Geology and Paleontology of Northwestern Kansas: Public Field Trip

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Introduction

As the title suggests, this field trip will focus on the geology and paleontology—that is, the rocks and fossils of northwestern Kansas. The five stops in Logan, Gove, and Scott counties (fig. 1) will take us through two of the state's physiographic regions: the Smoky Hills and the High Plains (see factsheets). Except for Stop 3, the field trip focuses on rocks deposited late in the Cretaceous Period, about 80 million years ago (see geologic timetable), specifically, the Niobrara Chalk (fig. 2). The field trip is cosponsored by The Nature Conservancy, Kansas Chapter.

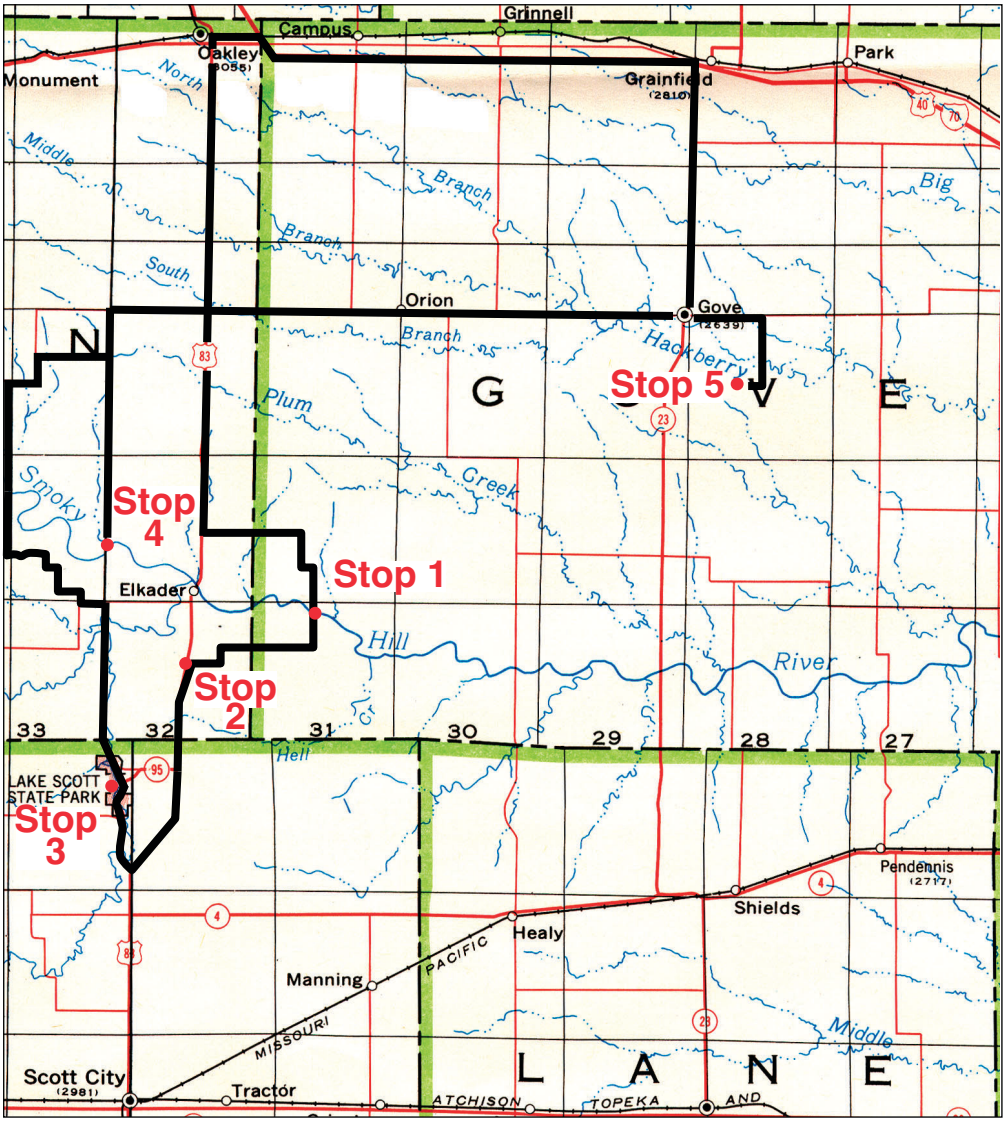

Fig. 1—Map of the May 3, 2003, field trip route.

