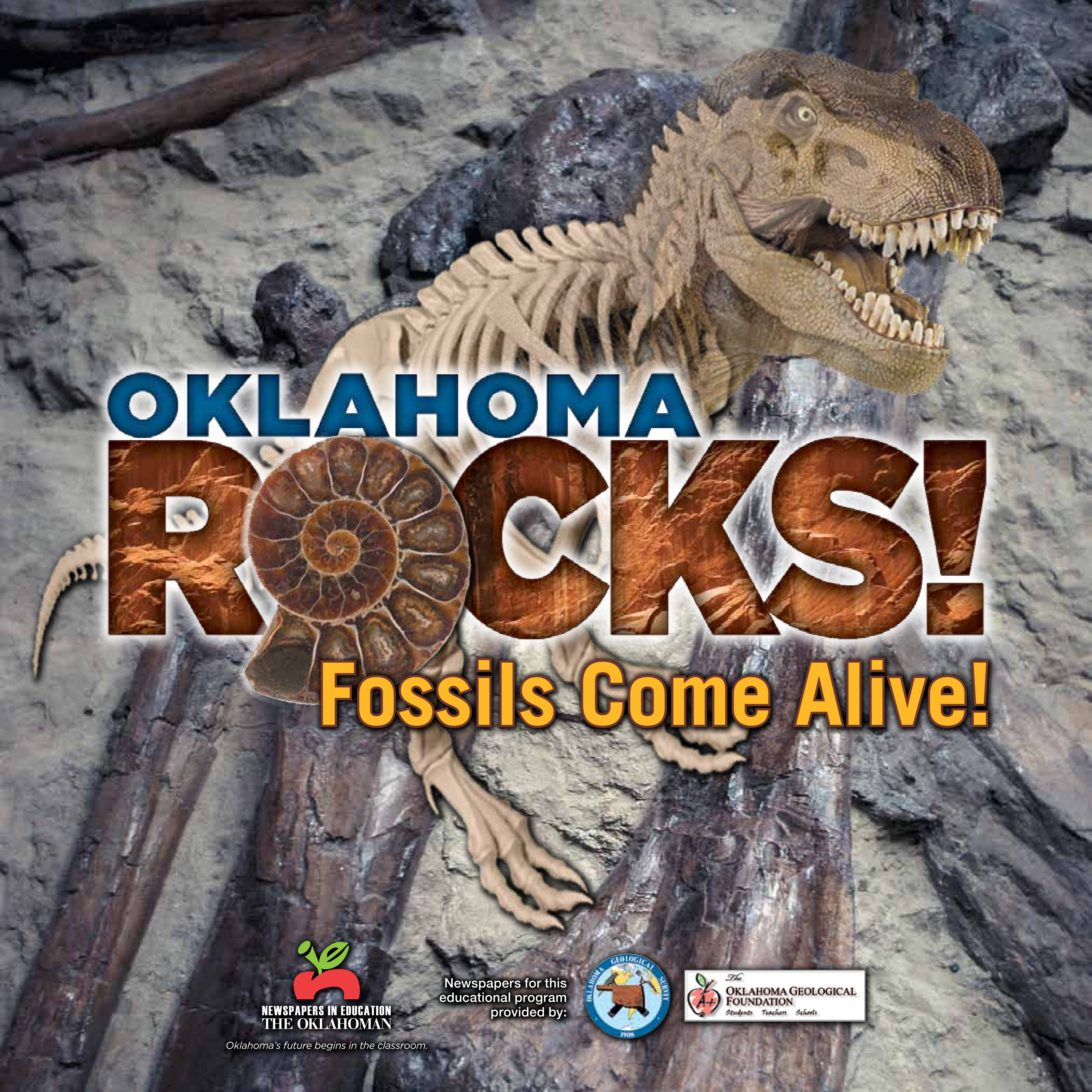

OKLAHOMA ROCKS!

Fossils Come Alive!

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Oklahoma Fossils Come Alive!

Once again, it is a pleasure, as Director of the Oklahoma Geological Survey, to support the Oklahoma Rocks! program. An important part of our mission is to communicate the information we have learned about Oklahoma geology to as wide an audience as possible. Giving information about the earth around us, especially to students (and their teachers) is both a priority and a pleasure.

This year, Oklahoma Rocks! concentrates on fossils, which are a readily available indicator of the very different environments Oklahoma has experienced through the years. Finding fossil shells and corals in the rock outcroppings around the state tells us that seas have covered Oklahoma for millions of years over the past several hundred million years.

Fossils help us understand earth history in two important ways. First, because species come in to being, live, and go extinct throughout geologic time, we can use the occurrence of fossils to correlate rock outcrops miles apart as being of the same age. This helps us understand the architecture of Oklahoma, with its folds and faults, basins and uplifts, as well as its history through time.

Second, we can use the groupings of fossils and the characteristics of the sediment that formed the rocks they are in to understand the environments they were deposited in – whether inshore or offshore, on reefs or in lagoons, in shallow or deep water. Together with the relative ages, this is how we understand the effects of plate tectonic forces and continental drift on the type of place that Oklahoma has been over the last several hundred million years.

Tom Stanley provides an excellent guide to help you classify the fossils you find, so that you can do some sleuthing about where the rocks you see around you fit into the overall picture of Oklahoma's history long before we humans came on the scene. The exercises can provide some guided examples to get you started. As always, we are especially interested in giving you more ways to understand and appreciate (and even retell) the stories buried in the rocks for millions of years, and brought to the surface by powerful forces acting across the continents to build the place we call home.

Dr. Jeremy Boak

Director, Oklahoma Geological Survey

Table of Contents

How to Identify Major Fossil Groups Common to Oklahoma

By Thomas M. Stanley, Geologist

So, you've found something. You're pretty sure it's a fossil, but you have no idea what kind. There are many excellent resources for fossil identification on the internet, but without a solid starting point that will help direct your search, you can get lost trying to figure out exactly what you've collected. Many of these sites begin at too fine a scale. That is, they show you numerous pictures of fossil genera and species without giving you an adequate understanding of how life is organized at higher levels, which is very important to correctly identify anything in this world. You need to learn how to identify fossils at higher levels first. Figure out what Phylum, Class, or Order it belongs to, which will make identifying it at the genus or species level much easier.

So let's start at the beginning. *Fossils* are the remains of once living plants and animals. Like many places in the world, here in Oklahoma, there are four basic types of fossils that have been collected.

Vertebrate fossils. Vertebrates are animals with an internal skeleton (an *endoskeleton*), and include fish, amphibians, reptiles, and, of course mammals (the group we belong to). As you would expect, a vertebrate fossil will look like bony material, but it will be mineralized (usually the original bone is converted to silica, much like what happens to petrified wood).

Invertebrate fossils. Invertebrates are animals that lack an internal skeleton, things such as worms, slugs, snails, clams, squids, etc. Unfortunately, things like worms and slugs are rarely preserved in the fossil record because they lack any kind of skeleton at all; however, many invertebrate groups, like snails and clams, do possess a hard, outer shell (an *exoskeleton*) that is readily preserved.

