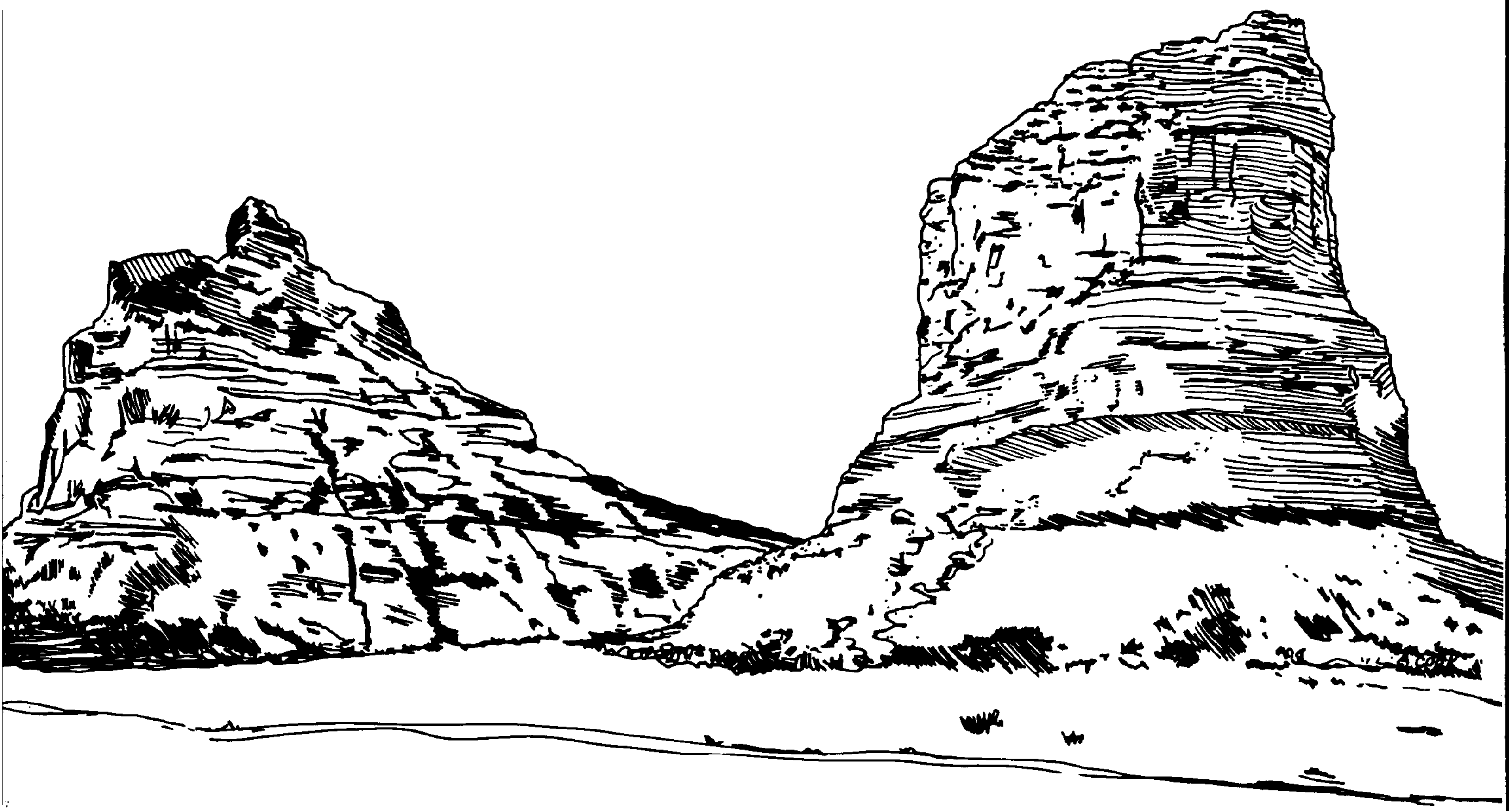
Guidebook to the Late Pliocene and Early Pleistocene of Nebraska



THE UNIVERSITY OF NEBRASKA
CONSERVATION AND SURVEY DIVISION, LINCOLN
NEBRASKA GEOLOGICAL SURVEY
April 1971

Guidebook to the Late Pliocene and Early Pleistocene of Nebraska

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To ALVIN LEONARD LUGN,

Professor Emeritus of Geology at The University of Nebraska,

In Grateful Recognition of His Long Teaching Career

and Many Contributions to Nebraska Geology

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> "The State of Nebraska is peculiarly and fortuitously situated in regard to the deposits of the Great Ice Age which occur within its borders. It has deposits of till of two definitely recognized glaciers, the Nebraskan and the Kansan, in the east; and, west of the till border, great fluviatile sand and gravel sheets are developed in such a manner that they can be correlated with the glacial formations to the east in eastern Nebraska, Iowa, and other areas and with the High Plains terraces along the major drainages to the west, and even with the elevated terrace remnants in the Rocky Mountains. ..."
> (Lugn, 1939b, p. 852).

INTRODUCTION

By the Field Trip Committee (T. M. Stout, H. M. DeGraw, L. G. Tanner, K. O. Stanley, W. J. Wayne, and J. B. Swinehart)

The interesting geographic and even strategic position of Nebraska between regions of mountain and interior glaciation during the Quaternary was emphasized by A. L. Lugn, Professor Emeritus of Geology at the University of Nebraska, more than thirty years ago. The earlier studies are summarized in two principal works by Lugn (1935; 1939a; see Selected References), to whom this guidebook is dedicated, but much has been learned since and much remains to be recorded concerning the Tertiary and Pleistocene of Nebraska. In this centennial year, commemorating the beginning of a second century of geological instruction at the University of Nebraska, it seems best to look ahead, not back. Those who honor the University and the Field Trip Committee by participating in this excursion and the following scientific sessions in Lincoln will surely ask questions which cannot now be answered. In the two days allotted for the trip on the Late Pliocene and Early Pleistocene (Fig. 1) we hope to visit fifteen selected geologic sections, which will give some background for this topic. May we welcome you to Nebraska!

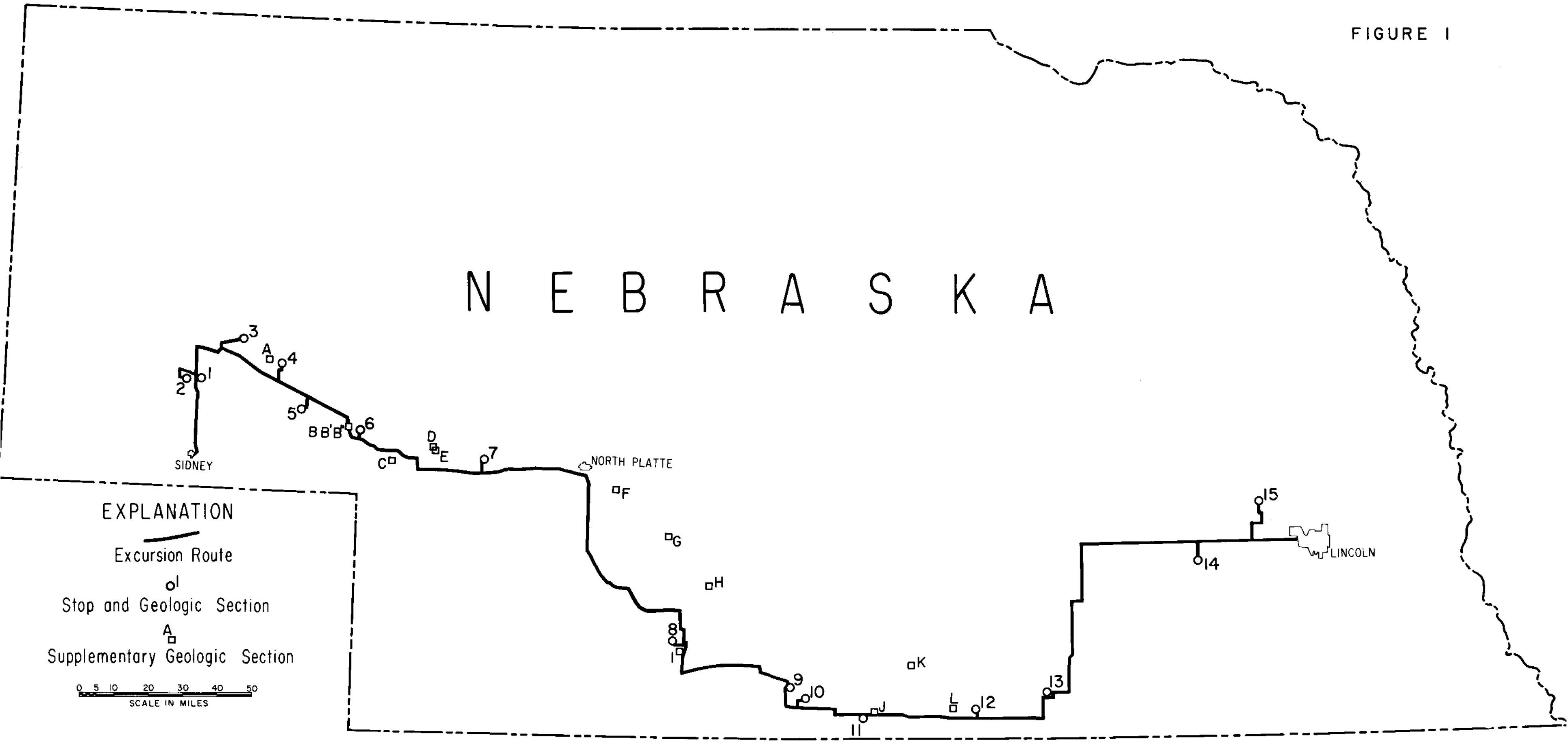

NEBRASKA
SIDNEY
NORTH PLATTE
LINCOLN
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
A
B B' B"
C
D
E
F
G
H
I
J
K
L
EXPLANATION
Excursion Route
Stop and Geologic Section
Supplementary Geologic Section
0 5 10 20 30 40 50
SCALE IN MILES

