2-1979

Geologic History of Scotts Bluff National Monument

Roger K. Pabian
University of Nebraska-Lincoln

James B. Swinehart III
University of Nebraska-Lincoln

GEOLOGIC HISTORY OF SCOTTS BLUFF NATIONAL MONUMENT

Roger K. Pabian and James B. Swinehart II

Educational Circular No. 3

Conservation and Survey Division
Institute of Agriculture and Natural Resources
The University of Nebraska--Lincoln

GEOLOGIC HISTORY OF SCOTTS BLUFF NATIONAL MONUMENT

Roger K. Pabian and James B. Swinehart II

Illustrated by Mary Tanner

EDUCATIONAL CIRCULAR NO. 3

Conservation and Survey Division
Institute of Agriculture and Natural Resources
The University of Nebraska—Lincoln

The Conservation and Survey Division of The University of Nebraska is the agency designated by statute to investigate and interpret the geologically related natural resources of the state, to make available to the public the results of these investigations, and to assist in the development and conservation of these resources.

The Division is authorized to enter into agreements with federal agencies to engage in cooperative surveys and investigations in the state. Publications of the Division and the cooperating agencies are available from the Conservation and Survey Division, The University of Nebraska, Lincoln, Nebraska 68588.

Publication and price lists are furnished upon request.

Cover photo courtesy of
Nebraskaland magazine

February 1979

Contents

Illustrations

Introduction

Scotts Bluff National Monument, located in central Scotts Bluff County, has an area of 3,084 acres (1 250 hectares). Established by act of Congress in 1919, it is one of three national monuments in Nebraska. The bluff—like those forming nearby Chimney Rock, Courthouse Rock, and Jail Rock—is an erosional outlier of Wildcat Ridge (fig. 1) and was an important landmark along the Mormon Trail and the Oregon Trail. Historians estimate that more than 250,000 pioneers passed Scotts Bluff on their trek to Utah or the Pacific Northwest. Most stopped to rest there and many climbed to the top of the bluff to view the terrain ahead.

Scotts Bluff is named for Captain Hiram Scott, whose skeleton was found at the base of the bluff in 1828. According to legend, Scott was traveling eastward when he fell ill near the junction of the Laramie and North Platte rivers in western Goshen County, Wyoming. His companions, who abandoned him, reported that he had died and was buried there. Actually, however, he survived long enough to walk or crawl 60 miles (97 km) to the spring at the foot of the bluff that now bears his name.

How to Reach the Monument and What to See

Starting from the junction of State Highways 71 and 92 in downtown Gering, proceed westwardly along State Highway 92 for 2.4 miles (3.85 km). The monument headquarters and museum are on the right, or north side, of the highway (fig. 2). Admittance can be gained by paying the National Park Service's nominal usage fee. By taking the road leading to the summit of the bluff and following the path to the North Overlook, visitors can gain an overall view of the surrounding terrain. Those wanting a closer look at the geology of the monument can hike along the 1.6-mile (2.55-km) trail that descends from the summit and ends back at the museum. Figure 3, a topographic map, depicts the summit area and points of interest along the trail to the museum.

This guidebook provides a description of the rocks exposed at the monument, an interpretation of the view from the North Overlook, an explanation of interesting rock features at viewing points along the hiking trails, and a summary of the geologic history of the area. The authors intend for this descriptive material to serve as a substitute for a personal tour guide and they hope that it will provide the visitor a better understanding and appreciation of the monument.

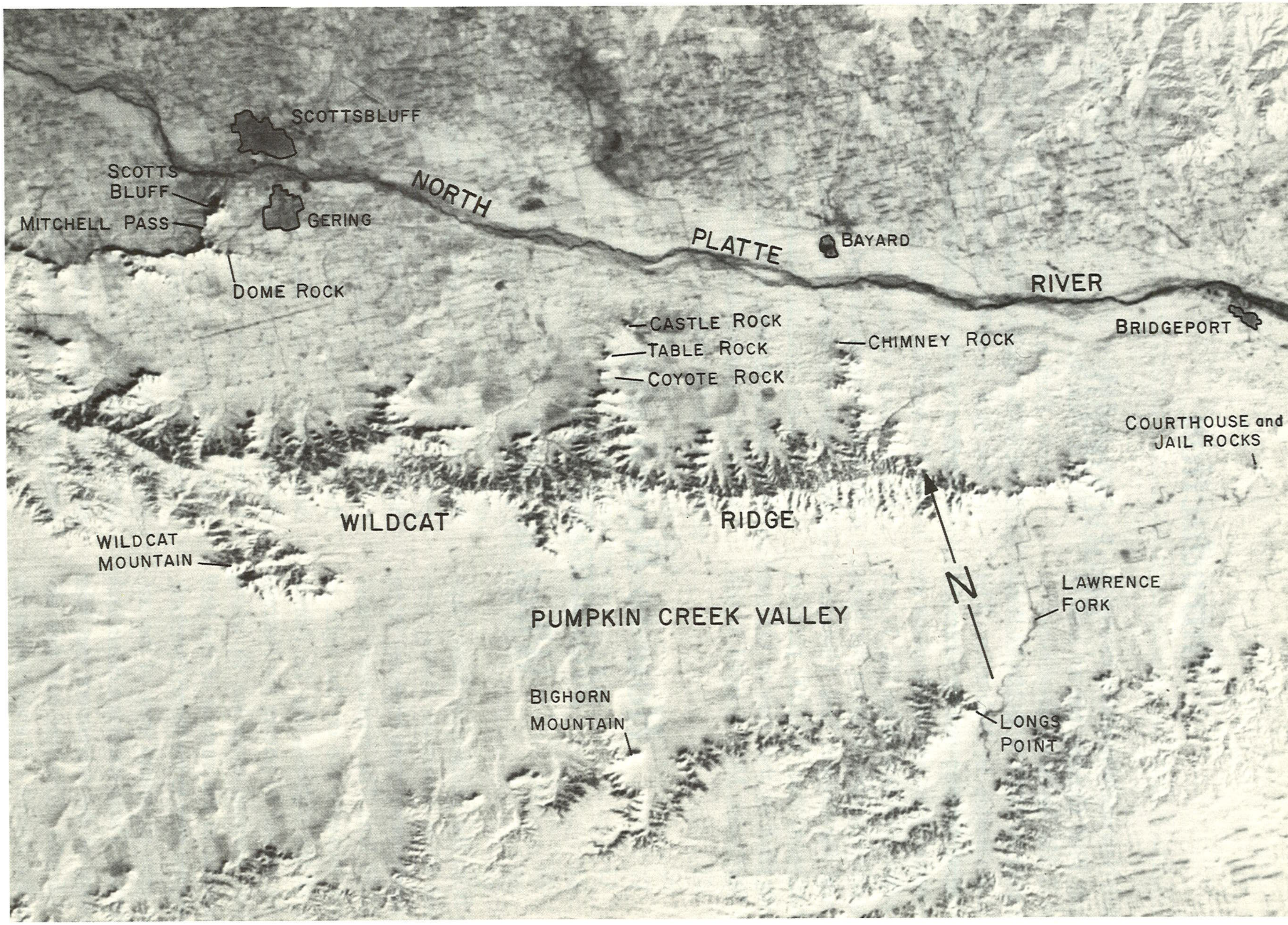
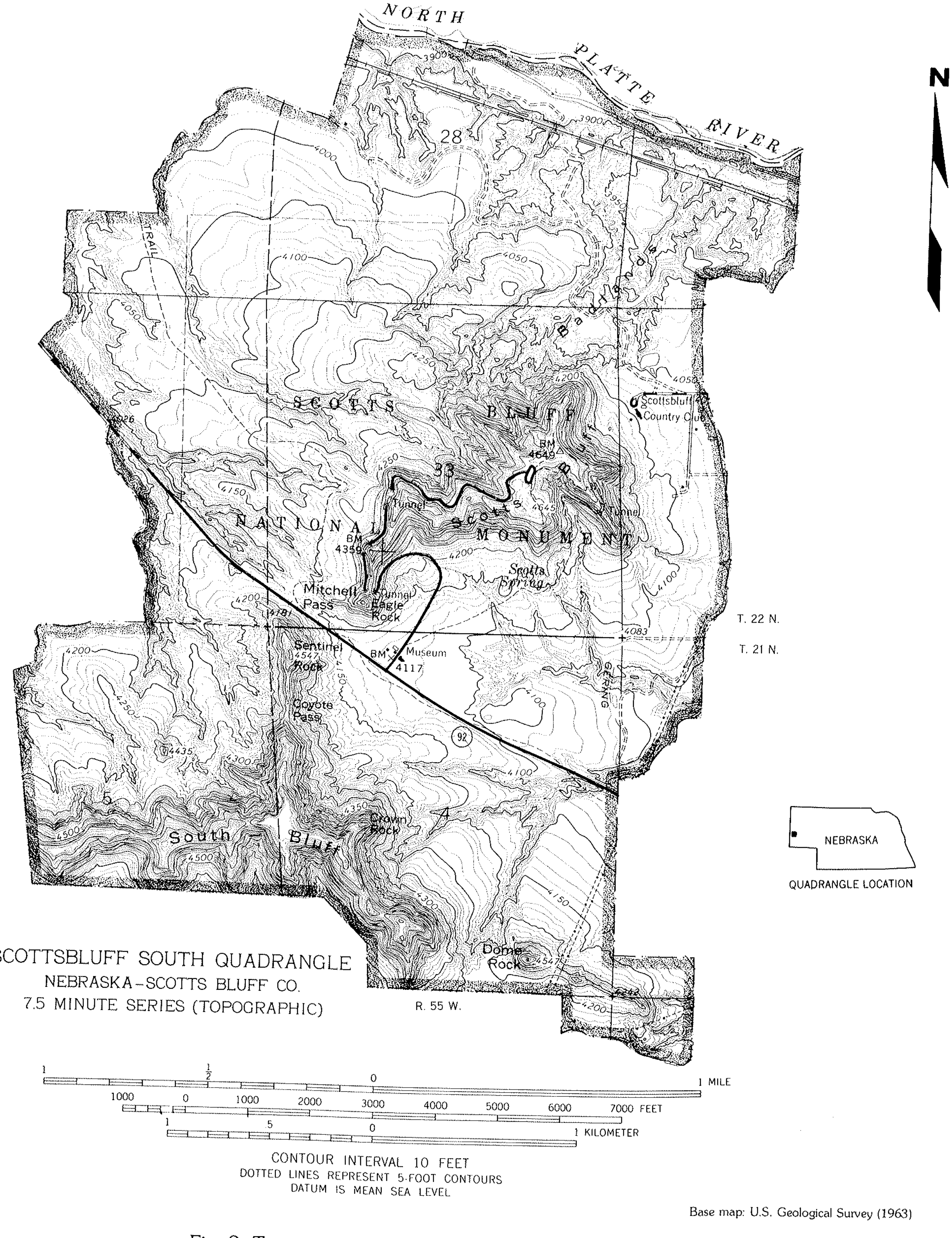
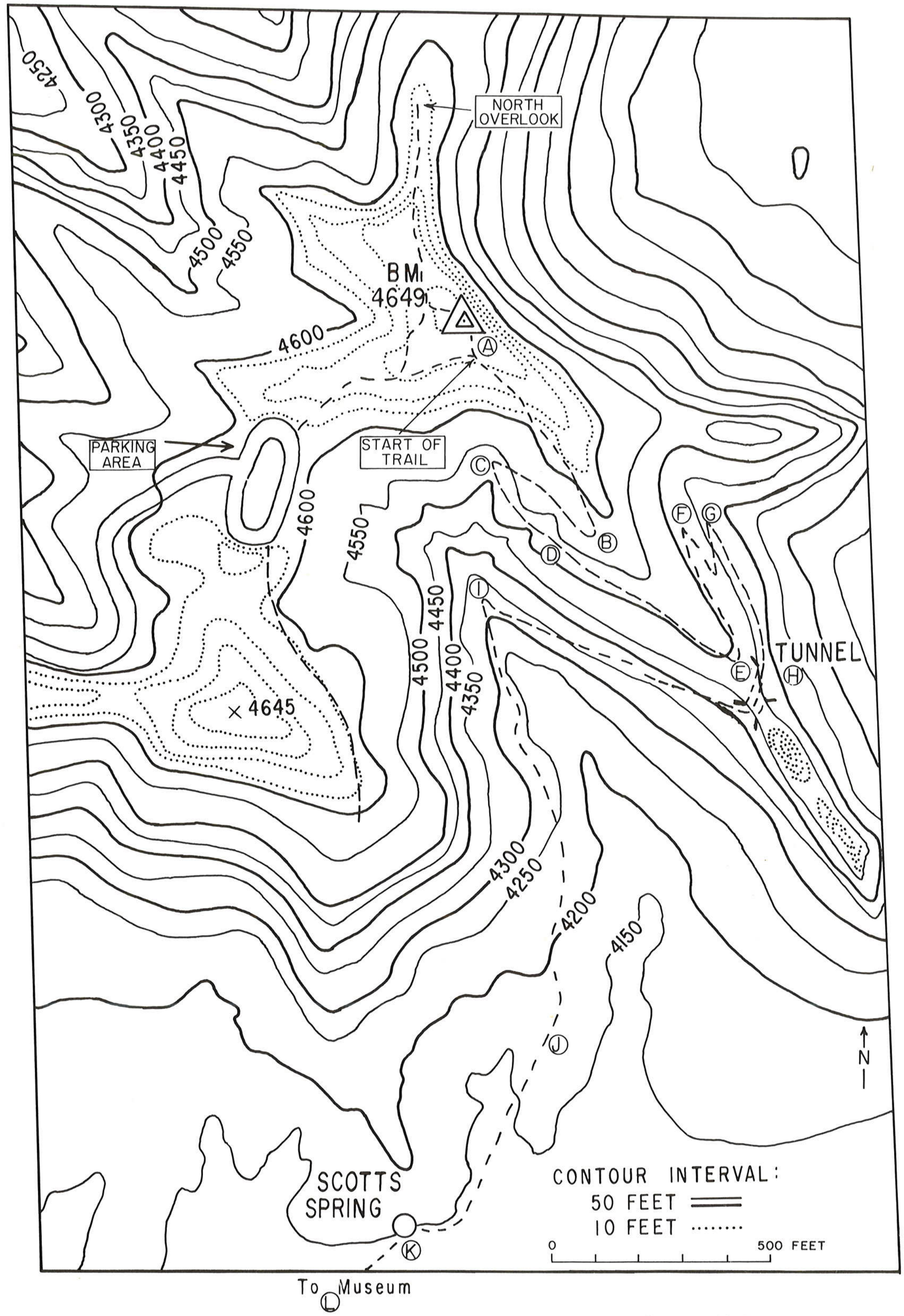


