The Niobrara
A River Running through Time
By Paul A. Johnsgard
University of Nebraska Press

Contents

Chapter One

The Ancient Niobrara Valley

The face of the earth is a graveyard, and so it has always been.
—PAUL SEARS

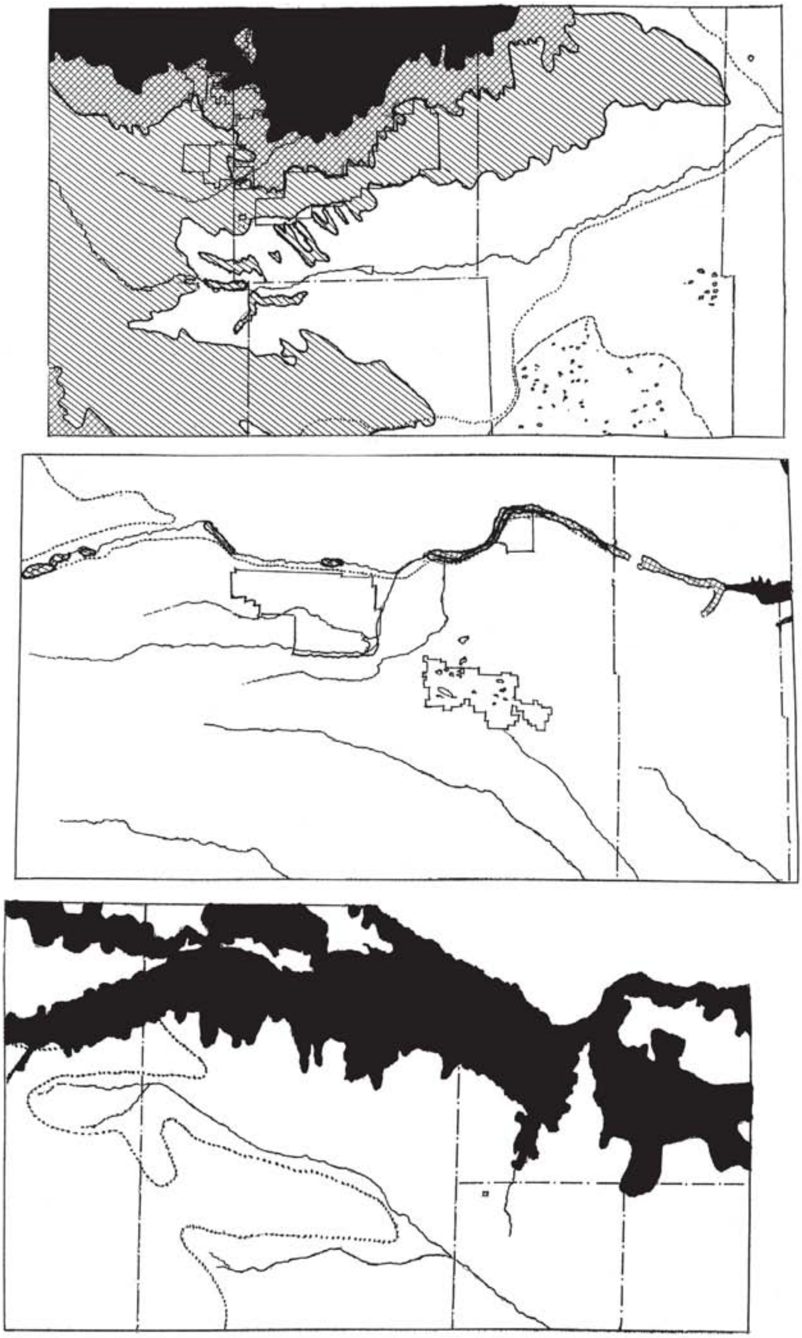
Like the rest of the world, the Niobrara River region is indeed a gigantic graveyard. A prodigious diversity of life forms has occupied its land surface ever since the region slowly emerged from the great Cretaceous sea that covered central North America until about 70 million years ago. These plants and animals left scattered mementos of their transient presence in the form of fossils and other permanent impressions upon the landscape.

