2-1-1993

GEOLOGICAL FIELD GUIDE TO THE CEDAR POINT BIOLOGICAL STATION, KEITH COUNTY, NEBRASKA

Robert F. Diffendal Jr.
University of Nebraska - Lincoln, rdiffendal1@unl.edu

Roger K. Pabian
University of Nebraska - Lincoln

GEOLOGICAL FIELD GUIDE TO THE CEDAR POINT BIOLOGICAL STATION. KEITH COUNTY. NEBRASKA

By

R. F. Diffendal. Jr. & Roger Pabian

Conservation & Survey Division

University of Nebraska - Lincoln

Revised February 1993

PREFACE

This field guide was produced by staff members of the Conservation and Survey Division of the University of Nebraska originally in 1979 at the request of Dr. Brent Nickol, former Director of the Cedar Point Biological Station. It is an introduction to the geologic history and paleoecology of the Cedar Point area intended for students, staff, and other persons using the camp. This revision has been made some 15 years after the first version to reflect changes in ideas resulting from new data collected during that time.

Users of this guide should take care when studying the rock exposures described herein because traverses up the slopes and beneath overhanging ledges can be dangerous. Rattlesnakes, ticks, and poison ivy are additional hazards encountered from time to time.

INTRODUCTION

Put yourself in the boots of a geologist during your participation in the field trip outlined on the following pages. Ask some of the questions that a geologist might ask as he studies the rocks and sediments both on the camp property and farther afield. Is there anything about the rocks and sediments that might indicate where their source was located? What mechanism brought them to the camp area (e.g., streams, wind)? What environmental conditions obtained here during and after their deposition? Are there any fossils (remains of organisms that lived in the past) in these rocks and if there are, what organisms do they represent? How old are the rocks and sediments in the camp area? The answers to such questions will allow you to draw conclusions about the geologic history and paleoecology of the area.

GEOLOGIC FIELD GUIDE TO CEDAR POINT CAMP

Let us begin our study of the geology of Cedar Point Camp on the front steps of the Dining Hall. If you look to the east and southeast you can see a series of discontinuous rock ledges which are covered in places by younger deposits derived from erosion of these older rocks. Sandwiched in between the rock ledges are layers of softer sediment primarily composed of sand and silt with local concentrations of coarser-grained gravel.

If you walk to the east end of the Dining Hall and look north across the flood plain of the North Platte River you can

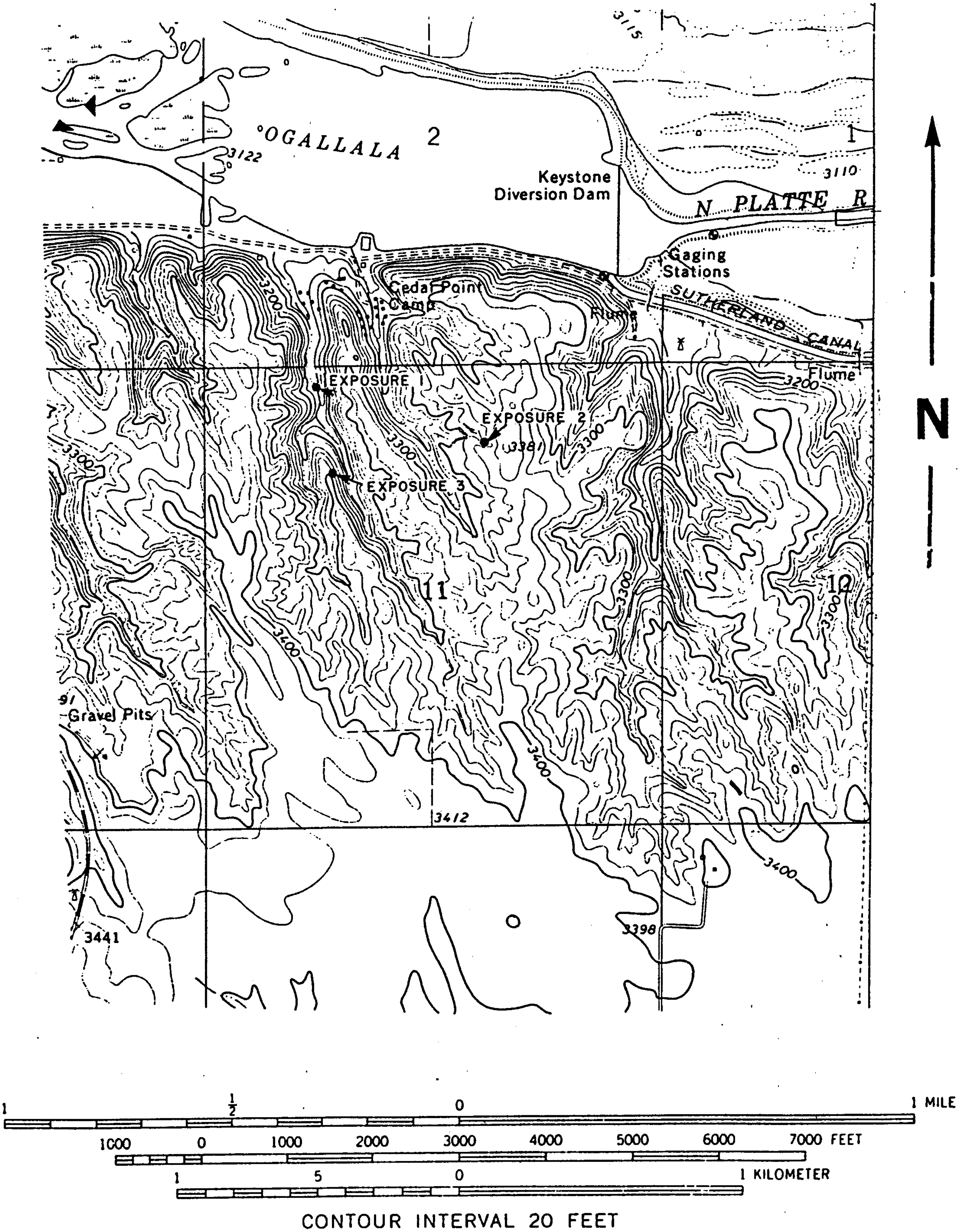


Figure 1. Map of exposure locations.

see the beginning of the Nebraska Sand Hills, a region of grass-covered sand dunes occupying about one-sixth of the area of the state. Notice that there are no obvious prominent ledges or deep valleys on the Sand Hills side of the valley. Both the Sand Hills and the North Platte Valley are relatively young geologically and together can obscure the view of the geologic development of this part of Keith County.