Fig. 1. Landsat satellite image of Wildcat Ridge and adjacent areas in the Scotts Bluff region of western Nebraska, recorded from an altitude of 565 miles on January 28, 1973. A light snow cover on the ground enhances the topography. Note the variation in the spelling of the city of Scottsbluff and of the Scotts Bluff National Monument. Scale 1:250,000 (1 inch = 4 miles).



Base map: U.S. Geological Survey (1963)

Fig. 2. Topographic map of Scotts Bluff National Monument.



Base map: U.S. Geological Survey (1963)

Fig. 3. Topographic map showing Summit Trail and main hiking trail at Scotts Bluff National Monument. The letters refer to stops along the hiking trail.

Rock Layers Exposed at the Monument

Rock exposures at the Scotts Bluff National Monument have been the subject of much geologic study since the late 1890s, when N. H. Darton of the U.S. Geological Survey made the first formal geologic investigation of the area. Studies have continued and by detailed examination of the outcrops and by study of samples from wells and test holes drilled near the monument, geologists have been able to reconstruct the different environments that existed in the area during several periods and epochs of geologic time.

The rocks exposed on the monument were deposited above sea level and belong to the Brule Formation of the White River Group deposited during the Oligocene epoch and to the Arikaree Group deposited during the succeeding Miocene epoch. The Brule has been subdivided into two members, the Orella below and the Whitney above. The Arikaree Group is often subdivided into three formations, but only the Monroe Creek Formation and possibly the Gering Formation are present at the monument. For the purpose of this guide, the term Arikaree will be used to refer to these rocks.

The Oligocene and Miocene epochs were parts of the Tertiary period, a division of the Cenozoic time that began about 70 million years ago. Tertiary time ended with the beginning of the Quaternary period, or Ice Age (fig. 4). Though the exposed rocks in the monument are very old (34 to 20 million years) in historical terms, they are relatively young in terms of geologic time, which began with the formation of the earth an estimated 5 billion years ago.

As shown on the geologic map of Nebraska (back cover) and the geologic map of Scotts Bluff County (fig. 5), the White River Group and the Arikaree Group are exposed throughout the Nebraska Panhandle. The White River Group and/or the Arikaree Group underlie younger Tertiary rocks throughout much of the western half of the state. In late Tertiary time these rocks were probably not exposed anywhere in the state, being buried beneath younger sediments that formed an extensive, relatively smooth, eastward-sloping plain. Then, when the rate of erosion began to exceed the rate of deposition, this plain was eroded to produce the present-day landscape. This process, which began about 4 to 5 million years ago, has involved the removal of a tremendous volume of sediment, since the plain was at least as high as the top of Wildcat Ridge. Now the steep sides of the ridge, as well as Scotts Bluff and the adjoining badlands area (fig. 6), provide an opportunity to view the layers of sediment deposited during the Oligocene and Miocene epochs. Moreover, study of these sediments provides clues to the variety of environments that existed in this area during deposition of these sediments 20 to 34 million years ago.

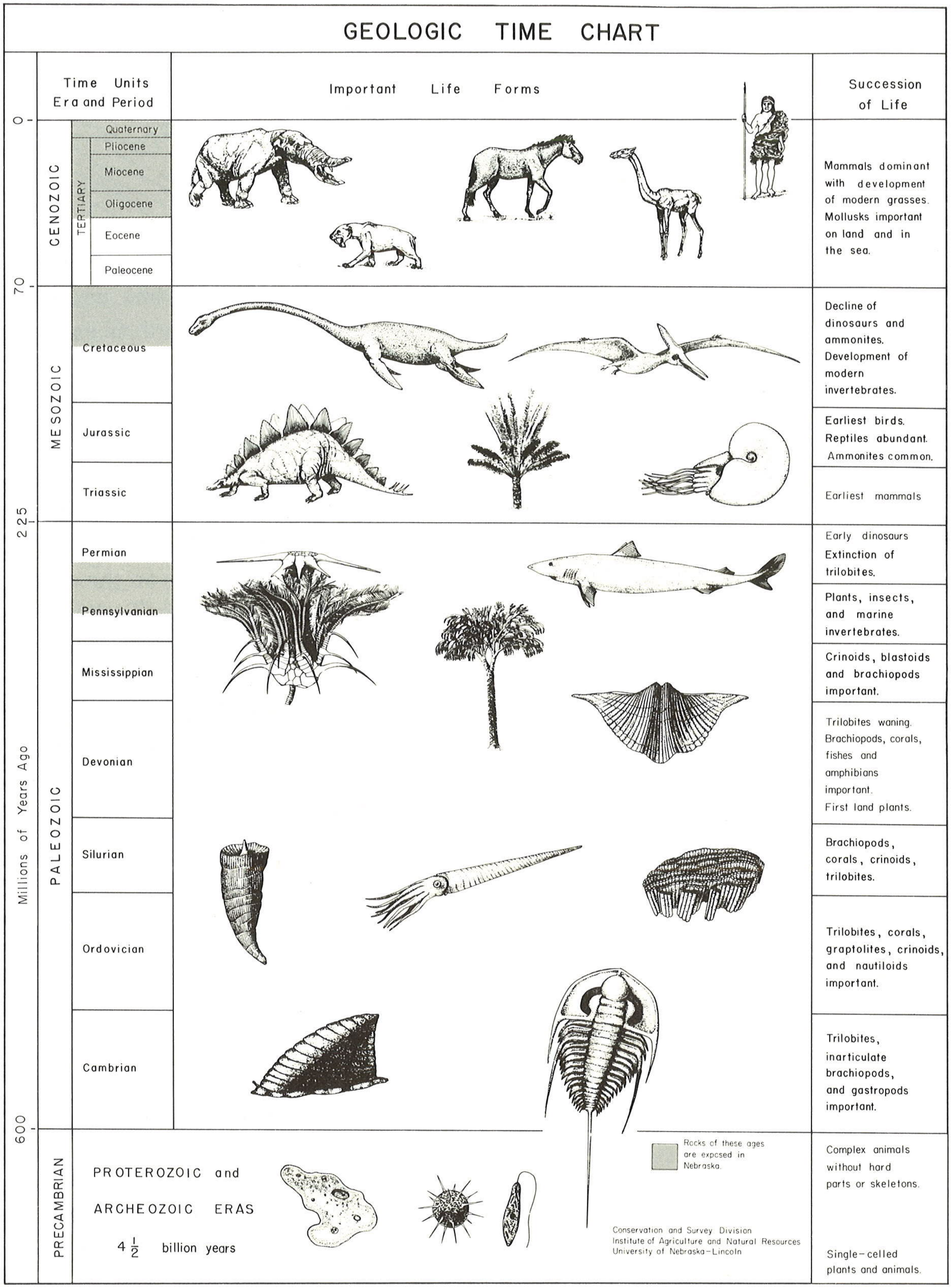
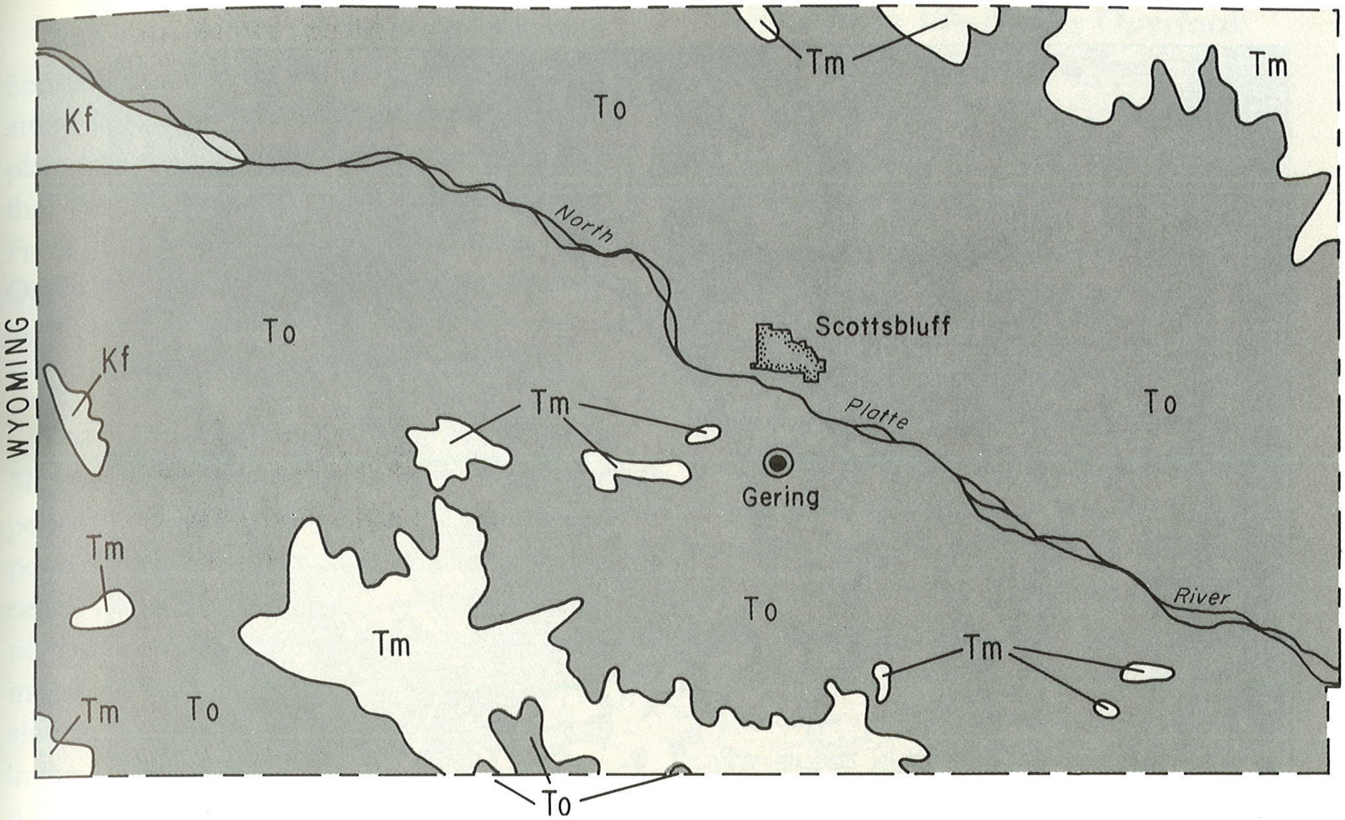