The Legalities of Fossil Collecting in Western Kansas

Commercial fossil collecting—collecting and restoring fossils for resale to private buyers and museums—became a contentious issue in the 1980's when a market for fossils, particularly large vertebrate fossils, began to develop. Landowners in the chalk beds became concerned that fossil hunters were trespassing on property to collect fossils and selling fossils without making landowners aware of their market value (McCauley et al., 1997).

In response, the 1990 legislature passed a law (Kansas Statutes Annotated 21-3759) requiring commercial fossil hunters to "obtain written authorization of the landowner to go upon such land for such purpose and when requesting such written authorization has identified oneself to the landowner as a commercial fossil hunter." Commercial fossil hunters must also provide landowners with "a description of the fossil" they intend to collect and receive owner authorization, in writing, to remove it.

This legislation applies only to commercial fossil collecting. It does not apply to casual collectors who are searching for fossils for their own use or for use in a classroom, or to groups such as school children, 4-H'ers, or boy and girl scouts. Of course, such casual collectors must obey existing laws related to trespass and must secure owner permission before entering private property to search for fossils.

This permission is particularly important because some landowners in the area have signed lease agreements with fossil collectors, in essence giving those collectors exclusive right to take fossils from their property. These agreements are somewhat akin to leases for mineral rights, and allow the landowner and the fossil hunter to share in the proceeds from the sale of any fossils. Because these leases may give the person holding the lease exclusive right to collect on a piece of property, landowners cannot allow other people, including casual collectors, to collect on their land.

From Oakley to STOP 1

We begin our field trip in Oakley, at the crossroads of two federal highways, U.S. 40 and U.S. 83. Located in the extreme northeastern corner of Logan County, Oakley is the county seat, replacing the more centrally located former county seat of Russell Springs. Its location on major transportation routes, including I-70 and the Union Pacific Railroad, has allowed Oakley to survive, while Russell Springs has faded in importance.

Oakley is situated in the High Plains physiographic region (see factsheet); the elevation of our starting point is 3,062 feet. Beneath Oakley is up to 226 feet of Ogallala Formation (fig. 2), the primary component of the High Plains aquifer. As we will discuss in more detail at Stop 3, the Ogallala consists of sediments that eroded off the Rocky Mountains during the Tertiary Period (see geologic timetable).

The High Plains aquifer supplies the numerous center-pivots that irrigate the fields around Oakley. Nearly all the irrigation in Logan County occurs along the northern fringe of the county. As we proceed south along U.S. 83 toward the Smoky Hill River, we will see the landscape and agriculture change. The irrigated fields will be replaced by dryland farms and shortgrass pastures and rangeland. Once we enter the Smoky Hills physiographic region (see factsheet), the topography will become more dissected and outcrops more common.

Much of the High Plains is covered by a fine, loose silt called loess. Much of this loess was deposited as windblown dust during the ice ages of the last few hundred thousand years. Although glaciers never reached this part of Kansas, glaciers in the Rockies to the west and in the upper Midwest and northern Plains produced large amounts of finely ground rock material that was carried by strong winds and deposited across large areas, including the High Plains of Kansas.

This loess has buried the Ogallala and older rocks that would ordinarily crop out across the High Plains. Outcrops are restricted to those areas where stream erosion has removed the overlying loess. Our first glimpse of the Ogallala occurs as we cross the Middle Branch of Hackberry Creek, about 8 miles south of Oakley. As we continue south, deeper into the Smoky Hill River valley, we enter an area where the Ogallala has been removed by erosion and the Niobrara Chalk from the Cretaceous Period pokes out from its loess covering.

Our first stop will be at Monument Rocks, where we'll get a close-up look at the Niobrara Chalk.