Imagine a time in the past when the rock ledges and softer sediments extended to the north across what is now the river valley and beneath the sands of the Sand Hills and you will have a picture of what this area would have looked like before the dunes formed and the valley was carved. Drilling by the Conservation and Survey Division of UNL to the north of the camp has proven that these rocks ledges are buried beneath the Sand Hills and, therefore, probably extended across the present river valley at some time in the past.

Now that we have looked at the general picture of the geology of the camp let's take a closer look at the rocks themselves. Walk south along the floor of the major valley south of thee camp parking lot to the rock exposures on the east side of the valley designated on Figure 1 as exposure #1. These outcrops are located where the intermittent stream bed cuts significantly into the rocks on the east side of the valley for the first time as you walk south.

You are standing at the base of exposure 1 looking at

horizons 1 and 2. About 40' above you are the first rocks that form prominent ledges which stick out from the rock face. The lowest of these ledges is the base of horizon 3. If you work your way carefully up the slope on the east side of the valley you should be able to pick out most of the other twelve horizons described below. Horizon 13, a layer with many rough, often vertically directed, so-called "root casts" in it, is very easy to find and is illustrated in greater detail for you in Figure 2.

Figure 3 illustrates the general sequence of rocks and sediments from the valley floor to the top of the hillside on the east side of the valley. A general description of the sequence from its base to its top follows.

STRATIGRAPHIC SECTION AT EXPOSURE #1 - CEDAR POINT CAMP. FROM FLOOR OF CANYON - EAST SIDE - FIRST MAJOR SECTION.

Oligocene-White River Group, Brule Formation

Horizon 1. Silt - dry-grayish orange, wet-moderate yellowish brown; blocky, massive on fresh exposures, vertical fracturing common; brecciated with slightly harder clasts standing out from face in relief, individual clasts up to 1.75" in diameter. 3'.

Horizon 2. Silt - dry-grayish orange, wet-moderate yellowish brown; blocky, massive with vertical fracturing common. Potato-shaped concretions common throughout; concretions are vertically elongate, lime rich, and associated with jointing. 35'.

Miocene-Ogallala Group, Ash Hollow Formation

Horizon 3. Silt - dry-grayish orange pink, wet-light brown; with hard ledges up to 8" thick irregularly interbedded; ledges die out laterally; no concretions. 6'.

Horizon 4. a. Very fine sand - wet and dry-grayish yellow. 2'3".
b. Very fine sandstone ledge - grayish yellow; some small granules and pebbles scattered throughout;

contains fossil hackberry seeds (endocarps). 10".

c. Fine sand - dry-yellowish gray. 1'5".

d. Fine sandstone - yellowish gray, poorly cemented, some lighter sandstone blebs scattered widely throughout; also a few widely spaced vertical white vein fillings; hackberry seeds. 2'4". Moving south approximately 100' upper 1' of 4d is blocky and silty with harder horizontal and vertical concretions.

Horizon 5. Very fine sandy silt - dry-light brown, wet-moderate, yellowish brown; massive with widely scattered lighter concretions. 2'.

Horizon 6. Sandstone - dry-pinkish gray; weathers gray; ledge former, poorly cemented, some granules present. 2'.

Horizon 7. a. Sand - dry-light brown; massive. 3'4".

b. Sandstone - light brown; poorly cemented. 1'6".

c. Sand - light brown, 2'4".

Horizon 8. Sandstone - dry-grayish orange; poorly sorted, poorly cemented; some granite-derived granules and pebbles present throughout; some irregular concretionary masses and root tubules; poor ledge former in basal 5'. 9'6".

Horizon 9. Fine sand and silt - dry-light brown with pinkish gray; limey interbeds at base; some sands contain slightly darker or lighter intraformational clasts and some granitic granules and pebbles; massive ledges up to 2' thick toward top; tubules and concretions in upper few feet. 21'.

Horizon 10. Sand, fine sand - dry-moderate orange pink to light brown; occasional ledges usually finer-grained; mottled appearance in bottom 2'. 23'.

Horizon 11. Sand and gravel - granitic; maximum clast size 1" or more; grades upward into fine silt with "floating" pebbles; grades laterally into pebbly sand. 1'2".

Horizon 12. Sand - dry-light brown; mottled at top with widely scattered granitic pebbles up to 1" long; some poorly developed vertical jointing in upper 4'. 20'.

Horizon 13. Sand - dry-light brown; contains many so-called "root casts", tubules, and concretions. 6'6" (on west side

of canyon divides into two well defined ledges separated by softer rock).

Horizon 14. Sand and sandstone - dry-moderate orange pink, darker mottling in places; forms ledges occasionally; has widely scattered tubules, granitic granules, and fossil hackberry seeds throughout. 18'.

Pliocene-Sediments equivalent in age to the Broadwater Formation.

Horizon 15. Sand and gravel - granitic; with fossil wood clasts up to 4" or longer. 5' - 10'.