FIGURE 1

Explanation of Figure 1 (opposite)

Summary of Stops (Numbered Geologic Sections) and of Supplementary Sections (Lettered):

STOP 1. (Fig. 10-1) Morrill County, about 3 miles north of Dalton

STOP 2. (Fig. 10-2) Morrill County, northwest of Dalton

STOP 3. (Fig. 10-3) Morrill County, Broadwater Quarries

A. (Fig. 10-A) Garden County, northeast of Lisco (Lisco Sites)

STOP 4. (Fig. 10-4) Garden County, east of Lisco (Lisco Sites)

STOP 5. (Fig. 10-5) Garden County, Oshkosh Quarries

B. (Fig. 10-B, B', B'') Garden County, Ash Hollow and vicinity

STOP 6. (Fig. 10-6) Garden County, east of Ash Hollow (Brule Canyon)

C. (Fig. 10-C) Keith County, east of Brule (Chase Canyon)

D, E. (Fig. 10-D and 10-E) Keith County, northeast of Ogallala

STOP 7. (Fig. 10-7) Keith County, north of Paxton (Paxton Cut)

Night Stop at North Platte, Lincoln County

F. (Fig. 11-F) Lincoln County, southeast of North Platte

G. (Fig. 11-G) Lincoln County, southeast of North Platte

H. (Fig. 11-H) Frontier County, southeast of North Platte

STOP 8. (Fig. 11-8) Frontier County, northeast of McCook

I. (Fig. 11-I) Frontier County, northeast of McCook

STOP 9. (Fig. 11-9) Furnas County, south of Oxford

STOP 10. (Fig. 11-10) Harlan County, west of Orleans

STOP 11. (Fig. 11-11) Harlan County, east of Republican City

J. (Fig. 11-J) Franklin County, west of Bloomington

K. (Fig. 11-K) Franklin County, north of Franklin

L. (Fig. 11-L) Webster County, northwest of Inavale

STOP 12. (Fig. 11-12) Webster County, northeast of Inavale

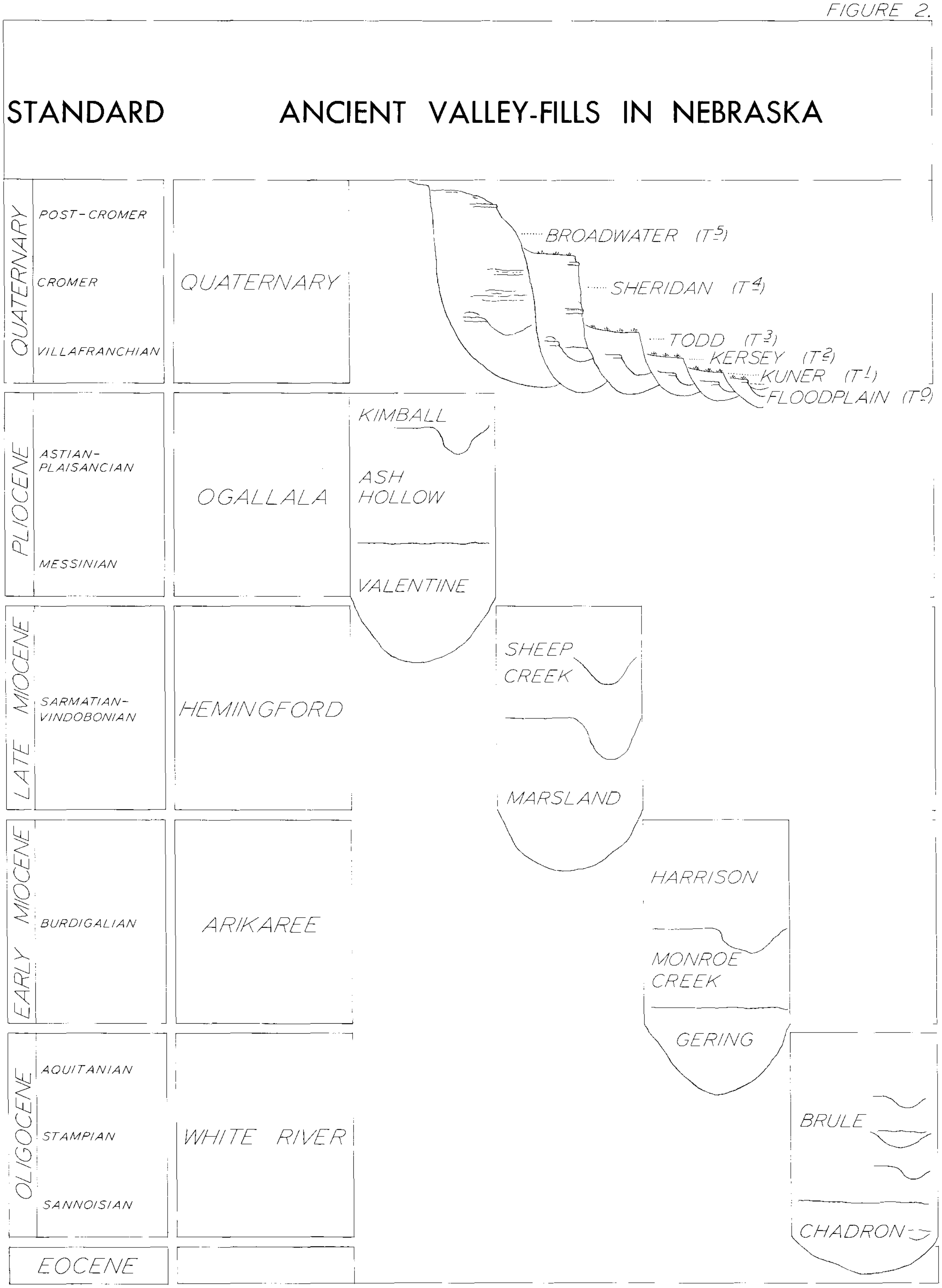
STOP 13. (Fig. 11-13) Nuckolls County, west of Nelson

STOP 14. (Fig. 11-14) Seward County, southwest of Seward

STOP 15. (Fig. 11-15) Seward County, northeast of Seward

Trip begins at Sidney (Cheyenne County) and ends at Lincoln (Lancaster County).

FIGURE 2.


STANDARD
ANCIENT VALLEY-FILLS IN NEBRASKA
QUATERNARY
POST-CROMER
CROMER
VILLAFRANCHIAN
QUATERNARY
BROADWATER (T5)
SHERIDAN (T4)
TODD (T3)
KERSEY (T2)
KUNER (T1)
FLOODPLAIN (T0)
PLIOCENE
ASTIAN-PLAISANCIAN
MESSINIAN
OGALLALA
KIMBALL
ASH HOLLOW
VALENTINE
LATE MIOCENE
SARMATIAN-VINDOBONIAN
HEMINGFORD
SHEEP CREEK
MARSLAND
EARLY MIOCENE
BURDIGALIAN
ARIKAREE
HARRISON
MONROE CREEK
GERING
OLIGOCENE
AQUITANIAN
STAMPIAN
SANNOISIAN
WHITE RIVER
BRULE
CHADRON
EOCENE

SOME PROBLEMS OF SURFICIAL GEOLOGY IN NEBRASKA

By T. M. Stout

This excursion, which begins at Sidney and ends at Lincoln, Nebraska (Fig. 1), gives the opportunity for field consideration and free discussion of some of the problems of Pliocene and Pleistocene stratigraphy in that interesting part of the Central Great Plains situated between the Rocky Mountains and the western edge of the glaciated region of the Central Lowland in eastern Nebraska. Fifteen stops are scheduled, for which geologic sections (numbered) and supplementary geologic sections (lettered) have been prepared (Figs. 1, 10-11), together with written descriptions and tentative correlations according to the views to be presented here.

Sidney is situated in the shallow valley of the Lodgepole Creek, that heads, like many other present and ancient drainages of the High Plains, in the Front Range of the Rocky Mountains, but more specifically at the north margin of the Gangplank Area near Cheyenne, Wyoming (Pl. 1). The Gangplank Area (Buffington, MS. of 1961), which is a High Plains remnant preserving the Tertiary sediments associated with the development of earlier Gangplanks, is the great ramp that allowed the first transcontinental railroad (the Union Pacific) easy ascent from the Lodgepole Creek Valley to Sherman Hill.

The earliest observations of geological importance concerning the Lodgepole Creek Valley west of Sidney were by Henry Engelmann, who in 1858 and 1859 thought that the strata "near the Pine Bluffs" (like those at Ash Hollow to the northeast) represented Hayden's Pliocene bed F, rather than the Post-Pliocene or Post-Tertiary (Engelmann, 1876, p. 260-265). It was near Pine Bluffs, too, that a decade later fossils were recovered by O. C. Marsh of Yale University from a deep well dug along the newly-constructed Union Pacific Railroad; this was at Antelope Station, also called Antelope Springs (Marsh, 1868, 1874; Schuchert and LeVene, 1940, p. 97-98, 106-108). In 1870, the Yale party made further explorations there and elsewhere in western Nebraska, continuing south into northeastern Colorado to discover the "*Mauvaises Terres* formation" (the White River, Oligocene; *see* Marsh, 1870). In 1873 and 1879, E. D. Cope, a private researcher from Philadelphia attached loosely to the Hayden and Wheeler Surveys, came into the region and found many interesting fossils also (Osborn, 1931, p. 194-196, 269-271). In other years during this same period, Cope's collectors were in western and southern Nebraska. The rich fossil fields in northeastern Colorado and in Nebraska much later (in 1898, and 1901-1902) attracted the expeditions of the American Museum of Natural History, led by W. D. Matthew (Matthew, 1899, 1901; Camp, 1969, p. 266), and subsequently those

Explanation of Figure 2 (opposite): Ancient Valley-fills of the Tertiary and Quaternary in Nebraska. Note the progressive offsetting of many of the ancient valley-fills; *see also* Plate 2.

from other institutions (Galbreath, 1953; Wilson, 1960; Schultz and Stout, 1941, 1948, 1961).