Although today we can easily travel the Niobrara Valley and enjoy its vistas for their sheer beauty alone, we cannot really appreciate it without some sense of the vast amount of geologic time that is writ large on its surface and especially is made evident along roadcuts and the steep bluffs that line the river itself. Here decades, centuries, and millennia are compressed into paper-thin horizontal layers, and the transient significance of individual lives and collective human history shrinks into insignificance. Based on this sobering fact alone, it is important to know something of the true age of the Niobrara region and its geologic underpinnings (see maps 1 and 2).

The Cretaceous Period

Before emerging as land near the end of the Mesozoic era, much of interior North America was covered by a shallow Cretaceous ocean. Before

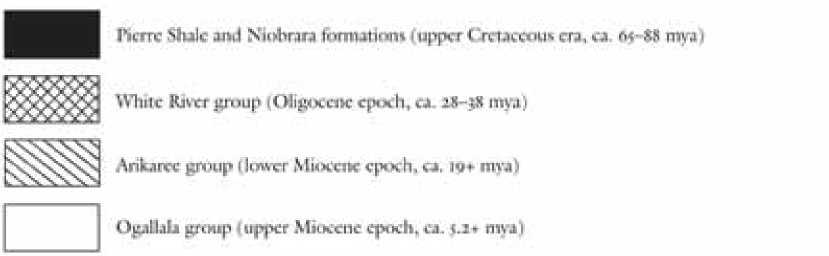
Map 1. Geologic bedrock map of the greater Niobrara region