Fig. 4. Geologic time chart. The shaded parts of the time units indicate the age of rocks exposed in Nebraska.



SYSTEM		SERIES	GROUP or FORMATION	
T	Tertiary	Miocene	Arikaree	Tm
		Oligocene	Brule	To
K	Cretaceous	Upper Cretaceous	Fox Hills	Kf

Fig. 5. Geologic bedrock map of Scotts Bluff County.

Fig. 6. Badlands of the Orella Member of the Brule Formation, viewed from the North Overlook on the Summit Trail.

The Orella Member of the Brule Formation consists of interbedded sandstone and siltstone layers that probably represent floodplain and channel deposits of ancient streams that flowed eastward from the then young Front Range and Laramie Mountains. The Orella is the oldest stratigraphic unit exposed in the area.

The next younger unit is the Whitney Member of the Brule Formation. It is composed mostly of silt-sized dust particles deposited by wind. This type of silt deposit is called loess. More than 50 percent of these silt particles are composed of angular fragments of volcanic glass called shards. The shards, derived from large volcanic eruptions in the western United States, were carried by winds to the Great Plains. Present in the Whitney are two layers of nearly pure volcanic ash also derived from volcanic eruptions to the west of Nebraska. The Whitney Member, about 250 feet (76 m) thick, is especially well exposed on Eagle Rock (fig. 7) northwest of the museum.

Overlying the Whitney is the Arikaree Group, which forms the upper part of Scotts Bluff. It consists mostly of silty sandstone, of which about 25 percent is volcanic glass shards. Like the Whitney, some of the Arikaree deposits may represent ancient loesses; however, river channel, floodplain, and pond deposits can also be found. Several layers of volcanic ash are also present in the Arikaree. Other interesting features of the Arikaree Group are pipy concretions (fig. 9), insect burrows (fig. 13), and deformed bedding (figs. 11 and 17). All these features can be examined at close range along the trail.

View from the North Overlook on the Summit Trail

(Stay on the trail at all times)

The small area of badlands visible from the North Overlook (fig. 6) resulted from rapid erosion of interbedded thin sandstones and clayey siltstones of the Orella Member of the Brule Formation. Fossils of horses, oreodonts (extinct, four-toed mammals), prairie dogs, foxes, rodents, beavers, and cats have been found in these rocks. Some of these fossils are on display in the University of Nebraska State Museum at Lincoln. They were collected in 1910, several years before the area was incorporated into the monument and became closed to further collecting activities.

The overlook also provides a panoramic view of the fertile cropland in the North Platte River valley, which is about 6 miles (9.7 km) wide at this location. Above this point, the North Platte River drains an area of 24,330 square miles (63 000 km^2), including some snow-capped peaks in the Rocky Mountains. Before reservoirs were built to retain spring snowmelt for irrigation during the summer, the flow of the river was much more variable and its channel was very much wider than it is now. Regulation of the river's flow by means of reservoir releases, together with irrigation-seepage returns to the river, results in flow during all seasons. Today the channel seldom runs dry, as it formerly did before the upstream dams were built. River discharge ranged from 449,000 to 1,700,000 acre-feet (0.55 km^3 to 2.10 km^3), averaging 822,000 acre-feet (1.01 km^3) during the 10-year period 1967-76. Most of the water used for

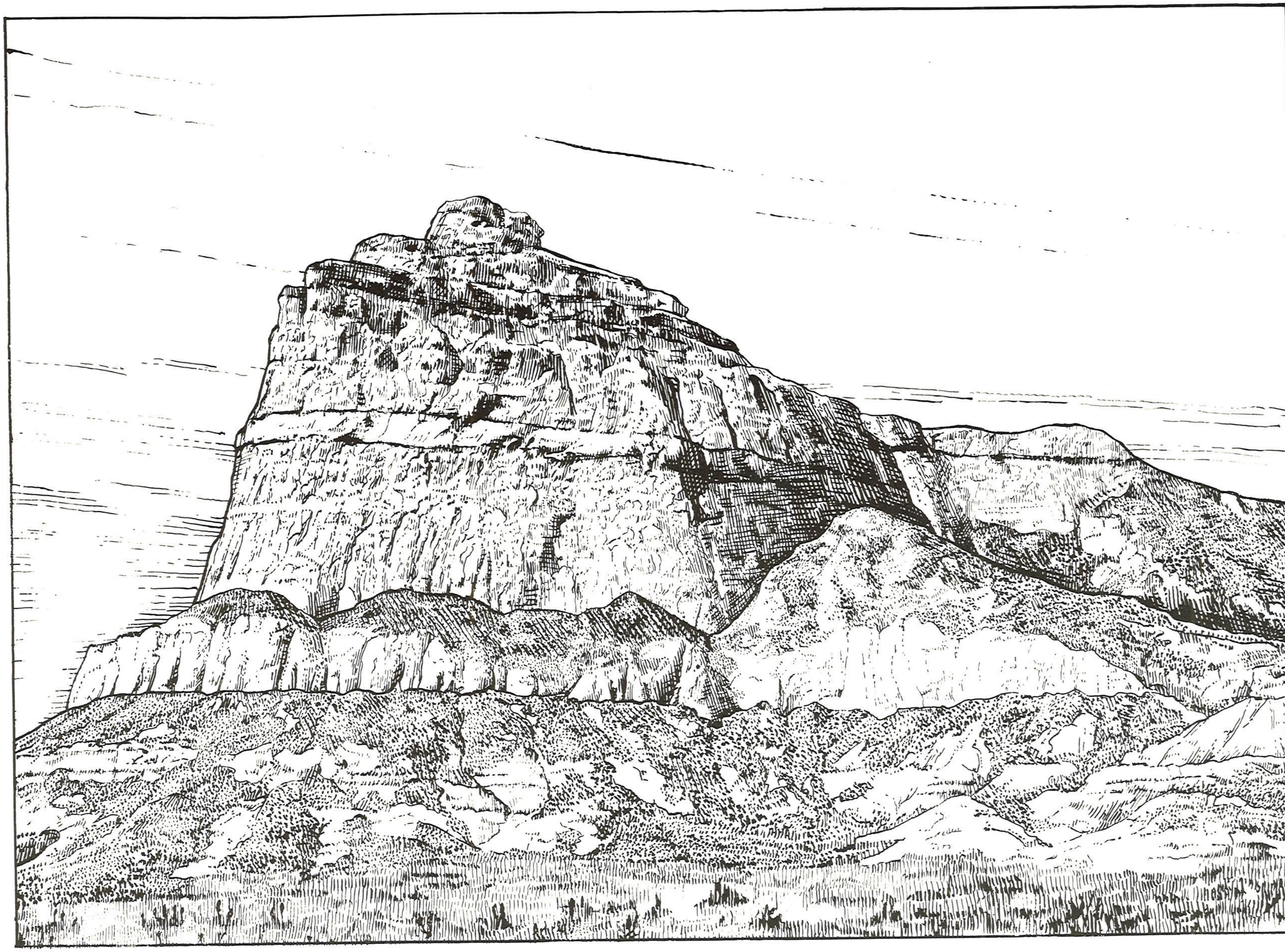


Fig. 7. Eagle Rock. Many travel guides incorrectly picture this feature as Scotts Bluff. The lower Whitney ash forms the prominent ledge about halfway up the cliff. The steep cliffs are composed of eolian (wind-deposited) siltstones of the Whitney Member of the Brule Formation.

irrigation within the North Platte valley is obtained from canals that divert water from the North Platte River in Wyoming and Nebraska. A relatively small acreage is irrigated with groundwater.