STOP 1—Monument Rocks

Monument Rocks is a series of chalk monoliths in western Gove County (fig. 3). Like Castle Rock in the eastern part of the county, Monument Rocks

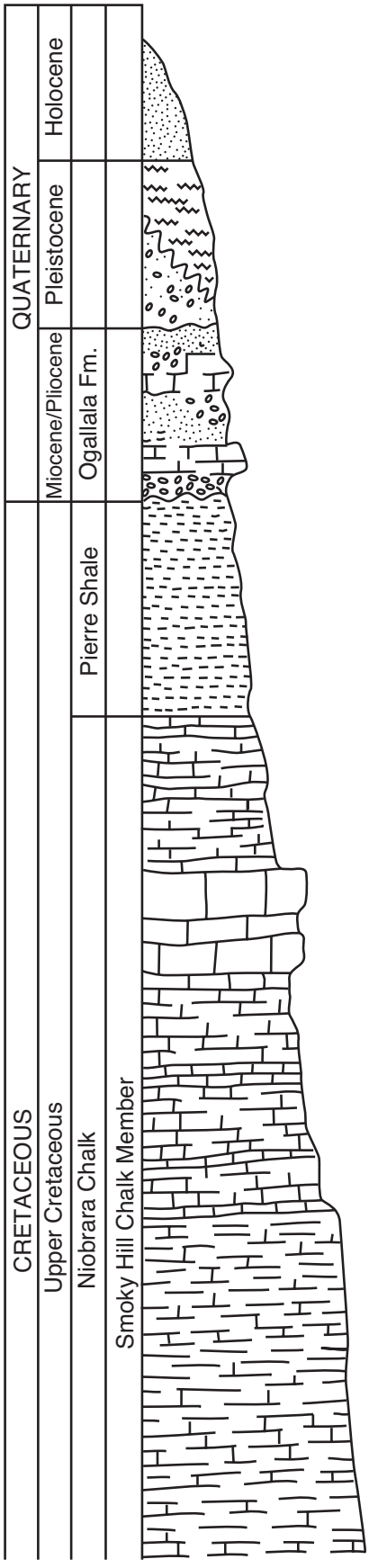

Fig. 2—Stratigraphic column of rocks encountered on this field trip.

Fig. 3—Monument Rocks, Gove County.

served as a landmark for early travelers and pioneers. It remains a popular tourist site in the Smoky Hill River valley.

Monument Rocks was carved by wind and water in the thick chalk of the Smoky Hill Chalk Member of the Niobrara Chalk (fig. 2). These rocks were deposited during the later part of the Cretaceous Period, about 80 million years ago, when Kansas (and the western United States) was covered by a vast inland sea, several hundred feet deep (figs. 4, 5). Hundreds of feet of shale, limestone, and chalk were deposited on the floor of this relatively shallow sea.

Chalk is a soft, fine-textured form of limestone, composed primarily (90–99%) of calcite. In its pure form, it is white, but it may be colored by iron oxide or other impurities. At Monument Rocks, harder layers within the chalk protect the relatively soft chalk below from erosion, creating the distinctive buttes or monuments. Nonetheless, erosion continues to wear away pieces of these monuments, as was demonstrated by the dramatic toppling of Cobra Rock in 1998 and the collapse of Castle Rock's tallest spire following a thunderstorm in July 2001 (fig. 6).

Chalk is made up of tiny marine organisms that lived near the surface and piled up on the seafloor after death. As the tiny shells accumulated, a soft limy ooze formed, perfect for engulfing and preserving the remains of other animals that fell to the bottom of the sea (some of which we'll see at the Keystone Gallery's museum).