Plant Fossils. These can also be preserved in the fossil record, but because of the soft nature of woody material and leaves, they need to be buried under special conditions in order to be preserved (see the section on petrified wood in this issue). As such, fossil plants tend to be uncommon.

These three major groups, vertebrate, invertebrate, and plants, are all considered *body fossils*. A fourth group of fossil that are often collected in Oklahoma are **trace fossils**. These are things like footprints, tracks, trails, and burrows that represent the *activity* of plants and animals, rather than the plant or animal themselves, as they interacted in the sedimentary environment at the time they were alive.

Due to their sheer numbers compared to other living organisms, and by the fact that most are readily preserved due to their hard exoskeleton, 90% of all fossils collected in Oklahoma are invertebrate fossils. The rest of this section will concentrate on identifying the major invertebrate groups that are found in Oklahoma rocks.

The first thing to do is look at how the body of the fossil is organized. What, if any, symmetry does it exhibit? Most animals, and some plants, possess some type of symmetry in their outward appearance. The importance of symmetry is that it reflects how the cells, organs, appendages, and limbs are organized by the DNA code during the development stages of a plant or animal's growth. All vertebrates, and many invertebrates, have *bilateral symmetry*, an imaginary plane that divides the body into two mirrored images.

In humans, our plane of symmetry runs straight down the front of our bodies, dividing us into a left side and a right side, with both sides being mirror images of the other. If you have a pet dog, cat, or even goldfish, their plane of symmetry is the same as ours, running right down the middle (long axis) of the body, forming two mirrored halves: left and right. To illustrate the uniqueness of symmetry further, draw an imaginary line through our waist, with our head, shoulders, and chest on one side of the plane, and our hips, legs and feet on the other side. Note that this plane does not produce mirrored halves. Both sides of this plane are different. We, as well as all vertebrates, have but one plane of symmetry, and it runs down the long axis of our bodies.

Another form of symmetry is *radial symmetry*, which is commonly seen in more primitive invertebrate groups like the sponges and corals. Radial symmetry is what one sees looking at a circle, where a near infinite number of planes of symmetry can be drawn through the center of the circle, each time dividing the object up into two mirrored halves.

Still, other groups exhibit no symmetry at all. These animals and plants are called *asymmetric*. Snails commonly exhibit this type of symmetry.

The type of symmetry that occurs, and its orientation to the body, is considered a major character in classifying animals into broad groups (*Phyla*).

With that initial setup, there are six major invertebrate groups (*Phyla*), and a number of subgroups (*Classes* and *Orders*) that are commonly found as fossils in Oklahoma. These are illustrated below:

Cnidaria (Nī · dare · ēa)

This is a primitive group of wholly *marine* (ocean living) animals that include *sea anemones* (corals) and *jellyfish*. In fact, like the caterpillar/butterfly relationship, where each represents a distinct life cycle of the same, more or less, individual, the coral and jellyfish share a similar relationship. The sea anemone, or coral, lives its life attached to the bottom of the sea, producing jellyfish. The jellyfish, in turn, can float and swim around the ocean, producing polyps that become sea anemones.

All cnidarians have a primitive, radial symmetry usually transverse (crosswise) to the long axis of the body (although, some more advanced corals can have a simple bilateral symmetry along the long axis), and all have a mouth surrounded by tentacles with stinging cells (one of the defining characters of the group).

As their name implies, jellyfish do not have any hard parts, so they have a poor fossil record. On the other hand, the sea anemone secretes a hard exoskeleton (i.e., coral) made of calcium carbonate that is well preserved in the fossil record. As such, corals are commonly found and collected from rocks in Oklahoma.

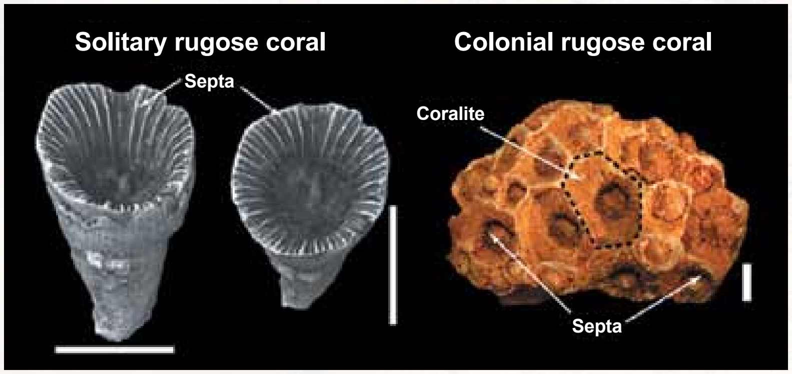


Figure 1. rugose corals fossils

There are three major subgroups of corals, but only two may be collected from rocks in Oklahoma: *rugose* corals (Figure 1) and *tabulate* corals (Figure 2). These two groups went extinct at the end of the Paleozoic. The third coral group includes modern corals, and are called the *scleractinians*.

The rugose corals display either a solitary (live as one, individual *corallite*) or colonial (many individual *corallites* living together) mode of life (Figure 1). The

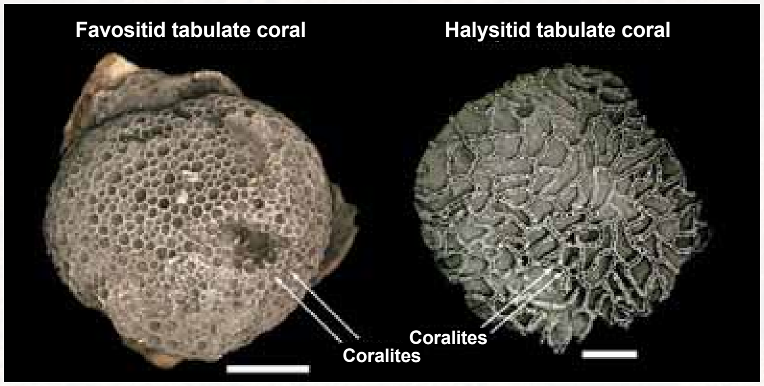


Figure 2. tabulate corals fossils

solitary rugose corals are usually cone-shaped or cylindrical, where the individual sea anemone lived in a cup-shaped depression at the top. Colonial corals have numerous, interconnected, corallites, with each housing its own anemone. Whether solitary or colonial, all rugose corals have radiating, vertical partitions called *septa*, which look like the spokes of a wheel. They are the defining character that separates fossil cnidarians from other fossil groups. The other coral group, the tabulates, are all colonial, but they can easily be differentiated from colonial rugose corals because their corallites are much smaller in size, and the septa appear weak compared to those found in colonial Rugosa (Figure 2).

Brachiopoda (Brăk · ēo · pōda)

The Brachiopoda, informally called brachiopods, are another, wholly marine animal that also lives attached to the bottom of the sea like the corals. Unlike some corals, however, all brachiopods represent an individual animal, and never occur as attached groups, or colonies, like some rugose and all tabulate corals.