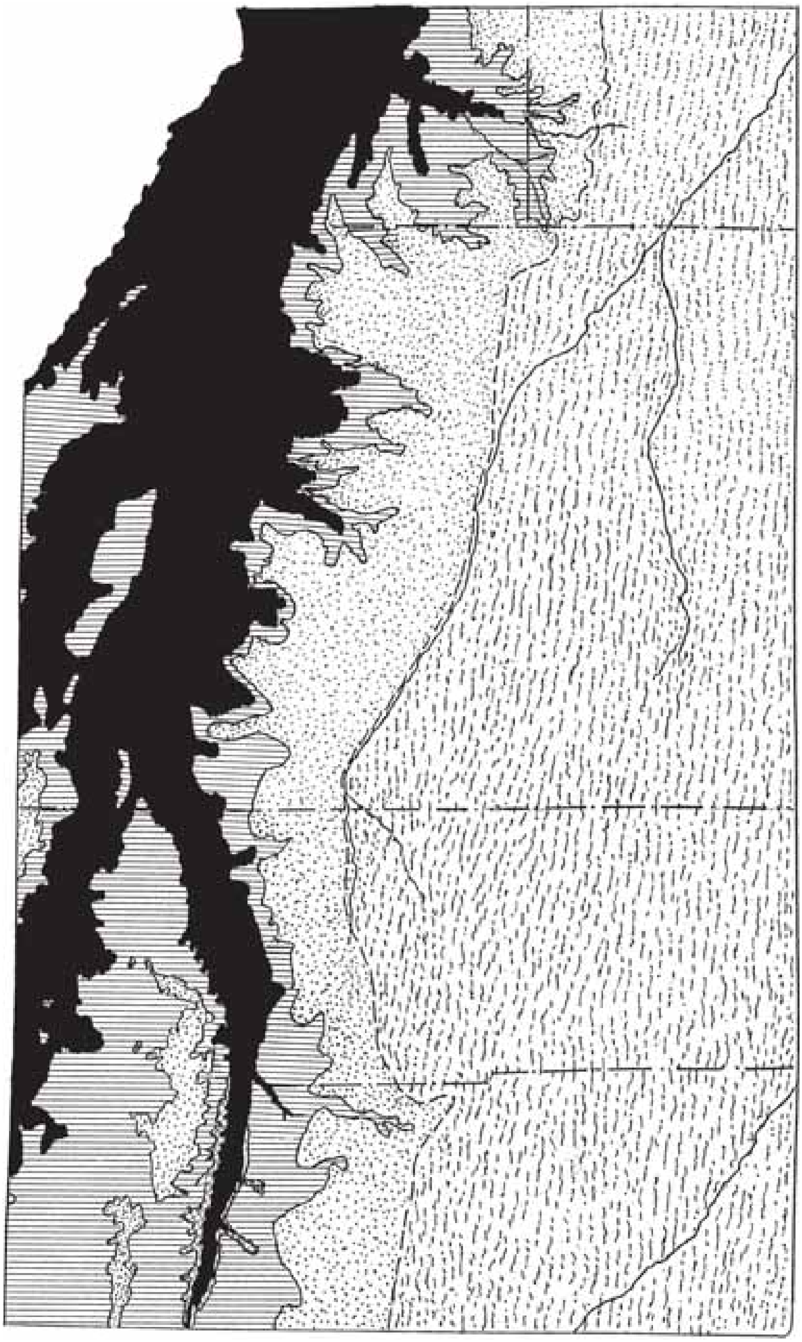
it disappeared under the combined influence of sediment accumulations and land uplifts, this Western Interior Seaway left a thick sedimentary deposit of whitish chalk over its vast bed. This chalk deposit, 82–88 million years old, is easily visible along the Niobrara and Missouri bluffs around Niobrara State Park, at the mouth of the Niobrara River. Microscopically, the chalk closely resembles the famous White Cliffs of Dover and is mostly composed of the same algal phytoplankton, called coccoliths, and calcareous foraminifera. Interred among these countless microscopic-sized skeletons are occasional larger fossils, the remnants of cephalopod ammonites and large clams. And living on such invertebrates as these were huge predatory reptiles and fish. One of these fish was the giant tarponlike *Xiphactinus*, ranging up to nearly twenty feet long. There were also diverse sharks with teeth of varied shapes, according to their food habits. Other major vertebrate predators of these late Cretaceous seas were large-jawed mosasaurs and long-necked plesiosaurs (Flowerday and Diffendal 1997).

One fossil mosasaur, *Mosasaurus missouriensis*, discovered in Niobrara State Park in 1986, is thirty-three feet long and is the largest known Nebraska fossil of that period. A few fossil fragments of sea turtles and of the flying reptiles called pterosaurs have also been found, but these are much better preserved in the vast and similar-aged Cretaceous chalk beds of Kansas.

As the Cretaceous seabed was slowly converted to low, moist shorelines and finally to dry uplands, it was certainly covered by relatively lush terrestrial vegetation, but apart from pollen evidence we have little direct knowledge of its specifics in the Nebraska region. An abrupt end of the



MAP 1. *Source:* After a map by Burchett (1986), as updated by R. R. Burchett and R. K. Pabian in 1991. More recent and superficial deposits (Pliocene and Quaternary epochs, less than 5 mya) are not shown.

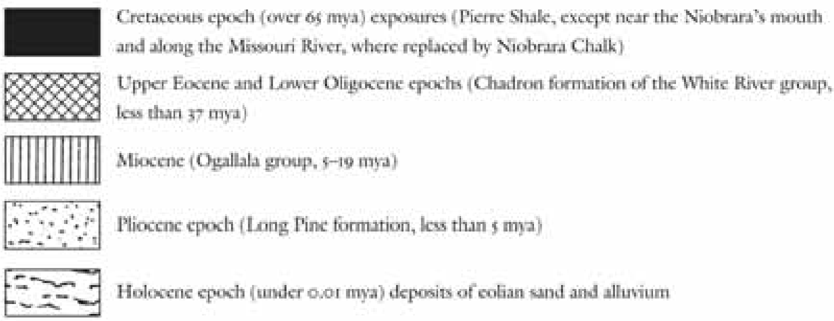


Map 2. Geologic map of the lower Niobrara Valley of Nebraska (west to the Niobrara Valley Preserve, or 100° west longitude)