From the top of the hill if you look S 70° E across the next valley to the east you will see an eroded cut on the east hillside. Our section will continue there. To get there walk south along this hilltop divide separating the two valleys. As you walk notice (1) the position of the "root cast" bed outcropping on the east side of the valley to the east, (2) the way the coarse sand and gravel capping the divide occurs as discontinuous knobs with finer-grained rock outcropping in the intervening spaces, and (3) the tan silt exposure on your left (this is loess) which also caps the tableland to the south.

STRATIGRAPHIC SECTION AT EXPOSURE #2

Pliocene-Sediments equivalent in age to the Broadwater Formation.

Horizon 15. Sand and gravel-becoming fine sand (light brown) with scattered pebbles at top. 35-40'.

Horizon 16. Silt - dry-moderate orange pink; with white lime tubules throughout, some granules and pebbles widely scattered throughout. 3'.

Pleistocene

Horizon 17. Loess - tan silt. about 10'.

So far you have seen four geologic units that are continuous

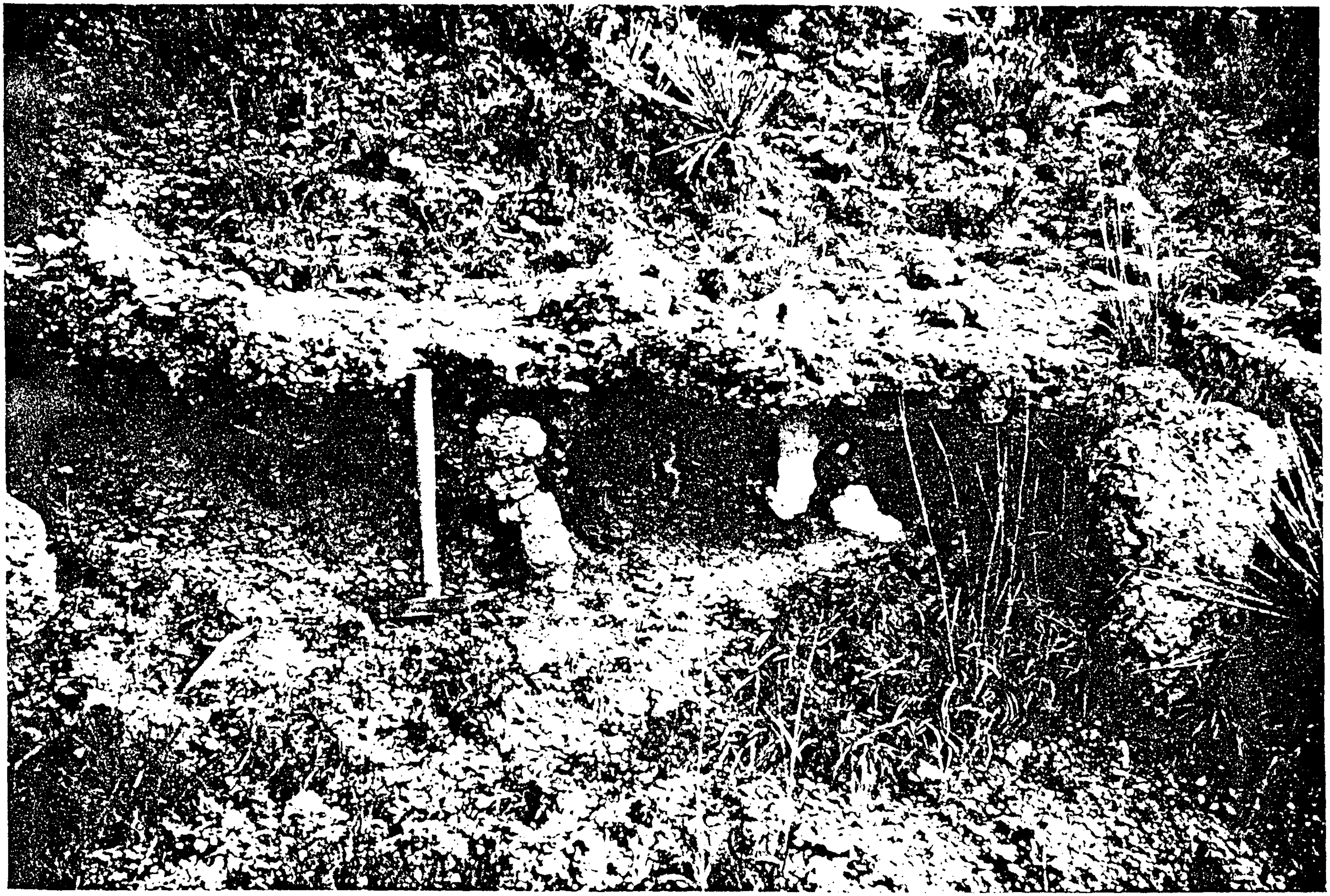


Figure 2. Casts of fossil "roots" as seen in the Ash Hollow Formation.