The brachiopod is composed of two hard shells made of calcium carbonate (just like clams), but, unlike clams, they are unequal in size and shape (Figure 3). The shells, or *valves*, are attached to each other along a hinge on one side of the animal, and open up along the opposite side, allowing the animal to filter water through so it can breathe and eat. The larger of the shells is called a *pedicle valve*, and usually has a hole in it near the hinge called a pedicle opening. The smaller valve is called the *brachial valve*. All brachiopods have bilateral symmetry, where the plane of symmetry runs perpendicular to how the valves open (Figure 3). This is different from clams, where their plane of symmetry runs parallel to where the valves open.

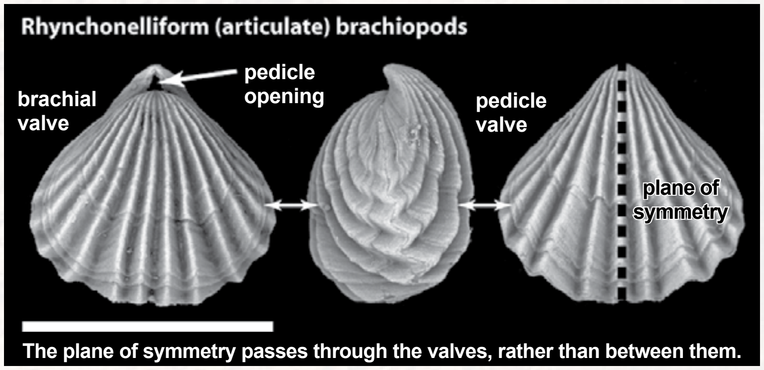
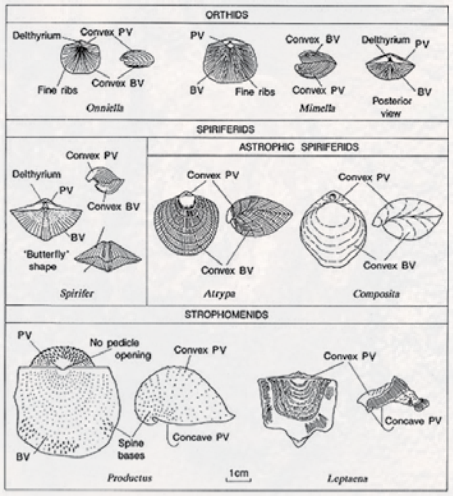


Figure 3. brachiopod fossils

There are six major subgroups (Orders) of brachiopod, but only five can be collected from Oklahoma rocks (Figure 4).

Orthids: valves are semi-circular in shape, *biconvex*, and attach along a long, straight hinge line. Usually, these fall apart (*disarticulate*), and are found as two, separate valves.



Strophomenids: (strō · fō · men · ids) valves attached along a long, straight hinge-line, but strophomenids are usually larger than orthids, and the two valves have a unique *concavo-convex* shape. Some strophomenid valves are very spiny. As with the orthids, the strophomenid valves easily separate after the animal dies.

Pentamerids: very large, robust, biconvex valves attached along a short, curved hinge line, and where the pedicle valve has no hole near the hinge.

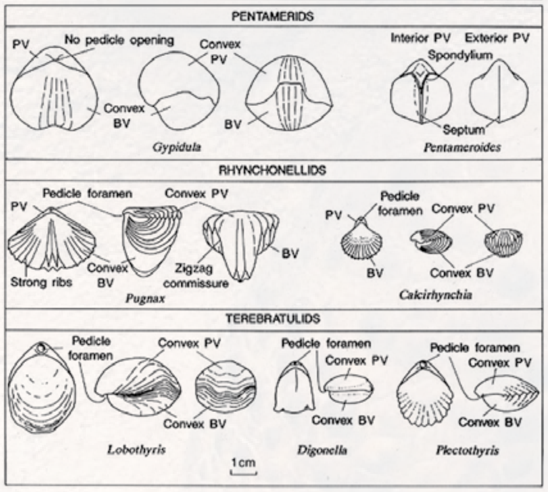


Figure 4. Six major subgroups of brachiopod

Spirifers: most spirifers are easy to identify, as their biconvex valves are attached along a very long, straight hinge, given them an exaggerated wing, or butterfly, shape. However, other spirifers have a short, curved hinge, which make them look similar to other brachiopod groups with similar hinge lines. Typically, though, these short hinge spirifers have valves adorned with coarse to fine surface ribbing that does not wrinkle the valves or valve opening. The valves of the spirifers usually remain attached and together, rarely disarticulating.

Rhynchonellids: (Rānk · on · el · ids) these are normally very small brachiopods (about the size of your pinky nail or a little larger), and have very uniquely shaped, biconvex valves attached along a very short, curved hinge line. Usually, the valves have coarse ribbing that, unlike some spirifers, wrinkles the shell, forming a very pronounced zig-zag shape to the opening of the valves. As with the spirifers, rhynchonellid valves remain together.

To be thorough, the sixth subgroup of brachiopod that isn't found in Oklahoma are the *terebratulids*, which resemble the pentamerids in many respects.

Bryozoa (Brī · ō · zō · ă)

This group is very common in Paleozoic-aged rocks of Oklahoma, but because they are small and often so delicate that they are broken, they tend to be overlooked by many collectors (Figure 5).

The majority of species are marine, living a life attached to the bottom of the sea, but there are a few fresh water species. The fresh water species are rare in the fossil record, however, it is safe to assume that all specimens collected in Oklahoma

Figure 5. Bryozoa fossils commonly found in Paleozoic-aged rocks of Oklahoma.

originally lived in a marine environment. All bryozoans are colonial, where a single colony can be made up of hundreds of individuals. Each individual of the colony lives in a hollow tube, called a *zooid* that is surrounded by a secreted exoskeleton made of calcium carbonate. Each zooid is small, usually no more than 1/16" in diameter, and is shaped like a simple, cylindrical tube. At first glance, the zooid can superficially resemble a tabulate corallite, and the colony as a whole often times is mistaken for a tabulate coral. To tell the difference between a bryozoan colony and coral colony, look closer at the openings, bryozoan zooids are much smaller in diameter and lack radial septa compared to tabulate corallites.

Unlike most other invertebrate groups, many species of bryozoa do not maintain an unchanging *growth form*, or exterior appearance, as the hard exoskeleton can change its look and character depending on the prevailing environmental conditions under which it's living at the time. As such, it is difficult to identify what major group of bryozoan a specimen belongs to, let alone what species it is, based on looking at the external characters alone. To identify a bryozoan specimen down to species, or even class level, one needs to section the fossil, and look at the internal structures of the zooids under a microscope—which is not very fun, and far too cumbersome for an amateur paleontologist to do. Although we cannot accurately identify what bryozoan we are looking at without more detailed work, the specimens external appearance can tell us a lot about what was going on in the marine realm, more so than most other invertebrate groups.

There are four basic bryozoan growth forms, each related to the strength of the ocean currents that the species experienced at the time it lived: 1) *encrusting forms* are bryozoan colonies that grow as low-lying mats on other hard surfaces such as hard marine substrates and shells; 2) *upright, robust branching forms* still imply strong currents, but not as strong as the encruster types; 3) *upright, delicate branching forms* probably suggests quiet water overall, but still experiencing moderate current activity at times; and 4) *fenestrate forms*, which are very delicately constructed colonies that look like lace cozies. These require very low to no current activity to be stable and not break.

