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R. K. Pabian
University of Nebraska - Lincoln

J. B. Swinehart
University of Nebraska - Lincoln

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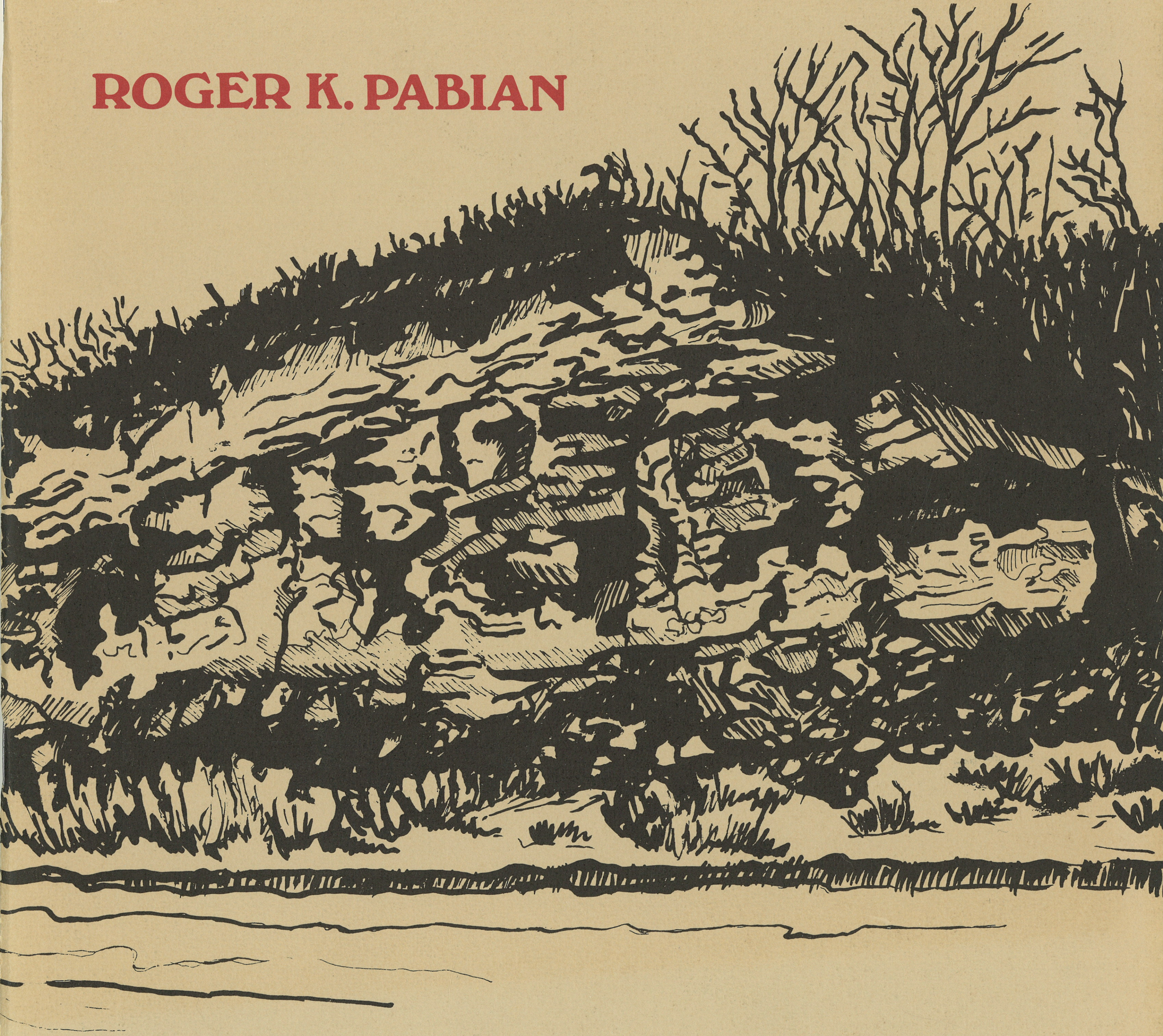

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Illustrated by Frankie Gould

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

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INTRODUCTION

The outcrops of rock along the Republican River valley south of Red Cloud, Nebraska, form a geologically important section (cf. figs. 1-6). Red Cloud derives its name from a nineteenth-century Indian chief of the Ogallala Sioux. The area around Red Cloud is thus important from a historical as well as from a geological point of view. Many notable persons, including novelist Will Cather and paleontologist C. Bertrand Schultz, grew up in the Red Cloud area.

The oldest rocks exposed along the south side of the Republican River valley near Red Cloud were deposited about 95 million years ago in late Cretaceous age seas (cf. figs. 7, 12). Directly overlying these rocks in most places are unconsolidated stream sediments, called alluvium, and aeolian (wind) deposits laid down in Pleistocene time beginning about two million years ago. Many younger rock layers were probably deposited here in the long interim, but almost all were subsequently removed by erosion. During this long interval of time, many different environments existed and were populated by life forms that are very much different from those we see in the Red Cloud area today. These rocks -- those that can be seen and those that lie beneath the surface of the Red Cloud area, together with the past environments indicated by them -- provide the subject of the following pages.

HOW TO LOCATE THE ROCK EXPOSURES

Two rock exposures about 2 miles south of Red Cloud in Webster County are described in this guide. Exposure 1 is situated in SW¼, SE¼, SE¼, sec. 11, T. 1 N., R. 11 W., and exposure 2 is in NE¼, NE¼, NE¼, sec. 14, T. 1 N., R. 11 W. (cf. fig. 1). Two additional rock exposures occur along the county road in N½, sec. 15, and a third occurs in N½, sec. 16, T. 1 N., R. 11 W.

To reach exposure 1 from the junction of U.S. Highway 281 and U.S. Highway 136 in downtown Red Cloud, proceed south on U.S. Highway 281 for 1.8 miles (2.90 km) and then turn right (west) onto the county road. Continue for about 0.25 mile (0.400 km). Exposure 1 is on the left (south) side of the road. The elevation at road level is about 1,695 feet (520 m) above sea level.

To reach exposure 2, return to U.S. Highway 281. Turn right (south) and proceed for 0.1 mile (0.161 km). The outcrop is on the right (west) side of the highway. The elevation of the base of the outcrop is about 1,740 feet (530 m) above mean sea level.

