

PALEONTOLOGY

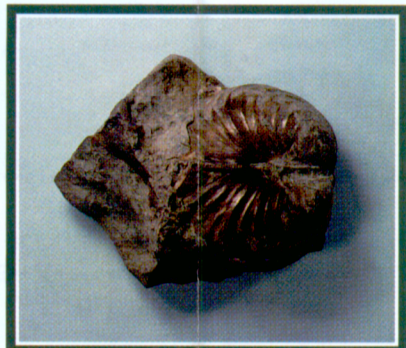
Rocks of the Carlile, Niobrara, and Pierre Formations are exposed in road cuts and along rivers in the Rendezvous Region. These rocks were deposited in subtropical to warm temperate seas, the Western Interior Seaway, which covered North Dakota during Late Cretaceous time from about 90 million to 80 million years ago. Fossils of animals and plants that inhabited those seas are entombed in these rocks. Remains of marine reptiles (mosasaurs, plesiosaurs, and turtles), fish (including sharks), birds, and invertebrates (including clams, cephalopods, snails, corals, and crabs) have been recovered from the rocks.



Cephalopod

Cephalopod, *Clinoscaphites chateausensis*, recovered from the Niobrara Formation.

- Height 1.5 inches
- Collected by the Ralph Werven family



Clam shell

Clam shell, *Inoceramus*, from the Pierre Formation.

- Height 4 inches
- Collected by Richard and Judith Johnson



Pecten shell

Clam shell, a pecten, from the Niobrara Formation.

- Width .5 inch



Oyster Cluster

Cluster of oysters, *Pseudoperma congesta*, found in the Niobrara Formation.

- Width 3.25 inches
- Collected by the Ralph Werven family



Fish Vertebrae

Five articulated fish vertebrae from the salmon-like fish, *Enchodus*, recovered from the Pierre Shale.

- Width 2.5 inches
- Collected by Bob Simmons

Painting of Plioplatecarpus

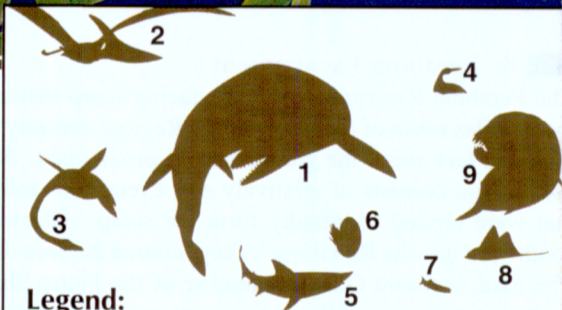
The mosasaur *Plioplatecarpus* was one of the reptiles that inhabited the Pierre Sea. Mosasaurs were huge animals, some up to 30 feet long, with lizard-like bodies. Unlike their terrestrial lizard relatives, the limbs of mosasaurs were modified to form flippers. Mosasaurs swam by lateral undulations of the posterior part of their bodies and laterally compressed tails. Their flippers were used primarily for steering rather than for propulsion as the animal glided through the water. Mosasaurs were active predators and among the main carnivores in the Pierre Sea. They probably preyed on other mosasaurs, fish, turtles, and invertebrates. Although mosasaurs were not dinosaurs, they became extinct at the same time as the dinosaurs, about 65 million years ago.

- Painting on cover panel by Dan Varner

GUIDE TO THE GEOLOGY AND PREHISTORIC LIFE OF THE RENDEZVOUS REGION



NORTH DAKOTA GEOLOGICAL SURVEY
NORTH DAKOTA PARKS AND RECREATION DEPARTMENT
STATE HISTORICAL SOCIETY OF NORTH DAKOTA
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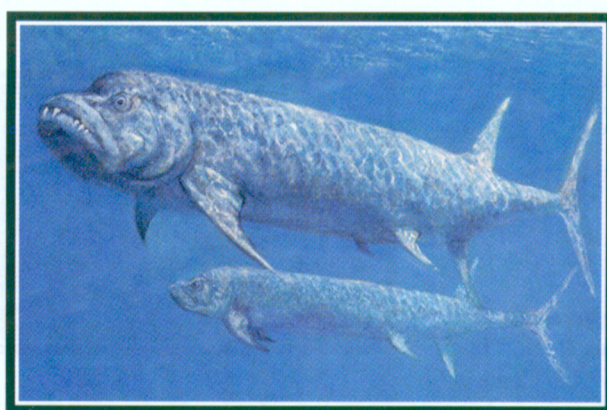