Mollusca (Mŏll · ŭs · că)

Mollusks include things like clams and oysters, snails, octopi and squids. Besides the wide range in body forms, they are one of the most diverse group of invertebrates when it comes to mode-of-life (the other being the arthropods). Some clams, and all oysters, live attached to the bottom of the sea and never move; whereas some clams can move about and also burrow into the sea bottom. Like the clams, snails are also bottom dwellers, but are very mobile, and, of course, squid and octopi are free swimming (what we call *nektonic*). Like the bryozoa, there are numerous fresh water species (clams and snails), and even one group of snail, the *pulmonates*, made the transition to living on land. Even with the diversity of body forms and habitats for this group, mollusks are united by having the same internal anatomy and a muscular 'foot'; although the foot has been greatly reduced in octopi and squids. All mollusks, except for advanced forms of snail, exhibit bilateral symmetry.

There are seven major groups of mollusk, but only three are commonly collected from rocks in Oklahoma.

Bivalves: this group encompasses the clams and oysters, and as the name implies, they are formed by two valves attached alone a hinge similar to brachiopods. Unlike the brachiopods, however, whose plane of symmetry is oriented perpendicular to the valve openings; the plane of symmetry in most bivalves parallels the valve opening (Figure 6). As such, the two valves of clams are mirror images of each other. Note that I said most bivalves, oysters, particularly more modern oysters, are slightly different from clams, where both valves look different from each other, and the animal develops an asymmetric body plan. So, if you find something that kind of looks like a clam, but you can't easily draw a plane of symmetry through any part of the body, you're probably looking at a fossil oyster. Another clue to tell them apart is that oyster shells tend to be very thick and heavy compared to clams. The heavy shell comes from them living in high-energy environments, like surf zones along rocky coasts.

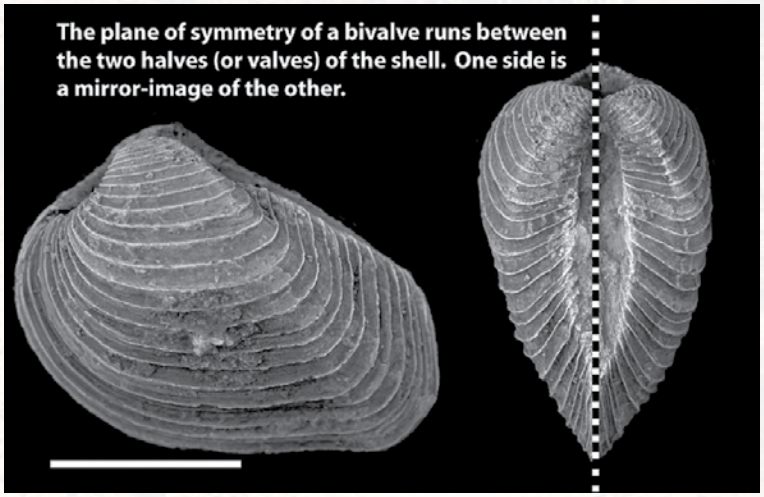


Figure 6. The plane of symmetry in most bivalves parallels the valve opening.

Gastropods: this is just a fancy name for snails and slugs, and since snails are the only members of the group with hard parts that can be preserved in the fossil record, we'll only deal with them in this section. The majority of snails are *asymmetric*, their bodies and shells have become so contorted through coiling that they have no symmetry at all. The exception to this is a primitive group of snails called the *bellerophons*, which have a bilateral symmetry (Figure 7).

Figure 7. Bellerophons fossils, a primitive group of snails with bilateral symmetry.

Cephalopods: this group includes octopi and squids, but these are rarely preserved in the fossil record. However, there is a large group of cephalopods that secrete a calcareous exoskeleton, making them readily preserved. These are the subgroups: *nautiloid* and *ammonoid* (Figure 8). Both subgroups have bilateral symmetry with the plane extending down the long axis of the body. Both groups' shells may be either straight or coiled (though most nautiloids you will collect will all be straight or gently curved). To differentiate the two groups, look closely at the sides of the shell. There you may see very fine lines that run laterally across the shell (perpendicular to the plane of symmetry). These are called suture lines, and represent the trace of internal walls that separate individual chambers within the body of the shell. The nautiloids tend to have very simple, straight suture lines, while the ammonoids can have very complex, suture patterns.

Figure 8. Nautiloid and ammonoid fossils, subgroups of cephalopods.

Echinodermata (Ē · kīn · ō · dērm · ătă)

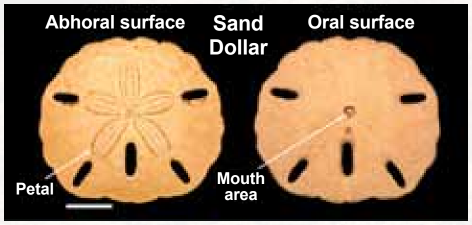


Figure 9. Sand dollar.

The echinoderms are considered the most advanced group of invertebrates because they have a water-vascular system (a complex system of tubes and bladders filled with fluid). Within the *Linnaean classification* scheme of zoology, they are placed just below the hemicordates (a group that eventually gave rise to the vertebrates). Modern-day echinoderms include starfish and brittle stars, sea urchins (Figure 9), sea cucumbers, and crinoids (Figure 10). There are also two major echinoderm groups that are *extinct*. All members of the echinoderms were/are marine; either fixed to the bottom of the ocean by a stalk, or are free-living. All have radial symmetry, particularly the more primitive, extinct groups. More advanced members of echinoderm have developed a secondary, *pentameral symmetry* (a five-sided symmetry) that is unique to the animal world (Figure 9).

Although echinoderms are very common in the fossil record, finding whole specimens is difficult (Figure 10). When living, the animal is composed of thick calcite plates that are readily preserved; however, the plates are only attached to each other by soft tissue. As such, when the animal dies, the soft tissue decomposes, all the plates then separate, causing the animal to fall apart, or *disarticulate*.

Still, if you were to break open any Oklahoma limestone, particularly from the Carboniferous Period, you can't help but find crinoid plates (usually five-sided due to the animal's symmetry), whole columns made of individual ossicles, and spines belonging to once living echinoderms (Figure 9). Most of this echinoderm debris belong to the group *Crinoidea* (called crinoid for short). In some Cretaceous-aged rocks in southern Oklahoma, however, many of these plates and spines belong to the group *Echinoidea* (Figure 9). This is the group that contains sea urchins and sand dollars that many people see if they vacation in Florida.

Figure 10. Crinoid fossils.

