OHIO GEOLOGY

GEOFACTS No. 4

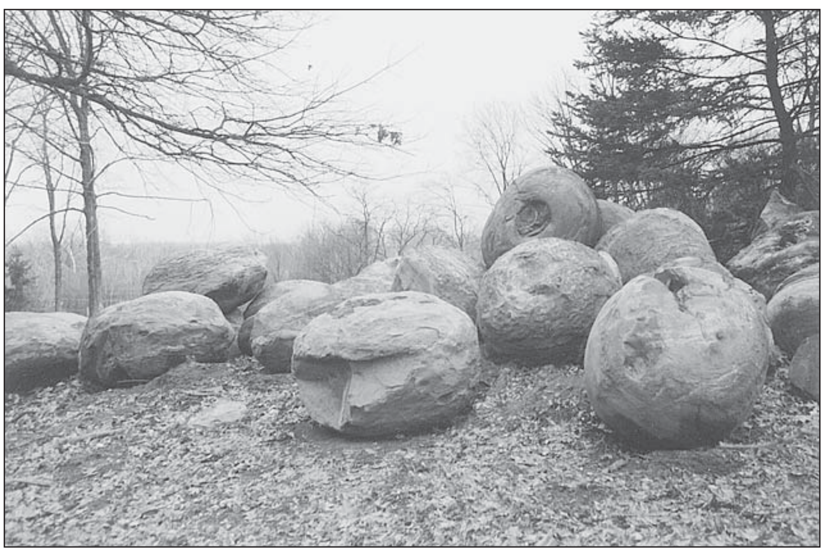
OHIO DEPARTMENT OF NATURAL RESOURCES • DIVISION OF GEOLOGICAL SURVEY

OHIO SHALE CONCRETIONS

Perhaps no other rocks found in Ohio generate so much public interest and curiosity than the large carbonate spheres, known as concretions, that weather out of the Devonian-age Ohio Shale. Along the outcrop belt of the Ohio Shale from Adams County on the Ohio River northward to Lake Erie, these orange-colored globes are a familiar sight as garden and yard ornaments and driveway markers. Many of them reach 9 feet or more in diameter. Speculation on the origin of these giant concretions abounds, and they are commonly confused with crystalline glacial erratics.

Ohio Shale concretions are composed primarily of carbonate (limestone or dolomite) rock and are enclosed within a dark-gray to black shale. They have been likened to "marbles pressed within the pages of a book," because the horizontally bedded shale bends around the concretion, both above and below. They range in diameter from a few inches to more than 9 feet, but most are less than 6 feet in diameter. Smaller concretions are nearly perfect spheres and resemble cannonballs, but larger ones tend to be flattened vertically and may have a funnel-shaped depression on the top and bottom. Concretions in the upper part of the Ohio Shale tend to be flattened and discoidal.

Most concretions have horizontal ribbing that represents layering of the surrounding shale before compaction. The ribs in the central portion of the concretion are the most prominent. Vertical cracks commonly are filled with secondary minerals such as calcite or barite. These concretions are referred to as septaria.



Pile of large "Huron boulders" excavated during construction of a road for a housing development on the west side of Olentangy River Road, Columbus. Several broken concretions revealed black, porous arthrodire bones in their centers. Note the funnel-shaped depression in the concretion at right center. Photo by Preston Fettrow, Sr., 1986.

The cores of larger concretions are typically calcite, which may surround an arthrodire fish bone or a fragment of fossil wood. The core is surrounded by fine-grained dolomite. The outer half inch or so of smaller concretions is commonly radially oriented pyrite. Freshly broken surfaces give off a fetid, sulfurous odor, attesting to the presence of altered organic matter.

Large, spherical concretions are confined to the lower 50 feet or so of the Ohio Shale. High cliffs of Ohio Shale along such streams as Scioto Brush Creek in Adams County, Paint Creek in Ross County, Deer Creek in Pickaway County, the Olentangy River in Delaware and Franklin Counties, and the Huron River in Erie and Huron Counties have concretions embedded in the shale. The stream beds are littered with whole concretions as well as ones that have broken into large, angular fragments. The middle part of the Ohio Shale yields small (2-3 inches in diameter), ovoid, ironstone concretions that have a variety of fossils at their center. The upper part of the Ohio Shale has flattened, lenticular, carbonate concretions that commonly contain arthrodire bones; some contain exquisitely preserved remains, including soft tissue, of early sharks.