EXPOSED ROCKS

Several interesting chapters in the geological history of Nebraska are revealed by the rocks exposed along the Republican River near Red Cloud. Here one may examine a rock sequence consisting of marine sedimentary strata of late Cretaceous age and stream-deposited alluvium and wind-deposited loess of

Topography of part of the Red Cloud Quadrangle, Nebraska--Kansas

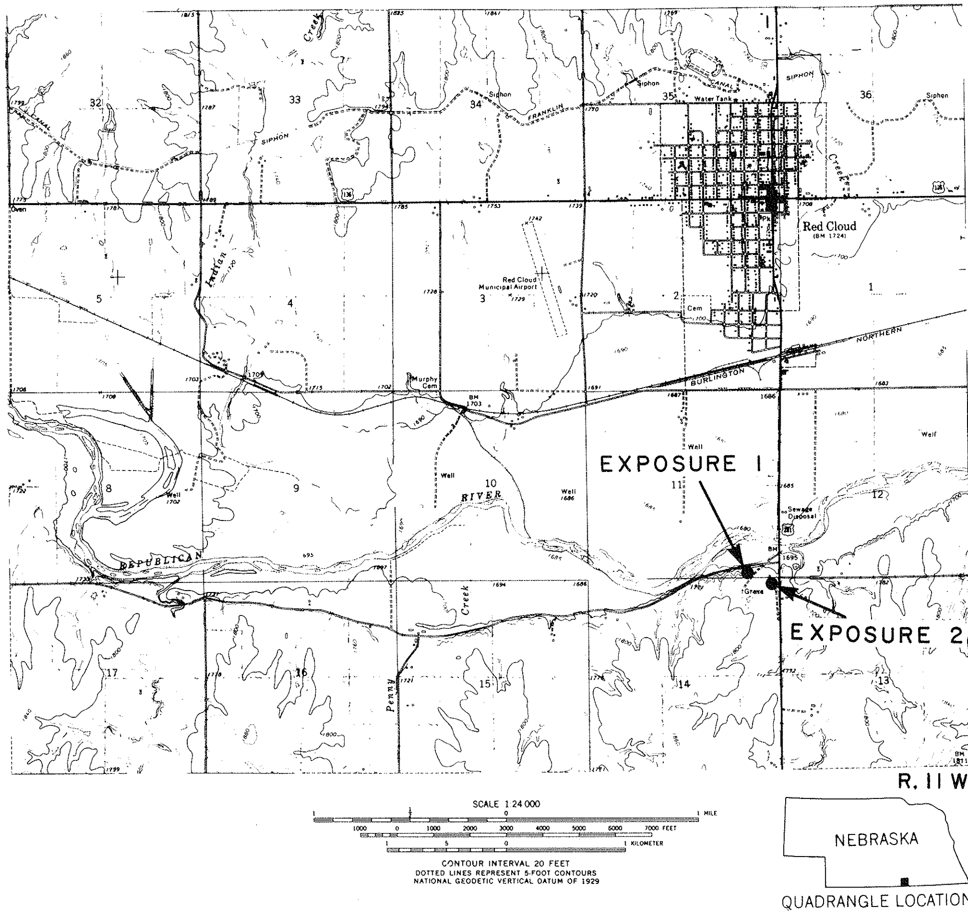

Fig. 1. Location of rock exposures in the Red Cloud area

Pleistocene age. The estimated age of the marine sedimentary rocks, called the Smoky Hill Chalk Member of the Niobrara Formation, is about 95 million years and the oldest loess deposit in the area is less than 1 million years old.

At exposure 1 (figs. 2-4), the Smoky Hill Member of the Niobrara Formation crops out in a steep rock bluff capped by a lower and an upper loess. Only part -- about 62 feet (18.9 m) -- of the full thickness of the Smoky Hill Member is exposed, an unknown additional thickness being present below that visible in the bluff. Although the thickness of the loess appears to be about 60 feet (18.3 m), actually it is 35 feet (10.7 m) or less measured perpendicularly to the sloping rock surface on which the loess rests.

Although only a short distance from exposure 1, exposure 2 (figs. 5, 6) differs from exposure 1 in that the basal unit is an ancient stream deposit composed almost wholly of weathered fragments of the Niobrara Formation and not the Niobrara Formation itself. Apparently the Niobrara was widely exposed in the drainage area of the stream that deposited the alluvium. How far back from the face of the exposure the alluvium extends is not known, but if a horizontal hole were to be bored into this alluvium, it would eventually reach the side wall of the valley in which the alluvium was deposited. That side wall would prove to be the Smoky Hill Member of the Niobrara Formation. At exposure 2, the lower loess rests directly on the alluvium and both the apparent and actual thicknesses of the loesses are somewhat less than at exposure 1.

EXPOSED ROCKS

Geologists, by identifying fossils, can determine both the geologic age of deposits and the environment in which the deposits were formed. Fossils in the marine limestones near Red Cloud contain tests (shells) of foraminifers, clam and cephalopod shells, and various hard parts of sharks and fishes (figs. 8-11). Fossils in the loess deposits include abundant shells of land snails (fig. 10) and teeth and bones of vertebrate land animals.

By magnifying a sample of the marine limestone, an observer can easily see the abundant fossils it contains. These are the tests of single-celled animals called foraminifers (fig. 8). The marine limestone is suitable for the manufacture of agricultural lime and cement but may contain up to 20 percent clay. Most of the limestone layers probably originated as calcareous ooze on the sea floor. Later such layers were compacted as water was squeezed from them by the weight of overlying sediments and the water column. Probably of organic origin, such ooze indicates that the ancient sea teemed with plants and animals that extracted lime from water to form their hard parts. After these organisms died, most of their hard parts were pulverized by the wave action of the water or by the digestive systems of scavengers. Those hard parts escaping pulverization became the well preserved micro- or macro-fossils that occur in limestone.

Clam shells (fig. 9) are fairly common in the marine limestone. Their abundance indicates that living conditions for these animals were ideal. The algae and foraminifers are very important, however, because they make up the first links of the

MEASURED SECTION AT EXPOSURE 1

QUATERNARY SYSTEM--PLEISTOCENE SERIES

Unit 9. Soil, silty, dark gray brown, as much as 1 foot (0.305 m) thick.

Bignell Loess

Unit 8. Silt, light gray, wind-deposited; apparent thickness as much as 10 feet (3.05 m); actual thickness as much as 5 feet (1.52 m).

Peoria Loess

Unit 7. Silt, calcareous, light yellowish brown, wind-deposited; fossil land snails (fig. 10) throughout dark, humic layer at top; apparent thickness as much as 50 feet (15.2 m); actual thickness as much as 30 feet (9.1 m).

CRETACEOUS SYSTEM--LATE CRETACEOUS SERIES

Niobrara Formation

Smoky Hill Chalk Member

Unit 6. Limestone, light yellow to light tan, silty, calcareous; contains few oyster fossils; as much as 15 feet (4.55 m) thick.

Unit 5. Limestone, medium gray, silty, tending to be slabby; contains some oyster and bivalve fossils; as much as 38 feet (11.6 m) thick.

Unit 4. Limestone, light gray, massive, calcareous, contains ammonite and clam fossils; as much as 6 feet (1.83 m) thick.

Unit 3. Bentonite, light yellow, clayey; about 0.1 foot (0.030 5 m) thick.

Unit 2. Limestone, medium gray, calcareous, massive near top but slabby toward base, contains fossils; as much as 3 feet (0.91 m) exposed.

Unit 1. Covered interval, 4.0 feet (1.22 m), to road level.