Geologic Features along the Trail to the Museum

(Stay on the trail at all times)

The main hiking trail begins between Summit Trail markers 12 and 13 – 200 feet (61 m) northeast of the north end of the summit parking area (fig. 3). It ends at the museum, a distance of 1.6 miles (2.55 km) to the south. The paved path is mostly an easy downhill walk, although a few sections are rather steep and narrow. The descent may be considered a backward trip through 10 to 14 million years of geologic time. The rocks at the beginning of the trail were deposited about 20 to 22 million years ago, while those near the end of the trail were deposited about 34 million years ago. Some of the sediments deposited here during this span of time are not preserved because they were lost to erosion in the geologic past. The total thickness of rocks exposed at Scotts Bluff is 740 feet (226 m). In the appendix is a descriptive measured section of the different rock units, numbered in order from the oldest (lowermost) to the youngest (uppermost). A diagrammatic geologic section of rocks exposed in the bluff is shown in figure 8, with letters corresponding to stops along the trail where geologic features of special interest occur.

Stop A. Cropping out here are hard, lime-cemented ledges called pipy concretions, part of the Arikaree Group of early Miocene age (fig. 9). These concretions formed from precipitation of calcium carbonate (lime) from groundwater.

The fine-grained sediments surrounding the ledges, which generally lack distinct bedding planes, were probably deposited by the wind. They are similar in general appearance to loess that was deposited throughout much of the Midwest during the Pleistocene epoch (ice ages). However, these deposits differ from loess in that they are slightly coarser grained, more consolidated, and contain a large amount—25 to 50 percent—of volcanic glass shards. Tremendous volcanic eruptions occurred in the western United States during deposition of the Arikaree. These volcanoes ejected large volumes of ash into the atmosphere. The ash, carried eastward by the wind, settled largely on the plains where it was incorporated in sediments of the Arikaree Group.

Stop B (at first switchback). These concretions in the lower part of rock unit 11 are knobby, potatolike concretions. Note that some bedding planes are inclined, possibly having been formed by migrating sand dunes.

Stop C (at second switchback). About 45 feet (13.7 m) down trail from the museum signpost is a bed of pinkish volcanic ash, from 2 to 6 inches (51 to 152 mm) thick but pinching out within a distance of 35 feet (10.7 m). The gray sandstone above and below the ash is thin-bedded and locally contains small-scale cross-bedding. These features probably indicate deposition within the channel of a small stream or on the floodplain of a large stream (fig. 11).

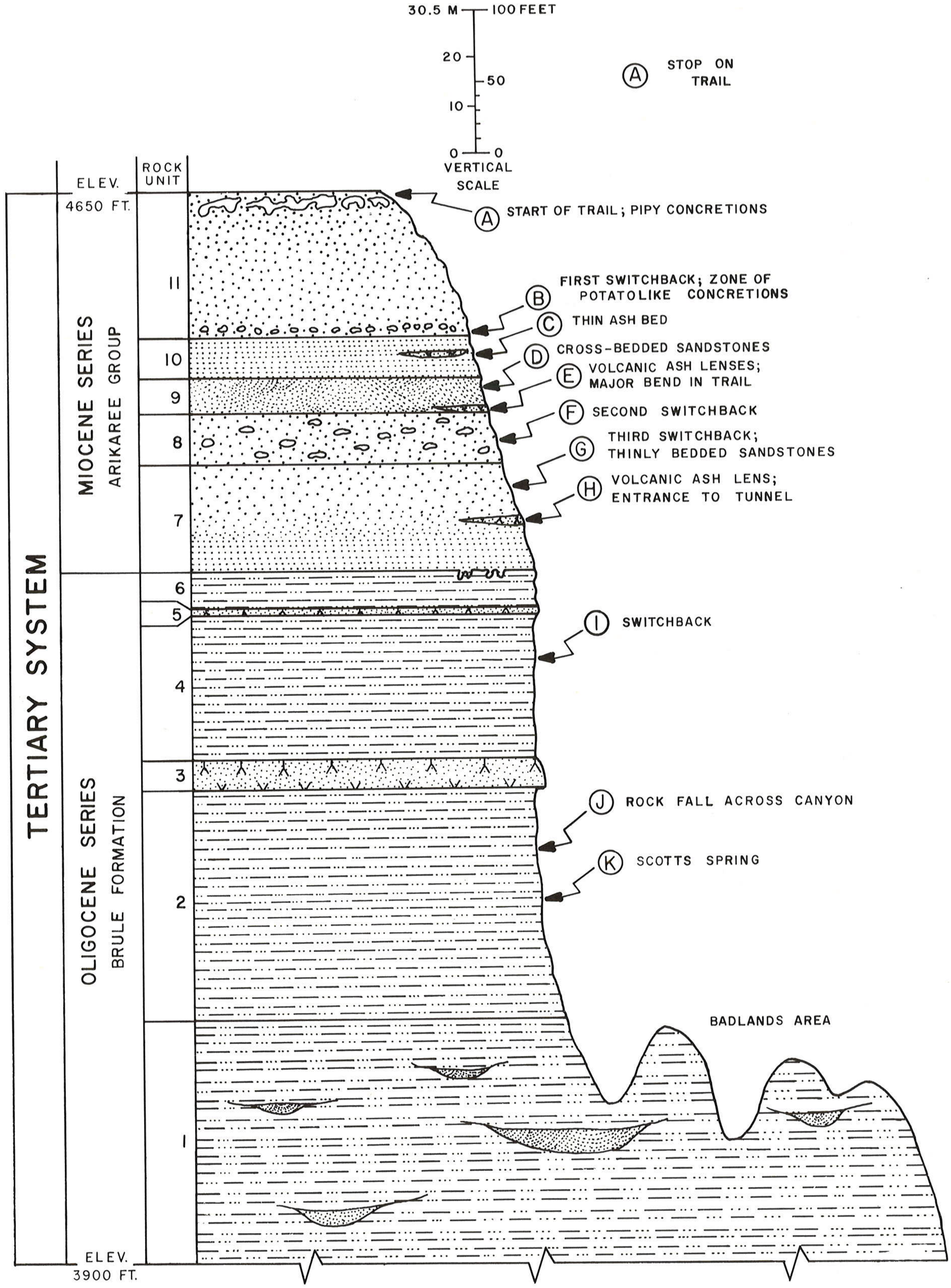


Fig. 8. Diagrammatic geologic section of Scotts Bluff. The letters refer to points of interest along the hiking trail.

Fig. 9. Pipy concretions in the sandstones of the Arikaree Group. These occur at stop A on the hiking trail, in the upper part of rock unit 11 (fig. 8).

Stop D (at concrete steps on trail). These cross-bedded rocks (fig. 10) are similar to the deposits of broad braided rivers such as the North Platte. Deposits such as these are formed underwater in a river channel as sand dunes and ripples migrate downstream; sand is carried over the steep side (slip face) of a dune forming cross-bedding that faces downstream (fig. 12). The cross-bedding at this locality indicates that the ancient river flowed southeastward. Formation of the pipy concretions in this outcrop obviously was subsequent to the deposition of the cross-bedded sand, because the concretions cut across the inclined laminations. Close examination of some weathered surfaces reveals a variety of vertical to horizontal cylindrical tubes, 1/16 inch to 3/4 inch (1.59 mm to 19.1 mm) in diameter (fig. 13). Because these also intersect the laminations, they too must have formed after the beds were deposited. These tubes were probably formed by insects, possibly beetles, burrowing in search of food and shelter in the sand deposited by the ancient stream. Similar burrows are common in sandbars of many modern rivers, the North Platte among them.

About 75 feet (22.9 m) down the trail from the concrete steps is an exposure of pinkish to yellowish volcanic ash (fig. 14) that accumulated in a shallow pond on either an ancient river island or an ancient river's floodplain (fig. 11). This ash bed, which is 40 feet (12.2 m) long and at least 1.5 feet (0.55 m) thick, occurs in the lower part of rock unit 9 (fig. 8). It also contains numerous burrows of ancient insects.

Stop E (at major bend in trail with museum signpost). Another lenticular bed of volcanic ash crops out about 12 feet (3.7 m) above the trail. Also exposed here is the contact between wind-deposited, fine-grained sand containing calcareous concretions and the overlying cross-bedded stream deposits. The wind-deposited sand (rock unit 8, fig. 8) is about 40 feet (12.2 m) thick and includes several beds of volcanic ash.

The castlelike promontories (fig. 15) that can be seen by looking to the southeast are eroded remnants of the Arikaree Group. Note that the pipy concretions help to hold up the steep sides of these promontories.

Stop F (first of three switchbacks on trail along northeast-facing bluff). Outcropping beds here are near the middle of rock unit 8 (fig. 8).

Stop G (at third of three switchbacks on trail along northeast-facing bluff). Outcrops along this part of the trail are part of rock unit 7 (fig. 8) and consist of up to 35 feet (10.7 m) of silty sandstone in beds 1/4 inch to 1 inch (6.4 to 25.4 mm) thick. Cross-bedding occurs within individual beds, which are miniature replicas of those in the thick cross-bedded sandstones at stop D. Interlayered with the thin beds of silty sandstone are several layers of gray volcanic ash 1/2 to 2 inches (15.7 to 51 mm) thick. These sediments were most likely deposited in relatively quiet water, probably a lake on a river floodplain (fig. 11). Rock units B through H are well exposed on the cliff across from this switchback (fig. 16).

Stop H (at entrance to tunnel). Exposed here is the lower part of rock unit 7 (fig. 8). Note the bed of volcanic ash above the tunnel and the conelike features projecting downward from it into the underlying thin-bedded gray sandstone. These conelike features may represent fillings of vertical burrows or root casts existing in surficial materials

Fig. 10. Cross-bedded sandstone of the Arikaree Group at stop D on the hiking trail. Such strata were probably deposited in the channel of a braided stream similar to the modern North Platte River. These strata are shown as rock unit 9 in figure 8.