Arthropoda (Ārth · rō · pōdă)

The name is Greek for 'jointed foot,' which is what unites all members of this group. It is the most diverse, successful, and extensive of the invertebrate groups, with members occupying every conceivable niche and habitat on the face of the Earth: from marine to fresh water environments, to the land, as well as the air. Members include crustaceans (crabs, lobsters, shrimp, and crayfish), centipedes and millipedes, insects, spiders, and, of course, the extinct *trilobites* and *eurypterids* (sea scorpions). All members exhibit well developed bilateral symmetry. Unlike the other invertebrate groups, which secrete a hard, calcium carbonate exoskeleton, arthropods' external skeleton is composed of *chitin*, a material similar to that of the human fingernail. As such, they are not as easily preserved in the fossil record as the other invertebrate groups.

The trilobites are really the only arthropod group with any kind of fossil record, and can be collected from some lower Paleozoic-aged limestones in the Arbuckle Mountains. They get their name because their body is constructed with three longitudinal sections, a middle axial lobe, accompanied with two lateral (*pleural*) lobes (Figure 11). Trilobite fossils usually represent molts, the carapace discarded by the animal as it grew. Look for things like the head, also called *cephalon* that houses the eyes; the main body, or *thorax*; and the *pygidium*, or tail.

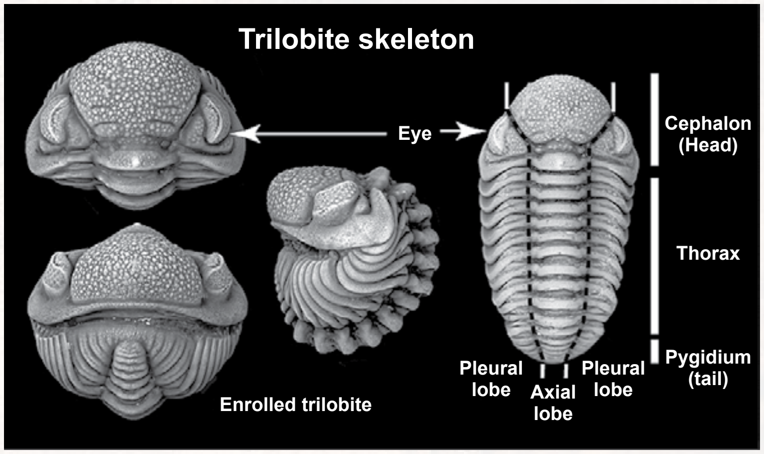


Figure 11. Trilobite fossils.

Formaninifera (Fōr · ăm · in · ifera)

Forams are single-celled animals that secrete (make) a hard shell-like structure in which they live. Even though they are small in size, microscopic to be exact, they play one of the biggest roles in paleontology and geology: because they are found everywhere and change their appearance rapidly, they provide geologists the ability to separate younger sedimentary rocks from older sedimentary rocks in a procedure called relative dating (see last issue of *Oklahoma Rocks! Can You Dig It?*).

Figure 12. Fusulinid fossils.

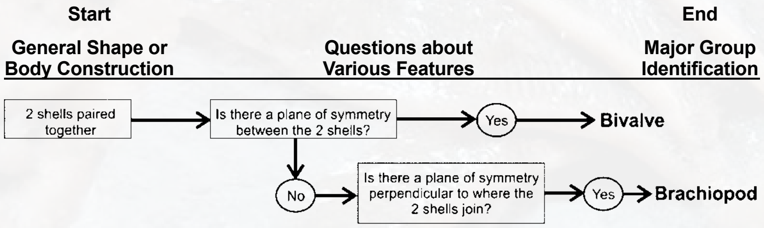
Now, because they are single-celled animals, most forams cannot be seen without the aid of a microscope; however, one group, the ***fusulinids*** (Few · sū · lĭn · ĭds), are large enough to be seen with the naked eye (Figure 12). If you look close at a typical, Oklahoman, Pennsylvanian- or Permian-aged limestone, you will see them if they are present in the rock, and look like grains of rice. They are quite unique, and can rarely be mistaken for any other fossil you might find in Oklahoma rocks.

Invertebrate Fossil Identification Flow Charts

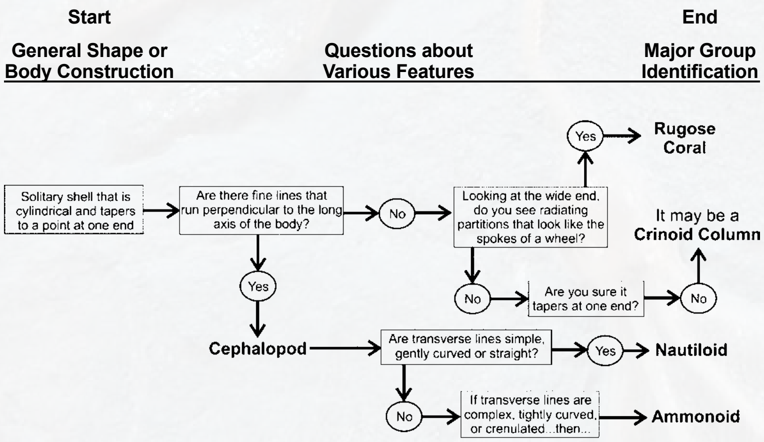
By Thomas M. Stanley, Geologist

Certain subgroups, and even major groups of fossils, may be difficult to distinguish from each other. Knowing this, I devised a series of identification flow charts that can aid you to correctly identify any invertebrate fossil you may find in Oklahoma. Once you have narrowed your search by knowing what major group your fossil belongs to, you can continue your search using many excellent internet sites and identify the fossil further down to genus or even to the species level.

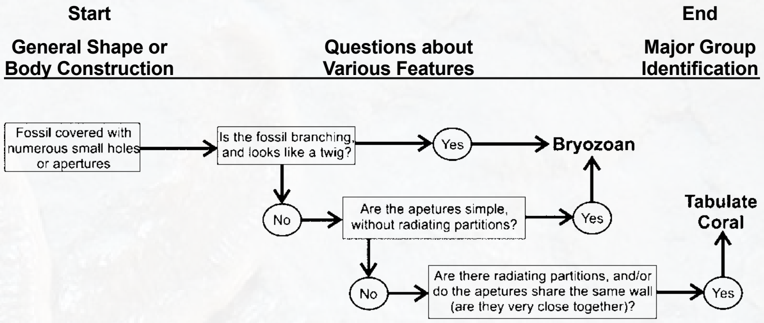
The main thing to do at the start is to look at the overall shape of the fossil and find its plane of symmetry (if it has one), see how it's put together (organized), and then continue from there. I've tried to anticipate all possible close fossil similarities that may be confused with other groups to the amateur's eye and provide as many clues to look for to differentiate similar looking groups.



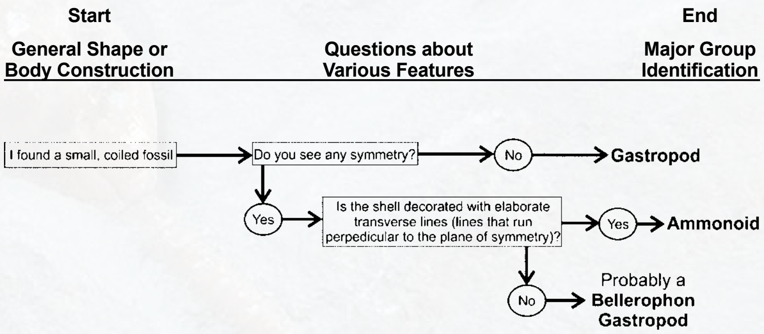
You should be able to distinguish between a bivalve and brachiopod even if you find one shell, as long as the shell is whole. Just look for a plane of symmetry. If it divides the valve in half (between left and right), it's most likely a brachiopod. If you can't see a plane of symmetry for the one shell, it's probably a bivalve shell.



