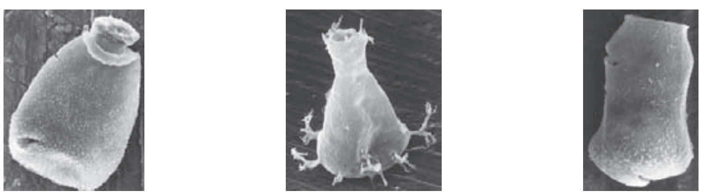
SEM (scanning electron microscope) micrographs of conodonts (A-E) and scolecodonts (F-K) characteristic of the Upper Ordovician rocks of Ohio. Specimens are about 0.2-2 mm. Conodont photographs (A-E) courtesy of J. G. Richardson. Scolecodont photographs (F-K) courtesy of C. F. Bergman; J, K from Eriksson and Bergman (1998).

continued

Paleozoic age (*c*. 505-360 million years ago). Moreover, because conodonts change color with temperature, they are used as paleothermometers. A color scale (known as the color alteration index, or CAI) has been compiled to which any new conodont find can be compared. The color indicates the temperature to which the rock has been heated. Conodonts can be found in most marine sedimentary rocks in Ohio and are especially abundant and well-preserved in limestones.

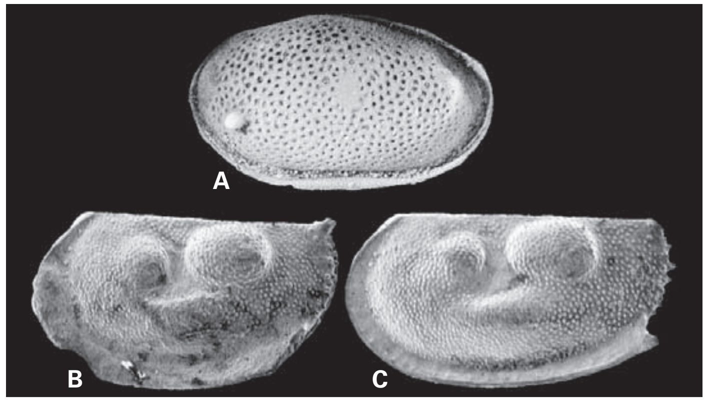
Scolecodonts are the jaws of marine worms belonging to the class Polychaeta of the phylum Annelida, which includes earthworms and leeches. Similar to the conodont animal, jaw-bearing polychaetes are equipped with a complex jaw apparatus generally composed of 10 to 15 elements. Scolecodonts are dark brown to black and can reach almost 10 mm in length, but are generally 0.1 to 2 mm long. The oldest scolecodonts are reported from rocks of late Cambrian age (*c*. 505 million years old). In present-day oceans, polychaete worms are very common and comprise one of the largest and most diverse groups of invertebrate organisms. Scolecodonts are potential index fossils and are well suited for ecological studies as many of them are associated with sediments deposited in a certain type of environment. Upper Ordovician rocks (*c*. 450-440 million years old) in southwestern Ohio contain an abundance of well-preserved scolecodonts.

Chitinozoans are hollow, jet-black to brown fossils characteristically shaped like bottles, flasks, or sacks with or without external ornamentation. The biological affinity of chitinozoans is debated. Many researchers currently think that chitinozoans are egg capsules of an as-yet unknown marine invertebrate. These fossils are placed in an exclusive group, the Chitinozoa, and occur in the fossil record from the late Cambrian to the end of the Devonian (*c*. 505-360 million years ago). These exclusively marine fossils are composed of strongly resistant, organic material known as pseudochitin and are generally smaller than 1 mm. Chitinozoans are useful for determining the age of rocks. They are widespread in the sedimentary rocks of Ohio and are particularly abundant and well-preserved in limestones of Ordovician and Middle Devonian age.



SEM micrographs of Middle Devonian chitinozoans from Lucas County, northwestern Ohio. Specimens are about 0.06 mm. From Feldmann and Hackathorn (1996).

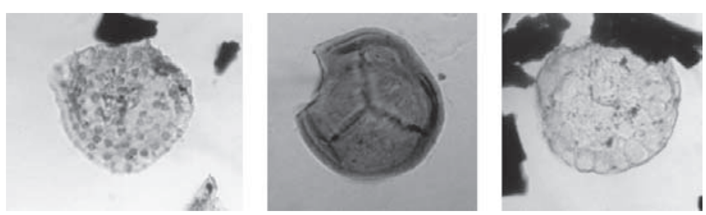
Ostracodes are bean-shaped, two-valved microscopic crustaceans of the phylum Arthropoda, which includes trilobites. Most ostracodes are less than 1 mm long. Ostracode valves generally are composed of calcium carbonate and may be smooth to heavily ornamented and equipped with spines and knobs. In some species it is possible to distinguish males from females by the shape and ornamentation of the valves (a feature known as sexual dimorphism). Ostracodes are known from the Ordovician Period to the present; they are very common in all modern aquatic environments. Ostracodes can be used as environmental indicators and for determining the age of a rock. Fossil ostracodes are found in marine and freshwater rocks throughout Ohio. They are especially well known from rocks of Ordovician (*c*. 505-440 million years old) and Devonian to Pennsylvanian (*c*. 410-290 million years old) age.



Middle Devonian (A) and Pennsylvanian (B, female, C, male) ostracodes from Ohio. Specimens are about 1.2-1.5 mm. From Feldmann and Hackathorn (1996).

Microvertebrates are the teeth, scales, bones, and other remains of fossil vertebrates that commonly fall into the microscopic size range. Microvertebrates may be found in samples processed for other microfossils, especially conodonts. These vertebrate remains are composed of calcium phosphate and may show a high degree of surface ornamentation. Some groups of microvertebrates are potentially useful for dating rocks. In Ohio, microvertebrates are abundant in the Columbus Limestone of Middle Devonian age (*c*. 380 million years old), where they commonly are concentrated in "bone beds" that were formed as lag deposits during storms. Pennsylvanian marine and freshwater rocks yield abundant microscopic remains of fishes and, rarely, amphibians. Freshwater Permian rocks yield similar microvertebrates.

Pollen and spores are reproductive tissues of plants that are extremely resistant to destruction. They are composed of a very tough, organic substance called sporopollenin. Pollen and spores are extracted from rocks using hydrofluoric acid, a very strong and hazardous acid that dissolves almost all constituents of a rock except for the specimens in question. Plants that produce pollen and spores have become increasingly common through time, from about the late Ordovician Period (*c*. 450 million years ago) onward. Pollen and spores are very common in sedimentary rocks of Ohio and, like most other microfossils, can be used for dating rocks. Perhaps more importantly though, plant remains from bog and lake sediments and other Ice Age deposits (*c*. 14,000 to 24,000 years old) of Ohio can tell the tale of dramatic climate changes. The study of the distribution of pollen grains through time (pollen analysis) enables researchers to reconstruct plant associations in an area and to find out how these associations changed through time. Such studies provide important information on vegetation and climate changes in a region.



Early Mississippian spores from northeastern Ohio. Specimens are about 0.02 mm. Photographs courtesy of J. G. Richardson.

FURTHER READING

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• This GeoFacts compiled by Mats Eriksson, The Ohio State University • January 2002 •

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