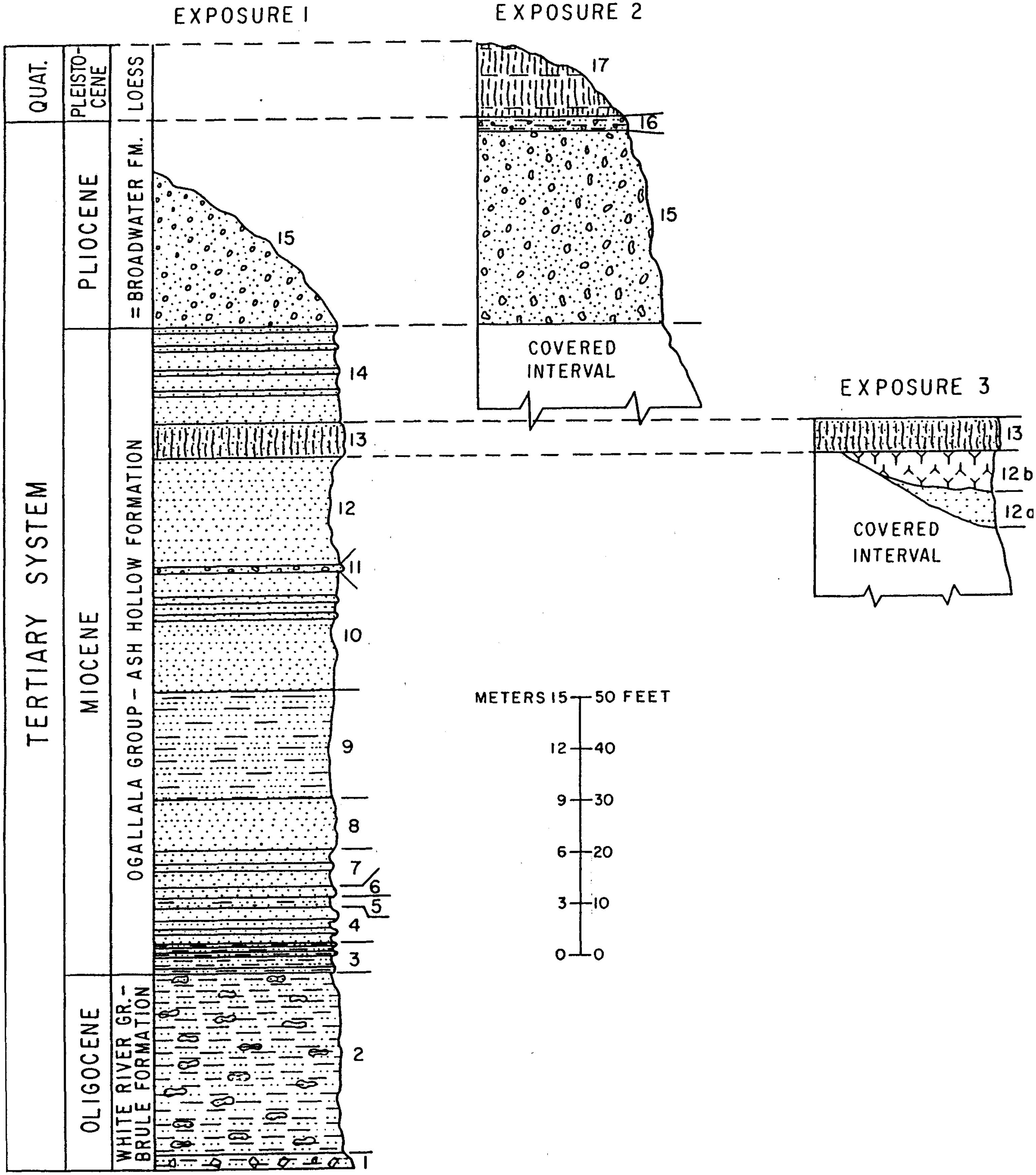

EXPOSURE 1
EXPOSURE 2
EXPOSURE 3
QUAT.
PLEISTO-CENE
LOESS
TERTIARY SYSTEM
PLIOCENE
= BROADWATER FM.
MIOCENE
OGALLALA GROUP - ASH HOLLOW FORMATION
OLIGOCENE
WHITE RIVER GR. - BRULE FORMATION
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
12b
12a
COVERED INTERVAL
COVERED INTERVAL
METERS 15 — 50 FEET
12 — 40
9 — 30
6 — 20
3 — 10
0 — 0

Figure 3.

from one canyon to another: horizon 2 with its characteristic brown, hard, potato-shaped concretions; horizon 13, the "root cast" bed; horizon 15, the sand and gravel; and the tan silt of horizon 17.

Return to exposure #1 and follow the stream valley south until it divides in two. Walk up the hill between the two branches of the valley to the "root cast" bed at exposure #3. There is an unusual light gray powdery volcanic ash formation (unit 12b) exposed directly beneath the "root cast" bed only at this locality on the camp property. Collect a small sample of the ash and examine it carefully. Notice that individual particles sparkle in sunlight. If you examine some of this material microscopically back at the camp you will see that it looks like broken glass. It is a natural glass formed when volcanic lava cools very rapidly.

After you have examined the ash in the field pause and reflect on what you have seen so far. The gravels, sands, silts, and their hardened rock equivalents in the camp area are like sediments deposited along the banks and in the channels of modern streams such as the North Platte and its tributaries. The silts of horizon 17 capping the tableland are like windblown silts of the "Dust Bowl." If we removed the concretions from horizon 2 and made it slightly softer it would look like the same sort of material as that of horizon 17. Could both silts have accumulated under the same environmental conditions? And what

about the volcanic ash? Where were the nearest volcanoes that could be the sources for this wind-transported deposit?

FOSSILS FROM THE CAMP AREA

A fossil land turtle has been found in the Brule Formation at the camp. If any others occur here they are most likely to be either in or below horizon 1. The Ash Hollow Formation has yielded large "root casts" interpreted by some as fossilized "yucca" roots because of their similarity to the modern yucca's root shape and size (these may be casts of other kinds of plant roots or even animal burrows). Fossil seeds from hackberry trees (<u>Celtis</u>) and borage herbs such as <u>Biorbia</u> illustrated in Figure 4 have also been found in the Ash Hollow Formation. Some of the coarser conglomerates (cemented sands and gravels) also contain bone fragments from fossil horses and rhinos (Fig. 4b). Pieces of fossil wood are associated with the sands and gravels of horizon 15.

Bison bones occur in the young colluvium (slope deposits) and alluvium exposed along the lower sides and floors of the canyons.