GEOLOGY OF THE OHIO SHALE

The Ohio Shale is a fissile, dark-gray to black, highly organic shale that weathers into small, brownish chips or flakes. The most extensive outcrop area includes 23 counties in central and northeastern Ohio, extending from the Ohio River northward to Lake Erie and then eastward along the lakeshore. A smaller outcrop is in west-central Ohio in Logan County and a small portion of Champaign County on the Bellefontaine Outlier. The Ohio Shale is the surface bedrock in seven counties in northwestern Ohio, but this area is relatively flat and covered by thick glacial drift, so there are few outcrops. All of eastern Ohio, east of the central outcrop belt, is underlain by a thickening wedge of Ohio Shale as the unit dips eastward into the Appalachian Basin at about 35 feet per mile.

Geologists have divided the Ohio Shale into three units. The lower unit is the Huron Shale Member, which averages about 410 feet in thickness. The lower part of the Huron contains the large, spherical concretions, which have been referred to as "Huron boulders."

The middle unit of the Ohio Shale is the Chagrin Shale Member; this gray shale is up to 1,200 feet thick in northeastern Ohio but thins rapidly to the south and west. In central and southern Ohio the Chagrin is recognizable as a thin, gray unit called the Three Lick Bed. In some areas of northeastern Ohio the Chagrin Shale Member is noted for small, elliptical, ironstone concretions that contain remains of fossils such as brachiopods, bivalves, cephalopods, conulariids, crinoids, and rare fishes. The most spectacular fossils are well-preserved crustaceans, of which eight species have been described. *Echinocaris* is the most common genus. Most of these specimens have been collected from Indian Point, at the confluence of the Grand River and Paine Creek in Lake County, and along Mill Creek just south of Ross Road, Harpersfield Township, Ashtabula County. The small concretions weather out of the shale and lie in the stream bed.

The uppermost unit of the Ohio Shale is the Cleveland Shale Member, which is very similar to the Huron Member but is only 20 to 60 feet thick on the outcrop. At least three zones of large, flattened concretions in the Cleveland Member have been observed along Big Creek and its tributaries in the Cleveland area.

The Ohio Shale accumulated in latest Devonian time, about 360 million years ago, along the western edge of the Catskill Delta. This delta complex was a great wedge of clastic sediments eroded from the rising Acadian Mountains, formed to the east by collision of northeastern North America with northern Europe. This continental mass is referred to as the Old Red Sandstone Continent, in reference to Devonian rocks of that name in Britain. Ohio was just south of the Equator at this time, and one theory suggests that the Acadian Mountains periodically blocked the westerly trade winds, forming a rain shadow on the western side. The relatively deep (some suggest 600 feet) sea was starved for sediment and became stagnant below a boundary layer known as a pycnocline. Although the upper waters in the sea were oxygenated, the bottom waters were foul, and black mud high in organic matter slowly accumulated. It was in this environment that the concretions formed.

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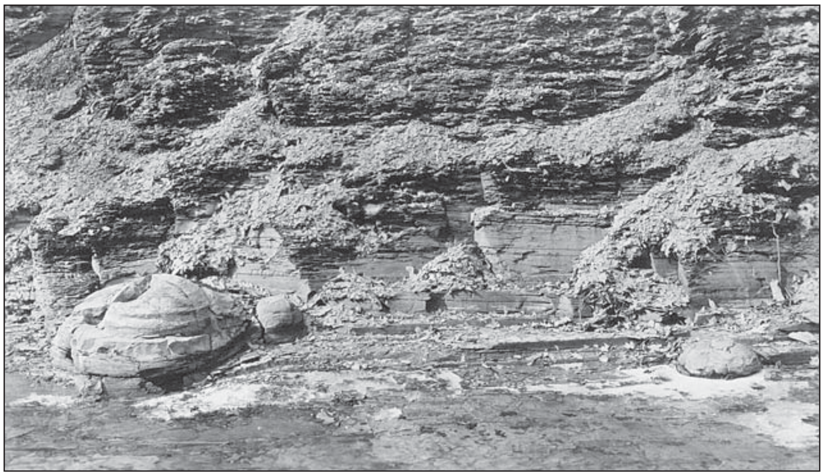
ORIGIN OF CONCRETIONS

The ideas on concretion development concentrate on the time of formation—did they form at the same time the shale was being deposited or did they form after deposition when the soft, black mud was being compressed? And why was concretion growth initiated at a particular site?