Legend:

1. Mosasaur (*Plioplatecarpus*)
2. Flying Reptile (Pterosaur)
3. Marine reptile (Plesiosaur)
4. Seabird (*Hesperornis*)
5. Sand-tiger shark (*Carcharias*)
6. Cephalopods
7. Salmon-like fish (*Enchodus*)
8. Rays
9. Tarpon-like fish (*Xiphactinus*)

Habitat reconstruction mural

This mural depicts animals that inhabited the Western Interior Seaway in the Rendezvous Region during the Late Cretaceous. The mural, on exhibit at the Pembina State Museum, is based on fossils found in North Dakota.



Painting of Xiphactinus

The tarpon-like fish, *Xiphactinus*, was one of the largest fish that inhabited the Pierre Sea. It grew to lengths of eighteen feet. Its large size, elongate body, powerful tail, and bulldog-like jaws suggest that it was an efficient predator. The large fangs at the front of the *Xiphactinus* mouth were probably used to strike or impale prey during initial attack.

- Painting by Dan Varner

Exhibits

Exhibits of fossils of the prehistoric life that inhabited the Rendezvous Region can be seen at the Pembina State Museum, Pembina; Icelandic State Park, Cavalier; Cavalier County Museum, Dresden; and the Morden Museum, Morden, Manitoba.



Painting of Hesperornis

Hesperornis was a large (up to about five-foot-tall), flightless seabird. It was equipped with sharp, pointed teeth and probably preyed on fish and squids underwater. Although it was incapable of flight, *Hesperornis* was a swift swimmer that could propel itself with its powerful hind legs through the shallow coastal waters of the Pierre Sea.

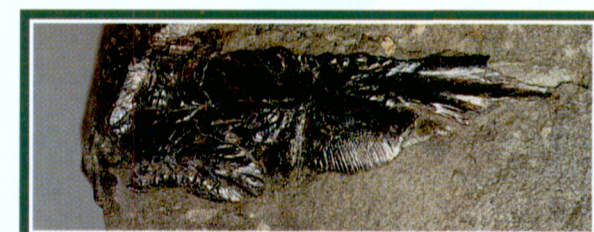
- Painting by Dan Varner



Fish Vertebrae

Six articulated fish vertebrae from the barracuda-like fish, *Stratodus apicalis*, collected from the Pierre Shale.

- Width 6.5 inches



Part of a fish skull

Part of a skull from the salmon-like fish, *Enchodus*, found in the Niobrara Formation.

- Width 2.25 inches
- Collected by the Ralph Werven family



Mosasaur jaw fragment

Front part of a mosasaur, *Plioplatecarpus*, upper jaw with four teeth, collected from the Pierre Shale.

- Width 3.75 inches
- Collected by Melanie Thornberg



Shark tooth

Tooth of the extinct cow shark, *Squalicorax*, found in the Pierre Shale.

- Width .75 inch



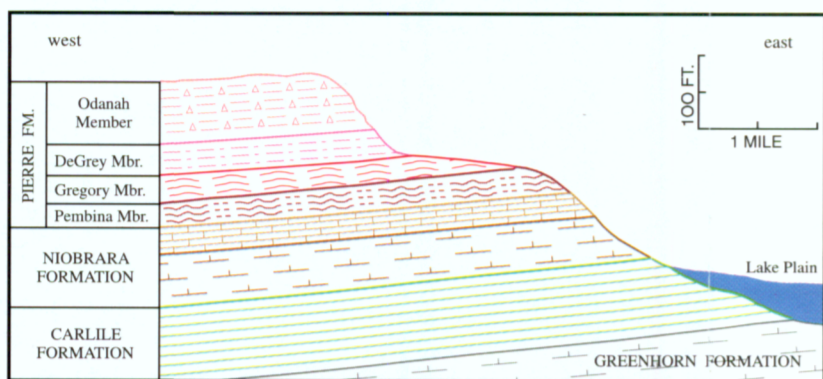
•Text and photographs by John W. Hoganson, N.D.G.S.

•Graphics and brochure layout by Brian R. Austin, S.H.S.N.D.

•Brochure is a cooperative project between the North Dakota Geological Survey, North Dakota Parks and Recreation Department, and State Historical Society of North Dakota.