Cretaceous was marked by the massive die-off of most of the huge reptiles and many other marine and terrestrial species that dominated that period until a massive asteroid crashed into the sea near the present-day Yucatán peninsula. Suddenly the climate was drastically changed, and the earth began to undergo a rapid and prolonged cooling trend as its atmosphere became obscured by dust clouds. By the end of the Cretaceous crocodiles and other larger reptiles had become rare, but early mammals including primates were common in North America. Palm trees and other tropical plants still abounded in central North America in the early Paleocene of 65 million years ago (mya), but this situation would also gradually change.

The Eocene Epoch (35–54 mya)

A long-term cooling and drying trend was initiated in the central plains of North America during the Eocene, as mountain building in the Rocky Mountains and other western mountain ranges progressed. These mountains increasingly intercepted the moist westerly winds coming from the Pacific Ocean, producing arid "rain shadow" reductions in precipitation to the east and making the interior of North America both more arid and more seasonally variable, a climatic feature increasingly typical of the incipient Great Plains. Additionally, erosion along the eastern mountain slopes carried sediments into the interior plains via early river systems that were created and fed by mountain-caused (orographic) precipitation. Other clay- and silt-sized particulate materials were probably



MAP 2. The location of a very confined exposure of the Rosebud formation (upper Oligocene and lower Miocene epochs, ca. 25 mya) is not indicated. *Source:* Modified from Diffendal and Voorhies (1994).

Table 1. Geologic timetable for life on planet Earth

Era	Period	Epoch	Years before the Present (mya)*	Major Events (with reference to Nebraska)
Cenozoic	Quaternary	Holocene	0–.011	Postglacial warming; Sandhills shaping
		Pleistocene	0.01–1.6	Several glaciations Sandhills forming; widespread loess, till, and alluvial deposits
		Pliocene	1.6–5.2	Grasslands spreading; cooler and drier climate
		Miocene	5.2–24	Ashfall Beds (ca. 10 mya); Agate Beds (ca. 20 mya)
		Oligocene	24–35	Mountain building in the west; spreading grasslands and grazing mammals on plains
	Tertiary	Eocene	35–54	Most modern mammal and bird families appearing
		Paleocene	54–65	Modern plants; North American interior emerging
Mesozoic	Cretaceous		65–135	Last of dinosaurs; North American interior submerged
	Jurassic		135–197	Peak of dinosaurs; early birds and mammals
	Triassic		197–225	Early dinosaurs appear
Paleozoic	Permian		225–280	Cooler and drier; many extinctions worldwide
	Carboniferous		280–345	Early reptiles appear
	Devonian		345–405	Seed plants appear
	Silurian		405–425	First land plants and early amphibians
	Ordovician		425–500	Early fishes appear
	Cambrian		500–570	Abundant marine life; many invertebrates

*mya = Millions of years ago

carried eastward by seasonal windstorms. Periodically, volcanism in the western mountains carried volcanic dust far eastward into the plains as well, sometimes smothering air-breathing animals but also adding to the mix of soil parent materials.

The central Rocky Mountains had their birth during the Laramide Revolution, a period of regional crustal uplifting that began in late Cretaceous times. By about 65 million years ago, the end of the Mesozoic era and start of the Cenozoic era or "Age of Mammals," the Targhee and Wind River uplifts in what is now western Wyoming had risen and generated a massive amount of surface erosion, removing perhaps 15,000 feet of overlying Paleozoic and Mesozoic strata before exposing their ancient quartzite core materials (Love and Reed 1971). These eroded surface materials formed vast gravel deposits in the basins between the mountain ranges and eventually spilled out onto the eastern plains. There early prairie rivers began to carry the smaller gravels and sands eastward into what would become Nebraska and South Dakota's portions of the Great Plains.