FOSSILS FROM THE SAME ROCK SEQUENCES IN OTHER AREAS

While fossils in the rocks and sediments on the camp property are sparse, equivalent deposits to the south and west frequently yield good fossils of plants and animals. The Brule Formation from Ash Hollow west contains bones and teeth of extinct animals such as three-toed forb eating horses and

Figure 4a. Seed, charophyte, ostracod fossils of Miocene-Recent Age. A-H. Miocene "seeds" and grains. A. Hackberry, Celtis, X15. B. Biorbia, X15. C. Krynitzkia, X15. D. Stipidium sp., X12. E. Stipidium sp., X12. F. Stipidium sp., X12. G. Panicum, X18. H. Berrichloa, X12. I. A charophyte, Chara (Pleistocene), X100. J-M. Ostracodes (Recent), X32.

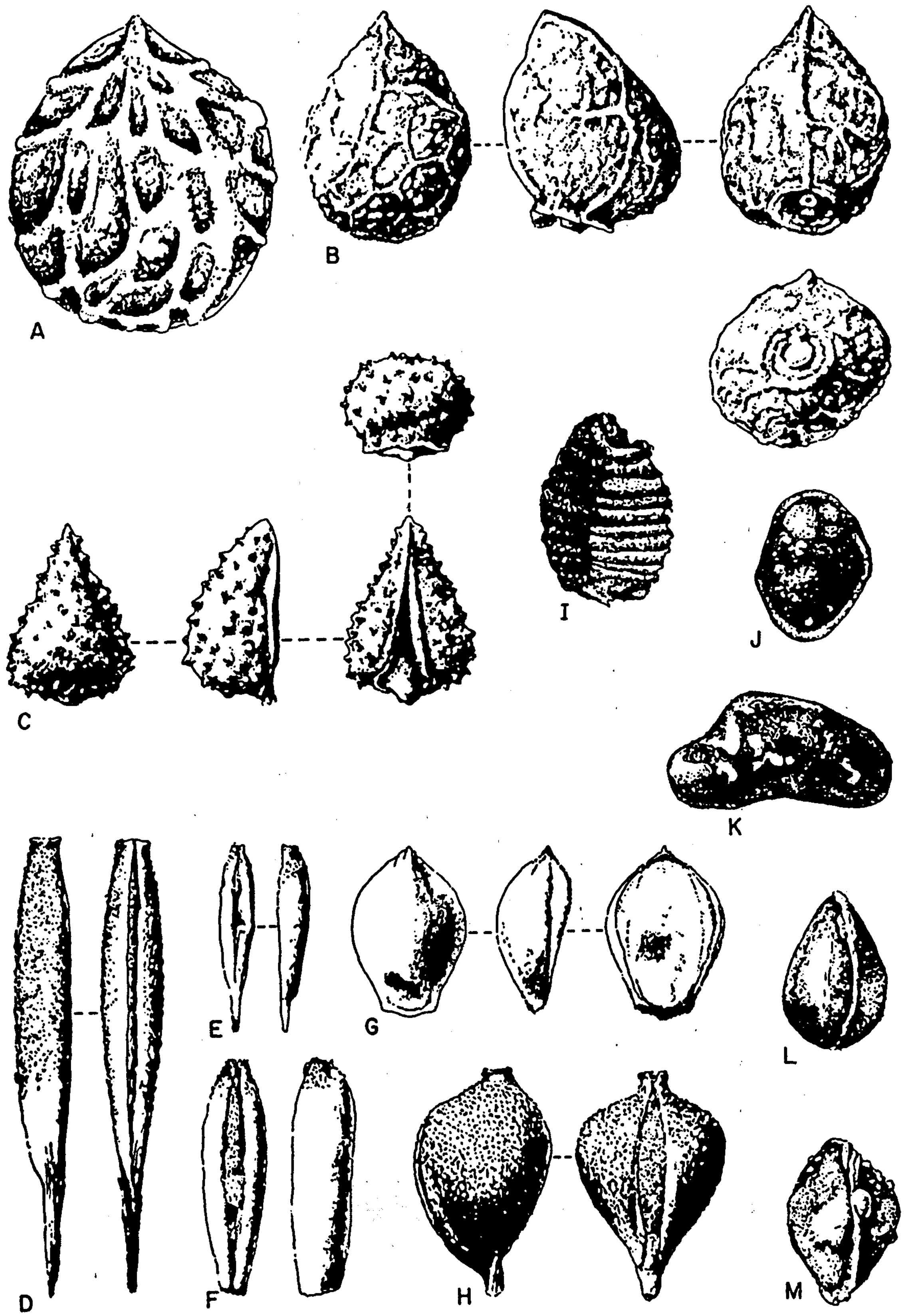
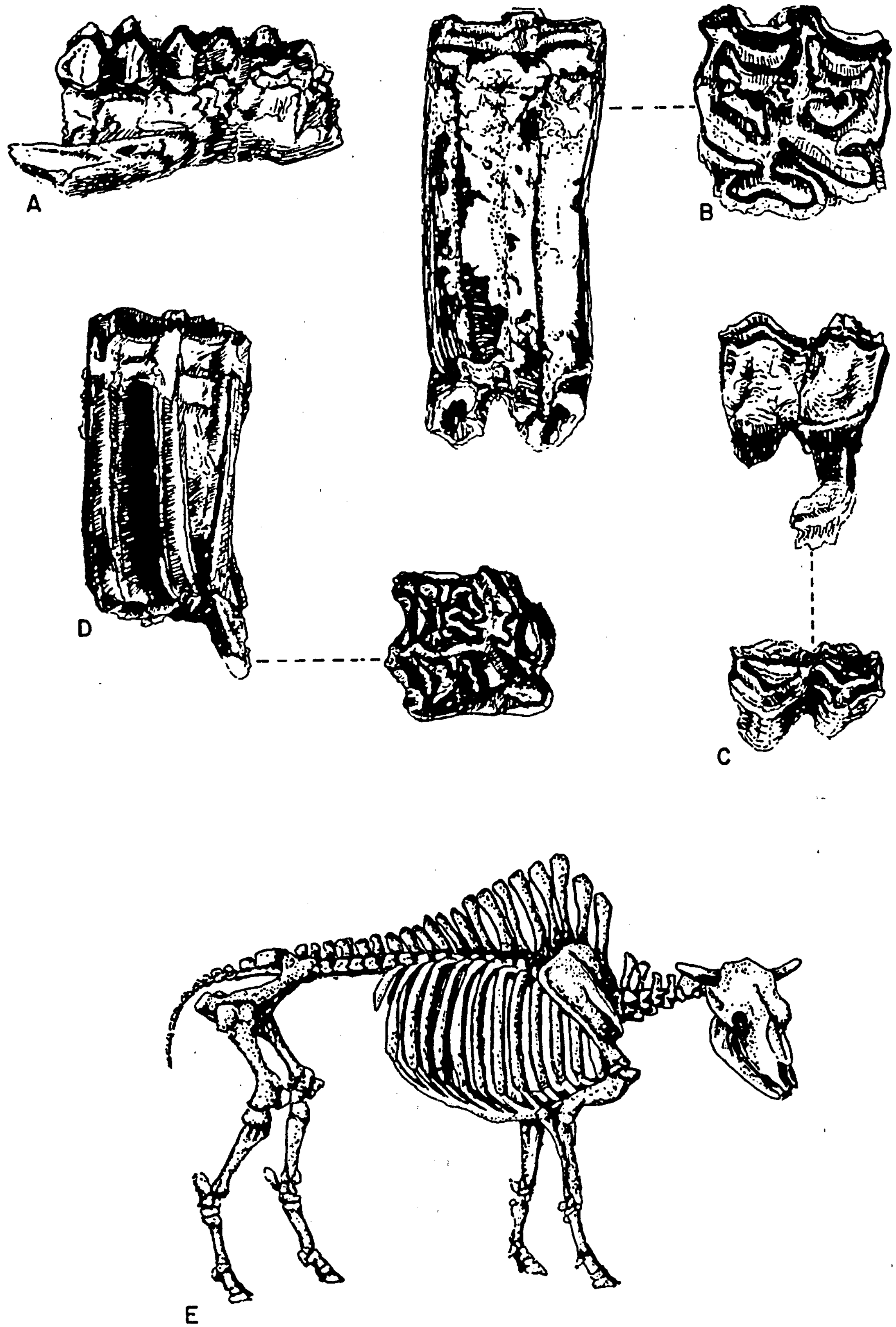