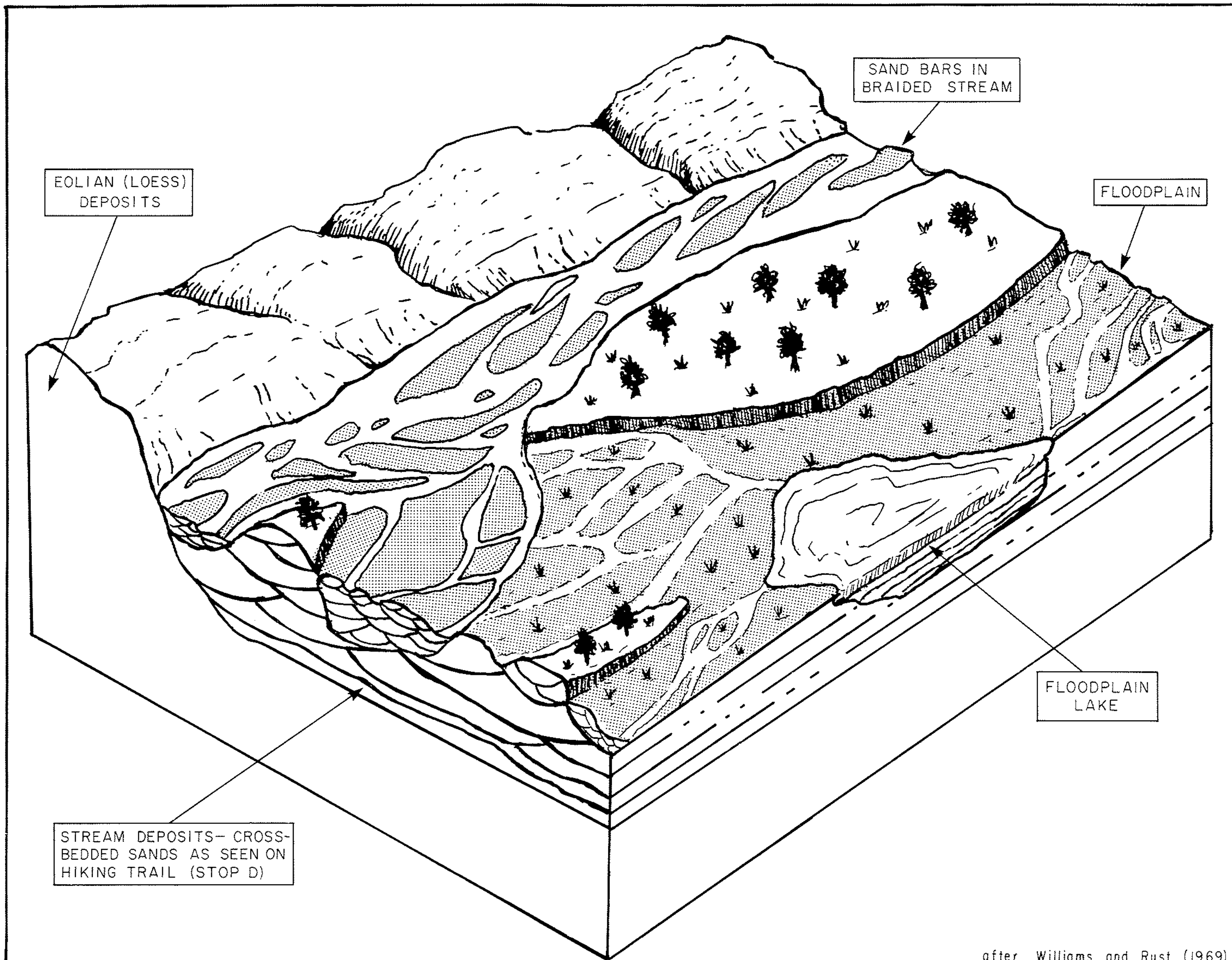


Fig. 11. Block diagram showing a braided stream and associated environments of deposition that probably existed at Scotts Bluff National Monument and surrounding areas during some of Miocene time (stop D).

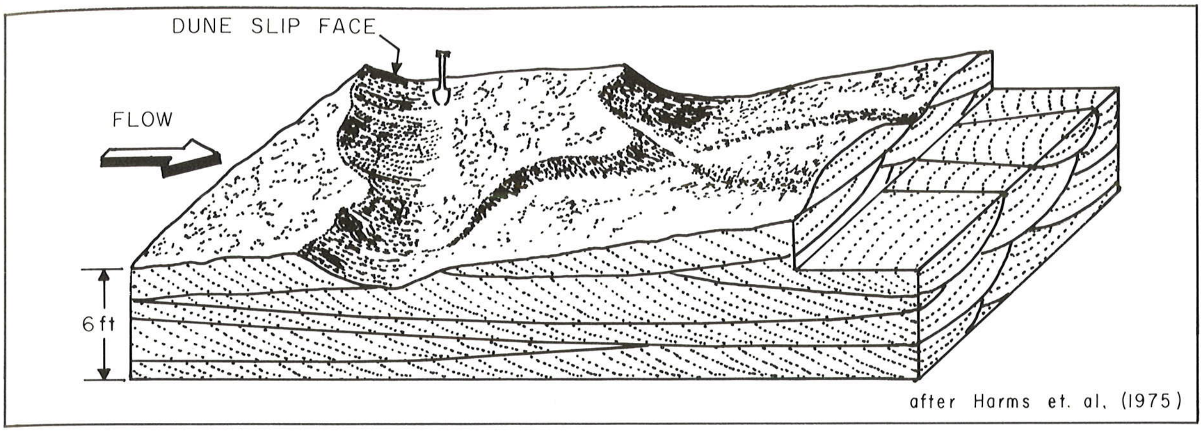


Fig. 12. Block diagram illustrating how cross-bedding is formed by migrating sand dunes in a river channel. The cross-beds are inclined in a downstream direction. When preserved in the rock record, they indicate the flow direction of ancient streams.

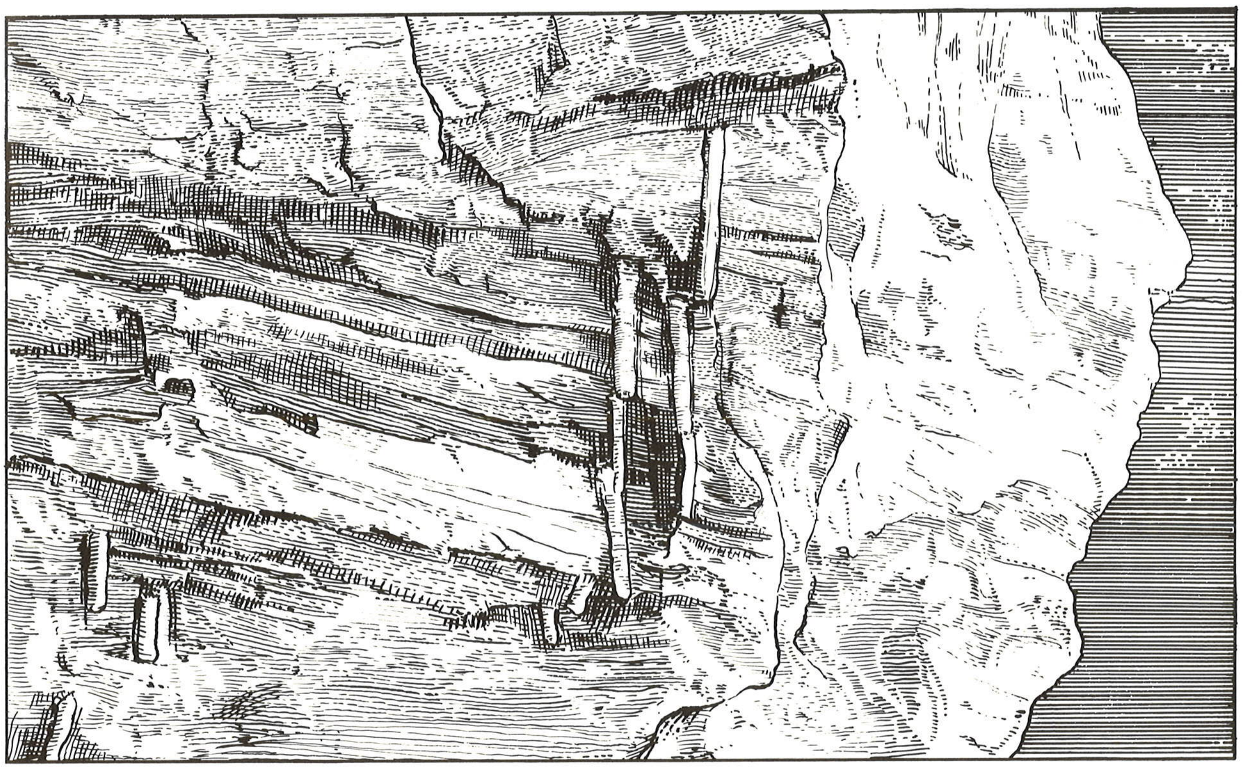


Fig. 13. Fossil insect burrows in Arikaree Group sandstones. Such burrows occur in several localities along the trail (stops D and E).