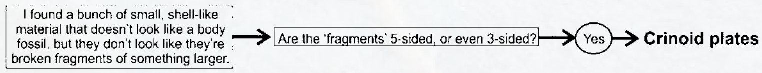
Usually fossils that are cylindrical, or longer than wide (like us), tend to have bilateral symmetry. Even though corals have a radial symmetry in their soft parts, many solitary rugose corals exhibit a weak bilaterial symmetry in their shells. This makes it tricky to tell them apart from a straight cephalopod without looking at other characters, such as the presence or absence of suture patterns on the shell exterior, or radial septa at the wide end of the fossil.



Bryozoans are pretty distinct and unique for invertebrates, but they can be misidentified as a colonial, tabulate coral at times if they exhibit an encrusting growth form. The thing to look at are the apetures (openings). Do you see septa, and are the openings so close together that they share the same wall? If you don't see either of these things, and the openings are greater than twice their diameter from each other, then it's probably a bryozoan. The corallites of tabulates are usually packed very close together, and are at least twice as large as those one sees in bryozoans.



Everyone knows what a snail looks like. Their distinctive, coiled asymmetry of the shell is easily recognizable. However, unlike most snails, the bellerophons do not exhibit that distinctive asymmetry, and instead exhibit a strong bilateral symmetry. As such, given their coiled shape, a bellerophon may be mistaken for an ammonoid cephalopod. If you find something coiled with symmetry, look for elaborate septa (lines) decorating the shell. All ammonoids will have them, but bellerophons will not.



Invertebrate Fossil Collecting Sites of Oklahoma

By Thomas M. Stanley, Geologist

The following is a short list of invertebrate fossil sites in the state. Typically, one will find the most fossils where limestones are exposed, and as such, this list is heavily weighted to areas around the Arbuckle Mountains (a geographic area that tends to have a lot of limestones). I have also included some sites I found in the Tulsa Metro area; although these are not as good as those further south in the state. For those of you not living in these areas, fear not. There are excellent resources for fossil locations at the Oklahoma Geological Survey web-site (http://www.ou.edu/ogs/). We have many county bulletins that provide county maps and show fossil locations for each county (provided any fossil sites occur in the county. Most counties west of Oklahoma City have very few to no fossils). These bulletins are free to download. Also, our Oklahoma Geologic Quadrangle Series shows the locations and trends of many fossil-bearing limestones, particularly in north-central Oklahoma and Tulsa (the Pawhuska and Keystone Lake 1-degree geology can be useful to those living in north-central Oklahoma). So find a map near you, and locate possible sites for finding fossils based on the presence of limestone.

Property of Frank Crabtee

WILL NEED PERMISSION TO COLLECT FROM MR. CRABTREE

Fossils: petrified wood (**Callixyton**), gastropods, coiled ammonids in concretions (**Goniatites choctawensis**)

Starting in Ada, go south on US 377. Turn east on County Road 162, then go 1.2 miles. Site is on both sides of the road.

Fossil plants in limestones

Fossils: Ferns, leaves, stems and root impressions in limestone.

Starting in Fittstown, go south on US 377. At the intersection of Hwy 99A and 377 just south of Mill Creek bridge is a white church with a petroleum well-head. Site is ~100 yds. SE of the well-head.

Jennings Quarry

WILL NEED PERMISSION FROM MR. RANDY JENNINGS TO COLLECT.

Fossils: Devonian-aged crinoid bulbs (**Camerocrinus ulrichi**) filled with quartz, large gastropods (**Platyceras**), trilobite fragments, and brachiopods (**Meristella**).

1 mile south of Mill Creek bridge in Fittstown and ½ mile west of US 377.

Old Township Quarry

NEED PERMISSION FROM MR. RANDY JENNINGS TO COLLECT.

Fossils: abundant Ordovician-aged marine fossil assemblage, predominantly brachiopods, crinoids, and gastropods.

From Jennings Quarry go southwest on section line road for 1/4 mile.

Cactus Hill

Fossils: Ordovician-aged marine fauna, mostly brachiopods and numerous trilobite cephlons

Go 3.5 miles south of Fittstown on US 377 until road runs through a narrows with rich outcroppings on either side. There's good parking on the southbound (east) side of road, but best collecting is on the west side of road in narrows.

Bar-X Ranch

NEED PERMISSION TO COLLECT.

Fossils: Mostly Devonian marine assemblage consisting of many species of brachiopod, crinoid bulbs, trilobites, rugose & tabulate corals, & bryozoans.

From US 377 go east on County Road 168 for 4 miles. Turn south for 1.4 miles until road ends at gate to ranch. Abundant fossils along road past gate.

Ada Brick Quarry

Fossils: well preserved and abundant Upper Pennsylvanian marine assemblage including numerous species of brachiopods (**Neochonetes**, **Chonetinella**, productids), gastropods (**Worthenia**), straight nautiloids, crinoid debris and columns, rugose corals, and robust, upright bryozoans

~100 yds. west of Kerr Lab Road and 400 yds. north of J.A. Richardson Loop.

Thomas Ranch

NEED PERMISSION BUT WELCOMES AMATEUR COLLECTORS GREATLY.

Fossils: a large, Middle Pennsylvanian fossil assemblage consisting of gastropods (**Meekospira**, **Belleraphon**, **Ianthrinopsis**), bivalves (**Yolida**, **Astarella**), small, coiled ammonoids (**Orthoceras tuba**), brachiopods (**Pugnax**, **Hustedia**, **Crurithyrus**, and **Mesolobus**), bryozoans, and crinoid material.

1.5 miles west of intersection of County Roads NS 361 and EW 157. About 2 miles southeast of downtown Ada.

Holland's Hill

NEED PERMISSION FROM MR. HOLLAND.

Fossils: Middle Pennsylvanian faunal assemblage dominated by brachiopods and some gastropods (**Rostroconch**), rare shark's teeth, coiled ammonoids, and conulariids (an extinct phylum of unknown affinities, having a pyramidal shape).

Go south from Ada on Hwy 3W toward Union Valley. At Union Valley, go 3.25 miles north, then 1 mile east, then S 1.25 miles. Site is on east side of section line.

Lake Holdenville

Fossils: Middle Pennsylvanian fauna consisting of brachiopods (Hustedia, Mesolobus, Lingula, and productids), gastropods (**Trepospira**, **Meekospira**, **Strobeus**, and **Euphemites**), ammonoid (**Brachicycloceras normale**), bivalves (**Astartella**, **Yoldia**, and **Nuculan**), and crinoid cup plates.