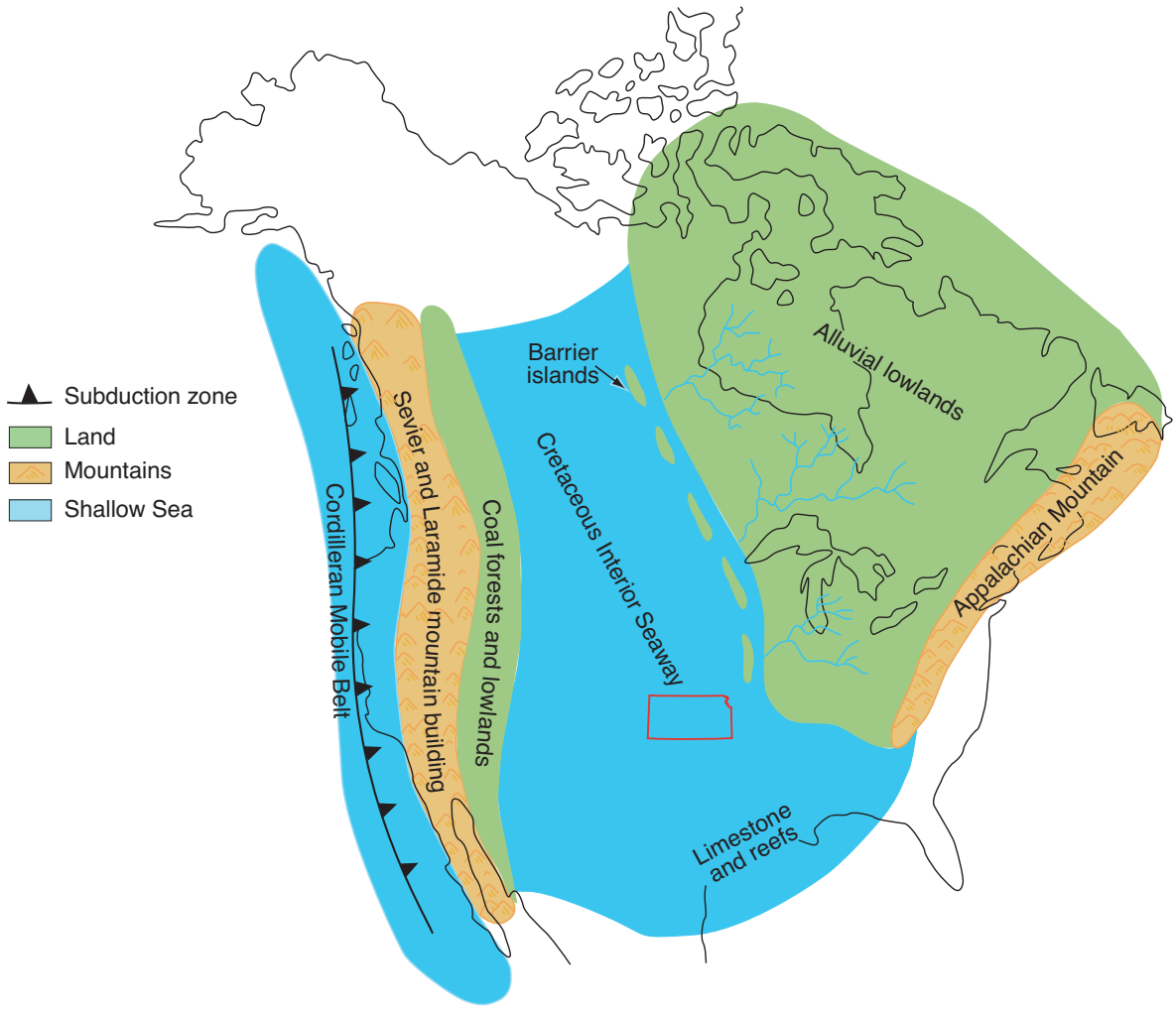

Fig. 4—Geography of North America during the Cretaceous Period, about 100 million years ago. Present-day Kansas is outlined in red (from Wicander and Monroe, 1989).

As we will discuss in more detail at our last stop, the Niobrara Chalk in western Kansas is world famous for its fossils. Beginning in 1868, with the discovery of a large swimming reptile called a plesiosaur, the Smoky Hill Chalk Member produced a variety of large vertebrate fossils that attracted paleontologists from around the world.

Monument Rocks has been designated a National Natural Landmark. Although Monument Rocks is open to the public, visitors should bear in mind that it is located on private property.

STOP 1 to STOP 2

From Monument Rocks we travel south, again crossing the Smoky Hill River. Here the bed of the river is 480 feet lower than our starting point in Oakley. We then travel west back to U.S. 83, passing numerous Niobrara outcrops before we arrive at the Keystone Gallery on the west side of the highway.