The University of Nebraska expeditions, under the leadership of E. H. Barbour, began explorations in northwestern Nebraska in 1891, and these have been continued for 80 years without prolonged interruptions, giving principal emphasis to work in Nebraska and adjacent States without use of State funds. Barbour, who was the first State Geologist of Nebraska as well as Museum Director and head of the Geology Department of the University for many years, was closely associated with the fundamental and extensive surveys of the Nebraska Tertiary made by N. H. Darton (1899, 1903, and other papers) for the United States Geological Survey.

Thus, in somewhat more than a century, there has resulted an extensive documentation on the Nebraska Tertiary and Pleistocene (see Selected References), especially by staff members of the University, but with important contributions also by persons from other institutions. Additional information and collections have been assembled at the University of Nebraska in Lincoln, in the offices of the Nebraska Geological Survey (Conservation and Survey Division), the State Museum, the Department of Geology, and cooperating state and federal agencies.

These data constitute the essential background for interpretation and discussion of Tertiary and Pleistocene problems in Nebraska, and the valuable collections in various museums elsewhere in the United States (such as the Frick Collection at the American Museum of Natural History) are likewise critical. But it is the basic stratigraphy, both surface and subsurface, and the geomorphic relations that must be given principal emphasis.

Tertiary and Quaternary Valley-fills

The ancient valley-fills of the Tertiary and Quaternary in Nebraska are shown in comparative form as Plate 2, and more diagrammatically as Figures 2 and 3. Each of the major divisions (White River, Arikaree, Hemingford, Ogallala, and Quaternary) has basic similarities and repetitive sedimentational patterns with respect to the others. These extend even to a possible matching of soils and erosional episodes from one to the other, as increasing field familiarity allows such comparative judgments. It is therefore reasonable to consider each of these larger divisions having the rank of a Group (or/and Stage, using the latter term in the correct European sense, following the recent analysis of d'Orbigny's ideas and work by Rioult, 1969). Except for the Quaternary (Stout, 1969), this was the earlier accepted view of most Nebraska workers when Lugn (1939) reviewed the basic classification of the Nebraska Tertiary.

The Quaternary valley-fills (Pl. 2; Figs. 2-3, 10-11), from oldest to youngest, are: Broadwater, Sheridan, Todd, Kersey, Kuner, and Floodplain. It seems necessary here to consider each as a formation, which would reduce their subdivisions to the status of members and beds (Stout and Schultz, 1971).

Quaternary Time Planes and Unconformities

As shown on Figures 10 and 11, six sets of time planes that define unconformities may be usefully projected through the Quaternary valley-fills and mantling sediments. These are summarized below.

Interval A-A'. - If the top of the Ogallala is taken as Time Plane A, and the base of the Broadwater (Terrace-5 fill) as Time Plane A', the unconformity between is the measure of the Pliocene-Pleistocene boundary in western and southern Nebraska. By the use of such fossil mammals as *Dipoides* for the Pliocene and *Equus* (*Plesippus*) for the Pleistocene, it is possible to project this boundary through much of the Northern Hemisphere (Schultz and Stout, 1948; Stout, unpublished studies).

Interval B-B'. - If the top of the caliche or other soil, or top of the diatomaceous marl and peat, in the Lisco Member of the Broadwater is considered to be Time Plane B, and the base of the Lisco loess (or base of the colluvial and alluvial silt in the Lisco) as Time Plane B', the unconformity is believed to be that immediately following the development of the "Afton" Soil (Soil "J"). It is presumably represented in eastern Nebraska by the "Afton" Soil and some part of the intertill sand that occurs between the Nebraskan and Kansan tills, much as described by Lugn (1935, p. 41-67, 98-103, figs. 10-13). The Fullerton in some places there probably corresponds to the whole of the Lisco (compare with discussions of Reed and Dreeszen, 1965, p. 25-26, 50-51; and of Reed, Dreeszen, Bayne, and Schultz, 1965). This implies that the Lower Gravel Member of the Broadwater is the equivalent of outwash from Nebraskan ice, while the Upper Gravel (or Red Cloud) Member of the Broadwater is the equivalent of outwash from Kansan ice (*see* Goll, MS. of 1961, pls. 14-15).

Interval C-C'. - At the top of the Upper Gravel or Red Cloud Member of the Broadwater, there is a heavy caliche or other soil ("True" Yarmouth Soil or Soil "K" of Geologic Sections 6 and C, and possibly in vicinity of Geologic Section 12); the top of this soil may be taken as the Time Plane C. After this, there was tremendous erosion throughout Nebraska, and the next younger sediment is the Grand Island Sand and Gravel Member, at the base of the Sheridan (Terrace-4 fill); Time Plane C' is to be considered as the base of the Grand Island and base of the Sheridan. The unconformity thus defined may be observed especially at three localities: (1) Along the road leading from Highway 26 to the Lisco Locality "C" (Geologic Section 4), where the Grand Island occurs in a different and lower valley-fill from the Broadwater (Schultz and Stout, 1945, fig. 2 on p. 235). (2) Near the type locality of the Red Cloud, in Webster County, Nebraska, at the Stop 12-1 of the 1965 INQUA Excursion "D"; (*see* also remarks *in* Stout, Dreeszen, and Caldwell, 1965, p. 96-97, concerning the Belleville Channel-fill, especially at the Thompson Sand and Gravel Pit near Cowles, as probably representing the entire Broadwater). (3) In Seward County, Nebraska, in the vicinity of

Geologic Sections 14 and 15, where the Sheridan Valley-fill occurs far below the Kansan till plain. At this higher level the till seems to be intercalated with the sand and gravel body that becomes the Red Cloud beyond the till border (Barbour, 1913, 1914; interpretations of Goll and Stout, in Goll, MS. of 1961, pl. 15, profile C-C'). The unconformity is surely the post-Kansan erosional interval, long interpreted by Stout (Fig. 3), as the time of major erosion associated with the maximum of the Early Illinoian ice advance, before release of the Grand Island as an outwash sand and gravel (or equivalent) from the stagnation of that ice.

Interval D-D'. - Above the Grand Island Sand and Gravel in central Nebraska (Geologic Section K), there is a very heavy soil developed on greenish gray silt and sand. This was called the "Upland" by Lugn (1935, p. 119-121, fig. 17), but the name was changed and the unit somewhat redefined as Sappa by Reed (1948b; see also Reed and Dreeszen, 1965; and Dreeszen and Souders in Stout, Dreeszen, and Caldwell, 1965, p. 89-94, fig. 11-55). The importance of this soil (Soil "L" here) was correctly stressed by Lugn (1935), and a series boundary was even proposed by him at the unconformity above it. The top of this soil establishes Time Plane D, and the base of the next younger sediments (these include the Pearlette Volcanic Ash Bed, or loess, or even colluvial and alluvial silts) on this surface of unconformity may be taken as Time Plane D'. The similarity of the entire Sappa, when compared with the Lisco Member in the Broadwater, requires mention at this point. The repetition is indeed striking, especially when it is realized that a thick diatomaceous marl and peat bed also occurs in the Sheridan (as in the Rushville and Hay Springs Quarries, Sheridan County, Nebraska) that occupies the position of the "Upland" Soil (Soil "L"). (For further discussion, see Schultz and Stout, 1945, 1948; Schultz and Tanner, 1957; Stout, Dreeszen, and Caldwell, 1965, p. 53-56, figs. 6-29 to 6-31). The Sappa, like the Lisco, is sandwiched between two sand and gravel sheets of regional importance, the Grand Island below and the Crete above. The latter is regarded by Stout as a Late Illinoian outwash (or equivalent).

Interval E-E'. - If the top of the Sangamon Soils (Soils "S" and "T", clearly two soils, as at Geologic Sections F and H, constituting the lower part of the Gilman Canyon) is taken as Time Plane E, the succeeding unconformity is defined by the base of the next younger sediments, the Todd (Time Plane E'). This unconformity is that between the Sheridan and the Todd (between the Terrace-4 and Terrace-3 valley-fills of Schultz and Stout, 1945, fig. 3; 1948).

Interval F-F'. - If the top of the Brady Soil (Soil "X") is considered to be Time Plane F, the succeeding unconformity is established by the base of the next younger valley-fill, the Kersey (Time Plane F'). This unconformity is that between the Todd and the Kersey (between the Terrace-3 and Terrace-2 valley-fills of

Schultz and Stout, 1945, figs. 3-4, table; 1948). It should be remarked that both the Kersey and the next-younger valley-fill, the Kuner, were named by Bryan and Ray (1940). These names were applied tentatively, but later more definitely, to Nebraska valley-fills by Schultz and Stout (1945, table on p. 243; 1948, fig. 4 on p. 573).

Quaternary Buried Soils

The importance of the buried soils of the Quaternary in establishing the above-discussed time planes, and even others, seems obvious. The simplicity of the initial scheme of applying letters of the latter part of the alphabet to those younger than the Sangamon Soils (Soils "S" and "T"), and letters before "S" progressively downward below the Sangamon, has been now somewhat abandoned. However, it has been retained for the present guidebook in its simplest form, as established by Schultz and Stout (1945, especially figs. 3-4, table on p. 243; 1948) and then extended downward by Stout (in Stout, Dreeszen, and Caldwell, 1965, p. 68-73, fig. 9-43). As now used, the oldest Quaternary soil is that designated Soil "J"; this is believed to correlate with the "Afton Soil" farther east, in eastern Nebraska and northeastern Kansas as well as in southwestern Iowa.