Take a gravel road east on north side of lake ~0.2 miles from Hwy 48, then walk 250 yds past gate to north side of small pond.

Hunton Anticline Quarry

Fossils: a nice Lower Devonian brachiopod assemblage, along with abundant crinoid debris, all set within a plunging anticline. Difficult to liberate the fossils from the limestone matrix, however. So, bring a rock hammer.

Go 6.5 miles south toward Dougherty on Hwy 110, east of Davis. Turn east on Goddard Youth Camp Road, and go ~0.5 mile, where you hit quarry entrance on south side of road. The entrance is gated, but you can go through it.

Rectangular Survey Coordinates: Center, Sec. 31, T.1S., R.3E., Dougherty Quad.

Shores of Lake Texoma

Fossils: Lower Cretaceous, large, coiled ammonoids, oysters (**Gryphaea**), echinoid spines and plates, and rare shark's teeth.

Go south from Madill on US 70 to State Hwy 106 that leads to Little Glasses Resort. Turn east onto 106 and go 3.9 miles. A side road leads north toward Lake Texoma. When you get to the lake begin collecting.

Rectangular Survey Coordinates: NE1/4, NE1/4, Sec. 9, T.6S., R.6E., Kingston North Quad.

Kingston

Fossils: Lower Cretaceous marine invertebrates; bivalves and the oysters **Gryphaea**, **Texigryphaea**, and **Ostrea**

From intersection of Hwys 70, 70A, and 70B in downtown Kingston, go east on US 70 for 2.5 miles, then turn south onto County Road 356. Then go south for 3 miles, then turn east onto EW 211 County Road. Go for 0.9 miles until you come to McLaughlin Creek. Collection on north side of road.

Rectangular Survey Coordinates: SE corner of Sec. 10, T.7S., R.6E., Kingston South Quad.

Lake Murray

Fossils: a rich Middle Pennsylvanian fauna that includes articulate crinoid cups and disarticulated plates and facetals.

At Lake Murray, go south on State Hwy 77S for 3 miles until road forks. Take east fork and continue for 1 mile. Continue north toward lake until you get to the spillway.

Rectangular Survey Coordinates: S1/2, Sec. 14, T.2S., R.6E., Lake Murray Quad.

Buckhorn

NEED PERMISSION FROM MR. AND MRS. HELTZEL.

Fossils: A well-known Middle Pennsylvanian-aged, cephalopod collecting site. Though most of the material is fragmentary, 3 species of nautiloid and ammonoid each have been collected here.

From intersection of US 177 and State Hwy 7 in SE Sulphur, go south on 177 for 4.3 miles. Site is on a hill on west side of road.

Rectangular Survey Coordinates: Center SE1/4, Sec. 23, T.1S., R.3E., Sulphur South Quad.

Northwest of Cedar Hill

Fossils: Upper Silurian-aged fossil assemblage that includes 10 species of brachiopod, several types of bryozoan, at least 2 gastropod species, several species of trilobite, crinoid plates, columns and ossicles, and Rugose corals.

From the south side of Ada, go south on Kerr Lab Road for 5 miles. Turn west and go 1 mile, then turn north and go 0.5 miles. Site is on the west side of road.

Rectangular Survey Coordinates: Center of east line, Sec. 32, T.2N., R.6E., Ahloso Quad.

North of Chimneyhill Creek

Fossils: Upper Silurian-Lower Devonian fauna, same as NW Cedar Hill, but no trilobites have been reported.

From Cedar Hill, continue north along section-line road until you cross a small bridge. Then go another 400 yds. Site is on west side of road is in Lower Devonian carbonates. Another good collecting area is on the east side of the road, and is in Upper Silurian carbonates.

Rectangular Survey Coordinates: NE1/4, Sec. 32, T.3N., R.6E. Ahloso Quad.

Henryhouse Local

Fossils: diverse, Upper Silurian fauna dominated by several species of brachiopod, as well as abundant crinoid debris.

From Chimneyhill Creek, continue north on road. It makes a northwest bend before going north again. The road then curves to the west, at which point go another 1/4 mile. Site is on the north side of the road.

Rectangular Survey Coordinates: Center Sec. 29, T.3N., R.6E. Ahloso Quad.

Croweburg Coal Pit

Fossils: near the bottom of the strip mine, in the black shale just above the Verdigris Limestone a well preserved, dwarf fauna of coiled ammonoids may be collected.

The most productive parts of the pit occur 6 miles due north of the town of Oneta.

Rectangular Survey Coordinates: E1/2 Sec. 20 and NW1/4 Sec. 21, T.19N., R.15E., Oneta Quad.

Bixhoma Lake

Fossils: Middle Pennsylvanian molluscan fauna represented by small bivalves and bellerophon gastropods.

Just 2 miles due south of Leonard. Best collecting right above the spillway for Bixhoma Lake.

Rectangular Survey Coordinates: SW1/4, NE1/4, Sec. 2, T.16N., R.14E., Leonard Quad.

US 412 Road Cut

Fossils: well-preserved monotypic assemblage of **Mesolobus** (brachiopod), within dark gray limestone at the base of the Fort Scott Formation.

Located on the south side of US 412, about 3/4 mile east of I44/412 interchange.

Rectangular Survey Coordinates: NW1/4, NE1/4, Sec. 6, T.19N., R. 15E., Catoosa Quad.

Catoosa West

Fossils: for those who don't like parking along busy highways, same as location 21, above, **Mesolobus** at the base of the Fort Scott Limestone.

Located on the south side of a shallow, E-W drainage, immediately to the southwest of the town of Catoosa, and ~3/4 mile northeast of the Indian Hills Country Club.

Rectangular Survey Coordinates: NE1/4, NW1/4, Sec. 3, T. 20N., R. 15E., Mingo Quad.

Wekiwa South

Fossils: Middle Pennsylvanian-aged assemblage at the top of the Muncie Creek Shale, consisting of **Meslobus**, productid brachiopods, crinoid debris, and rare conulariids.

Just on the north side of State Hwy. 51, 6.2 miles west of intersection between 51 and State Hwy. 97, south of the Arkansas River.

Rectangular Survey Coordinates: Center of N line, NE1/4, Sec. 14, T.19N., R.10E., Wekiwa Quad.

Petrified Wood in Oklahoma

By Neil H. Suneson

While not blessed with the abundance or beautiful colors of petrified wood from Arizona and other western states, Oklahoma can boast that it has the oldest *and* youngest petrified wood of any state in the nation. Our oldest wood is about 375 million years (m.y.) old and formed from the most primitive true trees that grew on the Earth, and our youngest wood, approximately 15 million years old, grew along rivers that were eroding the Rocky Mountains. Some of our most spectacular specimens of ancient trees, although not "technically" petrified wood, are associated with eastern Oklahoma's coal beds that were deposited about 310 m.y. ago. No other state has the diversity of ancient wood that Oklahoma does.