STOP 2—Keystone Gallery

Located on U.S. Highway 83, about 7 miles southwest of Monument Rocks, the Keystone Gallery is a museum and gift shop operated by Chuck Bonner and Barbara Shelton. This unique gallery features a variety of fossils collected from the Niobrara Chalk, as well as original artwork by Chuck Bonner.

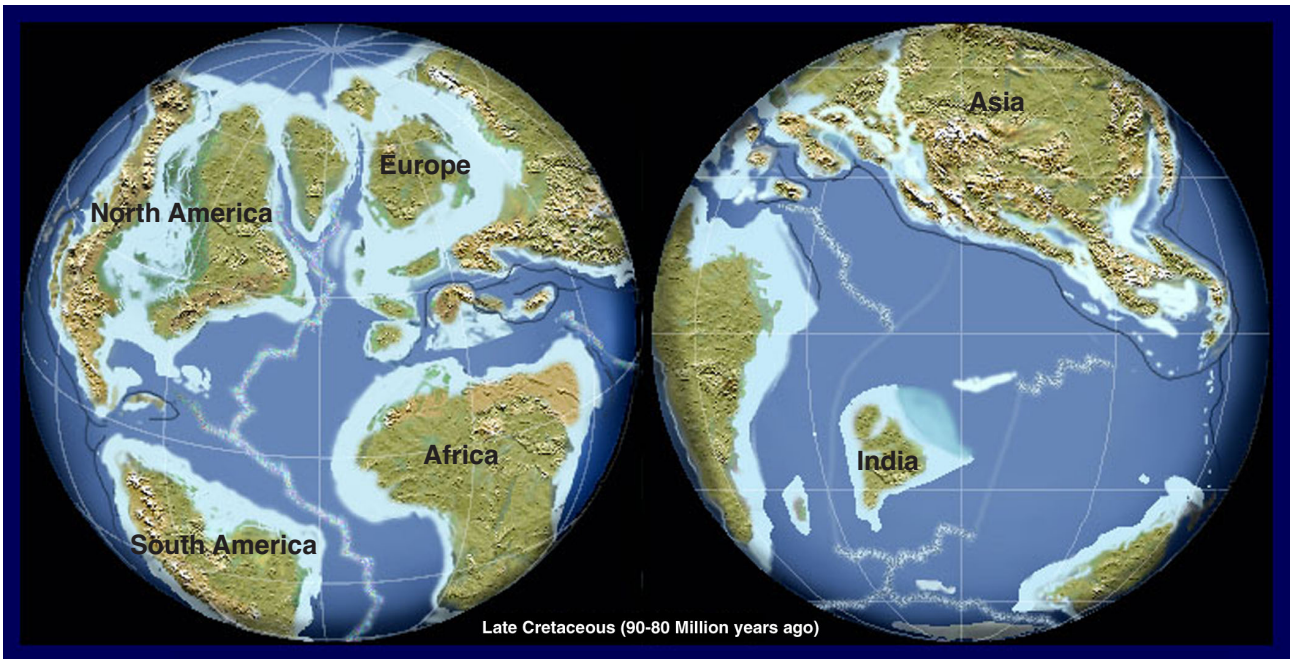

Fig. 5—Position of the continents during the later part of the Cretaceous Period (Blakey, 2001).

Fig. 6—Castle Rock before (1992) and after (2001) the toppling of its spire.

The gallery is housed in a former church, constructed in 1916 out of local chalk. Although officially named the Pilgrim Holiness Church, the church became known as the Keystone Church, and Bonner and Shelton kept this name for their gallery (Bonner, 2002).

Among the fossils on display inside the one-room gallery is a 14-foot-long fish *Xiphactinus audux*. *Xiphactinus* was the largest bony fish that ever lived, with some reaching a length of 18 feet (Bonner, 2002). Its teeth are fairly common fossils in the Cretaceous chalk. These enormous fish had voracious appetites and often ate other fish whole. In fact, some died with their dinners inside of them, as illustrated by the famous "fish within a fish" at the Sternberg Museum of Natural History in Hays, Kansas (Bonner, 2002).

Another important predator in the Cretaceous seas was the mosasaur—a large swimming reptile that sometimes reached 60 feet in length (fig. 7). Mosasaur fossils have been found throughout the Cretaceous chalk, and the gallery has one on display.