The Oligocene Epoch (24–35 mya)

Probably the major period of mountain building in western Wyoming was nearly completed by 45 million years ago. But then volcanoes began breaking though the earth's wrinkled crust, producing earthquakes and lava flows and sending showers of volcanic rock and dust over vast areas. Starting about 35 million years ago, incalculable amounts of gravel, sand, and clay sediments up to about 1,000 feet thick accumulated on the plains to the east of the Rocky Mountains. These materials, extending the length of the High Plains from present-day Saskatchewan to Texas, were mostly laid down during the first 10 million years of the Oligocene epoch, perhaps having originated from volcanic deposits in present-day Colorado. Now called the White River group, the sediments are easily visible about thirty miles north of the Niobrara River in the exposed strata of Toadstool Geologic Park northwest of Crawford, and also on the nearby monolithic landmark appropriately called Sugarloaf Butte.

In western Cherry County, where the White River group may be up to 1,000 feet thick, the top of these materials serves as the base of the massive Ogallala aquifer. The Arikaree group, deposited above the White River group materials in mid-Oligocene times, consists of alluvial and aeolian sandstones and siltstones that continued to be laid down into early Miocene times.

The base of Sugarloaf Butte near Toadstool Geologic Park is today visibly tinted with the reddish sandstone strata of early Oligocene times, which was deposited on a thin and even an earlier yellowish paleosol ("ancient soil") of Eocene times. These colorful layers cap the lower and still earlier Pierre Shales of late Cretaceous times.

Table 2. Geologic timetable for the greater Niobrara region

Era	Period	Epoch	Years before the Present (mya)*	Geologic Group	Formations (F.) and Pleistocene Deposits
Cenozoic[a]	Quaternary	Holocene	0–.011	—	Recent deposits
		Pleistocene	0.01–1.6	—	
		Wisconsin phase	(0.01–0.075)		Wisconsin till
		Sangamon Interglacial			Loveland loess
		Illinoian phase	(0.125–0.265)		Illinoian till
		Yarmouth Interglacial			Kansas gumbotil
		Kansan phase	(0.3–0.435)		Kansan till
		Aftonian Interglacial			Nebraskan gumbotil
		Nebraskan phase	(0.5–1.6)		Nebraskan till
		Pre-Nebraskan			Pettijohn F.
					Duffy F.
		Pliocene	1.6–5	—	Long Pine F. (2–2.5 mya)
					Keim F. (2.5–3 mya)
		Miocene	5–24	*Ogallala*	*Ash Hollow F.* (6–10 mya)
			(5–19)		*Valentine F.* (11–14 mya)
					Runningwater F. (>14 mya)
				Arikaree	Harrison F. (19–23 mya)
			(19–28)		Monroe Creek F. (ca. 24 mya)
					Rosebud F. (24–25 mya)
		Oligocene	24–35		Gering F. (ca. 28 mya)
				White River	*Brule F.* (28-32 mya)
			(28–38)		*Chadron F.* (32– 36 mya)

(continued)

Tertiary	Eocene	35–54		Chamberlain Pass F. (> 38 mya) (earlier Eocene strata absent)
	Paleocene	54–65	(Absent from region)	

Note: Adapted mainly from Swinehart and Diffendal (1998) and Diffendal and Voorhies (1993). Pleistocene periods and associated sediments after various sources. Some minor regional formations have been omittd. Associations of formations with specific geologic groups are identified combinations of italics and underlining.

[a]Cenozoic epoch limits based on Savage and Russell (1983).

*mya = millions of years ago (approximately).