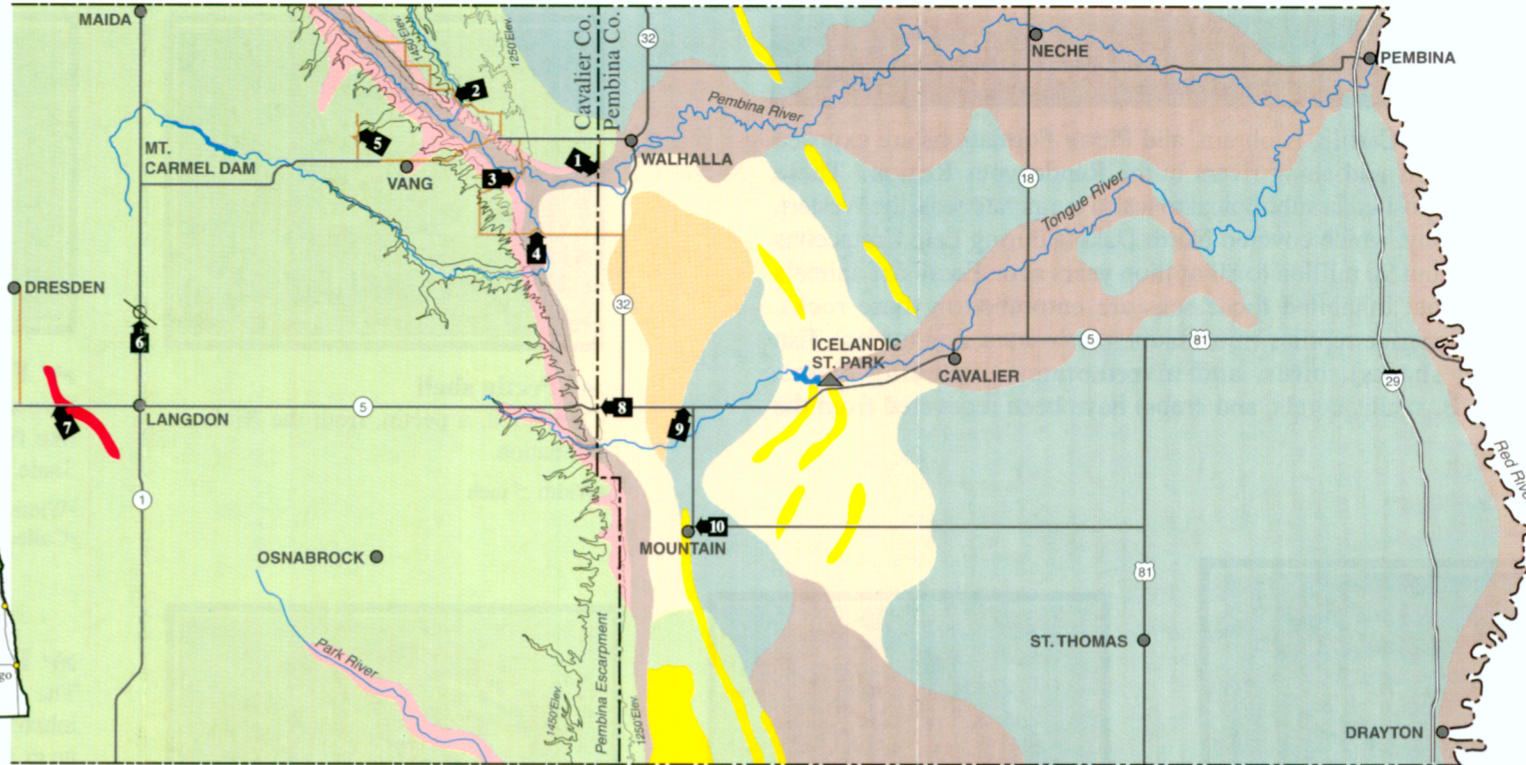
GEOLOGY

Nearly the entire surface of Cavalier County consists of gently rolling to undulating terrain and is underlain by sediments deposited during the last advance of glaciers into the Rendezvous Region about 12,000 years ago. Subtle land forms were produced by these glaciers. The Pembina Escarpment, along the eastern edge of Cavalier County, marks the eastern edge of this glaciated plain. East of the escarpment is the Red River Valley, which is the former floor of glacial Lake Agassiz that occupied the valley about 11,000 years ago. The extremely flat Lake Agassiz basin terrain of Pembina County, one of the flattest areas in the world, is interrupted in the western part of the county by low, elongate hills that were Lake Agassiz beaches. Cretaceous-age rocks that underlie the glacial deposits in the Rendezvous Region are exposed where rivers, primarily the Pembina River and its tributaries, have cut through the glacial deposits, primarily in the Pembina Gorge. These Cretaceous rocks were deposited in oceans that covered the area between about 90 million and 80 million years ago. The rocks contain fossils of the animals that lived in those oceans.