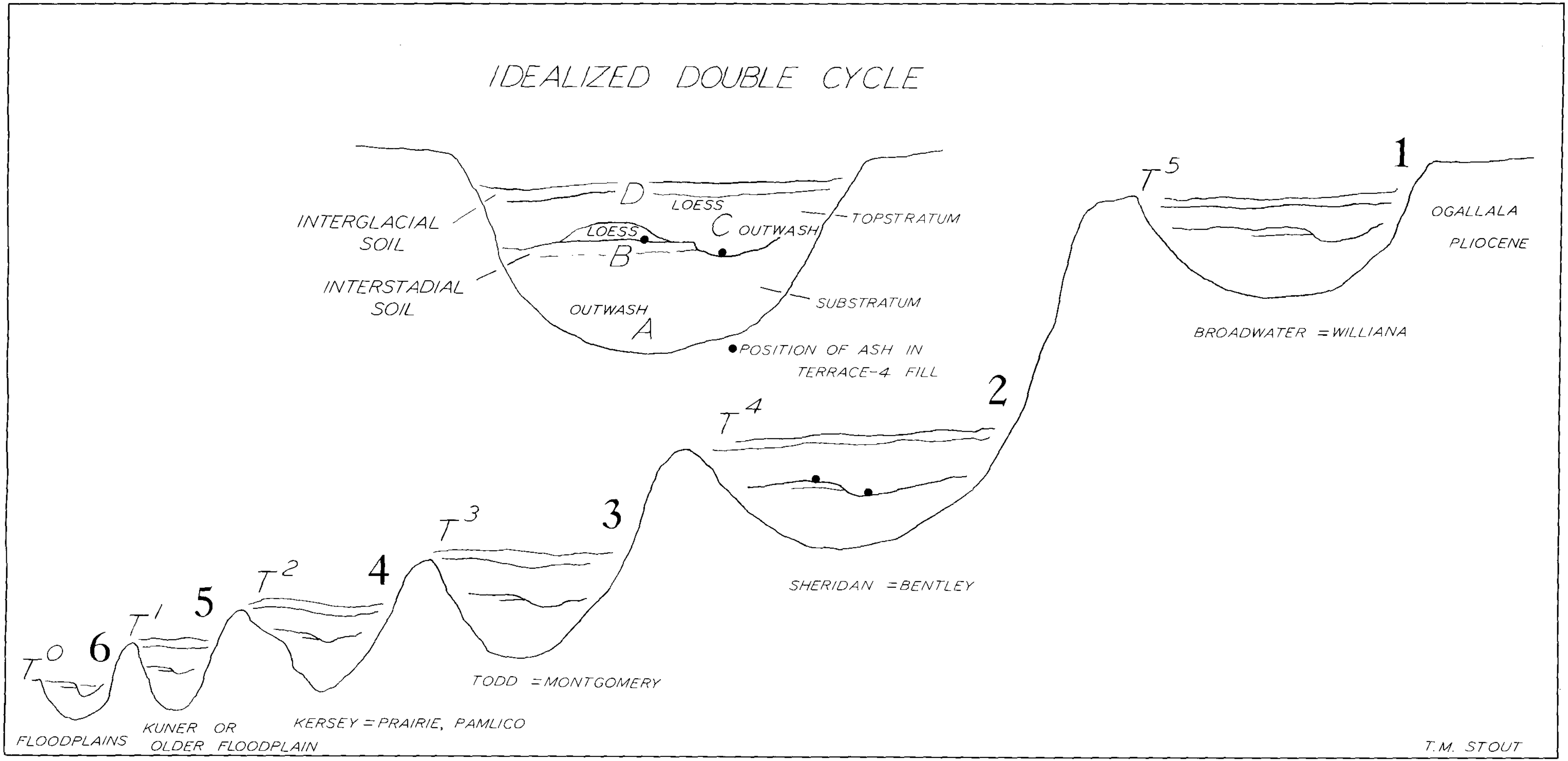
Pearlette Volcanic Ash Bed

Because of its unusual importance, a statement regarding the apparent stratigraphic position of the Pearlette Volcanic Ash Bed is required. It is the view here (by Stout) that the ash occurs only at the base of the upper part of the Sappa Member of the Sheridan Formation, or in equivalent position in the mantling sediments above the Red Cloud (Geologic Section 12) or on top of the Kansan till plain (in vicinity of Geologic Section 15). In this view, its age would seem to be mid-Illinoian.

Quaternary Interpretations

Figure 3 illustrates the ideas regarding the correlation with the glaciated regions that have been mentioned above. These were expanded in an abstract for the 1969 INQUA meetings at Paris (Stout, 1969). Alternative interpretations are well known, especially in the papers of Reed and Dreeszen (1965), Reed, Dreeszen, Bayne, and Schultz (1965), and Stout, Dreeszen, and Caldwell (1965). It is apparent that there has been a considerable evolution of ideas since Lugn's (1935) fundamental memoir on the Nebraska Pleistocene. Perhaps the Quaternary and Tertiary are convenient starting points for understanding even earlier geologic history? In any case, a <u>comparative</u> approach is now indicated: this may be called <u>comparative stratigraphy</u>.

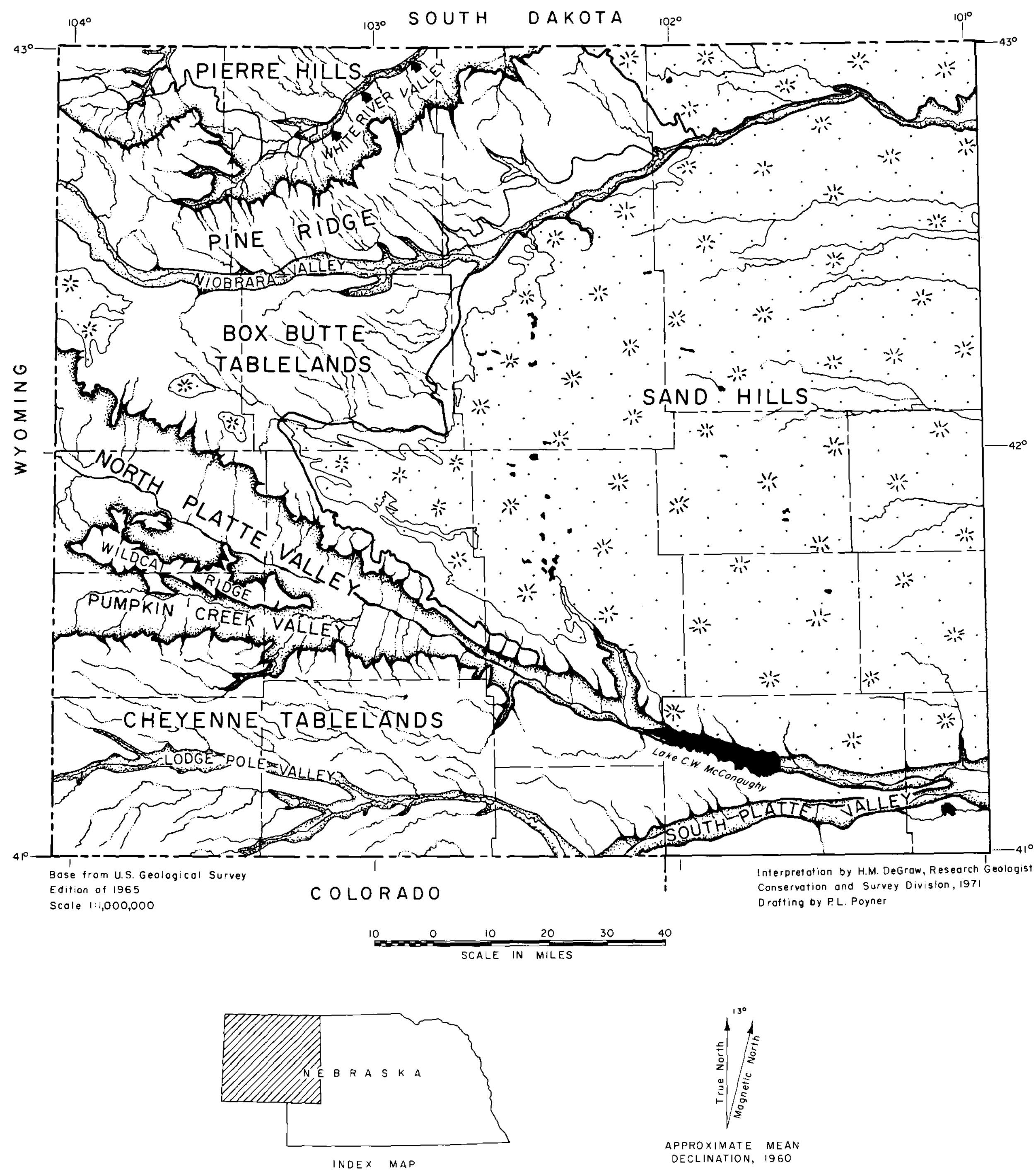
FIGURE 3.


IDEALIZED DOUBLE CYCLE
D
LOESS
TOPSTRATUM
INTERGLACIAL SOIL
LOESS
C OUTWASH
B
INTERSTADIAL SOIL
SUBSTRATUM
OUTWASH
A
• POSITION OF ASH IN TERRACE-4 FILL
T 5
1
OGALLALA
PLIOCENE
BROADWATER = WILLIANA
T 4
2
SHERIDAN = BENTLEY
T 3
3
TODD = MONTGOMERY
T 2
4
KERSEY = PRAIRIE, PAMLICO
T 1
5
KUNER OR OLDER FLOODPLAIN
T 0
6
FLOODPLAINS
T.M. STOUT

Explanation of Figure 3 (opposite)

Pleistocene classification and sedimentational patterns according to the interpretation of T. M. Stout. (Reproduced from Stout, Dreeszen, and Caldwell, 1965, fig. 3-7 on p. 17; legend quoted below). "Six progressively-weaker double cycles or valley-fills are suggested as present in the periglacial areas, the last of which is incomplete. Each double cycle consists of a substratum (A-B) and overlying topstratum (C-D), separated by an unconformity that is weaker than either the initial or terminal unconformities. The double cycle is thus thought to have been initiated by the erosion that is the only record outside the glaciated regions of the onset of glaciation and the coincident drop of sea level (ultimate and controlling base levels). The outwash or equivalent sediment (A) marks the initial melting of the ice, and the interstadial soil (B) indicates the temporary restoration of conditions like those of the present. The second glacial (stadial) episode is shown by the interstadial unconformity, with relatively thin loess deposited seasonally and locally, mostly marginal to and over the generally frozen or dry stream courses. With the waning of glaciation, the second outwash or its equivalent (C) is deposited in the valleys, and the transition to the long interglacial terminal episode is marked by thick loess and weak soils, culminating in a thicker and stronger soil profile (D). Correlations with the marine benches of the Lower Mississippi River and Gulf Coastal Plain also are suggested here, giving emphasis to the famous dictum of A. Penck (quoted in Pfannenstiel, 1951, p. 82): 'Eiszeiten sind Zeiten der Regressionen, Zwischeneiszeiten solche der Transgressionen'." (See also Stout, 1969).