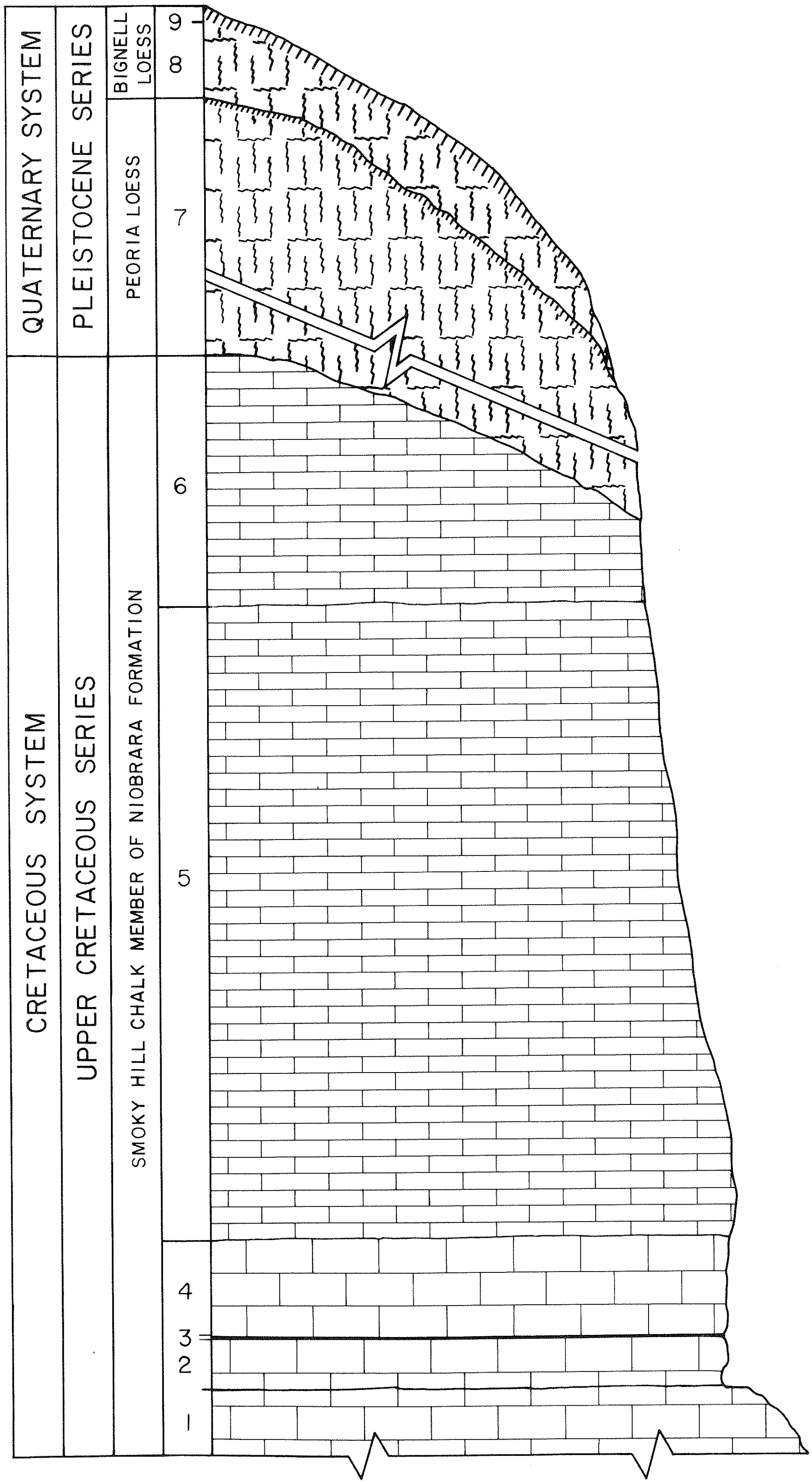

Fig. 2. Measured section of Cretaceous and Pleistocene sediments at exposure 1

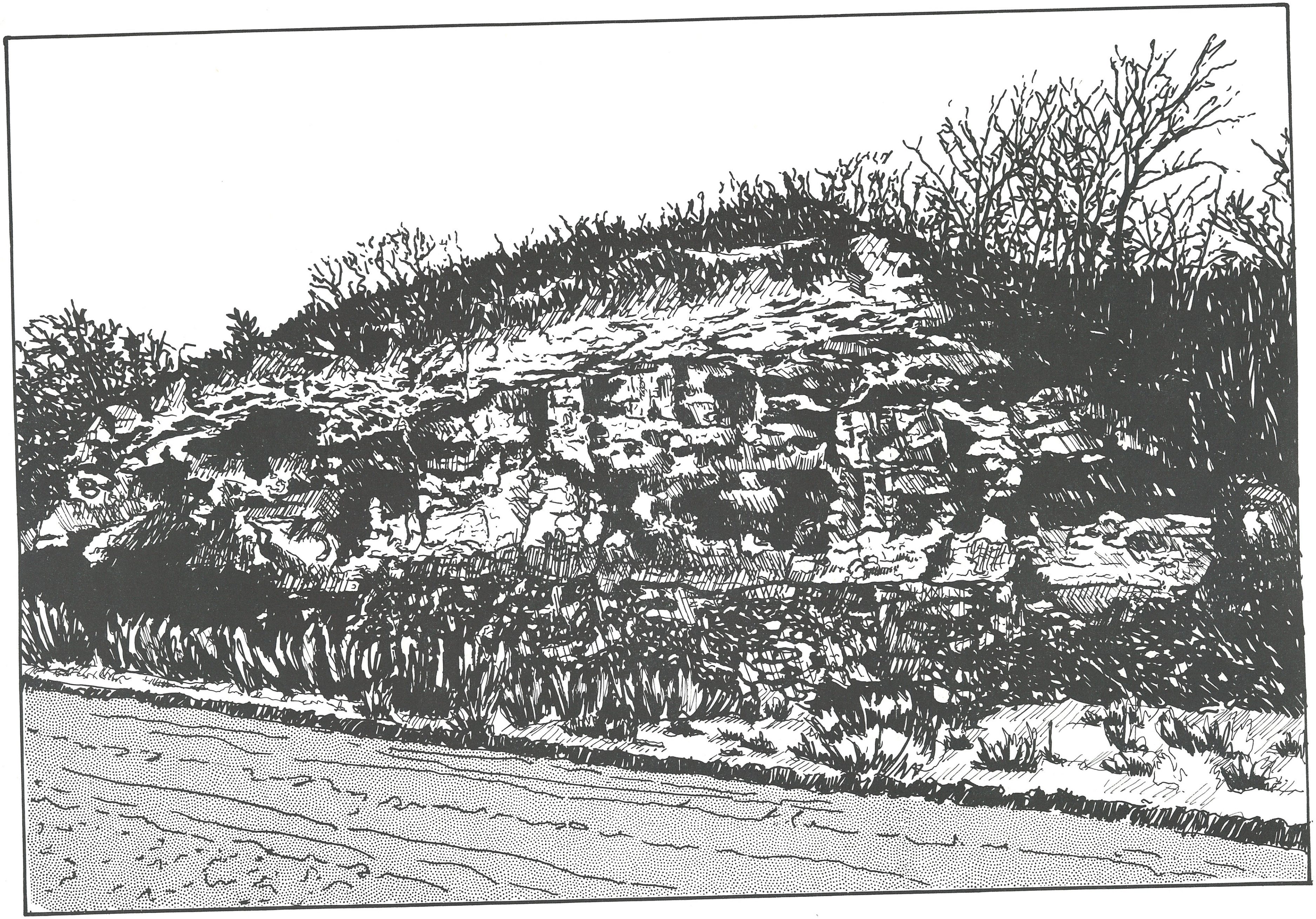

Fig. 3. Niobrara Chalk and Peoria Loess as seen at exposure 1. Slumping may alter the appearance of the exposure. View looking south.

Fig. 4. Westward continuation of Niobrara Chalk and Peoria Loess at exposure 1. Slumping may alter the appearance of the exposure. View looking south.

