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## FOSSILS OF THE BADLANDS OF SOUTH DAKOTA

### What Are Fossils?

A fossil is any physical evidence of life that occurred before the end of the last ice age, approximately 10,000 years ago. Fossils consist of skeletons, impressions, *casts*, tracks, trails, and burrows. Ancient seashells, footprints, *petrified* wood, and coal are all types of fossils. Fossils that are evidence of disturbance by once-living creatures, such as tracks, trails and burrows are referred to as trace fossils. The oldest known fossils are of single-celled bacteria, and may be billions of years old.

Most fossils are found in *sedimentary rocks*. The fossils are preserved in the rock at the time the rock forms. Such rocks may be *claystone*, *shale*, *siltstone*, *sandstone*, *limestone*, or *conglomerate*. A rock type that extends over a large mappable area is called a *formation*.

### How Are Fossils Formed?

Fossils may be formed by molding, *casting*, or by *permineralization*. A mold is the imprint of a living organism that has survived the length of time necessary to

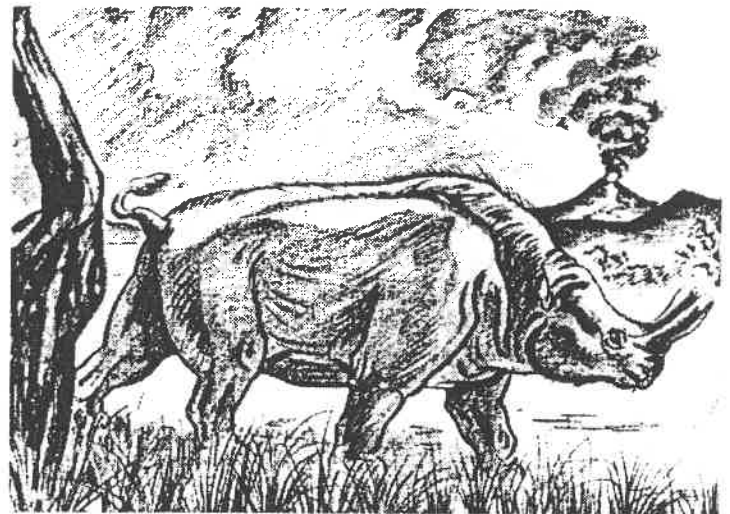


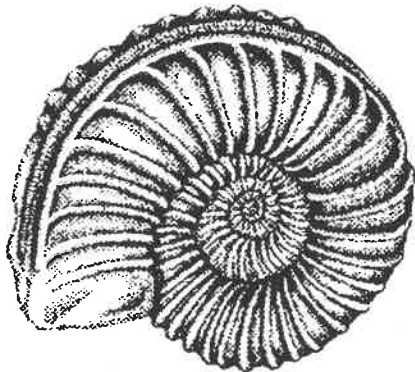
Figure 1. *Brontothere*

be considered a fossil. For example, a footprint preserved in rock is a mold. A *cast* may be formed when an organism decays away and leaves a mold in the rock. The mold is then filled in with silt, ash, or other material that eventually hardens into rock and preserves the exact shape of the original organism. Such a fossil is called a *cast*. Tree roots or animal burrows may be preserved as *casts*. *Permineralization*, sometimes called *petrification*, is the process that turns bone, shell, or wood into rock, but retains the original structures, such as

cells, growth lines, and tree rings. If one mineral is exchanged for another mineral, the process is called replacement.

## What Fossils Are Found In The Badlands?

The Badlands are known for their abundance of fossil mammals. Preserved in the layers of exposed rock and ancient soils are fossil *brontotheres* (see Figures 1 and 3), rhinoceroses, horses, *oreodonts*, camels, *entelodonts* (pigs), rabbits, rodents, and carnivores. Non-mammal species include turtles, crocodiles, birds, small lizards, and snails. Plant fossils, in the form of seeds and root tracings, are common as well. Fossils from the Pierre shale include *ammonites*, shown in Figure 2, and *mosasaurs*.



**Figure 2. Fossilized Remains of an Ammonite.**

## Where Are Badlands Fossils Found?

Fossils of the Badlands are found in two major *formations*, the Chadron and the Brule. The Chadron *formation* is made up of *sedimentary rock* that was deposited between 37 and 34 million years ago. The climate during that time period was much warmer than it is today. South Dakota was sub-tropical and had animals such as crocodiles, *brontotheres*, and horses. There were no grasses here at

the time, so the plant eating animals had to browse, much like deer do today.