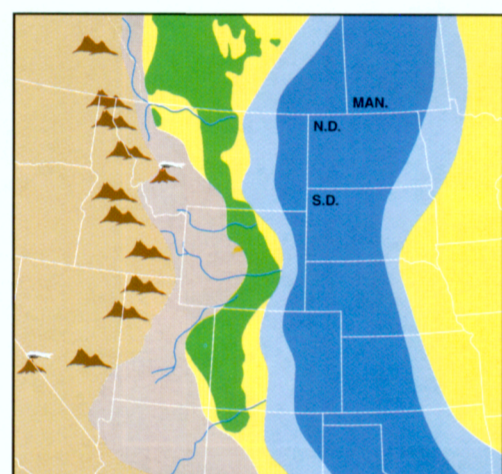


Pembina Escarpment Cross Section

Profile of the Cretaceous rocks exposed along the Pembina Escarpment.

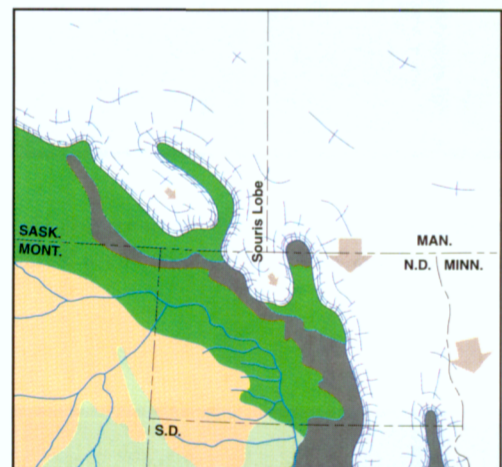


Geologic Map of the Rendezvous Region



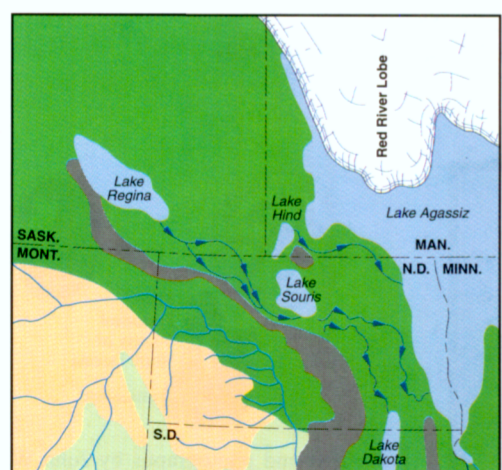
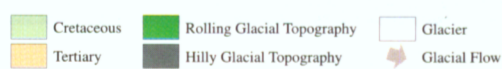
Cretaceous Sea ~ 85 Million Years Ago

During the Late Cretaceous, North Dakota was covered by an ocean known as the Western Interior Seaway.



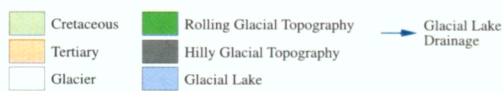
North Dakota ~ 14,000 Years Ago

Eastern North Dakota, including the Rendezvous Region, was covered by glaciers during the Ice Age.



North Dakota ~ 11,000 Years Ago

At the end of the Ice Age, glacial Lake Agassiz covered the eastern portion of the Rendezvous Region.



A GEOLOGIC TOUR OF THE RENDEZVOUS REGION

To tour the geologic features of the Pembina Gorge and the Red River Valley in the Rendezvous Region, follow the numbered black arrows on the map above. The numbers and arrow directions correspond to the following photographs.



1: Pembina River Gorge Overlook

The Pembina River has eroded through glacial sediments and Cretaceous bedrock to form the Pembina Gorge, one of the most scenic areas in North Dakota. View is to the southeast from Tertrault Overlook west of Walhalla.