A
B
C
D
E
F
G
H
I
J
K
L
M

Figure 4b. Vertebrate fossil remains of Oligocene-Recent Age. Oreodont (Oliogocene), X1. B. Horse (Pleistocene), X1. C. Camel (Miocene), X1. D. Horse (Miocene), X1. E. Bison Skeleton (Recent), X 1/15.


A
B
C
D
E

oreodonts (a grazing animal filling a niche similar to that of a sheep). Ostracod carapaces and gastropod shells occur in local lime-rich layers in the Brule interpreted as lake deposits. The Ash Hollow Formation along the north valley side of the South Platte River and from Cedar Point west contains locally abundant fossil grass, borage herb (Stipidium and Biorbia) and hackberry (Celtis) "seeds". Root casts from prairie grasses, and other plants are common as are the so-called larger "root casts". Vertebrate fossils include teeth and bones from three-toed grazing and browsing horses, rodents, rhinoceroses, camels, elephants (Mastodonts) as well as material from other groups. The youngest deposits, loessic silts, colluvium, lake beds and alluvium, contain remains of charophytes, diatoms, fossil wood, bison, camels, and horses.

PALEOENVIRONMENTAL INTERPRETATIONS

Just as an ecologist studies the relationships of modern organisms both to one another and to the abiotic part of the environment, geologists try to interpret past environments from studies of the fossils and the structures and mineral components preserved in the rocks and sediments. Let's see how a geologist might use such studies to reconstruct the past environments represented by the rock sequence at the camp.

Most of the Brule Formation is clay-cemented unlayered silt with few structural features. At Ash Hollow State Historical Park several dark layers in this formation represent the

development and burial of old soil profiles but otherwise there is little else that outwardly can help us in interpreting the environmental conditions at the time of Brule deposition. As stated previously, however, silt deposits themselves are often unusual geologically and in this case are most likely to have been transported by the wind.

The wind transport hypothesis is supported by at least two pieces of evidence. Microscopic examination of the silts reveals that they often contain as much as 60% wind blown volcanic ash shards and occasionally more than 90%. The geometry of the Brule Formation also supports the hypothesis. The formation is very uniform with few of the sharp vertical or lateral changes in grain size typical of stream depositional environments.

There are a few lime-rich, lens-shaped, deposits in the Brule Formation which contain fossils of fresh water ostracodes and snails. The shape of the deposits and nature of the faunas suggest that these deposits represent fillings of local ponds.

So what was western Nebraska like when the Brule layers were deposited? In all probability it was often drier and dustier than today. Now and then rainier periods with reduced silt deposition must have occurred over the region since soils, pond deposits, and very infrequent stream channel deposits occur in the formation.

The Ash Hollow Formation is very different. Sediment types often change character rapidly both vertically and laterally.

Inclined layering (cross-bedding), ripple marks, disturbed and burrowed horizons, buried soils, channel fillings, and many other features are like deposits and structures developed on the floors and along the sides of modern stream valleys. Fossil plants are similar to those living on the plains and along streams in western Nebraska today. The animals also are typical of those living in semi-arid environments. While the vertebrate fossils in the Ogallala are of species different than the modern organisms living in the area now, studies of them by paleontologists indicate that they occupied similar environmental niches to those filled by deer, bison, and so on at present.