FIGURE 4



PHYSIOGRAPHIC FEATURES IN WESTERN NEBRASKA

THE PRE-OLIGOCENE SURFACE IN WESTERN NEBRASKA--ITS RELATION TO STRUCTURE AND SUBSEQUENT TOPOGRAPHIES

By Harold M. DeGraw

INTRODUCTION

The pre-Oligocene, mostly pre-Chadron, surface has been exhumed and either truncated or partially eroded in Wyoming, Colorado, South Dakota, Nebraska, and probably other states of the High Plains Region. Numerous workers have observed and interpreted its relations; some workers (Pettyjohn, 1966; Schultz and Stout, 1955; and Toepelman, 1922) were essentially correct in their interpretation of its various outcrop occurrences whereas others were mostly incorrect. Much of the pre-Oligocene surface is covered by Tertiary and Quaternary sediments having a considerable range in thickness, thus making impossible detailed study of that surface from outcrops alone.

In western Nebraska, the pre-Oligocene surface consists of Cretaceous and some Jurassic rocks; Eocene and Paleocene rocks have not been recognized in the region. In that region, more than nine thousand deep exploratory wells for oil and gas and approximately two hundred shallow groundwater test wells have provided abundant data for a subsurface study of the pre-Oligocene unconformity. Electric logs, which are available for nearly all the wells, proved to be a precise tool for making subsurface correlations. Rock samples, available for most of the groundwater test wells and a few of the oil and gas exploratory wells, were used to relate lithic characteristics to electric log characteristics.

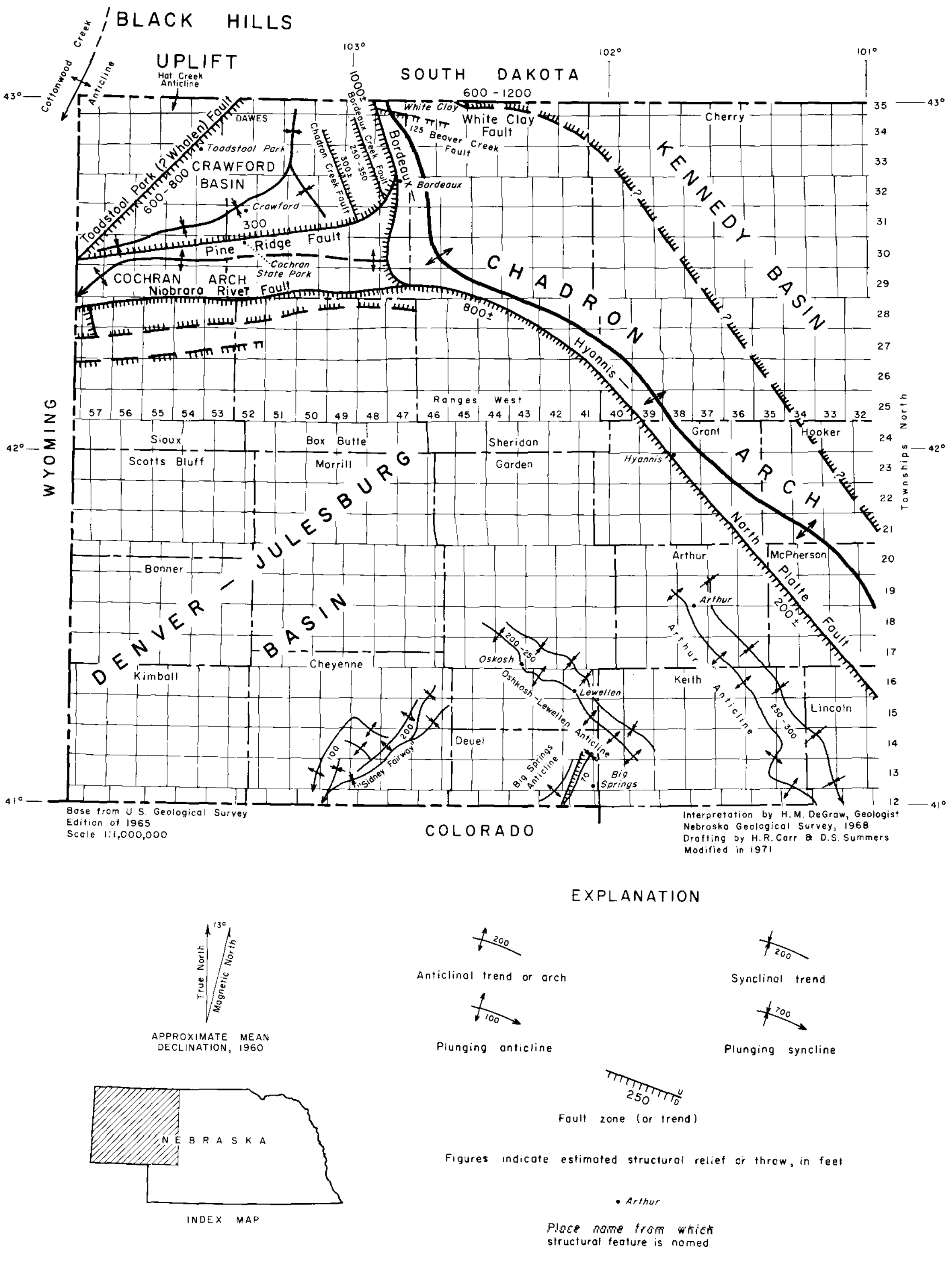
The physiographic features of the modern surface in western Nebraska are shown in figure 4.

STRUCTURAL SETTING

Structural relations in western Nebraska are impossible to decipher from outcrop data alone. Faults and folds in Cretaceous and older rocks are effectively concealed by the thick sequence of Tertiary and Quaternary sediments. Structural deformities within the Tertiary-Quaternary sequence are obscure owing to lateral changes in lithology within short distances, paucity of marker beds, and a succession of unconformities. However, the major structures have long been recognized, and now, through use of abundant subsurface data, several subsidiary structures have been defined by DeGraw (1969) and are shown in figure 5 with some modifications.

Large parts of the Denver-Julesburg Basin and Chadron Arch and smaller parts of the Black Hills Uplift and Kennedy Basin extend into western Nebraska. Also present are several secondary

FIGURE 5



STRUCTURAL FEATURES IN WESTERN NEBRASKA

(Interpreted from "X" Bentonite Datum of the "Graneros")

10 0 10 20 30 40
SCALE IN MILES

structural features. Two of these, informally designated the Crawford Basin and the Cochran Arch, are in the northwestern part of the state and are now considered to be subsidiary features of the Denver-Julesburg Basin. Their limits are fairly well defined but the indicated intrabasinal structural trends of the Crawford Basin are only inferred. Other secondary features, such as the informally named Arthur, Oshkosh-Lewellyn, and Big Springs Anticlines in the southeastern part of the region, cannot now be defined accurately. The "Sidney Fairway" in eastern Cheyenne County is known to be structurally complex but is shown in figure 5 as a generalized pattern as it has not been satisfactorily analyzed.