Table 3. Paleontology of the greater Niobrara region

Era	Period	Epoch (mya)*	Formation (mya)	Typical Fossils and Environments
Cenozoic	Quaternary	Holocene (0–0.01)		Modern mammals; human occupation
		Pleistocene (0.01–1.6)		Alternating glacial and interglacial periods; many large mammals
		Pliocene (1.6–5.2)	Long Pine (ca.2) Keim (2.5–3)	Temperate grasses and woodlands; grazers, dogs, rodents
		Miocene (5.2–24)	Ash Hollow (6–11)	Savannas, warm and dry; many grazers, few browsers; tortoises
			Valentine (11–14)	Large streams and forests; warm climate; abundant and diverse fossils
			Turtle Butte (22–24)	Warm climate; channel and floodplain; fossils uncommon
		Oligocene (24–38)	Rosebud (24–28)	Seasonally arid; fossils rare
			Chadron (32–38)	Warm, humid fluvial; fossils unidentified
	Tertiary	(Paleocene and Eocene strata largely absent from region)		
Mesozoic		Cretaceous (65–135)	Pierre Shale (70–76)	Shallow marine; fish, reptiles, invertebrates
			Niobrara Chalk (82–88)	Shallow marine; fish, reptiles, invertebrates

Source: Adapted mainly from Diffendal and Voorhies (1993).
*mya = Millions of years ago (approximate).

Within Toadstool Park itself the Oligocene time span that is painted as horizontal bands on the steep slopes ranges from 36 to 24 million years ago, mostly in the form of softer light-buff claystones and darker and harder sandstones. An ancient river flowed through the area, along which lived now-vanished piglike entelodonts, camel-like oreodonts, and double-horned, rhinoceros-like titanotheres, as did ancestral forms of surviving mammal groups such as dogs, cats, horses, and deer. Fossilized tracks of rhinos, entelodonts, shorebirds, and waterfowl are still visible in the park, along what was once probably a muddy creek.

Between about 30 and 35 million years ago, the climate of Wyoming, Colorado, and probably also western Nebraska was shifting from warm-subtropical to warm-temperate, with increasingly familiar trees such as oaks, maples, beeches, alders, and ashes becoming evident. In the 34-million-year-old strata of Florissant Fossil Beds National Monument, east-central Colorado, at least 140 species of fossil plants have been found. The fossil trees include redwoods, cedars, pines, hackberries, walnuts, maples, hickories, and oaks. Shrubs included sumac and serviceberry, and there were also ferns, mosses, horsetails, and cattails growing in moist areas (National Park Service Web site: http://www.nps.gov/flfo/).

By these Oligocene times of about 30 million years ago, primitive horses, rabbits, rodents, camels, dogs, cats, and titanotheres were roaming the broad-leaved and coniferous woodlands, both in what is now Wyoming and also on the western plains of present-day South Dakota and Nebraska. By 25–30 million years ago the mountains of central Wyoming, such as the Beartooth Mountains and Wind River Range, were well formed. By about 20 million years ago the central Rocky Mountains were probably approaching their present-day heights, although in western Wyoming the now-spectacular Teton range had not yet begun to rise under the influence of continuing violent earthquakes (Love and Reed 1971).

The Miocene Epoch (5–24 mya)

Abundant evidence of the 20-million-year-old early Miocene landscape and its animal life has been preserved at Agate Spring Fossil Bed National Monument, in Nebraska's Sioux County. This internationally famous fossil site was discovered in 1885 by James H. Cook while he was courting Kate Graham at her father's cattle ranch along the upper Niobrara River near Harrison. After the two were married in 1886, Cook purchased the land and renamed it the Agate Spring Ranch. Cook then invited paleontologists from the University of Nebraska to his ranch to examine the fossil artifacts he had collected. The first director of the university's State Museum, Erwin Barbour, started his many visits in 1891 and soon realized the significance of Cook's discoveries. Later other famous paleontologists such as E. D. Cope from Yale University, O. C. Marsh from Philadelphia's Academy of Natural Sciences, and Olaf Peterson from the Carnegie Museum also excavated at the site. The site was also studied by H. F. Osborn and Albert Thompson of the Amer-