Lens- or channel-shaped volcanic ash deposits are relatively rare but very pure when they occur in the Ash Hollow. They occupy positions of former channels, swales or ponds present on floodplains during parts of Ash Hollow time. In some places the ash beds contain grass and hackberry seeds, root casts, ripple marks, disturbed beds, vertebrate fossil skeletons and tracks, and even ash pellets interpreted as accumulations concentrated in hailstones or frozen raindrops.

The purity and thickness of the volcanic ash deposits has led many geologists to speculate on their mode of transport and deposition. It seems likely that the ash was produced during periods of explosive volcanic eruptions in the western United States and was carried by winds to Nebraska and adjacent states. But what could have produced a fall of material rapidly enough so

that the deposit was both relatively free of stream-deposited sediments and was in places over twenty feet thick? One reasonable hypothesis is that the ash cloud was blown into a thunderstorm cell and was washed out of the atmosphere in a short period of time. The ash pellets mentioned earlier tend to support this view of the origin of at least some of the deposits.

As you have seen on the field trip much of the Ash Hollow Formation has an orange or orangish-pink color. This color is generally due to the presence of large quantities of decomposed granite in the sediment. The source of this granite lies primarily to the west in the Rocky Mountains.

After deposition of the Ash Hollow Formation ceased, stream erosion began to remove the upper parts of the Ash Hollow forming valleys. A major river valley, trending generally northeast, crossed the area in the vicinity of present-day Cedar Point. This valley was subsequently filled with sands and gravels deposited by the river. These sands and gravels have maximum gravel sizes larger than any gravels from the Ash Hollow Formation in the camp area, thus indicating that the river depositing the former either was capable of carrying larger gravels than were Ash Hollow streams or was supplied larger gravels than were Ash Hollow streams. The types of rocks in the gravels indicate a source in north-central Colorado near present-day Rocky Mountain Park and thus a river course somewhat like that of the South Platte River. Fossils from the sands and

gravels indicate that the deposits are roughly equivalent in age to the Pliocene Broadwater Formation which crops out along the north valley side of the North Platte Valley west of Cedar Point.

The wind blown tan silts (loess) capping the tableland were deposited after deposition of the sands and gravels equivalent to the Broadwater Formation. Widespread darker buried soil horizons in the loess, just as in the Brule Formation, indicate periods of stability and little deposition separated from one another by periods of rapid silt accumulation. Occasional lime-rich layers with organic remains from organisms that lived in fresh water indicate the presence of small ponds and lakes in the area when the loess accumulated.

After deposition of the Pleistocene loess, stream erosion once again affected the area producing the North Platte Valley and the valleys of its tributaries like those at Cedar Point. From time to time erosion was either slowed or stopped and deposition occurred along these valleys. Some of these deposits are still preserved along the sides and beneath the floors of the canyons at Cedar Point. During the last 10,000 years or so the Sand Hills principally formed and sand dunes may have even blocked the developing North Platte Valley on one or more occasions in the vicinity of Cedar Point.

METHODS FOR DETERMINING THE AGE OF THE DEPOSITS AT CEDAR POINT

One of the questions at the beginning of our exploration of the area was how old are these deposits? Over the years

geologists have devised a number of methods for determining the ages of rocks and sediments. These methods fall into two broad groups, those which merely aid in establishing a chronological relationship (relative dating methods) and those which are used to determine actual times when events occurred (absolute dating methods).

Three "laws" or general rules can be used in the camp area to determine the relative ages of the deposits. The "law" of superposition, which states that sedimentary layers become progressively younger from the bottom to the top of the sequence, can be used to determine that the Brule Formation is the oldest unit exposed at Cedar Point and that the loess is one of the youngest units. The "law" of cross-cutting relationships states that any geologic feature that cuts through another one must be the younger of the two. So-called "root casts" of horizon 13 penetrate the upper part of horizon 12 and must be the younger of the two features. Finally, time and time again fossils of particular types have been demonstrated to occur only in limited thicknesses of strata. In the camp area bison remains are found in the youngest deposits while some of the fossil seeds are restricted to the Ash Hollow Formation.

Volcanic ash shards can be used to obtain absolute age dates. Radiometric dating techniques applied to ash samples from the Ash Hollow and Brule formations by John Boellstorff and his colleagues at the Conservation and Survey Division and by Carl

Swisher have yielded 6 to 10 million year dates for the Ash Hollow and 30 to 32 million years for the Brule.

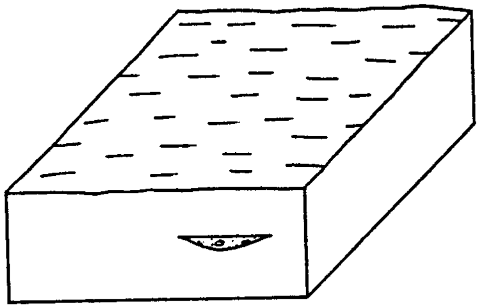
GENERAL GEOLOGIC HISTORY OF THE CAMP AREA

Figure 5 illustrates the general sequence of geologic events at the camp. The sequence and absolute ages from the oldest to the youngest (most recent event) are as follows:

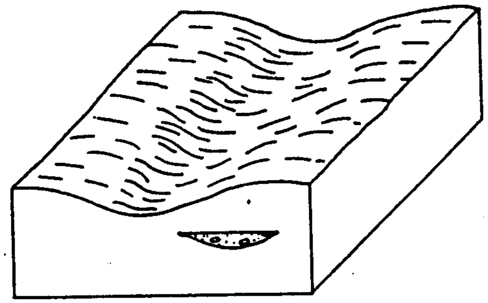
Sequence	Age	Years Before Present
1. Deposition of wind blown Brule volcanic silts;	Oligocene	30-32 million
2. Period of non-deposition, soil formation, and erosion;	Oligocene?-Miocene	
3. Deposition primarily by streams of the Ash Hollow Formation;	Miocene	6-10 million
4. Period of erosion;	Miocene?-Pliocene	
5. Deposition by streams of sands and gravels equivalent in age to the Broadwater Formation;	Pliocene	
6. Period of erosion;	Pliocene to Pleistocene	
7. Wind deposition of loess on top of tableland;	Pleistocene to Recent	
8. Stream erosion cuts into Ash Hollow and Brule formations producing the North Platte valley and tributary canyons on the camp property;	Pleistocene to Recent	
9. Periodic erosion and then deposition produce the stream deposits and channel cuts presently seen in the canyon bottoms and on the North Platte floodplain; also formation of colluvium on valley sides.	Recent	

Figure 5.