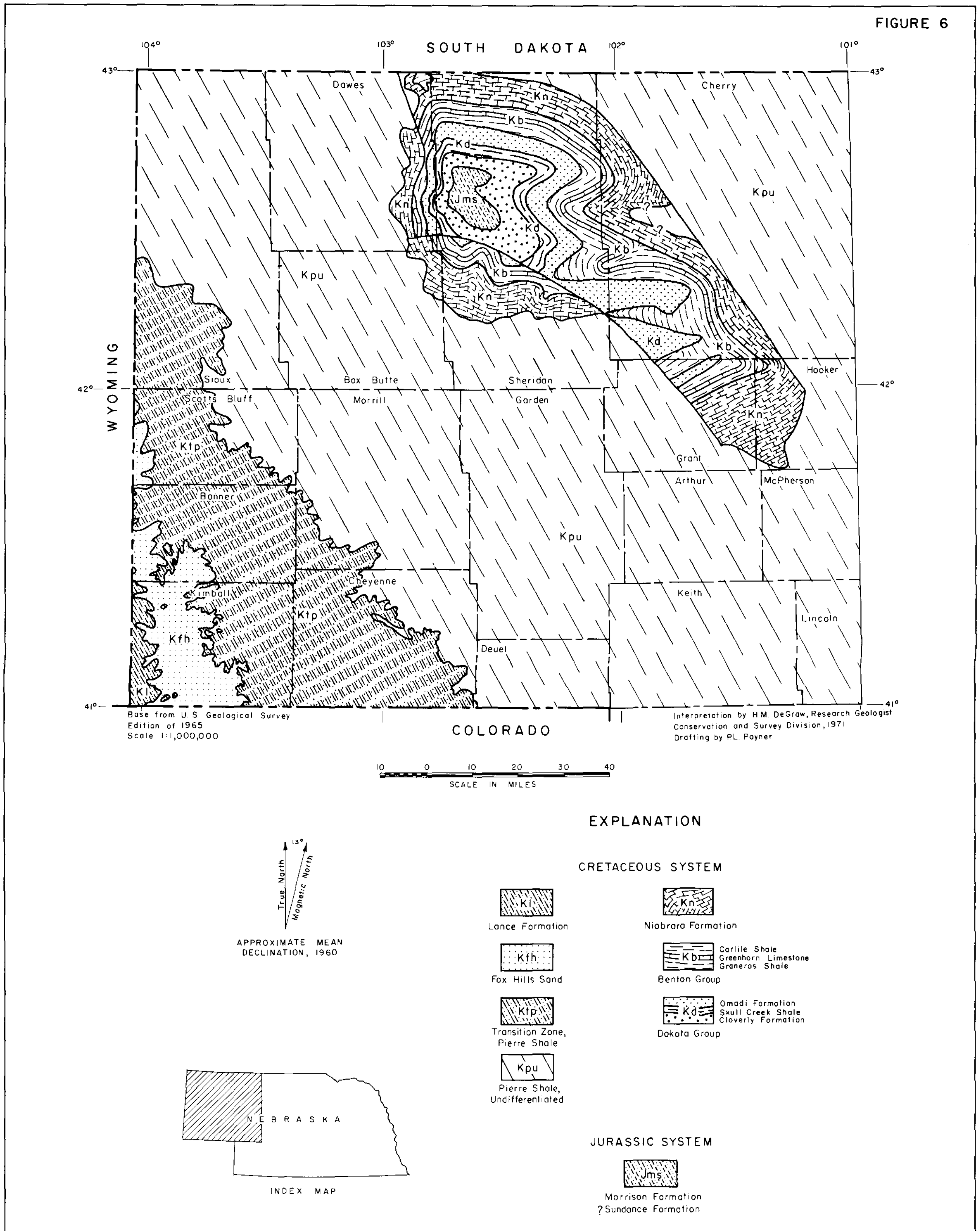
Normal faults are common structural features throughout western Nebraska and appear to be associated with all recognized structural trends as well as many undesignated features of smaller scale. Most faults have a pre-Oligocene age but some faulting has been recognized in Tertiary strata in both outcropping and subsurface situations. Some reevaluation of the interpreted pre-Oligocene surface configuration and drainage patterns (figure 7) in parts of the region are required as it is now known that Tertiary faulting is more prevalent than earlier believed.

STRATIGRAPHIC RELATIONS

Relations of the strata overlying and underlying the pre-Oligocene surface are those expectable for a regional unconformity. In western Nebraska, as shown in figure 6, truncated formations range from uppermost Cretaceous (Lance and Fox Hills) down through basal Cretaceous ("Dakota") and locally include Jurassic (Morrison and probably Sundance). Pierre, Fox Hills, and Lance strata subcrop in the Denver-Julesburg Basin but the Pierre is by far the most extensive unit. The Pierre also subcrops in the Kennedy Basin and along the flanks and in structurally low areas of the Chadron Arch. Subcrops of the Niobrara and older strata are restricted to this arch.

Sediments resting directly on the pre-Oligocene surface are almost exclusively Chadron (basal Oligocene). The distribution patterns of different lithologies for the basal Chadron sediments show conclusively that they were topographically controlled. Furthermore, these basal sediments serve as a clue to post-Oligocene faulting in areas where their relation to the configuration of the pre-Oligocene surface appears to be out of character.

Post-Oligocene truncation and subsequent sedimentation resulted in younger sediments overlying pre-Oligocene strata in a few places. In at least one place--the modern Cheyenne Tablelands in northwestern Kimball and southwestern Banner Counties--pre-Miocene erosion (channel cutting) removed Oligocene strata, and Miocene (probably Arikaree) valley-fill sediments were deposited on Fox Hills strata (DeGraw, 1969). In a few other places, such as in the Pierre Hills area and, locally, in the North Platte



PRE-OLIGOCENE GEOLOGIC MAP OF WESTERN NEBRASKA

valley, none of the Tertiary sequence remains and Quaternary sediments directly overlie Cretaceous rocks. Thus the pre-Oligocene surface in western Nebraska is an almost intact paleo-topographic surface that locally has been truncated and shifted during later erosional and tectonic episodes.

PALEOTOPOGRAPHIC CHARACTERISTICS

Across western Nebraska (figure 7), the relief on the pre-Oligocene surface exceeds 3,300 feet. The highest point, located in the southwestern corner of the state, is about 4,800 feet above sea level and the lowest point, in the eastern part of the region, is below 1,500 feet. Local relief between adjacent ridges and valleys commonly exceeds 300 feet.

Only two principal pre-Oligocene valleys enter Nebraska from the west; one, in southwestern Sioux County, subparallels the modern North Platte River, and the other, in northwestern Sioux County, occurs south of the Pine Ridge Escarpment. These two paleo-valleys are tributaries of the same major paleo-valley which extends beneath the modern Sand Hills Region in north-central Nebraska. In fact, virtually all of western Nebraska was within the drainage basin of that major paleo-valley.

For much of the High Plains Region, in both outcrop and subsurface situations, the "Interior Paleosol Complex" of Schultz and Stout (1955) provides an excellent "lithologic" marker of the pre-Oligocene surface. Characterized by vivid coloration, it exhibits some zonation and banding and has a wide range in thickness. This weathered zone is commonly thicker and better developed on upland areas and where formed on more permeable strata; it is thinner or entirely truncated in the larger paleo-valleys. Of great stratigraphic importance, this ancient lateritic soil has been misinterpreted by several previous workers when making surface and subsurface correlations. For example, varicolored strata have been considered as characteristic of the Lance (Schlaikjer, 1935; Wenzel, Cady, and Waite, 1946) and also evidence for the Fox Hills (Ward, 1922). In the Chadron Arch area, where this paleosol formed on "Dakota" strata, at least one petroleum geologist assumed it to be a local environmental characteristic of the "Dakota."

In some pre-Oligocene paleo-valleys, the coloration and lithology of basal Chadron sediments closely resemble the "Interior Paleosol," and in such places the Tertiary-Cretaceous contact is nearly impossible to define.[1/] This contact is also obscure in

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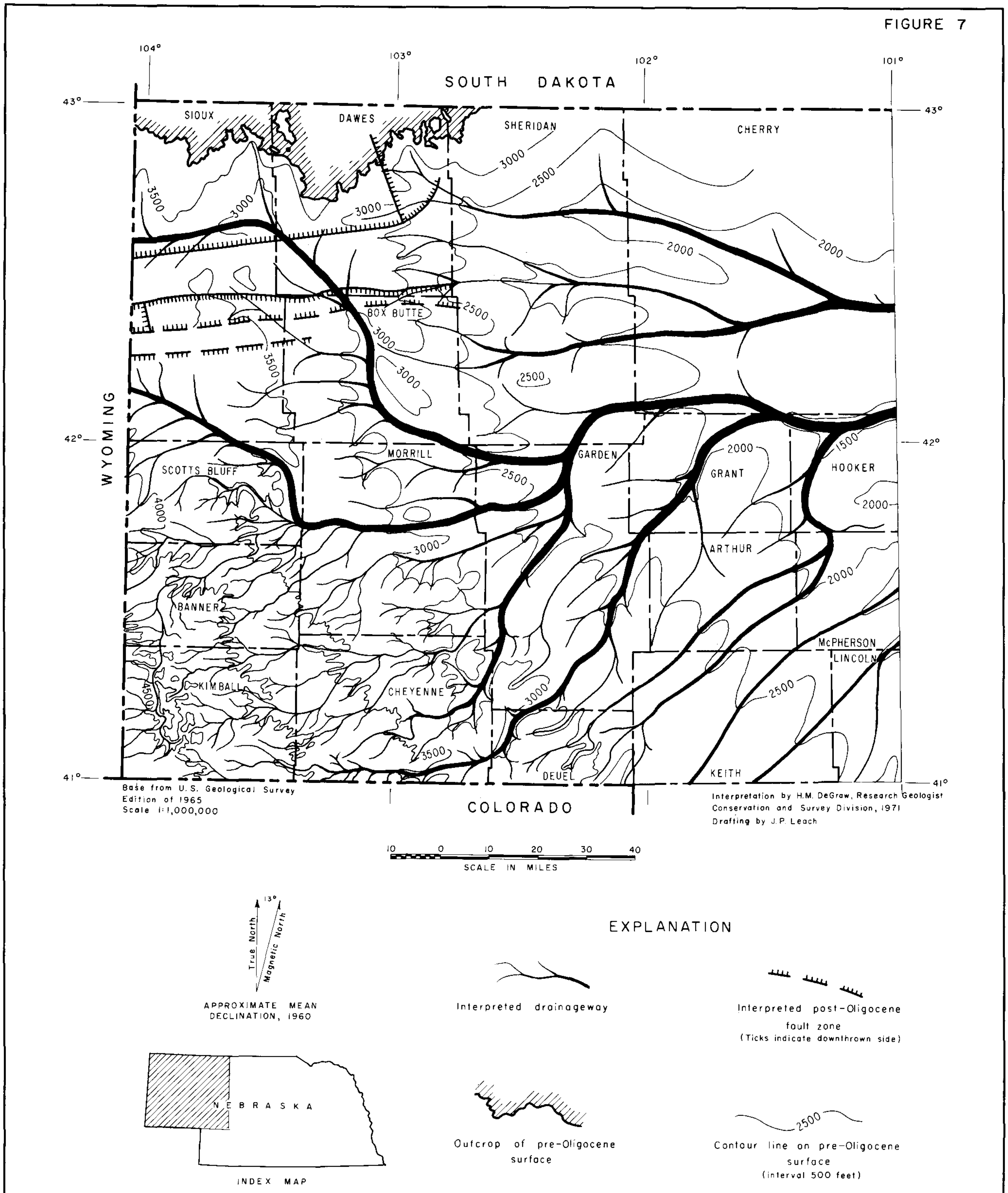
1/This stratigraphic problem is common for continental deposits. For example, at one site in Banner County, Quaternary sediments consisting of reworked Brule (Oligocene) can be distinguished from _in situ_ Brule only by close inspection. Also, along the base of the Pine Ridge Escarpment in Dawes and Sioux Counties, Quaternary sediments consisting of reworked Chadron so closely resemble _in situ_ Chadron that different geologic maps of that area commonly are not in accord.



