GEOFACTS
OHIO GEOLOGICAL SURVEY • DEPARTMENT OF NATURAL RESOURCES

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, there are facets of paleontology that are virtually unknown to the general public but of great importance to geologists. One such field is micropaleontology, the study of microscopic fossils ("microfossils" for short). Seemingly lifeless pieces of rock can contain thousands of entombed miniature fossils that are very important for understanding the history of our changing planet. Microfossils encompass a wide variety of organisms, including single-celled algae and animals; tiny remains of ancient plants, such as pollen and spores; and small pieces of larger animals, such as teeth and scales. 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 help answer complex geological questions. 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). Index fossils help scientists determine if bodies of rock in different locations were deposited at the same time. Such information allows reconstructions of the geologic history of Earth. Additionally, the chemical composition of a microfossil can be useful. Some groups, such as conodonts (discussed later), permanently change color when exposed to increasing temperatures (fig. 1). Because the change is permanent, they can be used to estimate the temperature of rocks when they were buried to their greatest depth. Both oil and natural gas are formed within a specific temperature range, so it is very important to know to what degree a rock has been heated during its geologic history to determine if it contains hydrocarbons. Thus, microfossils not only have great scientific value but are also of crucial economic importance.

Color Alteration Index	Example Conodonts	Temperature
1		<50˚–80˚C (<122˚–176˚F)
2		60˚–140˚C (140˚–284˚F)
3		110˚–200˚C (230˚–392˚F)
4		190˚–300˚C (374˚–572˚F)
5		>300˚C (>572˚F)

Figure 1. Light microscope photographs showing conodont color alteration at different temperatures. Conodonts become darker as they are subjected to more heat. Conodont images from Epstein and others (1977).

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. Microfossil preparation basically consists of the following steps: breaking up the rock sample, removing fine sediment through sieving, drying the residue, and handpicking under a microscope. Methods used to break up the rock sample depend on the relative hardness of the rock. For loose sediments and soil, wet or dry sieving is usually enough. For rocks such as limestone and shale, harsher methods such as dissolving the rock in acid (if the desired fossils are resistant to acid) or soaking the sample in kerosene are necessary to break up the rock. Once the sample has been sieved, a light microscope and paintbrush can be used to pick out the microfossils. Some light microscopes contain cameras and can take photographs of the microfossils. If more detail is needed, or if the microfossils are too small to be seen clearly with a light microscope, a scanning electron microscope is commonly used.

Highlights of some microfossil groups

Some of the more common microfossil groups found in the sedimentary rocks of Ohio are discussed here. Except for 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 scolecodonts (jaw parts and teeth of marine worms), acritarchs (algal-like planktonic organisms), chitinozoans (flask-shaped remains of an as-yet unknown marine organism), dinoflagellates (single-celled algae), foraminifera (single-celled organisms with usually carbonate skeletons) 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 (fig. 2) are one of the best known and most widely used groups of microfossils. They are made of calcium phosphate ($Ca_3[PO_4]_2$) and are the tooth elements of an extinct lamprey-like marine animal. The tooth elements were the only mineralized (hard) parts of the organism, and therefore are the only parts of the animal regularly found in the rock record. Until a few rare fossil body impressions of conodonts were discovered, researchers did not know how to classify them within the animal kingdom. Today, many researchers now think that conodonts were primitive vertebrates. Most conodont elements are less than 2 mm long, but a few known conodont species reach a centimeter or more in size. The conodont animal first appeared in the Cambrian Period and became extinct at the end of the Triassic Period (fig. 2). Conodonts are abundant in most sedimentary rocks of marine origin in Ohio and are very useful for determining the geologic age of specific rocks.

Ostracodes (fig. 2) are bean-shaped, two-valved microscopic crustaceans of the phylum Arthropoda. Most ostracodes are less than 1 mm long. Ostracode valves generally are composed of calcium carbonate ($CaCO_3$) and may be smooth to extensively ornamented with spines and knobs. In some species, it is possible to distinguish males from females by