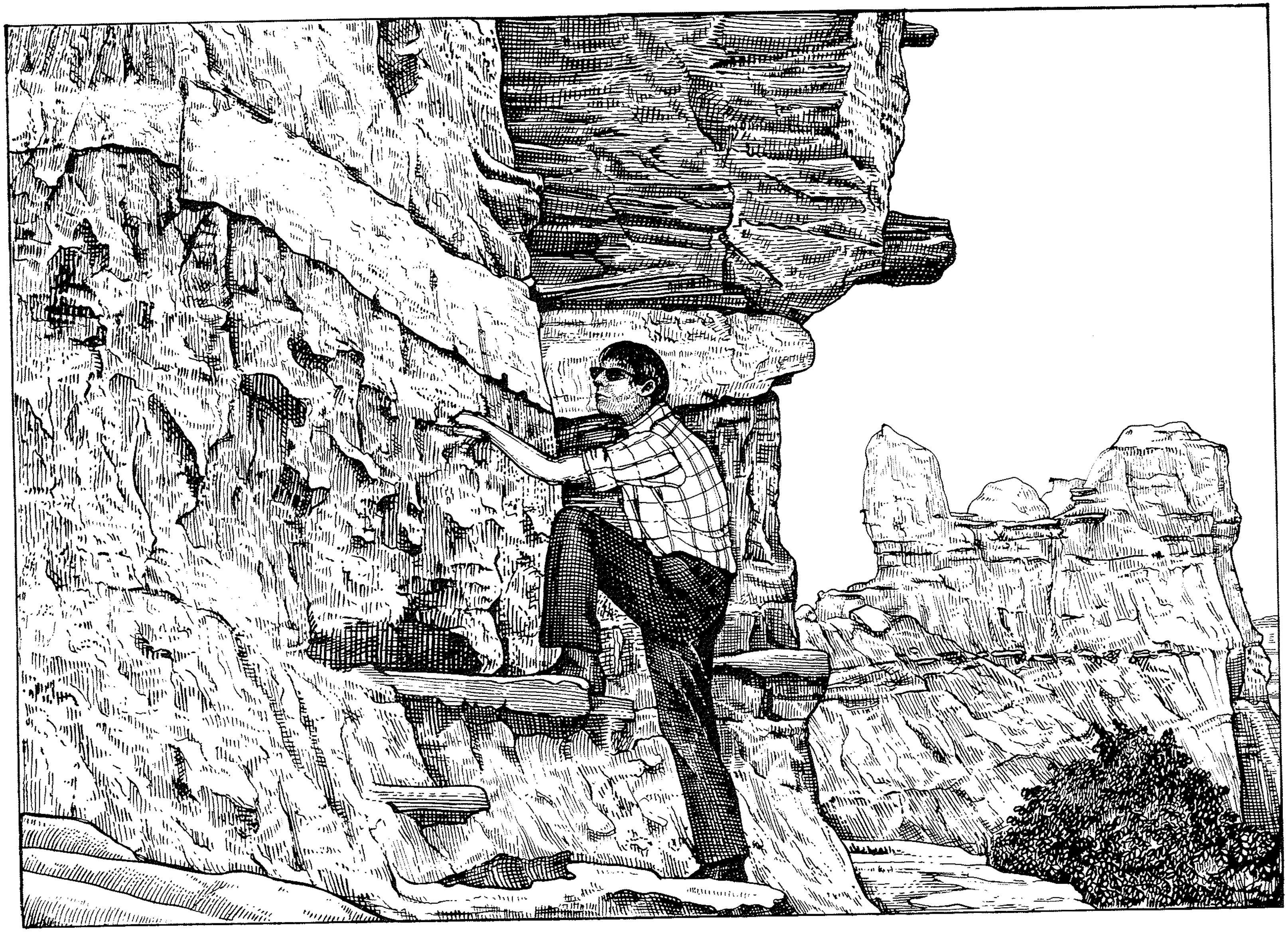


Fig. 14. A lens-shaped volcanic ash deposit in an Arikaree sandstone about 8 feet above the trail between stops D and E. The ash was probably deposited in shallow ponds or lakes on the floodplain of the ancient stream (fig. 11). This ash lens is in the lower part of rock unit 9 (fig. 8).

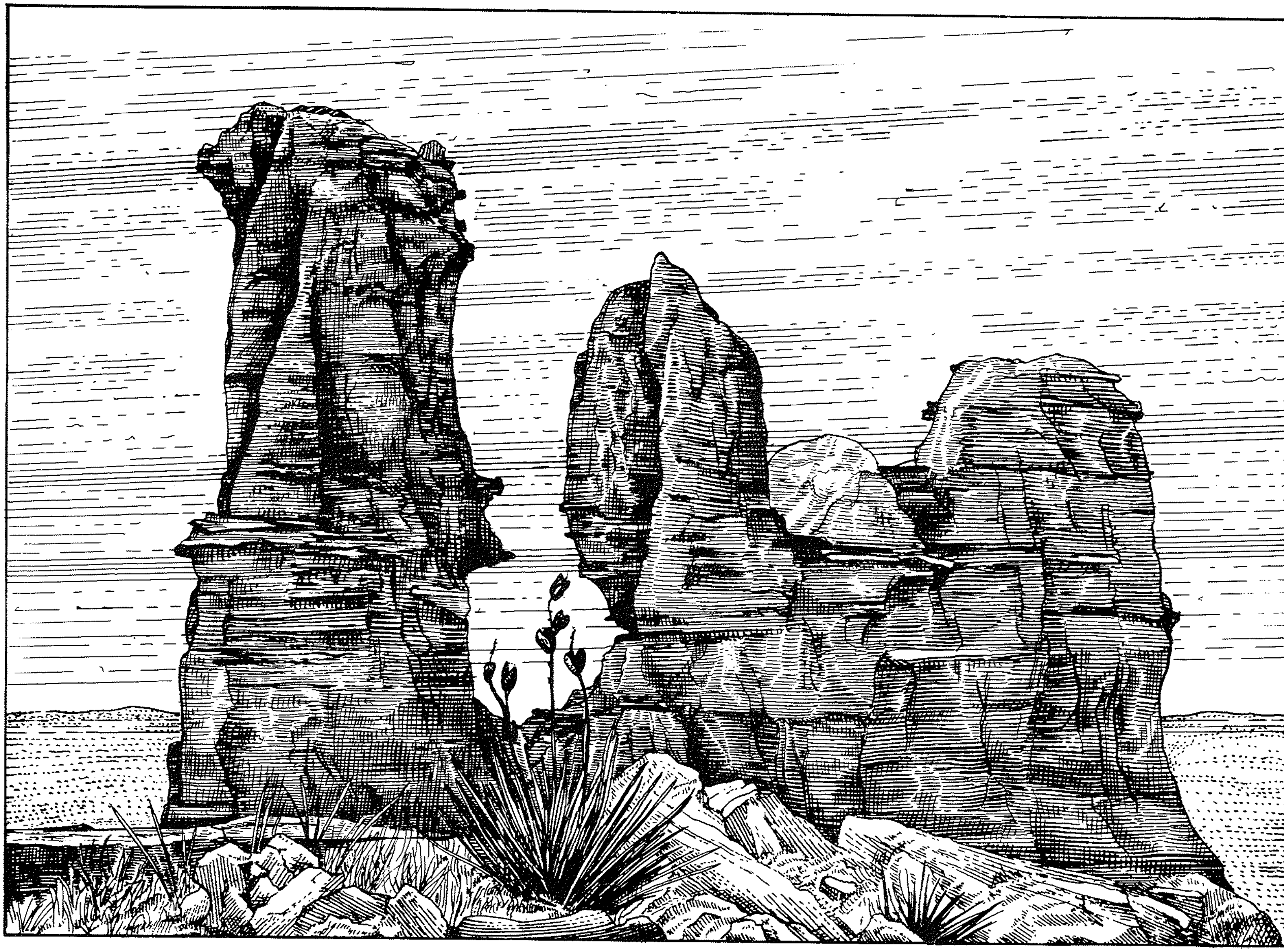


Fig. 15. Castlelike promontories near stop E on the hiking trail. These are held up in large part by the pipy concretions of the Arikaree Group (fig. 8).

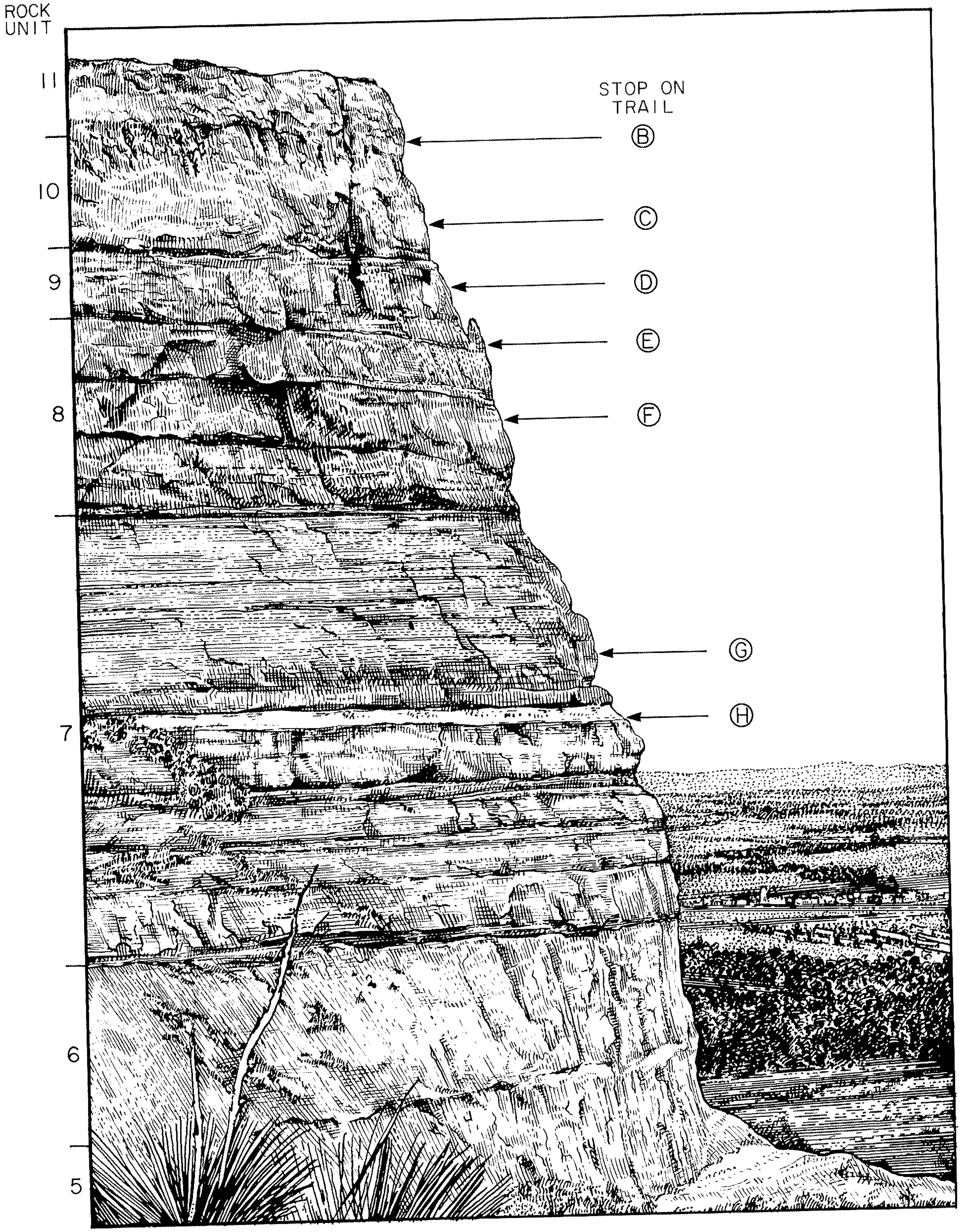


Fig. 16. Large cliff to the northeast of trail stop G. The numbers on the left are the rock units described in the measured section (see appendix and fig. 8). The letters on the right indicate the positions of trail stops B through H.

when the ash fall began. Beds below the ash are oxidized to a depth of 1 to 3 feet (0.305 to 0.91 m). Although the sediments comprising these rock layers were deposited in horizontal beds, the latter were strongly contorted in some places into a myriad of cusplike shapes (fig. 17). These features are best seen 30 to 45 feet (9.1 to 13.7 m) up trail from the tunnel entrance and 1 foot (0.305 m) above the ash. This deformation may have resulted from unequal densities of accumulating sediments.

The contact of the Arikaree Group with the underlying Whitney Member of the Brule Formation can be seen across the canyon from the south end of the tunnel (fig. 8).