PRE-OLIGOCENE TOPOGRAPHY AND DRAINAGE PATTERN IN WESTERN NEBRASKA

some areas where electric log resistivities of the Oligocene and Cretaceous strata are similar. This latter problem is most common where coarse clastics occur in both sequences. In most places where considerable data are available, valid correlations can be made with much detailed study; but in a few places, additional data are required.

PALEOTOPOGRAPHIC CONTROL

Two geologic factors--structural trends and subcrop lithologies--appear to have had the most influence on the configuration of the pre-Oligocene surface as interpreted in figure 7. In those areas in which abundant well data allow detailed study, structural trends appear to have been the dominant factor.

Structural control is best considered in terms of time of occurrence--either Laramide (Late Cretaceous-Early Tertiary) or post-Laramide even though structural trends of Laramide and post-Laramide tectonisms cannot always be differentiated. Laramide tectonism most certainly provided the "grain" for topographic development on the pre-Oligocene surface, but post-Laramide tectonism materially influences interpretation of the pre-Oligocene surface (figure 7). Moreover, post-Laramide adjustments may have occurred along the Laramide zones of weakness, thus further complicating the relations.

The regional slope of the pre-Oligocene surface is attributed to epeirogeny. Although development of major drainageways commonly is controlled by structural patterns, neither the ancient nor the modern North Platte River appears to be related to any recognizable structural trend in western Nebraska. However, both drainageways are believed to have been locally controlled by structural trends in the Hartville Uplift in eastern Wyoming, and,thence, by the regional slope eastward into Nebraska.

The relation of the pre-Oligocene surface to local Laramide structural trends in western Nebraska is especially apparent when paleotopographic trends are compared with the location of oil and gas field locations (DeGraw, 1969, pl. 3). The consistent coincidence of paleotopographic ridges and oil and gas occurrence suggests a common controlling factor.

Many of the structural features in the northwestern part of the state appear to be related to post-Laramide deformation. Here, basal Chadron coarse clastics in oil-test wells on the Cochran Arch occur at elevations nearly 300 feet higher than correlative Chadron sediments in nearby wells of the Crawford Basin. In cross section, this relation is suggestive of "hanging valleys."

The influence of subcropping rock on the pre-Oligocene surface configuration (figure 7) cannot be reasonably assessed for much of the region because well control is too sparse. It is to

be expected, certainly, that differing lithologies of the subcropping formations on the Chadron Arch would be reflected in their eroding characteristics and, thus, their paleo-surface characteristics. Also, the shale lithology of the "Undifferentiated Pierre" is so uniform that it alone should not significantly affect local topographic relief. However, in western Kimball County considerable data indicate that some lithologies of uppermost Cretaceous strata exhibit preferential topographic positions. For example, sands of the Fox Hills subcrop in local drainageways whereas the Lance, which is lithologically variable, commonly forms the adjacent ridges (figures 6 and 7).

INHERITANCE OF TOPOGRAPHIES

Although the general configuration of the modern High Plains surface in western Nebraska (figure 4) differs considerably from that of the pre-Oligocene surface (figure 7), some local characteristics of the modern surface apparently were inherited from features of the paleosurface. For example, the areas of highest elevation of both surfaces nearly coincide in the southwestern corner of Kimball County. Also, as already mentioned, the course of the modern North Platte River in Scotts Bluff County is close to and subparallel to that of the ancient "North Platte" tributary in the same area.

Coincidence for segments of drainageways also has been recognized for other Tertiary unconformable surfaces. Rush Creek, a prominent north-trending tributary of the North Platte River in eastern Cheyenne and southwestern Garden Counties, coincides with an underlying pre-Pliocene (pre-Ogallala) as well as a pre-Oligocene drainageway. Additionally, the downthrown block of the Big Springs Fault in eastern Deuel County (figure 5) is overlain by both pre-Pliocene and pre-Oligocene paleo-valleys. This latter example demonstrates the relation of structure to paleotopography and the inheritance of topographies especially well.

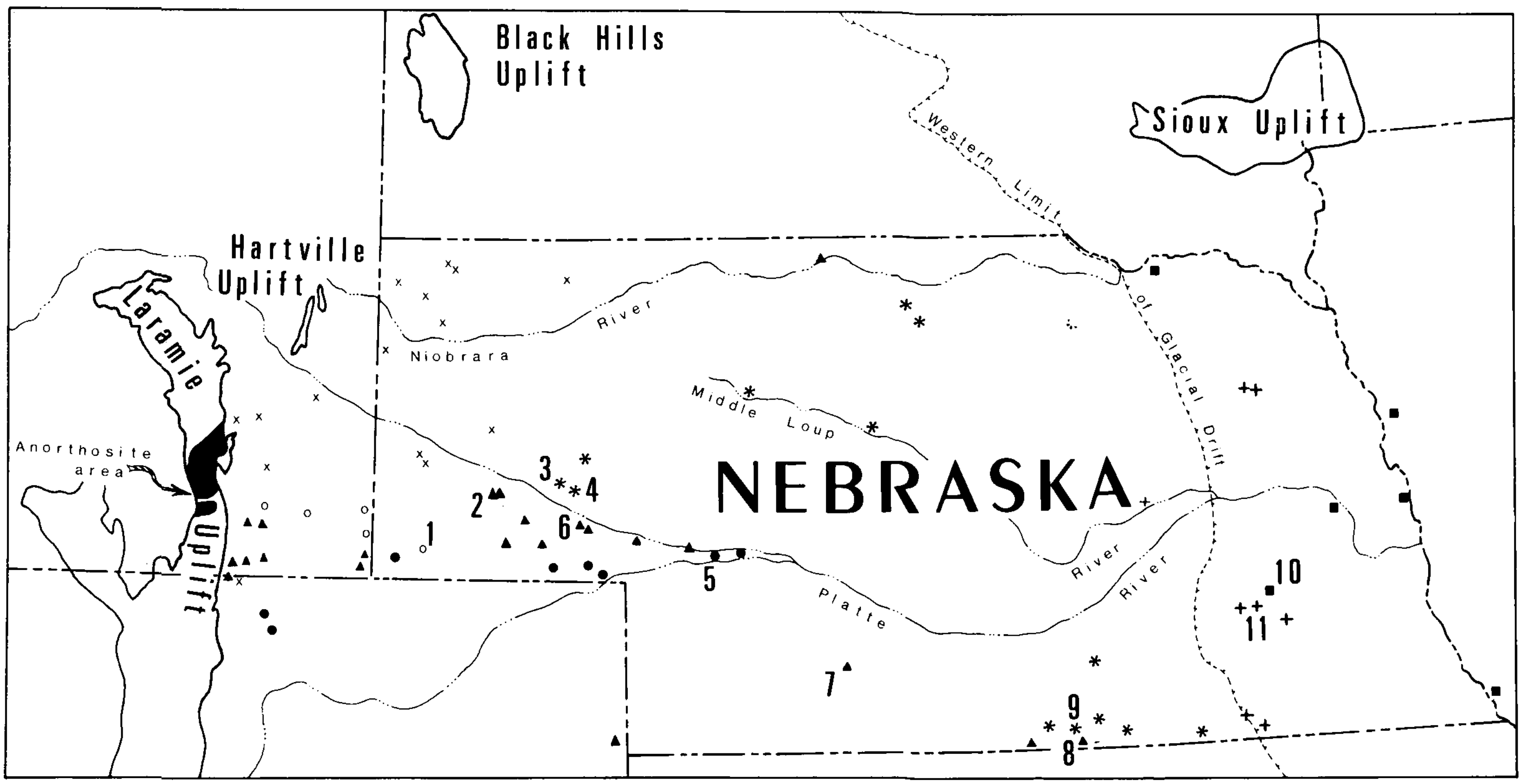
Part of the pre-Oligocene topography may have been inherited from older (Late Cretaceous and early Tertiary) topographies which, in turn, probably were structurally controlled. Certainly, the prominent south-trending valley and adjacent ridge of the pre-Oligocene surface in Box Butte County (figure 7) reflect Laramide structural "grain" (that is, they sub-parallel the Chadron Arch). They also may reflect uppermost Cretaceous drainage trends (Degraw, 1967).

Numerous topographic changes occurred during Tertiary sedimentation in western Nebraska, as is suggested by the Tertiary bedrock pattern of the Nebraska geologic map. Stratigraphic evidence supports the conclusion that previously established topographic patterns were partially inherited by progressively younger surfaces and that the significant modifications were due primarily to intervening structural movements.

SUMMARY

The pre-Oligocene (pre-Chadron) surface in western Nebraska is an important regional unconformity that truncates Cretaceous and Jurassic strata. This surface exhibits the characteristics of a moderate topography with local relief of 300 feet or more. Basal Chadron sediments relate well with this surface as coarse clastics and clays occupy the drainageways, whereas silts mantle the uplands. Topographic configuration is primarily controlled by both regional and local structural trends and is secondarily influenced by the lithic characteristics of underlying rocks. Younger structural patterns superimposed on the region complicate the relations and make valid interpretations difficult.

The coincidence of some topographic patterns of the modern and pre-Pliocene surfaces with paleotopographic patterns of the pre-Oligocene surface emphasizes the importance of topographic inheritance. Conversely, major differences in younger Tertiary and modern topographies combined with available evidence for faulting support the conclusion that lateral structural trends were the primary cause of modification in younger topographies.



OLIGOCENE AND MIOCENE GRAVEL - x, PLIOCENE GRANITIC GRAVEL-▲, PLIOCENE ANORTHOSITE-BEARING GRAVEL-o, PLEISTOCENE GRANITIC GRAVEL-●, PLEISTOCENE ANORTHOSITE-BEARING GRAVEL-*, PLEISTOCENE RED QUARTZITE-BEARING GRAVEL-■, PLEISTOCENE GRAVEL WITH ANORTHOSITE AND RED QUARTZITE CLASTS-+.