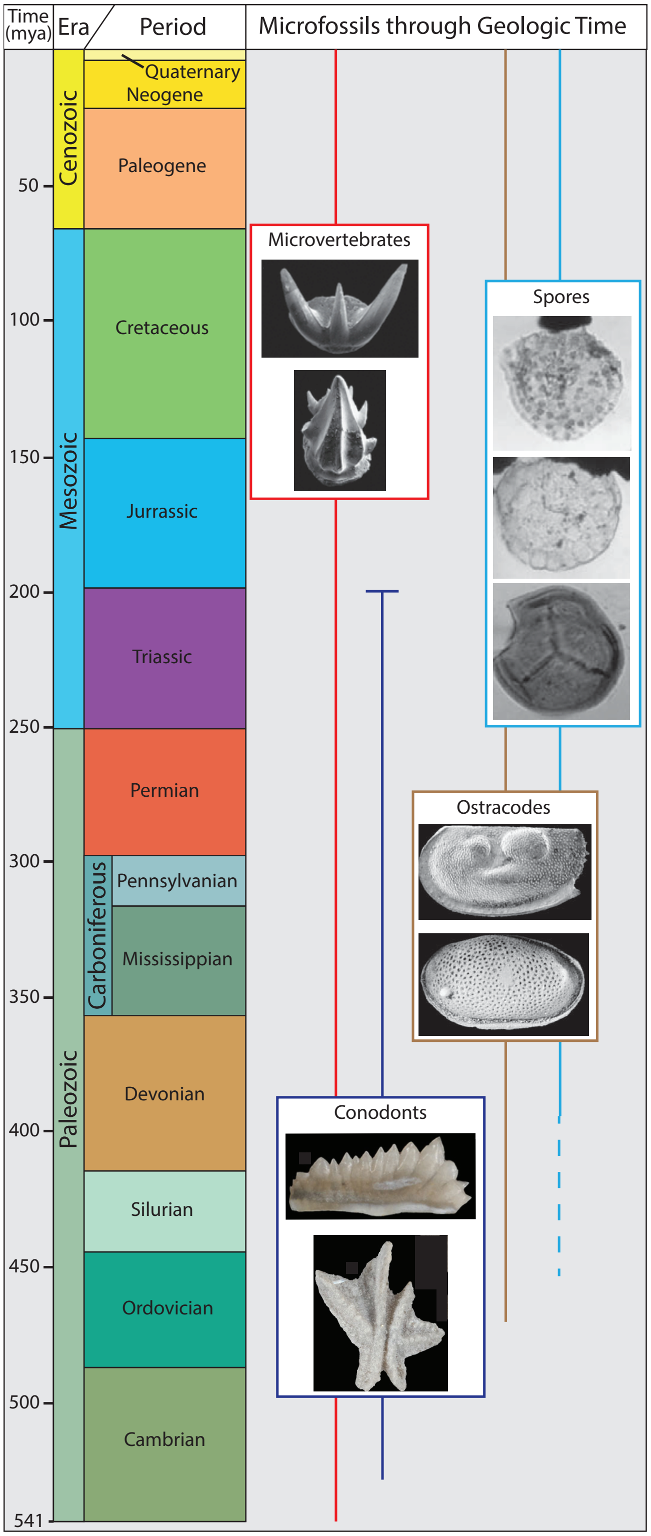

Figure 2. Geological time scale from the Cambrian Period to present and ranges of select microfossil groups in the rock record. The lines extending up and down from the microfossil photographs show where they can be found in the rock record. Numbers on the geological time scale indicate millions of years before present. Conodont photographs from Waid and Cramer (2017). Microvertebrate (fish tooth and scale) photographs from Trinajstic and George (2009). Ostracode and spore photographs from Feldmann and Hackathorn (1996).

the shape and ornamentation of the valves (a feature known as sexual dimorphism). Ostracodes are known from the Ordovician Period to the present (Fig. 2); 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, particularly from rocks of Ordovician and Devonian to Pennsylvanian age.

Microvertebrates (fig. 2) 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 because both are composed of calcium phosphate. Some groups of microvertebrates are potentially useful for dating rocks. In Ohio, microvertebrates are abundant in the Middle Devonian-age Columbus Limestone, where they are commonly concentrated in "bone beds" that were formed during storms. Pennsylvanian-age marine and freshwater rocks and Permian-age freshwater rocks yield abundant microscopic remains of fishes and, rarely, amphibians.

Pollen and spores (fig. 2) are reproductive tissues of plants and fungi that are extremely resistant to destruction. They are composed of a very tough, organic substance called sporopollenin. Plants that produce pollen and spores first appear in the rock record during the Late Ordovician (Fig. 2) but become especially common after the extensive colonization of land by plants beginning in the Late Devonian. Pollen and spores, like many other microfossils, can be used for dating rocks. But perhaps more importantly, plant remains from bog and lake sediments and other Ice Age deposits (from ~14,000–24,000 years ago) 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 with varying climate conditions.

References & Further Reading

Epstein, A.G., Epstein, J.B, and Harris, L.D., 1977, Conodont Color Alteration—an Index to Organic Metamorphism: USGS Professional Paper 995, 27 p.

Feldmann, R.M., and Hackathorn, Merrianne, eds., 1996, Fossils of Ohio: Ohio Department of Natural Resources, Division of Geological Survey Bulletin 70, 577 p.

Trinajstic, Kate, and George, A.D, 2009, Microvertebrate biostratigraphy of upper Devonian (Frasnian) carbonate rocks in the Canning and Carnarvon basins of western Australia: Palaeontology, v. 52, no. 3, p. 641–659.

Waid, C.B.T., and Cramer, B.D., 2017, Telychian (Llandovery, Silurian) conodonts from the LaPorte City Formation of eastern Iowa, USA (East-Central Iowa Basin) and their implications for global Telychian conodont biostratigraphic correlation: Palaeontologia Electronica, v. 20.2.39A, 37 p.