2: Walhalla Mosasaur Site

At this road cut, the Cretaceous Niobrara Formation is overlain by the Pembina Member, the lowermost member of the Pierre Shale in the area. These rocks were laid down in oceans that covered most of North Dakota about 84 million years ago. The Niobrara consists of light-gray to yellowish-tan, blocky, calcareous clay. Fossils of ammonites, clams, fish (including shark teeth), and sea turtles have been found in the Niobrara in the Rendezvous Region. The Pembina Member is a soft, black, noncalcareous shale that contains gypsum. It also contains numerous beds of yellowish-white bentonite clay (altered volcanic ash derived from volcanoes active in western Montana at that time), particularly at its base. The contact between the Niobrara and Pierre Formations is beneath the lowest bentonite band. Fish and mosasaur (large marine reptiles) remains have been found in the Pembina Member. This site was a promising fossil site until it was destroyed by road construction activity in 1996. Because this site is located on land owned by the State of North Dakota, destruction of the site violated North Dakota's Paleontological Resource Protection Act. Collecting of vertebrate fossils at this site and any site on State of North Dakota land is prohibited without a permit issued by the North Dakota Geological Survey. View is to the west.



3: Exposures of the Carlile Formation in Pembina Gorge

The Cretaceous-age, 90-million-year-old Carlile Formation is well exposed in this area of the Pembina Gorge. The Carlile Formation consists of soft, black, noncalcareous shale deposited in an offshore marine environment. At this locality, the Carlile is about 160 feet thick and is overlain by 30 feet of light-colored Niobrara Formation. The Carlile contains fossil shells of invertebrate animals and fish scales. It is the oldest rock formation exposed in North Dakota. View is to the east.



4: Glacial Erratics in Little South Pembina River

Glacial erratics, boulders carried to the Rendezvous Region by glaciers, are seen on the upland, glaciated areas of Cavalier County and in the rivers. The composition of the erratics provides information about where they came from and the direction the glaciers moved. View is to the north.



5: Exposures of the Odanah Member of the Pierre Shale in gravel pits

The uppermost named member of the Pierre Shale, the Odanah Member, is exposed in this gravel pit. It was deposited in a shallow-water marine environment during the Cretaceous about 80 million years ago. The Odanah Member is a hard, siliceous, light-gray shale. Because of its hardness, it forms conspicuous cliffs and is quarried for road surfacing material. Fossils are scarce in the Odanah, although oyster fossils have been recovered. View is to the northwest.



6: Drumlin north of Langdon

Highway 1, four miles north of Langdon, cuts through a northwest-southeast trending, elongate hill called a "drumlin." Drumlins are streamlined hills that were molded beneath sliding glaciers. The position of the drumlin indicates that the glacier flowed from the northwest to the southeast. View is to the north.



7: Esker west of Langdon

Highway 5, four miles west of Langdon, cuts through a long, northwest-southeast trending, sinuous ridge called an esker. Eskers consist of sand and gravel that were deposited by streams and rivers that flowed through tunnels and cracks in glaciers. View is to the northwest.



8: Pembina Escarpment

The Pembina Escarpment, an east-facing scarp that extends for many miles south of the Rendezvous Region, abruptly rises more than 250 feet above the glacial Lake Agassiz plain. Most of the escarpment consists of relatively soft Cretaceous marine shales that were eroded to initially form the scarp. Glaciers moving southward into the Red River Valley scoured the face of the scarp. The hard, resistant Odanah Member of the Pierre Shale, which occurs near the top of the escarpment, prevents rapid erosion of the scarp. View is to the west.



9: Sand dunes west of Cavalier

Highway 5, about 11.5 miles west of Cavalier, cuts through sand dunes. These dunes were formed by winds transporting and depositing sediments derived from the Pembina Delta. The delta was formed where the ancient Pembina River emptied into glacial Lake Agassiz and deposited large amounts of sand about 9,000 to 10,000 years ago. These sand dunes also began to form several thousand years ago. View is to the north.



10: Campbell Beach Ridge at Mountain

The town of Mountain is built on one of the beaches, called the Campbell beach ridge, that formed along the shore of glacial Lake Agassiz about 11,000 years ago. The Campbell beach ridge represents a still stand of the water level in Lake Agassiz that probably lasted about 100 years. The Campbell beach ridge can be traced around the Red River Valley and is present on both the western and eastern sides of the Lake Agassiz plain in North Dakota and Minnesota. View is to the west.