Stop I (at head-of-canyon switchback). Here beds of siltstone comprising the Whitney Member of the Brule Formation can be viewed at close range. The grain size, texture, and thick massive character of these sediments indicate deposition by wind. Volcanic glass shards constitute 50 to 80 percent of the siltstone. Because the Whitney glass shards are smaller than those present in the Arikaree, they possibly were transported from more distant volcanoes by high-altitude winds, since larger shards would settle sooner. The eruptions producing this volcanic material occurred 28 to 32 million years ago and were probably located as far away as Utah and Nevada. One of the two distinct beds of volcanic ash in the Whitney crops out 30 feet (9.1 m) above the trail at this stop. It has a thin, gray coating of lichens on its surface. Ash beds in the Whitney are more continuous than those in the Arikaree Group and can be traced throughout much of the Nebraska panhandle.

Stop J (700 feet [213 m] down the trail from stop I). The remains of a large rock fall that occurred in October 1974 can be seen near the end of the ridge through which the tunnel passes. A large section of the bluff face gave way along a vertical fracture plane and crashed to the slope below. Much of the erosion at Scotts Bluff and along all of Wildcat Ridge occurs through rock falls such as this one.

The lower Whitney ash, which represents a major volcanic eruption or a series of closely spaced eruptions, can be seen above the trail to the west. It is about 20 feet (6.1 m) thick and can be traced for many miles.

Stop K (Scotts Spring). This spring issues from fractures in siltstones of rock unit 2, the lowest of the five rock units composing the Whitney Member. Water from the spring supports the luxuriant vegetation at this site.

Stop L (Eagle Rock). The prominent feature visible here is Eagle Rock (fig. 7). It provides excellent exposures of the Whitney and its two volcanic ash beds. Several nationally circulated travel folders have pictured Eagle Rock but have mistakenly labeled it Scotts Bluff.

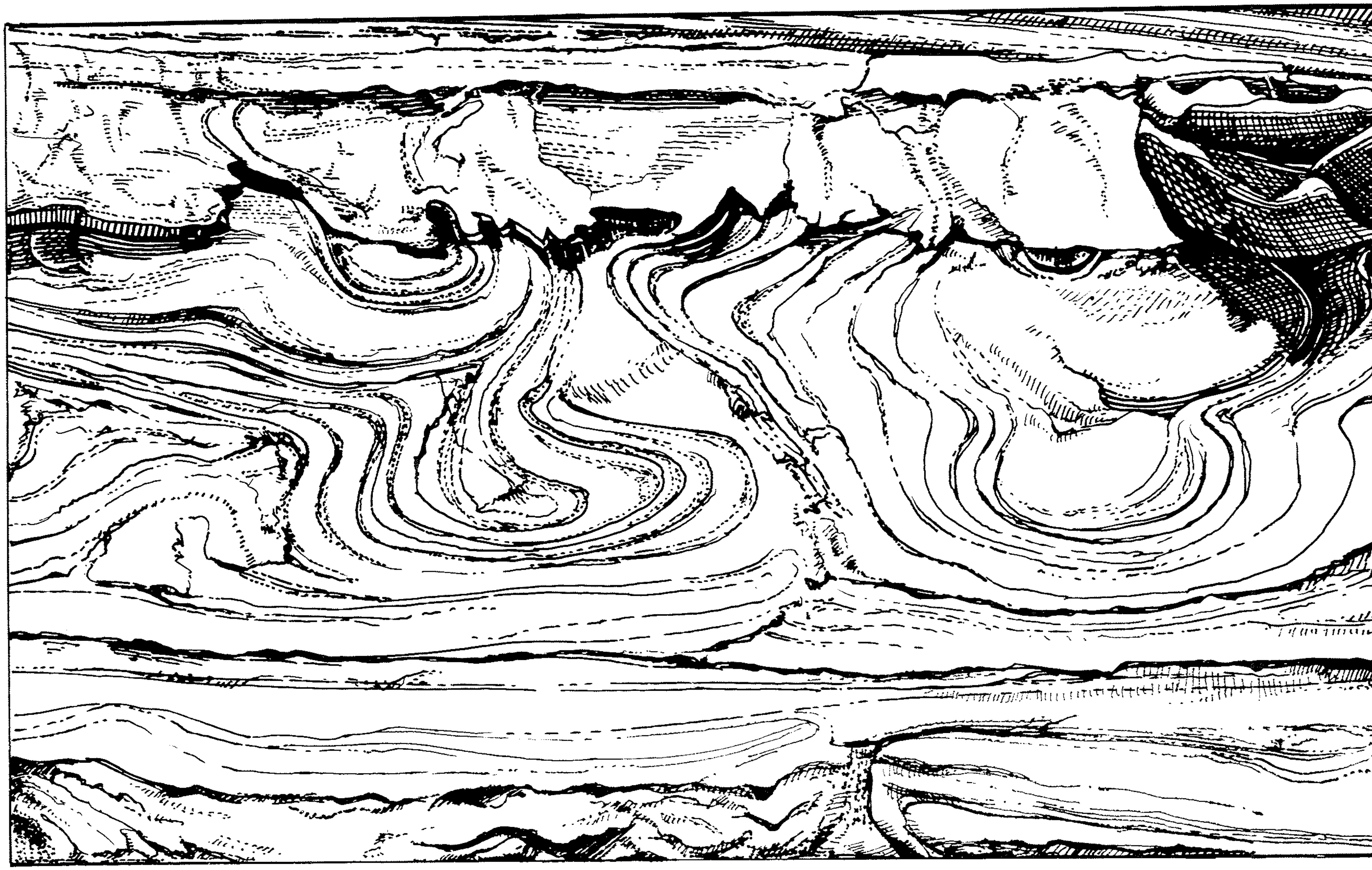


Fig. 17. Deformed bedding in fine-grained Arikaree sandstones about 40 feet (13.7 m) up trail from the tunnel entrance (stop H). The deformed bed is about 8 inches (203 mm) thick.

Geologic History of the Monument Vicinity

Rock layers exposed within the boundary of the Scotts Bluff National Monument may be considered as pages in a book describing the geologic history of the area. If thus regarded, they represent pages from two chapters (Oligocene and Miocene) in the first section (Teritary) of the last part (Cenozoic). Many more pages, all belonging to earlier chapters in the book, remain buried below the monument area. Their existence can be surmised from the relation of rock layers in other areas but can be proved only by drilling holes through them. If a hole were drilled at the monument to a depth of 8,000 feet (2 440 m), or 4,000 feet (1 220 m) below sea level, the bit would penetrate to rocks formed more than 600 million years ago. Even though these rocks are very much older than those exposed within the boundary of the monument, they are still far from the beginning of the book, the first page of which represents rocks formed as much as 4.5 to 5 billion years ago.

Rocks 8,000 feet (2 440 m) below the oldest rock layer exposed in the monument area are of Precambrian age and consist of igneous and metamorphic rocks such as granite and gneiss. The igneous rocks once were molten but crystallized on cooling within the upper part of the earth's crust. Metamorphic rocks are of two kinds—those formed by alteration of preexisting sedimentary rocks and those formed by alteration of preexisting igneous rocks. Neither the igneous nor the metamorphic rocks resemble pages in a book, as do the sedimentary rock layers in the Paleozoic, Mesozoic, and Cenozoic parts of the geologic history book. Rock layers representing pages from only the Permian chapter of the Paleozoic era and from the Jurassic and Cretaceous chapters of the Mesozoic era constitute the 8,000 feet (2 440 m) of sedimentary rocks buried beneath the monument area.

All the rock layers of Permian age were formed from sediments and calcareous ooze in the seawater and thus are proof that the monument area was, for at least those parts of geologic time, in a marine environment. Such creatures as brachiopods, pelecypods, gastropods, cephalopods, trilobites, ostracoderms, selachians, bony fishes, and lung fishes were abundant in these seas. Living in adjacent land areas were small to large amphibians and reptiles, many insects (including enormous dragon flies and cockroaches), and a flora rich in ferns and scale trees.

The rock layers of Jurassic age constitute the Morrison Formation, which consists of continental sedimentary rocks deposited on the floodplains of ancient streams. Armored and carnivorous dinosaurs were dominant creatures then on the scene.

Most of the rock layers of Cretaceous age were formed in a seaway that connected the Gulf of Mexico with Hudson Bay about 95 million years ago. The combined thickness of all Cretaceous rocks in this area may be as much as 5,000 feet (1 520 m). Abundant in the Cretaceous seas were reptiles—icthyosaurs, mosasaurs, plesiosaurs, and turtles—and a large variety of cephalopods, including some ammonites as much as 5 feet (1.52 m) in diameter. Pelecypods, gastropods, and echinoderms were also common. On adjacent land areas were abundant cycads, ferns, and conifers, and living among them were the dinosaurs and flying reptiles that then were at the zenith of their evolutionary development. All the oil produced in Scotts Bluff County has come from sandstones of the Dakota Group of Cretaceous age.

Toward the end of Cretaceous time, a mountain-building episode called the Laramide orogeny had begun. Tremendous forces within the earth caused a widespread regional uplift and a thrusting up of the Front Range and other mountain chains. Dinosaurs and many other animal and plant groups became extinct at this time.

If any sediments accumulated in the monument area during early Tertiary (Paleocene and Eocene) time, they were removed by erosion before the deposition of the Oligocene age sediments. Stream-deposited sediments in the Orella indicate a greater abundance of moisture than do the sediments comprising the overlying Whitney Member, which appears to have been deposited under increasingly arid conditions. The two prominent beds of ash and the high percentage of volcanic glass in the Whitney are evidence of extreme volcanic activity in the western United States during this time. Oreodonts, titanotheres, deer, rhinoceros, and a variety of carnivores were the principal large mammals living in western Nebraska during Oligocene time.

The abundance of water-deposited sediments in the Arikaree Group is evidence of increased moisture supplies due to increased precipitation during Miocene time. Volcanic eruptions to the west must have been numerous for so many shards of glass to be incorporated into Arikaree sediments. These rocks of Miocene age yield fossils of giant hoglike creatures called *Dinohyus* and huge slothlike creatures called *Moropus*. The skeletons of these animals are on display at the University of Nebraska State Museum in Lincoln.

Whether sedimentation occurred in the monument area during Pliocene time is not certain since no rocks of that age are present. Because Pliocene rocks occur in parts of the Nebraska panhandle and are widespread in central Nebraska, it seems likely that they once may have been present in the monument area but later were removed by erosion.