The Brule *formation* is made of layered *sedimentary rock* that formed between 34 and 29 million years ago. The Brule *formation*, a series of fine layers like pages in a book, tells a different climatic story than the Chadron. A cooler and drier climate caused swamps to dry up, crocodiles to leave the area, and *brontotheres* to become *extinct*. This was the time of the *oreodonts*, whose populations ran in the millions. Horses, rhinoceroses, camels, *entelodonts* (pigs), rabbits, rodents and *carnivores* were also common. The Brule *formation* of South Dakota has one of the largest and most complete assemblage of fossil mammals in the world.

Above the Brule *formation* lies the slightly younger Sharps *formation*. The Sharps' *sedimentary* layers are composed mostly of volcanic ash, and show evidence of a time of active volcanoes farther west, possibly in present-day Colorado or Nevada. Another *formation* that is often found near the Badlands, and is much older than either the Brule or Chadron *formation*, is the Pierre *shale*. The Pierre *shale* is the *sedimentary rock* formed on the bottom of an inland sea that covered the area from 75 to 70 million years ago. These years were during the time of the dinosaurs, but since dinosaurs were land organisms, none is found in the *shale*. Common fossil remains found in Pierre *shale* include the *extinct ammonites* and *mosasaurs*.

## Why Are Badlands Fossils Important?

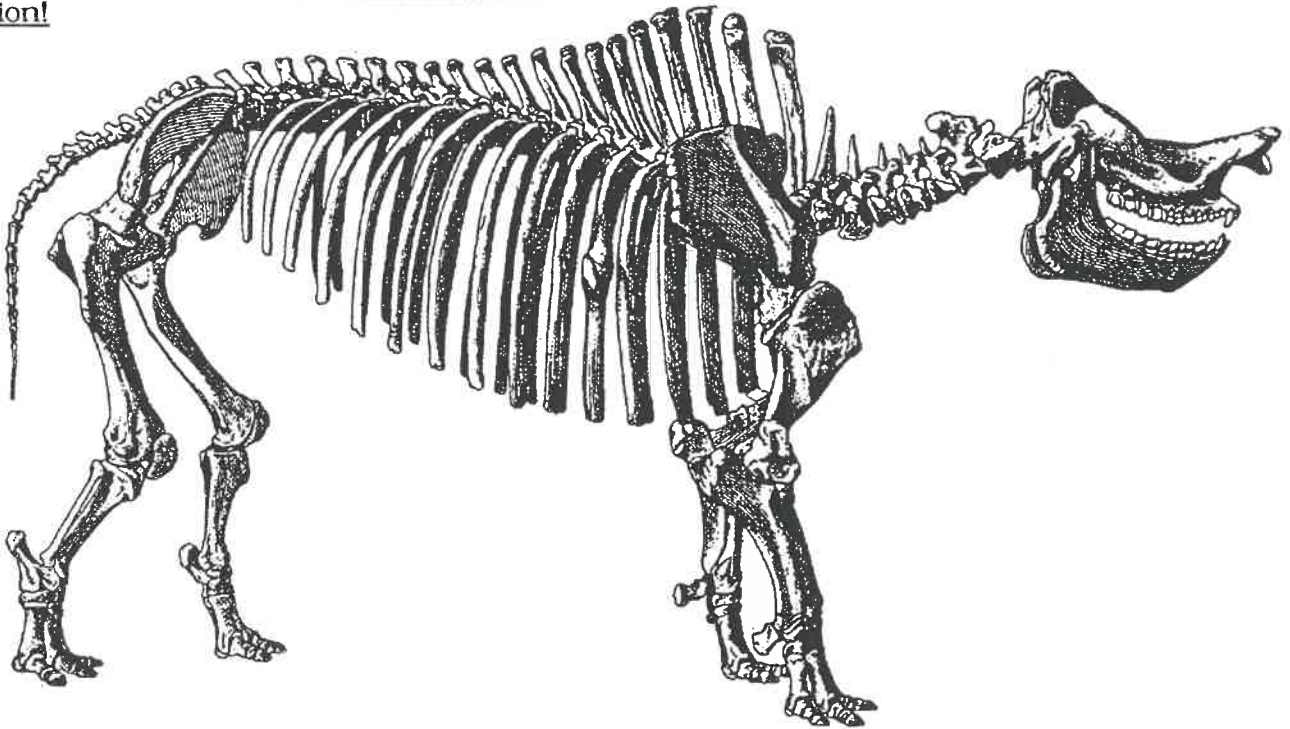
The fossils of the Badlands are important because they represent a well-preserved window into the past. They not only tell us what lived here, but also what the environment was like at the time. From fossils we can learn about food webs and food chains during ancient times and how they compare to today.