MEASURED SECTION AT EXPOSURE 2

QUATERNARY SYSTEM--PLEISTOCENE SERIES

Bignell Loess

Unit 3. Light gray, wind-deposited silt; apparent thickness up to 10 feet (3.05 m); actual thickness 5 feet (1.52 m).

Peoria Loess

Unit 2. Light yellow brown, wind-deposited, calcareous silt, with fossil land snails throughout and dark, humic region near top; apparent thickness up to 30 feet (9.1 m); actual thickness up to 25 feet (7.6 m).

Alluvium

Unit 1. Light yellow to light brown, stream deposits with silt and limestone pebbles from underlying Niobrara Formation; up to 20 feet (6.1 m) exposed.

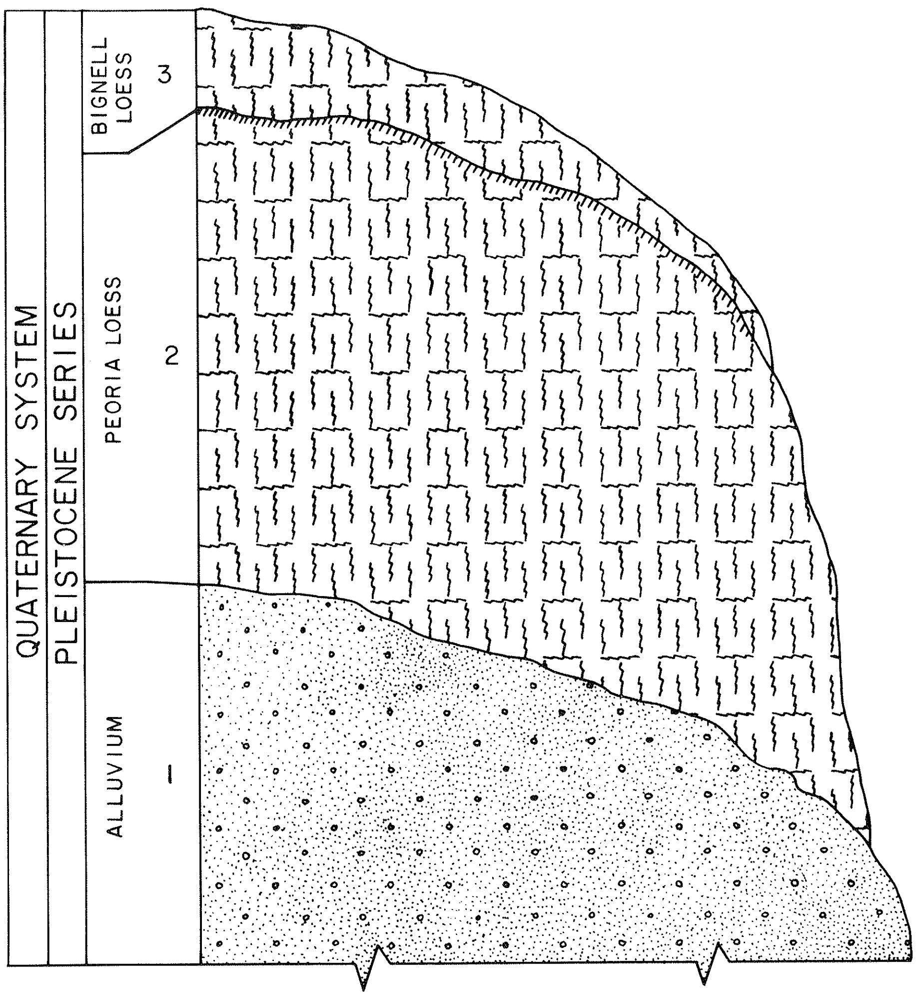

Fig. 5. Measured section of Pleistocene sediments at exposure 2

Fig. 6. Alluvium and loess deposits at exposure 2. Slumping may alter appearance of the exposure. View looking southwest.

food chain, the last links of which were fish, sharks, or marine reptiles (including mosasaurs and plesiosaurs). The algae and foraminifers provided food for such animals as worms and clams, which in turn provided food for small fishes and cephalopods, which in turn provided food for the larger carnivores (fig. 11).

The absence of reef building organisms such as sponges, corals, and ectoprocts (bryozoans) indicates that the substrate may have been too soft and too unstable to support solid structures.

Of particular interest is the large clam genus *Inoceramus* sp., some examples of which are several feet in diameter. Covering these large shells are usually shells of the small oyster, *Ostrea congesta* Conrad (fig. 10). Attached to some large shells are scutes of the barnacle *Loricula*, although this occurrence is comparatively rare.

At exposure 2 (figs. 5, 6), alluvium of the Pleistocene age forms the lower part of the section. This alluvium -- basically stream-deposited silt, sand, and gravel -- is composed of limestone particles derived from the Niobrara Formation. Originally such deposits were gravel bars along an ancient stream which, compared to the Republican River, was less deeply incised and had a much smaller drainage area.

The wind-deposited loess overlying the alluvium or resting directly on the limestone is typical of many valley-side outcrops of Pleistocene deposits. It consists mostly of light yellowish brown silt (below) and light gray silt (above) separated by a dark humic layer (an ancient soil horizon). Capping the upper silt is modern-day soil.

The loess deposits exposed along the Republican River rest on sloping surfaces. For that reason, the apparent loess thicknesses, which are measured vertically, are much greater than their actual thicknesses would be if measured perpendicular to the surface on which the loess rests. Cross sections extending from the uplands on one side would show that the loess is, in effect, draped over topographic irregularities. Two loess deposits can be recognized in this area. The lower is the thicker and is named the Peoria Loess; the upper is the Bignell Loess.

Loess is made up of silt-sized particles deposited on dry land by wind. Unlike other unconsolidated sediments, it maintains nearly vertical walls when being eroded. This characteristic of loess accounts for the steep slopes along the Republican River valley. Numerous fossil land snails occur in the loess (fig. 10).

GEOLOGIC HISTORY

A geologic history accounting for the rock sequence exposed near Red Cloud can be interpreted from the composition and texture of the rock layers, from the fossils they contain, and from the relationship of one rock layer to another. See figure 12.

The geologic history of the Red Cloud area began with the origin of the earth. If a hole were to be drilled to a depth of about 4,400 feet (1 341 m) below the exposure area, granite or grandodiorite of Precambrian age (fig. 7) would be reached. These are igneous rocks composed of the minerals feldspar, quartz, mica, and amphibole. Overlying these ancient rocks are, successively, sediments of the Cambrian, Ordovician, Silurian Devonian, Mississippian, Pennsylvanian, and Permian periods of the Paleozoic era. The geologic periods during which these rocks were deposited have been determined by their fossil content. Common marine life forms during that part of the earth's history were trilobites, corals, snails, clams, crinoids, brachiopods, primitive fishes, and sharks. Common land forms were amphibians, reptiles, and primitive plants. Drill cores show that many of the Permian age rock layers consist of chemical evaporites such as halite (salt) and gypsum.