In a 1957 study of the Ohio Shale concretions, it was suggested that the concretions formed after deposition of the shale but before it had undergone complete compaction. Crystallization began at a nucleus and spread outward. Replacement and secondary growth of crystals were important aspects of concretion development. It was also suggested that the largest, somewhat flattened concretions achieved this configuration because water within the sediments tended to circulate in horizontal planes, thus favoring lateral growth until compaction proceeded to the point that mineral-bearing water was cut off.

Although many geologists who have studied these concretions have noted that crystallization appears to have begun around a nucleus of organic material, such as a fish bone, few seem to have speculated as to the chemical processes that would cause a large mass of carbonate to migrate to and accumulate around this nucleus. In a 1988 U.S. Geological Survey bulletin, researchers suggested that the concretions began to form around decaying organic matter and initially may have been masses of low-density, organic, soapy matter known as adipocere. The concretions formed very near the sediment-water interface, where minerals filled in and cemented the void space of the sediment, which, before compaction, had between 81 and 94 percent pore space.



Concretions in the Huron Member of the Ohio Shale along Slate Run, Franklin County. Stratification planes, representing the original bedding, are clearly visible on the largest concretion.

Ammonia is the principal decay product from a dead fish in an oxygen-deficient environment. The ammonia creates a high pH halo around the decaying remains, which causes carbonate to precipitate. At an early stage in concretion formation the adipocere was replaced by calcite, which was later replaced by calcium- and iron-rich dolomite, except at the cores of larger concretions, where the calcite was not replaced.

The U.S. Geological Survey researchers suggested that at a later time the calcite cores of the large concretions recrystallized, forming the funnel-shaped depressions at the top and bottom. But there is a paradox: in the early growth stages of the concretion the highly porous, uncompacted sediment could not hydrostatically support the mineralized concretion. These researchers proposed that low-density adipocere may be the logical answer to the paradox, as it may have maintained the spherical shape of the concretion until compaction of the sediment had proceeded sufficiently to support a mineralized concretion.

Although most researchers acknowledge that organic material such as a fish bone was the nucleus of crystallization, they have not addressed the fact that many concretions (perhaps as many as 90 percent) do not have recognizable organic remains at their center. Some knowledge of the anatomy of arthrodire fishes, which dominated the fauna of the Huron Member of the Ohio Shale, may help to explain this paradox.

The ossified skeleton of most arthrodires consists of the head and thoracic shield, each of which is made up of a number of bony plates. Remains of the post-thoracic portion of these fishes have not been found in the large concretions from the Huron Member, which leads to the conclusion that the vertebrae were cartilaginous, or only weakly ossified, similar to the skeletons of sharks.

As arthrodires died and floated on the surface waters, buoyed by decomposition gases, their carcasses began to disintegrate and individual bones, covered with decaying flesh, began to rain into the soupy bottom muds. Portions of the arthrodire body that were apparently unmineralized, such as the entire body posterior to the thorax, fell into the bottom mud and generated an adipocere mass, which would eventually become a concretion. However, the lack of fossilizable hard parts in this mass would preclude the possibility of fossilization of recognizable organic remains, particularly after recrystallization and mineral replacement of the nucleus of the concretion.

Yet another problem arises—why are many bones of arthrodires found in the Huron and Cleveland Members with no concretionary matter surrounding them? In some cases these bones have been reported from the same zones in which the concretions occur. Did the bones have so little flesh remaining when they settled into the bottom mud that no adipocere could form? Factors such as water depth, availability of carbonate in substrate waters, and perhaps other chemical and physical factors may have been operating during concretion formation. The occurrence of concretions in vertical and perhaps horizontal zones suggests that a multitude of conditions had to be just right for them to form.

FURTHER READING

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