## Regulations

A *paleontologist* is a person who studies ancient life. *Paleontologists* enjoy both *geology* and *biology* and split their time between collecting fossils in the field and studying fossils in the laboratory. *Paleontologists* also spend a lot of time researching and studying fossils in museums and libraries. When a *paleontologist* finds a fossil, a map is made, pictures are taken, and careful documentation is entered in a field notebook. Before a fossil is removed, permission must be secured from the owner of the land. On private land, a verbal contract may be enough. On federal land, permission is granted by securing a fossil collecting permit. A good *paleontologist* never removes a fossil without permission!

## Conservation Measures

Most *paleontologists* do not keep the fossils that they collect. The fossils are prepared and placed into museum collections. There they are cleaned, catalogued, protected, and are always available for research and viewing by the public. The South Dakota School of Mines and Technology Museum of Geology in Rapid City is the best place to view fossils in South Dakota. The collections include an extensive display of fossils from the Badlands of South Dakota.



**Figure 3. Skeleton of a *Brontothere*.**

## Glossary

**Ammonite** - an extinct mollusk that is related to squid and octopus but has a chambered and often spiraled shell. The word ammonite is derived from Ammon, an Egyptian god who took the form of a ram. Ammonites are similar in appearance to a ram's horn.

**Biology** - the study of living organisms and systems.

**Brontothere** - a large extinct mammal that was distantly related to rhinoceroses and horses. The word is derived from *bronto* meaning thunder and *there* meaning beast.

**Browse** - to feed on young shoots, twigs, leaves and buds of shrubs and trees.

**Casts** - the preserved sediment or rock that fills a mold or impression, taking the shape of the once living organism.

**Carnivore** - any organism that eats meat.

**Claystone** - a sedimentary rock composed of extremely fine grains.

**Conglomerate** - a coarse sedimentary rock that is composed of varying sizes of other rock.

**Entelodont** - an extinct relative of the modern pig that once grew to the size of a cow.

**Extinct** - applied to a species of organisms that no longer lives.

**Formation** - a unit of rock that may be mapped over a large area.

**Geology** - the study of the earth and the processes that build, form, and modify it.

**Limestone** - a calcium-carbonate sedimentary rock that is often made up of shell material of once-living organisms.

**Mosasaur** - an extinct aquatic lizard that reached twenty to thirty feet in length and fed on fish and ammonites.

**Oreodont** - an extinct group of ungulates distantly related to camels or pigs. The word oreodont is derived from *oreo* meaning mountain and *dont* meaning teeth.

**Paleontologist** - a person who studies ancient life.

**Permineralization** - a fossilization process that changes organic matter to rock but preserves all original structures such as cell spaces, growth lines, stress fractures, and tree rings; sometimes called petrification.

**Petrification** - The process of changing organic matter to rock, called permineralization.

**Sandstone** - a sedimentary rock whose main constituent is cemented sand grains.

**Sedimentary rock** - a rock that is made up of clay, silt, sand, or cobbles which are compacted or cemented together.

**Shale** - a dark fine-grained layered sedimentary rock that usually originates in deep calm water.

**Siltstone** - an exceptionally fine-grained sedimentary rock.

**Ungulates** - hooved mammals, such as deer and horses.

### References

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- Bates, Robert L., Julia A. Jackson, editors, 1984. *Dictionary of Geological Terms*, third edition, American Geological Institute, Anchor Books.
- Carroll, Robert L., 1988. *Vertebrate Paleontology and Evolution*, W. H. Freeman and Company, New York.

### Selected Resources For Teachers

- The White River Badlands* by C.C. O'Harra, 1920. South Dakota School of Mines Bulletin No. 13, Rapid City. 57701
- Teacher's packets and specific information requests put out by Badlands National Park. Office of the Superintendent, P.O. Box 6, Interior, SD 57750.
- South Dakota Museum of Geology, located on the campus of South Dakota School of Mines and Technology, Rapid City, SD. 57701

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