Petrified wood forms when wood is quickly buried in sand or mud, typically in a river channel during a flood. In some cases, however, wood can be buried in a beach or deep-marine environment. Under just the right conditions, silica (SiO_2) dissolved in groundwater is "templated" on the organic material in the wood; in addition, some silica crystallizes within the pore spaces in the wood. Depending on the timing of the various processes and the degree to which they progress, the wood can be fragile and splintery or completely solid, and the cellular structure of the wood can be perfectly preserved or completely destroyed.

Some "fossil wood" in Oklahoma, while it looks and "feels" like petrified wood is, in fact, not petrified wood. Rather, it is a "cast" that forms when wood buried in sediment, decays, leaving a mold that preserves many of the features present on the outside of the wood. If the mold fills with sediment which then hardens, the cast that forms resembles petrified wood but did not form as a result of silica-templating or pore-filling of organic material.

Where does petrified wood occur in Oklahoma? The oldest is called *Callixylon* and occurs in the Devonian-age Woodford Shale formation in the Arbuckle Mountains and near Ada. A superb specimen can be seen at the entrance to East Central University in Ada. Most Pennsylvanian (about 320 to 300 m.y. ago) wood in Oklahoma are casts that, while not as spectacular as the one on the display at the Canadian Historical Society's museum in El Reno (originally found in Alderson), can be found in some sandstone beds in LeFlore, Latimer, Haskell, and Pittsburg Counties. Some true Pennsylvanian petrified wood occurs near Ada and near the coal beds of northeastern Oklahoma. Permian petrified wood (about 280 m.y.old) is associated with some of the state's small, uneconomic copper deposits in Payne and Noble Counties. Cretaceous (145 to 65 m.y. ago) wood is Oklahoma's most common and is found in the same age rocks as many of the state's dinosaurs, particularly the Antlers Formation in southeastern Oklahoma; some buildings in Ardmore are built of Antlers petrified wood. The same-age rocks near Kenton once had tree trunks as large as 2.5 feet in diameter and 85 feet long, but these have long since been removed by collectors. The youngest petrified wood in Oklahoma is in the mostly Miocene (25 to 5 m.y. ago) Ogallala Formation of Beaver, Harper, and Ellis Counties.

BECOMING A GEODETECTIVE – SOLVING EARTH'S MYSTERIES

ACTIVITY #1

OBJECTIVES

- To use trace fossils to determine if sediment surfaces have been reworked.
- To learn some conditions that might help explain the lack of trace fossils within a stratum (rock layers).
- To learn what is meant by facies change, a time-rock unit, and reworking of sediment.

CLASS DISCUSSION

- A ***facies change*** represents a lateral or vertical variation in the lithologic (rock features) or paleontological (fossil) characteristics of contemporaneous sedimentary deposits (deposits that occurred during the same period of time) caused by, or reflects, a change in the sedimentary environment.
- A ***time-rock unit*** is a subdivision of rocks considered solely as the record of a specific interval of geologic time.
- Discuss ***reworking***. Reworked means sediment, fossil, rock fragment, or other geologic material has been removed or displaced by natural agents (wind, water, etc.) from its place of origin and incorporated in recognizable form in a younger succession of strata.

CLUES

- We represent examples of trace fossils preserved in the rock record reflecting changes in the depositional (sedimentary) environment.

QUESTIONS

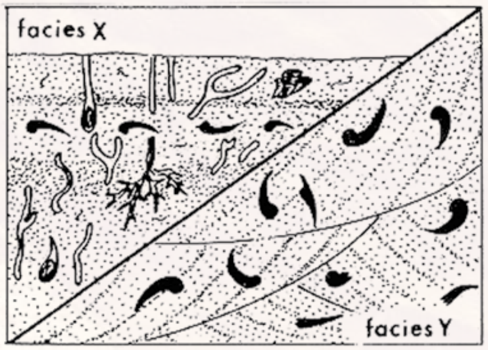
Using the illustration shown, answer the following questions.

1. A. What biological evidence suggests the sediment of Facies X does *not* represent a reworked sediment?____________________

   ____

   B. What evidence suggests the sediment of Facies Y *does* represent a reworked sediment?____________________________

   ____



Trace fossil patterns resulting from facies changes within a succession of rocks deposited in a specified interval of geologic time (after Brice & Levin, 1981).

Suggest some conditions other than the reworking of sediments that might account for the lack of trace fossils within a stratum.

____

ACTIVITY #2

OBJECTIVES

- To introduce the concept of a trace fossil.
- To point out that the fossil record contains not only body fossils but also the preserved behavioral patterns of animals.
- To introduce a clastic sedimentary rock called shale/sandstone that in the geologic past was once soft, unconsolidated, within and upon which animals may have crawled, dwelled, grazed, rested, and/or preyed.

CLASS DISCUSSION

- Traces, both fossil and modern, are biologically produced sedimentary structures that include tracks, trails, burrows, borings, fecal pellets, and other traces made by the life processes of organisms.
- Many trace fossils are formed by the activities of organisms that generally are not preserved because they lack hard parts. For example, worms, sea anemones, starfishes, sea cucumbers, and shrimp.
- Traces reflect the behavioral functions of organism such as resting, crawling, dwelling, grazing, feeding, preying, and escaping.
- Trace fossils are of importance primarily as indicators of animal behavior and where preserved intact, they are closely related to the environment in which they were formed.
- Trace-makers are rarely preserved with their traces.
- Look for "traces" of modern organisms near their home, for example, dog or cat footprints, bird tracks, deer tracks, people footprints, insect trackways left on a dried-up mud puddle, earthworm burrows, mud-dauber nest, slug trail, etc.

GLOSSARY

burrow – A biogenic sedimentary structure produced in soft sediment below the water/sediment interface.

ichnology – The scientific study of trace fossils preserved in the rock record.

trace fossil – Any indirect evidence of the former activity of an organism; examples, footprints, tracks, trackways, gastroliths, coprolites, nests, and feeding, mating, crawling, and escaping burrows made in now lithified sediments.

track – A trace left by an appendage of an animal, typically as a result of its locomotion. If a trace is found in the fossil record, it would be considered a type of trace fossil.

trackway – A series of two or more successive tracks made by the same foot.

trail – A path worn by repeated movement of animals along a route, typically the result of numerous trackways.

Some Examples of Trace Fossils

CLUES

- *I am the result of some behavioral activity of an organism.*
- *What produced me is rarely preserved with me.*
- *Some other examples of me include footprints, tunnels, and trackways.*

QUESTIONS

1. What am I called? ____________________________
2. What organism do you think made me? __________________
3. Why is the trace-maker rarely found with the trace fossil?

   ____
4. Name some biological activities of organisms that may be found preserved as trace fossils in the rock record. ______________

   ____
5. How do geologists hypothesize as to what organism may have produced a particular trace fossil in rocks millions of years old?

   ____

Answer these questions by visiting: https://nie.newsok.com/educators/curriculum/oklahoma-rocks-fossils-come-alive/ and be entered into a drawing to win a **$250.00 VISA Gift Card.** **ALL ENTRIES ARE DUE BY DECEMBER 28, 2016.** Also, if you win, your teacher will win a **$500.00 VISA Gift Card.** The drawing will be held on December 28, 2016.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