The Bonner family has been collecting Cretaceous fossils from the Niobrara Chalk for several generations, since 1928. Some of the specimens they've collected over the years, including a sea turtle and a plesiosaur (a cousin of the mosasaur), are on display in the Sternberg Museum of Natural History (Bonner, 2002).

STOP 2 to STOP 3

From the Keystone gallery we travel south on U.S. 83, climbing back onto the High Plains surface that overlies the Ogallala Formation. We turn north on K-95 and follow it into the oasis-like Ladder Creek valley, descending through rugged outcrops of the Ogallala Formation that surround Lake Scott. We will proceed into Lake Scott State Park, where we will get a look at outcrops of the Ogallala Formation and visit one of the large springs that have created this oasis.

STOP 3—Lake Scott State Park

Listed by National Geographic's Traveler magazine as one of the country's 50 must-see state parks, Lake Scott State Park is located west of U.S. 83, between Oakley and Scott City on K-95. The park's

Fig. 7—Mosasaurs were large, swimming reptiles whose fossils are common in Kansas Cretaceous deposits. Kansas mosasaurs ranged in size from the 14-foot *Platecarpus* to the giant *Tylosaurus,* which grew up to 60 feet long. The largest *Tylosaurus* ever found is displayed at the KU Natural History Museum (drawing by Jennifer Sims, Kansas Geological Survey).

rugged canyons and craggy bluffs stand out from the typical shortgrass prairie of the surrounding High Plains region. The 1,200-acre park with its 100-acre lake is a popular place for boating, swimming, camping, hiking, and wildlife observation.

The park officially opened on June 12, 1930, one of the first areas set aside in the Kansas parks system. It averages about 180,000 visitors a year.

In addition to the campsites, swimming beach, playground, and concession area, the park has nature trails that accommodate hikers, horseback riders, and naturalists. Wild turkey, deer, beaver, and bobcat have been found in the park. A privately owned herd of buffalo and elk can be viewed at the south end of the park. The park is also home to the Lake Scott riffle beetle, a very small insect that lives in the well-oxygenated riffles of the park's natural springs. This is the only location on earth in which this species is known to occur.

Ogallala Formation—The park is a good place to see outcrops of the Ogallala Formation, which is well known as an underground aquifer throughout the High Plains. Most of the water pumped for irrigation in the eight-state High Plains region is pumped from the Ogallala Formation.

The Ogallala Formation consists of unconsolidated gravel, sand, silt, and clay that eroded off the Rocky Mountains during late Tertiary times, just a few million years ago. At the park, the Ogallala crops out at the surface as hard, dense sandstones and conglomerates cemented with calcium carbonate, known locally as mortar beds (fig. 8). At the south end of the park, the Ogallala forms a long ridge called Devil's Backbone.

Big Spring—Springs of any sort are relatively rare on the arid landscape of western Kansas. Several historic springs have now dried up with the lowering of the water table in the Ogallala Formation, primarily because of irrigation. However, Big Spring, one of the largest springs in the Ladder Creek valley, continues to flow at about 350 gallons per minute, a rate roughly comparable to estimates made in the 1950's, making it among the most productive springs in the western third of Kansas. Water moves through the Ogallala Formation before encountering the relatively impermeable rocks in the underlying Niobara, then comes out here. In addition to their historic importance, the springs in the Ladder Creek valley are also important ecologically, providing habitat for a species of riffle beetle that is only found in this location.

Fig. 8—Big Spring at Lake Scott, with Ogallala outcrop in background.

STOP 3 to STOP 4

From Stop 3 we will continue south along the west side of Lake Scott and pass the El Cuartelejo ruins. Turning north, we pass the dam on Ladder Creek that forms Lake Scott and then continue down the valley where the contact between the Cretaceous Niobrara Chalk and overlying Ogallala Formation is visible in the canyon walls.

After crossing Chalk Creek, we pass a cluster of chalk monuments known as the Little Pyramids. After turning west and again north, we will see a large area of chalk badlands called Little Jerusalem. This is the largest exposure of Niobrara Chalk in the state.