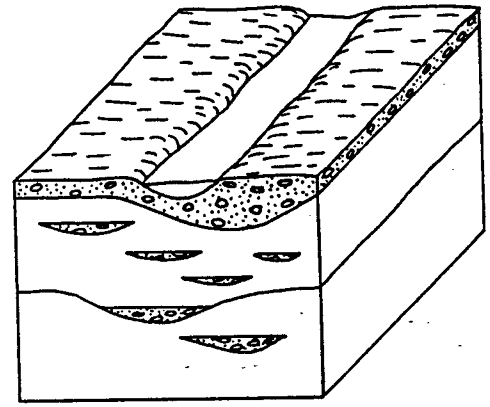
SEQUENCE OF EVENTS AT CEDAR POINT



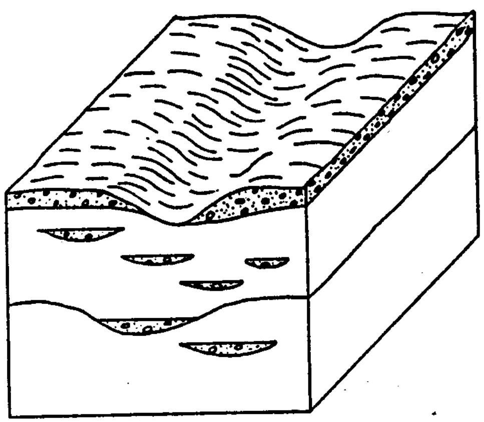
1. Deposition of Brule Formation



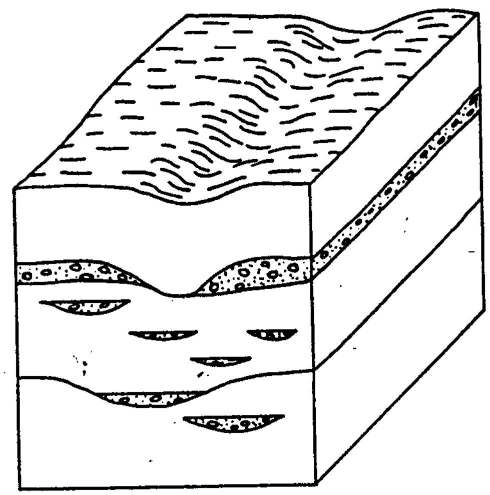
2. Erosion and soil formation on Brule surface



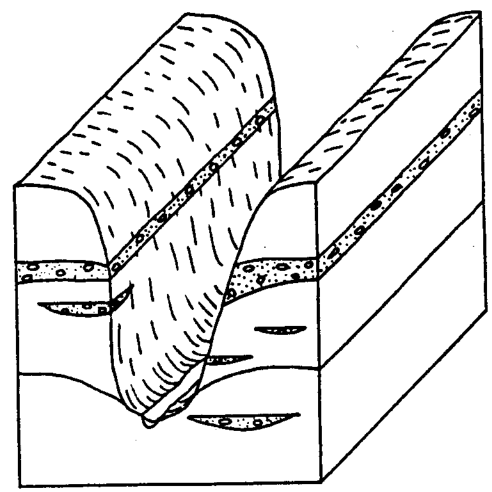
3.-5. Deposition of Ash Hollow Formation on Brule; Erosion of Ash Hollow and Deposition of "Broadwater Formation"



6. Erosion of "Broadwater" and Ash Hollow Formations



7. Deposition of loess



8.-9. Stream erosion produces North Platte Valley

CONCLUSIONS

Previously cited evidence from fossils and sediments indicates that the environmental conditions over what is now the Great Plains must have been similar to those occurring today. While the climate at times has been moister and at times drier than at present in the Cedar Point area organic remains tend to support this general conclusion. Furthermore, differences in elevation on erosional surfaces are more pronounced today than at any time since the Oligocene Epoch.

OTHER REFERENCES TO GEOLOGY OF THE AREA

Bleed, A., and Flowerday, C., eds., 1990, An atlas of the Sand Hills: University of Nebraska, Conservation and Survey Division Resource Atlas 5a, 265p.

Diffendal, R.F., Jr., 1991, Geologic map showing configuration of the bedrock surface, North Platte 1° x 2° Quadrangle, Nebraska: U.S. Geological Survey Miscellaneous Investigations Map I-2277.

Diffendal, R.F., Jr., Pabian, R.K., and Thomasson, J.R., 1982, Geology of Ash Hollow Park, Nebraska: University of Nebraska, Conservation and Survey Division Educational Circular 5, 33p.

Pabian, R.K., and Diffendal, R.F., Jr., 1981, Geology of Lake McConaughy Area, Keith County, Nebraska: University of Nebraska, Conservation and Survey Division Guidebook, 22p.

Swinehart, J.B., Souders, V.L., DeGraw, H.M. and Diffendal, R.F.,

Jr., 1985, Cenozoic paleogeography of western Nebraska: University of Nebraska, Conservation and Survey Division Reprint Series RS-52, 21p.

Wenzel, L.K., and Waite, H.A., 1941, Ground water in Keith County, Nebraska: U.S. Geological Survey Water-Supply Paper 848, 68p.