The present landscape was shaped largely during Pliocene time and Pleistocene time, the latter being commonly referred to as the Ice Age. Although none of the continental ice sheets or large glaciers in the Rocky Mountains invaded central or western Nebraska, erosion was accelerated by other land-shaping forces such as increased stream discharge. It was during Pleistocene time that tremendous amounts of rock were removed from the North Platte and Pumpkin Creek valleys by wind and water, leaving only Wildcat Ridge and other landmarks, such as Scotts Bluff, as proof that the Brule Formation and Arikaree Group were once continuous with equivalent rock units to the north and south of those valleys. Stream-deposited coarse gravels preserved as terrace deposits in parts of Scotts Bluff County and as alluvium beneath the floodplains of the North Platte River and Pumpkin Creek indicate the nature of the sediment load transported by streams draining this area during Pliocene and Pleistocene time.

Scotts Bluff National Monument not only preserves unspoiled a scenic and historic site but also provides evidence of the awesome earth-building and earth-removing processes that combined to shape this area as it appears today.

Acknowledgments

The volcanic ash date was provided by John Boellstorff. Ray Bentall and Vern Souders critically reviewed the manuscript. Harry Dowell, science teacher of the Scottsbluff High School, also helped.

Appendix

Measured Section of Exposed Rocks at Scotts Bluff*

Tertiary System: Miocene Series

Arikaree Group

Rock unit 11. Sandstone, very pale brown, fine-grained, silty, poorly consolidated; 20 to 40 percent volcanic glass shards; generally no bedding present (massive). Numerous pipy concretions in upper part (stop A on hiking trail) and potatolike concretions (stop B on hiking trail) in lower part. Thickness 100 feet (30.5 m).

Rock unit 10. Sandstone, light-gray, silty, thinly laminated; up to 40 percent volcanic glass shards, lenticular deposits of volcanic ash (stop C on hiking trail). Thickness 28 feet (8.5 m).

Rock unit 9. Sandstone, very pale brown, fine- to medium-grained, cross-bedded; abundant ash shards; some concretions and volcanic ash lenses (stop D on hiking trail). Thickness 25 feet (7.6 m).

Rock unit 8. Sandstone, very pale brown, fine- to medium-grained; up to 50 percent volcanic ash shards; nodular concretions (stop F on hiking trail). Thickness 35 feet (10.7 m).

Rock unit 7. Sandstone, very pale brown, fine- to medium-grained; massive to thick-bedded at top, thinly laminated toward base of unit (stop G), abundant ash shards; lenticular volcanic ash deposit (stop H on hiking trail). Thickness 65 feet (19.8 m).

*Cf. fig. 8.

Tertiary System: Oligocene Series

Brule Formation

Whitney Member

Rock unit 6. Siltstone, pink, clayey, compact, massive, blocky to platy fracture, irregular contact with overlying Arikaree. Thickness 25 feet (7.6 m).

Rock unit 5. Volcanic ash (upper Whitney ash), white. Crops out about 30 feet (9.1 m) above trail level at stop I. Thickness 3 feet (0.91 m).

Rock unit 4. Siltstone, pink, clayey and dense, blocky to platy fractures. Thickness 100 feet (30.5 m).

Rock unit 3. Volcanic ash (lower Whitney ash), white. Thickness 20 feet (6.1 m).

Rock unit 2. Siltstone, pink, clayey, compact massive, blocky to platy fractures. Scotts Spring (stop K) occurs near the middle of this unit. Thickness 160 feet (49.0 m).

Orella Member

Rock unit 1. Siltstone, pink, thin- to thick-bedded, contains some stream channel sandstone. Exposed thickness about 170 feet (52 m).

Selected Readings

Anonymous. Summit self-guiding trail: Scotts Bluff National Monument, Nebraska. Oregon Trail Museum Association, 14 pp.

Bart, H. A. 1975. Miocene sediment dispersal for western Nebraska and southeastern Wyoming. University of Wyoming: Contributions to Geology 14:27-39.

Darton, N. H. 1898. Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian. U.S. Geological Survey: 19th annual report, pp. 719-814.

Everenden, J. F.; Savage, D. E.; Curtis, G. H.; and James, G. T. 1964. Potassium-argon dates and the Cenozoic mammalian chronology of North America. American Journal of Science 262: 145-198.

Harms, J. C.; Southard, J. B.; Spearing, J. R.; and Walker, R. G. 1975. Depositional environments as interpreted from primary sedimentary structures and stratification sequences. Society of Economic Paleontologists and Mineralogists: Short Course No. 2, 161 pp.

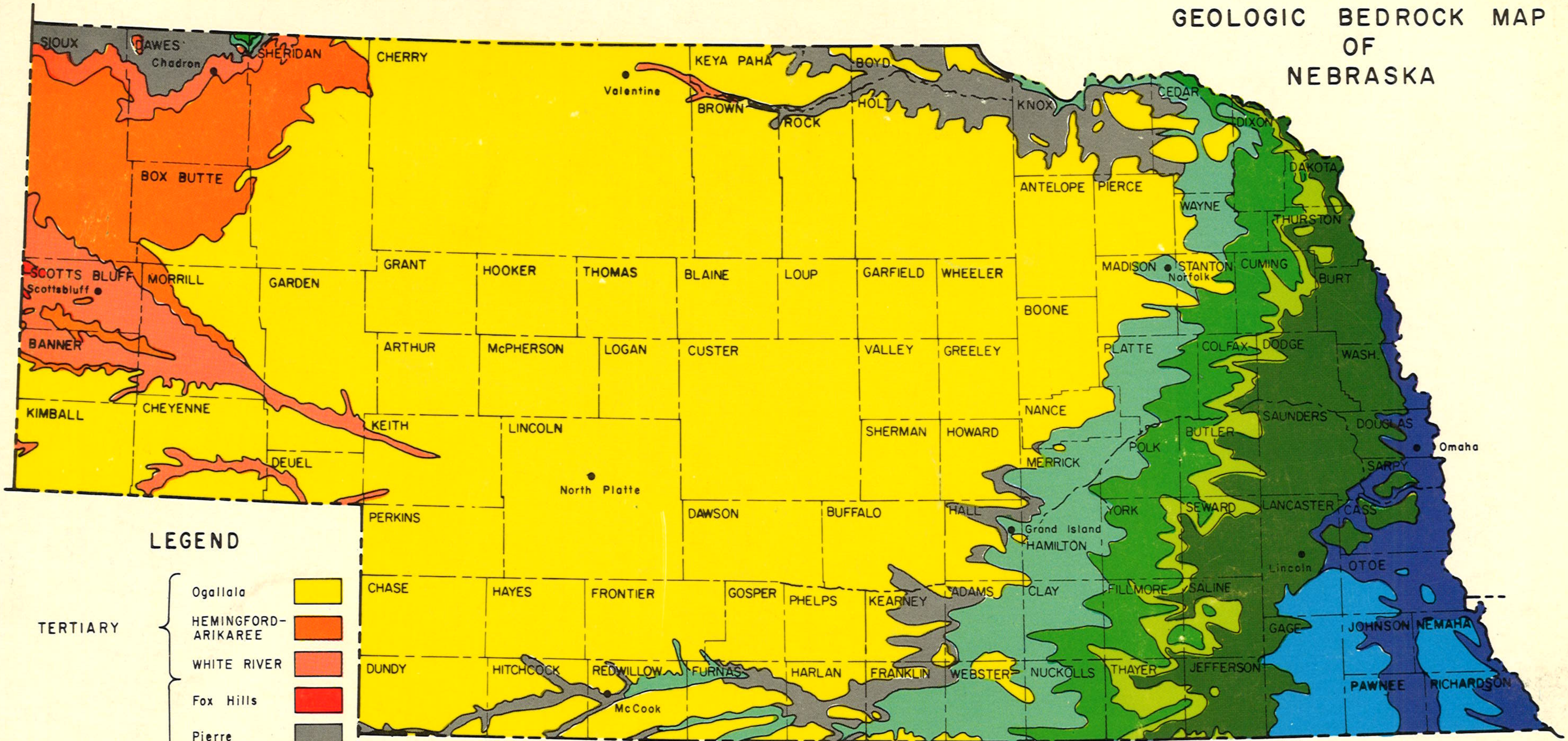
Schultz, C. B., and Stout, T. M. 1955. Classification of Oligocene sediments in Nebraska. Bulletin of the University of Nebraska State Museum 4/2:17-52.

Stanley, K. O., and Fagerstrom, J. A. 1974. Miocene invertebrate trace fossils from a braided river environment, western Nebraska, U.S.A. Paleogeography, Paleoclimatology, and Paleoecology 15:63-82.

Vondra, C. F.; Schultz, C. B.; and Stout, T. M. 1969. New members of the Gering Formation (Miocene) in western Nebraska *including* a geological map of Wildcat Ridge and related outliers. Nebraska Geological Survey Paper 18.

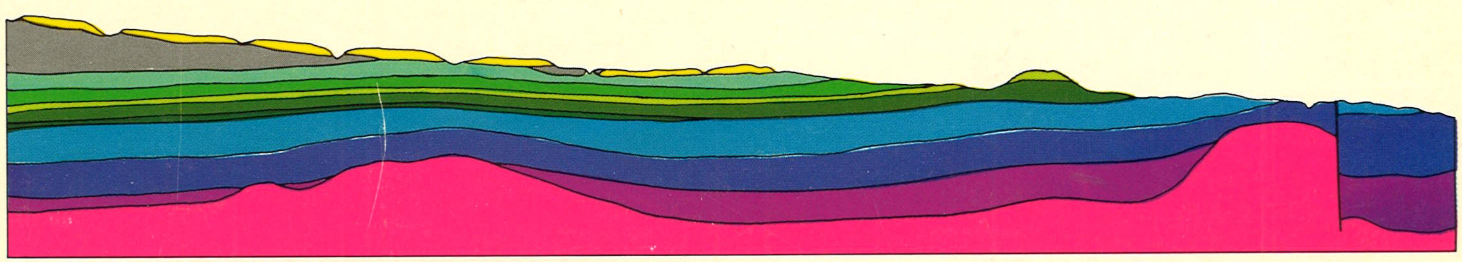
Williams, P. F., and Rust, B. R. 1969. The sedimentology of a braided river. Journal of Sedimentary Petrology 39:649-679.

GEOLOGIC BEDROCK MAP OF NEBRASKA



LEGEND

- TERTIARY
  - Ogallala
  - HEMINGFORD-ARIKAREE
  - WHITE RIVER
- CRETACEOUS
  - Fox Hills
  - Pierre
  - Niobrara
  - Carlile
  - Greenhorn-Graneros
  - DAKOTA
- JURASSIC
- PERMIAN
- PENNSYLVANIAN
- MISSISSIPPIAN, DEVONIAN, SILURIAN, ORDOVICIAN, CAMBRIAN
- PRECAMBRIAN



Cross Section Along Southern Nebraska Border

20 0 20 40 60
Scale in Miles

NOTE: Unconsolidated sediments of Pleistocene age cover the bedrock throughout much of the State and are not shown.

EC-3

~~$5.00~~