Withdrawal of the sea from the midcontinent at the end of the Permian was followed by a long period of erosion. This lasted through the Jurassic, Triassic, and early part of the Cretaceous periods of the Mesozoic era. The only evidence of sedimentation during that interval of geologic time is a few feet of continental deposits that may represent the Morrison Formation of Jurassic age. In the middle of the Cretaceous period, subsidence of the area that now is the Great Plains and eastern part of the mountainous area to the west created a shallow seaway that extended from the Gulf of Mexico to Hudson Bay. In the Red Cloud area, deposition of beach sands and lagoonal and tidal flat deposits of the Dakota Group was followed successively by deposition of the Graneros Shale, the Greenhorn Limestone, the Carlile Shale, and the Niobrara Formation -- all of Cretaceous age. Mesozoic life forms in the sea included clams, cephalopods, snails, sharks, fishes, mosasaurs, and plesiosaurs. On the land, such forms included dinosaurs, primitive mammals, and advanced plants. The

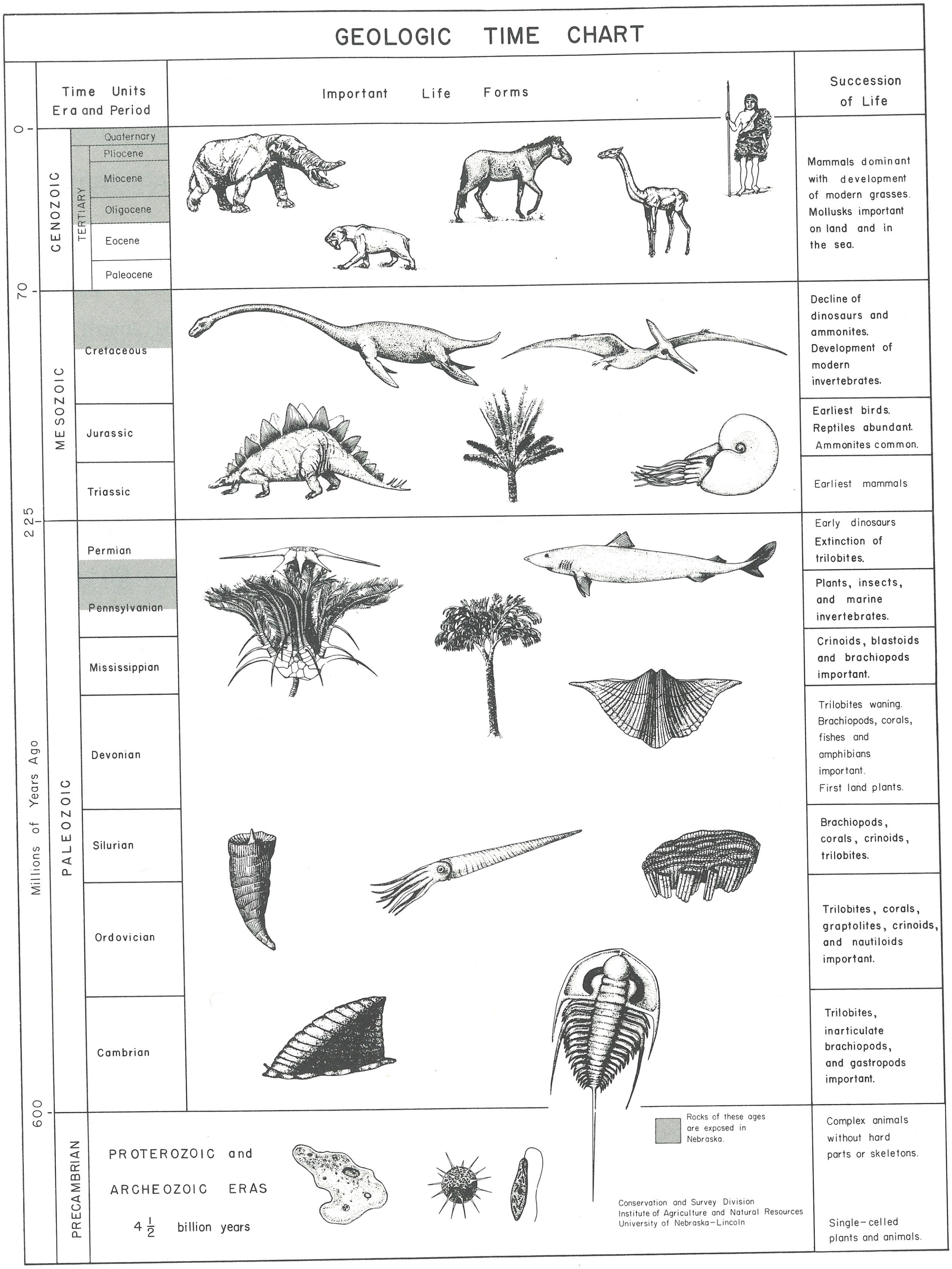

Fig. 7. Geologic time chart. The shaded parts of the time units indicate the age of rocks exposed in Nebraska.

end of the Cretaceous period was marked by uplift accompanied by a withdrawal of the sea from the western interior of the North American continent. Ash falls related to volcanism killed much of the vegetation, possibly contributing to the extinction of the once-abundant dinosaurs. Ammonites, a group of coiled cephlapods, also became extinct.

During the early and middle parts of the Tertiary period of the Cenozoic era, mountain building was taking place in western United States while erosion was removing the upper rock layers deposited during the Cretaceous in the Red Cloud area. During the Pliocene epoch of the Tertiary period, a broad alluvial plain consisting of rock particles eroded from mountains in Colorado and Wyoming continued to expand eastward, eventually burying the Red Cloud area beneath layers of sand and gravel. Subsequent erosion removed most of these layers from the Red Cloud area but some remain beneath the highest part of the upland valley. Those that remain are considered by geologists to be remnants of the Ogallala Formation, which underlies the Great Plains from western Texas to southern South Dakota. Some very fine vertebrate fossils, among them a mastodont (elephant) that is now on display at the University of Nebraska State Museum, have been found in the Pliocene rock layers.

The Pleistocene epoch of the Cenozoic era was characterized by recurring drops in temperature together with expansion of glaciers from centers of ice accumulation near both of the earth's poles. Although some of the North American ice sheets overrode the eastern part of Nebraska, none advanced far enough to reach the Red Cloud area. Possibly some of the deposits of sand and gravel beneath loess in upland areas were deposited by meltwater from the glacial margin. Fossil remains of mammoths, camels, giant beavers, saber-toothed tigers, and man have been found in Pleistocene deposits in Nebraska.

It was during the Pleistocene that the Republican River carved the valley it flows in today. Test drilling by the Conservation and Survey Division of the University of Nebraska shows that a broad, deep valley carved by an ancient stream bed now filled with sand and gravel is about 6 miles (9.7 km) north of the Republican River valley in western Webster County and enters the Republican River valley a short distance east of Red Cloud. The sand and gravel filling that ancient valley is saturated and constitutes an important aquifer in Webster County.

The Republican River drains about 22,000 square miles (57 000 km^2) upstream from Red Cloud. Its average discharge here since the last reservoir was created in its drainage area has been 380 cubic feet per second (10.8 m^3/s), or 275,000 acre-feet (3.39 km^3) per year. Crops grown on the fertile soils, many acres of which are irrigated with diverted surface water or with groundwater, contribute significantly to Nebraska's economy.

The floodplain of the Republican River is about 2 miles (3.20 km) wide. Although extensive flooding has caused much loss of life and damage to property in the past, such events are unlikely now that flood waters can be held back in the several large upstream reservoirs and released at controlled rates.