As we skirt the south and west edge of the Smoky Valley Ranch, we will again cross the Smoky Hill River. We will enter the ranch from the north and pass the site of an old quarry in an orange-colored outcrop of Niobrara Chalk.

STOP 4—Smoky Valley Ranch

With the acquisition of the Smoky Valley Ranch in Logan County in January 1999, The Nature Conservancy, Kansas Chapter, established a 16,800-acre (more than 25 square miles) preserve. This preserve is large enough to support much of the rich diversity of animals and plants that inhabited the shortgrass prairie region. Most of the shortgrass prairie that once covered western Kansas has been cultivated over the past century.

In addition to the Smoky Valley Ranch Preserve, significant remnants of native prairie remain along the Smoky Hill River and its tributaries in Wallace, Logan, and Gove counties. Many of these prairies have been well managed as grazing pastures for decades. However, periodic dislocations in the cattle market and improved dryland crop varieties have induced increasing numbers of landowners to convert their native pastures to cropland.

The ranch is characterized by chalk bluffs overlooking the Smoky Hill River, large expanses of grassland, and rocky ravines. The breaks along the upper reaches of the Smoky Hill River represent the transition zone between the mixed grass and shortgrass prairie regions.

Geology—The oldest rocks exposed at the Smoky Valley Ranch Preserve belong to the Smoky Hill Chalk Member of the Niobrara Chalk (fig. 2), the same rock that makes up Monument Rocks. The Smoky Hill Chalk Member crops out at several localities on the preserve. The largest areas, some covering tens of acres, are found along the Smoky Hill River, but the three main north-south tributaries that cross the preserve north of the river also contain some excellent chalk exposures. These badlands offer scenic views of steep bluffs, steep-walled canyons, and pinnacles carved from the soft chalk by the action of wind and water.

As mentioned earlier, chalk is a soft, porous, very fine grained limestone that forms from the seafloor accumulation of tiny marine organisms that lived near the ocean's surface. The resulting sediment—a soft limy ooze—was the perfect medium for engulfing and preserving the remains of other animals—such as fish, sharks, turtles, clams, and marine reptiles—that fell to the bottom of the sea.

The upper part of the Smoky Hill Chalk Member was quarried for building stone at several locations about 3 miles north of the preserve's ranch house. Saw marks, cut blocks, and other remnants of the quarry operation can be seen at three different sites in this area. The cap rock, a harder, more resistant layer near the top of the Smoky Hill Chalk, was the stone of choice for building. When first uncovered, the stone is soft enough to cut with a saw; after it is exposed to the air, it becomes harder. Examples of structures built from the chalk are the ranch headquarters and the abandoned house near Blue Knob, about a mile southwest of the headquarters.

Rocks in the Pierre Shale, also Cretaceous in age, overlie the Niobrara but crop out only in the northern part of the preserve (Sawin et al., 1999). The uplands are mantled by sand and gravel and windblown silt (loess) deposited during the Pleistocene Epoch, which began about 1.8 million years ago. The youngest rocks on the preserve are sand dunes in the uplands and alluvium in the Smoky Hill River valley that were deposited during the last 10,000 years, during the Holocene Epoch.

STOP 4 to STOP 5

As we leave the Smoky Valley Ranch, we will travel north and then head east into Gove county, crossing U.S. Highway 83. Travelling east, we pass through a crossroad known as Orion and the town of Gove. From the point where we turn east in Logan County, the high point of our trip topographically, we travel on the High Plains surface, but drop 570 feet in elevation by the time we cross Hackberry Creek near our fossil-collecting site at Stop 5.

STOP 5—Fossils in the Niobrara Chalk

Because of the value of large vertebrate fossils, and because of the popularity of fossil collecting in western Kansas, landowners here are particularly sensitive about fossil collecting on their property (see section on legal issues, p. 4). Out of respect for the landowners who have been considerate enough to allow us onto their property, we will not be describing this site in any detail and we ask participants to bear in mind the following:

(1) The Kansas Geological Survey has received permission from the landowner for participants to collect fossils. That permission applies only to this trip, however, and does not constitute permission to return to this location for future visits. Failure to obtain permission from landowners for any future visit would make you liable to prosecution for trespassing, and may mean that

landowners will not allow future field trips to visit this site.