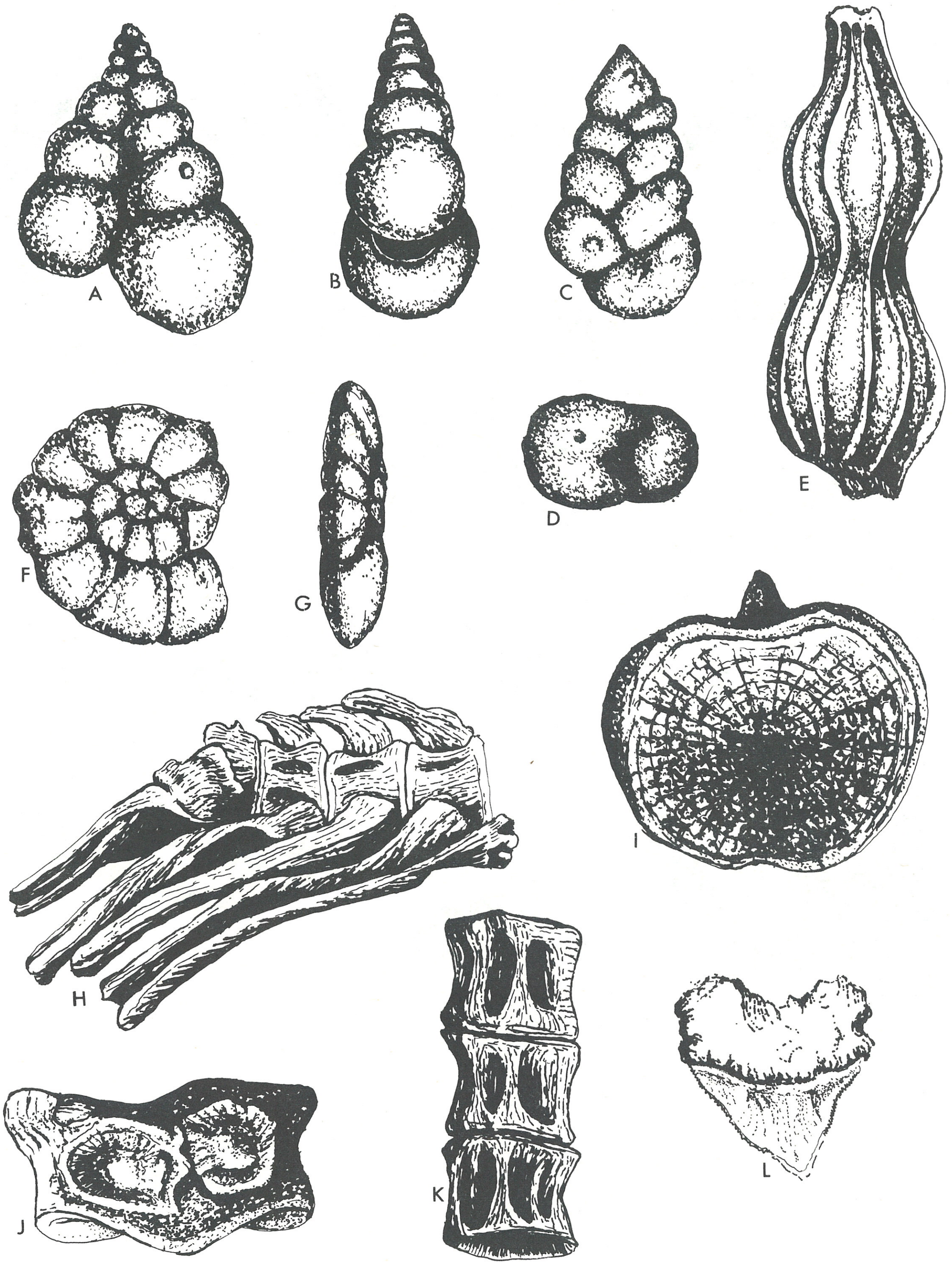

Fig. 8. Cretaceous fossils. [A-G. Foraminifers.] A, B. Gumbelina, lateral and peripheral views, X 180. C, D. Gaudryina, lateral and apertural views, X 120. E. Nodosaria, lateral view, X 80. F, G. Planulina, dorsal and peripheral views, X 120. [H-L. Fish remains.] H, K. Ichthyodectes, vertebrae and portion of caudal fin, X 2. I, J. Xiphacanthus, posterior and superior views of first anterior vertebra, X 2. L. Shark tooth, Squalicorax, X 4.

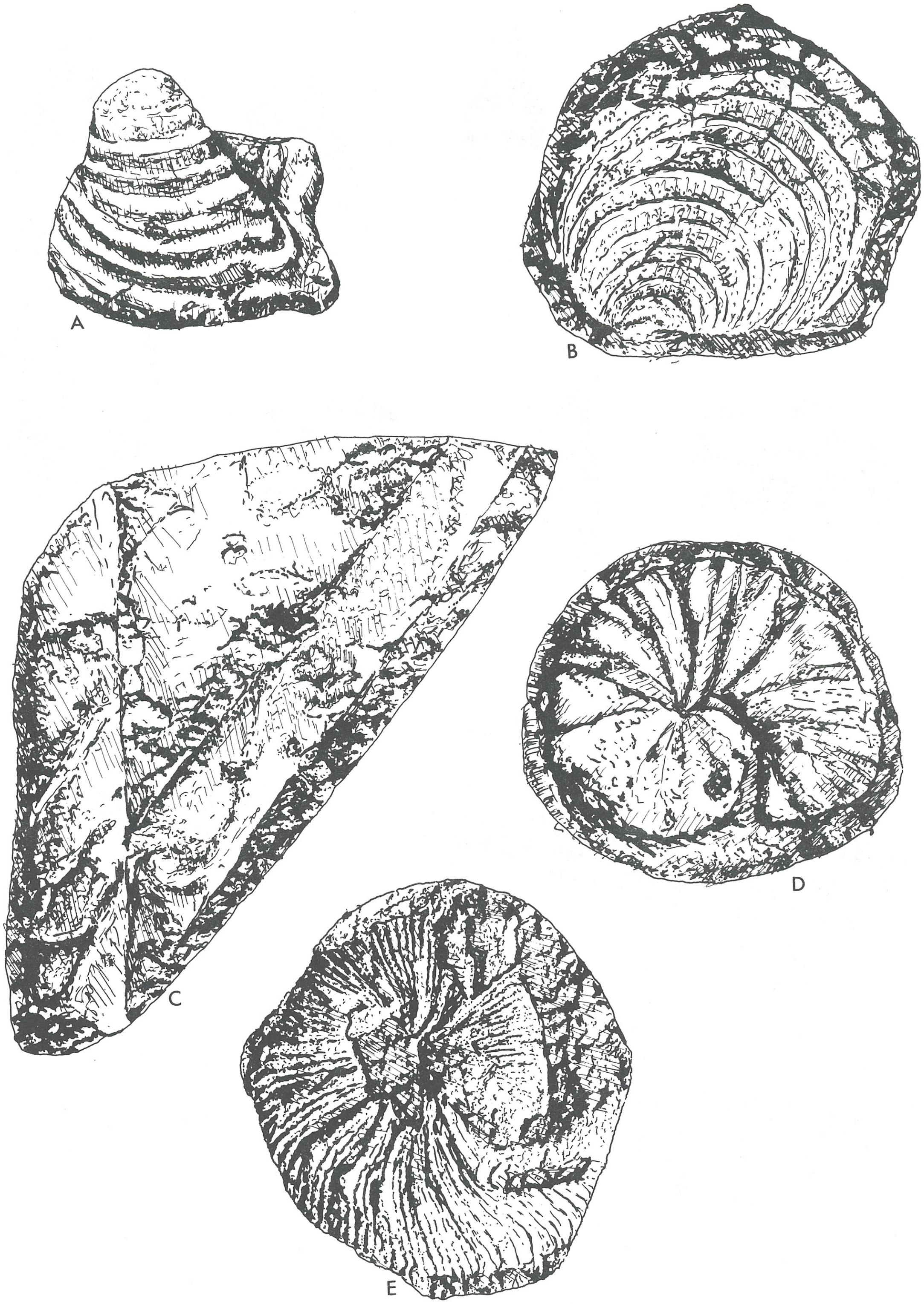

Fig. 9. Cretaceous mollusk fossils. [A, B. Clams.] A. Inoceramus cordiformis Sowerby, X 1. B. Inoceramus, cf. I. patootensis de Toriol, X 1. [C-E. Ammonites.] C. Baculites sp., X 1. D. Clioscaphites saxitonianus (McLearn), X 1. E. C. choteauensis Cobban, X 1.

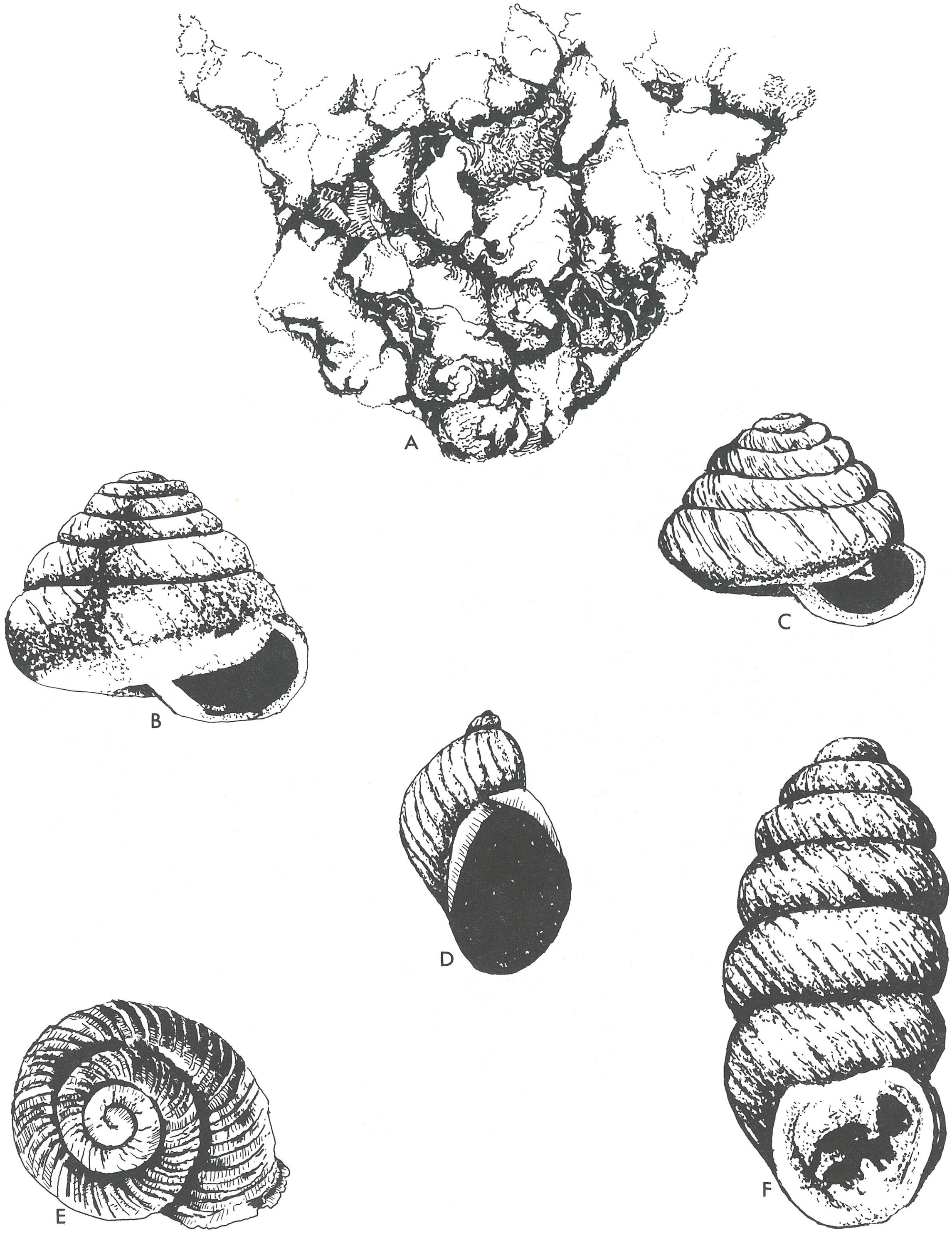

Fig. 10. Cretaceous and Pleistocene fossils. A. Oysters, Ostrea congesta Conrad, X 1. [B-F. Pleistocene land snails.] B. Euconulus, X 20. C. Strobilops, X 20. D. Succinea, X 20. E. Vallonia, X 40. F. Gastrocopta, X 30.