(2) If you find fossils that you believe are particularly unusual or valuable, we ask that you provide that information to the landowners. Then you and the landowner can determine how such fossils should be recovered and where they should eventually reside.

Note: Watch out for rattlesnakes. Local residents have lots of stories about the number of rattlesnakes they've seen in these canyons. While you walk through the chalk beds looking for fossils, or when you turn over rocks, keep an eye out for snakes.

Fossils in the Niobrara Chalk—As we've already mentioned, the Smoky Hill Chalk Member of the Niobrara Chalk is world famous for its well-preserved and scientifically significant fossils. The first vertebrate fossil collected from the chalk was found by Capt. Theophilus H. Turner, the post surgeon at Fort Wallace in the 1860's (Almy, 1987). Turner discovered the remains of a plesiosaur, a large swimming reptile related to the mosasaur. Other collectors soon uncovered additional remains of the vertebrate and invertebrate animals that lived in the vast inland sea that covered Kansas during the Cretaceous Period, some 80 million years ago.

The Cretaceous Period was part of the Age of Reptiles, an era famous for its dinosaurs. Although dinosaurs were restricted to landmasses far from western Kansas, their marine cousins—mosasaurs and plesiosaurs—roamed the seas. Besides these large marine reptiles, huge turtles, sharks, flying reptiles, and toothed-birds also inhabited the area and their fossils have been found in the chalk.

Sharks' teeth and the remains of fish (teeth, vertebrae, bones, and scales) are found at almost all chalk exposures in the region. In general, however, vertebrate fossils are less common than the remains of invertebrates, creatures without backbones.

Probably the most common invertebrate fossils in the chalk are clams and oysters. In fact, the largest clams known, the inoceramids, come from the chalk beds of western Kansas. These extinct clams, some of which had shells with diameters of 6 feet, lived in colonies on the sea floor of the shallow Cretaceous ocean. Great numbers are preserved in the Niobrara Chalk. Some of these huge fossils are covered with encrusting oysters (fig. 9). Others have been found

Fig. 9—This inoceramid clam shell, covered with the shells of encrusting oysters (*Ostrea*), was collected in the Niobrara Chalk of Trego County, Kansas.

Fig. 10—*Uintacrinus socialis* is a stemless crinoid that lived in the Cretaceous seas that covered Kansas roughly 80 million years ago. Among the numerous segmented arms preserved in this slab, a segmented calyx is also visible. This slab was collected in the Niobrara Chalk of Gove County.

with a variety of fish fossils between their shells, indicating that the fish used the giant clam as a safe feeding place.

The crinoid *Uintacrinus* is another noteworthy fossil found in the Niobrara Chalk. Crinoids are echinoderms, relatives of starfishes and sea urchins. Most crinoids have a cluster of segmented arms that sits on top of a long stem, but *Uintacrinus* is different. This spectacular and rare fossil is a stemless crinoid and entire specimens have been found in the chalk (fig. 10). Because *Uintacrinus* occurs in thin layers and weathers easily, finds are rare; one locality for this fossil is Blue Knob at the Smoky Valley Ranch Preserve.

Ammonoids, extinct squidlike creatures that lived inside an external shell, are also fairly common in the Cretaceous chalk. Ammonoids are relatives of the modern squid as well as the octopus and chambered *Nautilus,* all of which belong to the class of animals called cephalopods.

Specimens from the Kansas Cretaceous are exhibited in museums around the world. Some of these include the Smithsonian Institution in Washington, D.C., the American Museum of Natural History in New York, the Denver Natural History Museum, and, here in Kansas, the Sternberg Museum of Natural History in Hays, the KU Natural History Museum in Lawrence, and the Fick Fossil Museum in Oakley.

Stop 5 to Oakley

Following Stop 5, we proceed north and west to the town of Gove. According to the 2000 census, Gove has a population of 105, making it the smallest county seat in Kansas. Some Gove County facilities and offices have been moved to Grainfield in the northern part of the county, which is larger (population 327) and located on I-70.

From Gove we head north to I-70 at Grainfield and travel west, climbing 500 feet to our starting point in Oakley.

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