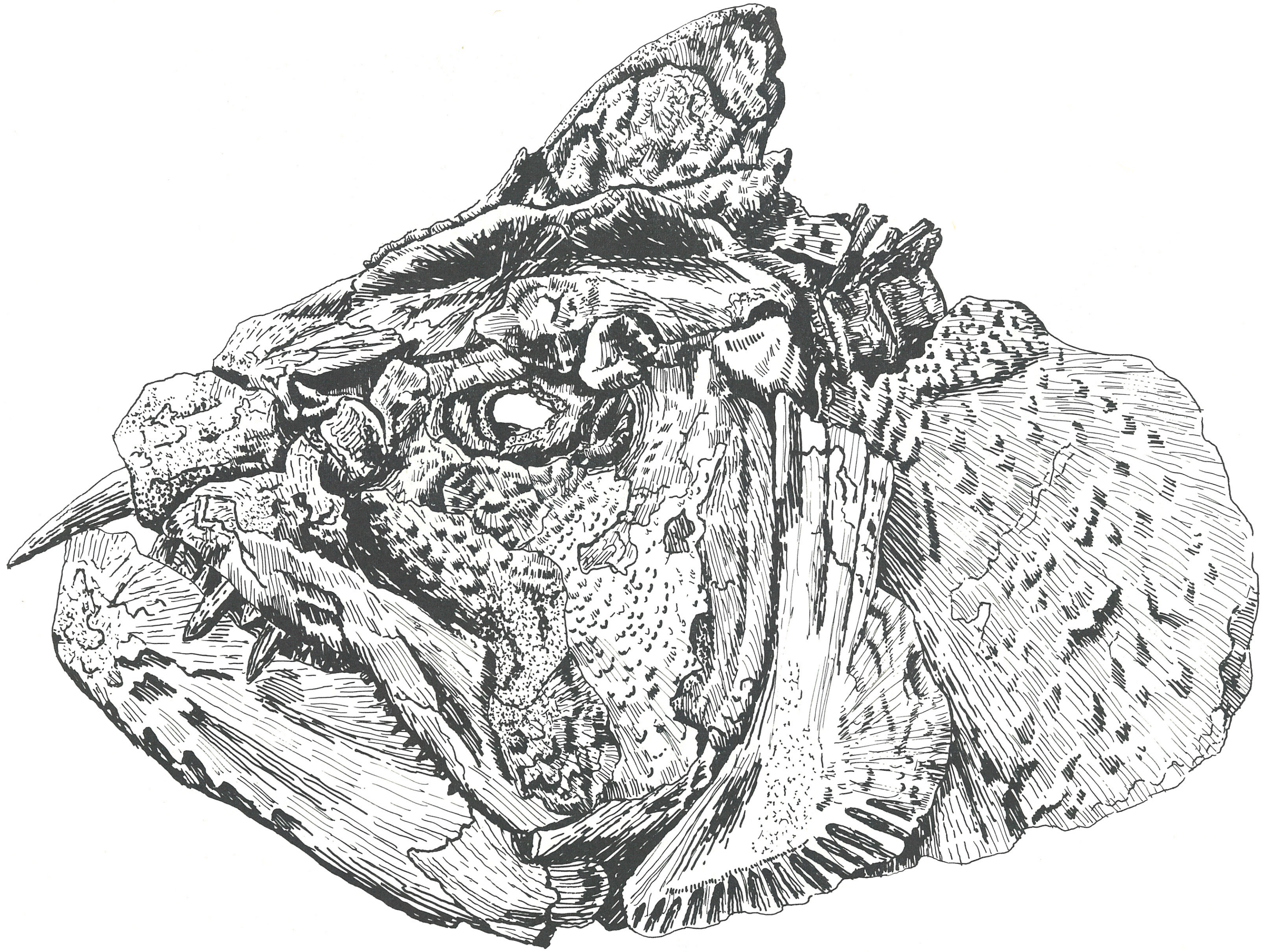

Fig. 11. Skull of a Cretaceous fish, <u>Xiphacanthus</u>, X 1

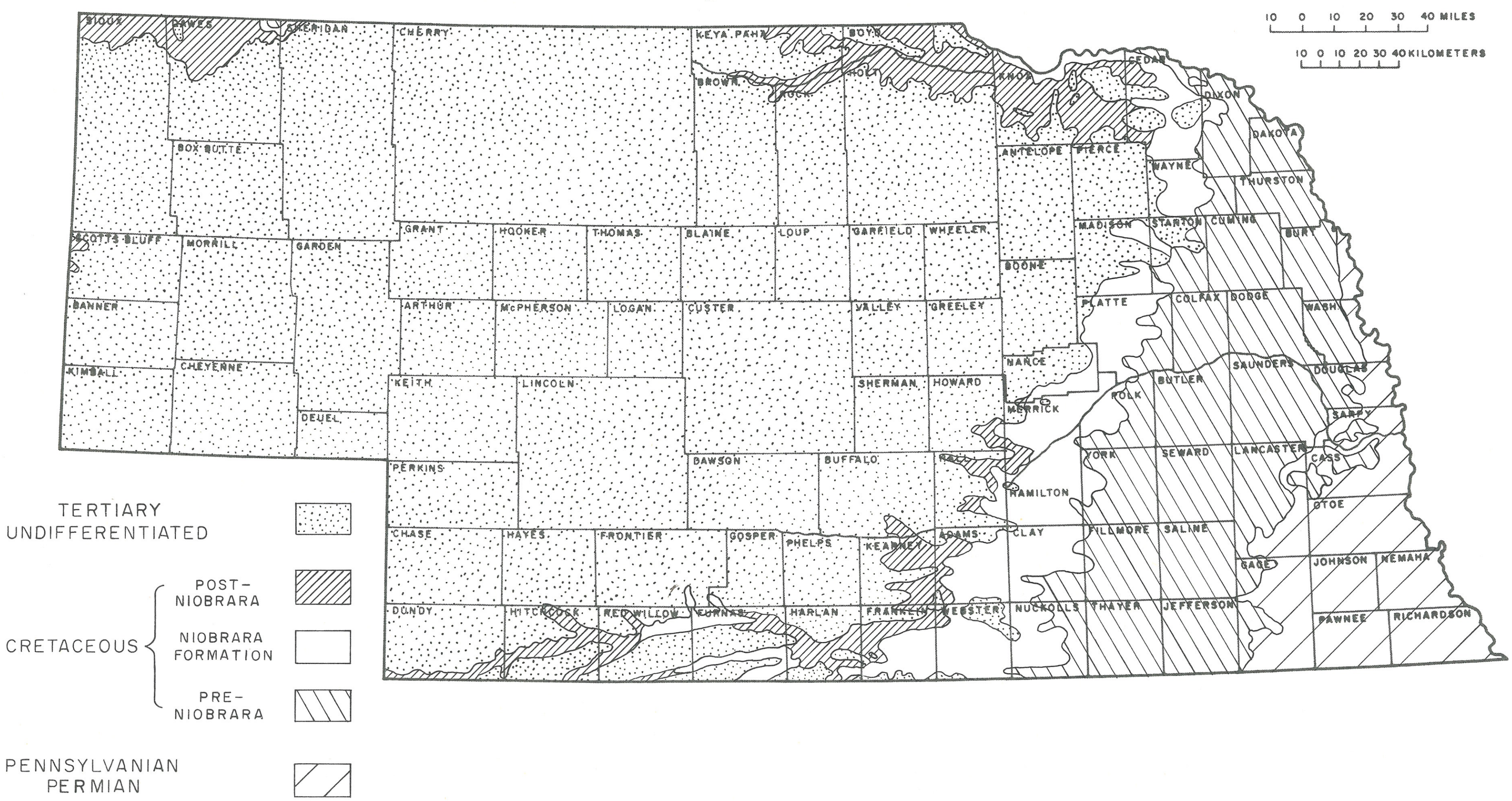

Fig. 12. Geologic map showing the distribution of the Niobrara Formation in Nebraska

WHILE YOU ARE THERE

A grave on the hill above the two exposures is reputed to contain the remains of Blue Cloud, daughter of the Sioux Chief Red Cloud. The hilltop is an excellent vantage point for viewing the Republican River valley.

The city of Red Cloud has played an important role in the history of Nebraska. It is an important railroad center and many of Nebraska's agricultural products are loaded in freight cars there to begin their journey to distant markets. The Old Burlington Depot is maintained by the Willa Cather Foundation and antique railroad paraphenalia are kept on display there. The depot was built about 1897.

Red Cloud is the birthplace of several notable persons. Perhaps the most famous was the novelist Willa Cather, whose childhood home is at Third and Cedar Streets. Both her home and the Willa Cather Pioneer Memorial Building near Fourth and Webster Streets are popular attractions.

The Roman Catholic Church at Red Cloud is also a historical attraction. It is of interest to point out that the Rev. Denis Fitzgerald studied the geology of the Red Cloud area in the early years of the twentieth century.

The city of Red Cloud maintains a park with picnic facilities. The park is two blocks south of the junction of U.S. Highway 136 and U.S. Highway 281.

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