Figure 8. Index map showing the locations of Cenozoic gravel deposits exposed in Nebraska and adjoining Wyoming where pebble-composition data were collected. Columns 1 to 11 in table 1 refer to the numbered sample localities 1 to 11 on the index map.

AREAL AND TEMPORAL DIFFERENCES IN PLIO-PLEISTOCENE GRAVEL COMPOSITION, NEBRASKA

By Kenneth O. Stanley

A reconstruction of late Neogene stratigraphy and the history of sediment dispersal in Nebraska depends upon the formulation of a working hypothesis that is consistent with all known geologic data. The chronology of events that we now recognize was determined largely from paleontologic and stratigraphic observations with little knowledge of the composition of the sediments in question. Vertical variations in Tertiary heavy mineral suites recognized by Denson (1969) and chemical and petrographic differences in Pleistocene ash beds described by Izett et al. (1970) indicate that compositional data can be a powerful tool in stratigraphic and provenance studies of Neogene rocks (Miocene and younger) in the Great Plains. These data add a new dimension to our knowledge of Neogene stratigraphy and sedimentation in Nebraska particularly when considered in conjunction with paleontologic and stratigraphic data. However, benefits to be derived from studies of Neogene sediment composition are by no means exhausted. Preliminary studies of sand and gravel composition suggest that these lithologies also are useful for identification of Neogene formations, as well as for recognition and delineation of fluvial sediment dispersal. Gravel data are particularly useful because diagnostic clast-types are easily recognized in the field; hence, laborious laboratory analyses are not required to obtain meaningful results.

The itinerary set forth in this guidebook enables us to examine the composition of Plio-Pleistocene gravels over a large part of Nebraska and to consider their areal and temporal trends. The compositional data and their interpretation reported herein represent part of a study of Cenozoic sedimentation in Nebraska and adjoining Wyoming which is still in progress. Additional data and further interpretation of their sedimentologic and tectonic implications will be forthcoming in later publications.

Data were collected from Cenozoic gravels exposed in Nebraska and adjoining Wyoming (figure 8). To facilitate comparisons only the results of the -4.0 to -5.0 phi fraction of the sediment are considered. In general these pebble data fall into four distinct populations: (1) Plio-Pleistocene granitic gravel derived from the Rocky Mountains; (2) lithic gravel derived from local Tertiary formations; (3) early Pleistocene outwash gravel rich in pre-Tertiary sedimentary clasts, derived from Pleistocene tills in eastern Nebraska; and (4) early Pleistocene gravel containing an admixture of clasts common to both outwash and granitic gravels (figure 9). Gravel types 1 and 2 occur in western and central Nebraska, whereas gravel types 3 and 4 occur only in eastern Nebraska (figure 8). Point counts of plutonic to sedimentary and metamorphic clasts are most useful for revealing Rocky Mountain-derived gravels, proglacial outwash, and admixed gravels

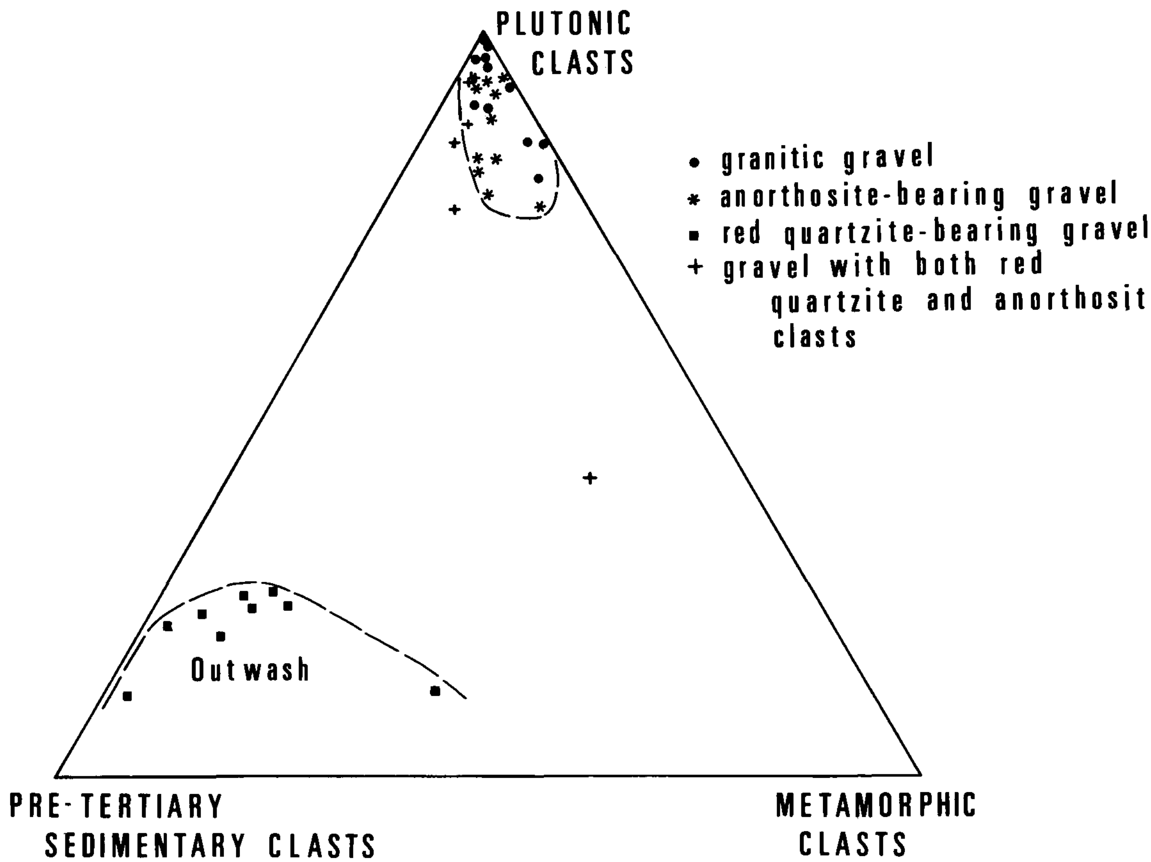


Figure 9. Triangular diagram showing the relationship between bulk pebble composition (i.e. plutonic to sedimentary and metamorphic clasts) and the presence or absence of diagnostic clast types (i.e. anorthosite or red-colored Sioux Quartzite clasts) in early Pleistocene gravels exposed in Nebraska.

in Nebraska (figure 9). These gravel populations also are characterized by distinctive clast-types (figure 9). Although they occur in small quantities, the mere presence or absence of these diagnostic clast-types is helpful in distinguishing gravel populations, sediment dispersal, and provenance.

Most Pliocene (Ogallala) gravels exposed in Nebraska are similar in composition to pebble counts reported in table 1 for gravels at Greenwood Canyon (col. 2), Oshkosh (col. 6), and Cambridge (col. 7). Granitic gravels in the southwestern part of the panhandle of Nebraska (Kimball area) differ from Ogallala gravels to the east, southwest (Cheyenne-Wyoming area) and northeast (Greenwood Canyon area) in that they contain anorthosite clasts, a diagnostic clast-type attributed to erosion of anorthosite bodies that have restricted geographic areas in the Laramie Range (figure 8). Early Pleistocene (Nebraskan and Kansan) granitic gravels, like Pliocene granitic gravels, are divisible into those that contain anorthosite clasts and those that do not. In general, both Pliocene and early Pleistocene gravels contain the same clast-types, but in different proportions. However, early Pleistocene granitic gravels contain clasts more than twice as large as those found in Pliocene gravel. Early Pleistocene anorthosite-bearing granitic gravels are not restricted to the panhandle of Nebraska as are similar Pliocene gravels, but can be found throughout the state (figure 8). Early Pleistocene gravels free of anorthosite clasts occur only in southwestern Nebraska, reflecting derivation of granitic and metamorphic fragments from the Laramie Range south of the anorthosite area and from the Front Range in Colorado (figure 8). Granitic gravels exposed at Paxton Cut (col. 5) are characteristic of anorthosite-free gravels in Nebraska (figure 8). Throughout most parts of Nebraska anorthosite-bearing early Pleistocene gravels rest on pre-Pleistocene rocks devoid of anorthosite clasts. This relationship can be recognized in the Broadwater area (col. 3) and in the Red Cloud area (col. 8) of table 1. It appears, therefore, that the presence or absence of anorthosite clasts and the size of the largest gravel clast can be useful tools to discriminate between unfossiliferous Pliocene and early Pleistocene gravels.

Unlike granitic gravels, proglacial outwash gravels are characterized by a preponderance of sedimentary clasts derived from local Paleozoic and Mesozoic units. In addition, these gravels contain clasts derived from afar and transported into Nebraska by continental ice sheets. Red-colored Sioux Quartzite present in outwash gravels, such as those exposed in Seward County (col. 10), is the most diagnostic of these clasts, having been derived from the Sioux Uplift in South Dakota and Minnesota (figure 8).

A dual source of early Pleistocene gravels in Nebraska was first suggested by Lugn (1935), but his "outwash and inwash" types have not been documented heretofore. It is notable, however, that early Pleistocene outwash from continental glacial ice is surprisingly rare. Most fluvial gravels exposed within the glaciated

Table 1. Average composition of Pliocene and early Pleistocene gravels (-4.0 to -4.5 phi size interval) collected from localities 1 thorugh 11 shown on figure 8. Four samples were collected at each locality. At least 500 pebbles were counted per sample, the sample means were then averaged for each locality and reported in the table.

COLUMN	1	2	3	4	5	6	7	8	9	10	11
QUARTZ	9.0	7.3	16.0	12.6	13.4	4.7	9.0	20.8	15.0	5.0	8.4
PLUTONIC CLASTS	83.1	76.6	74.1	69.0	79.2	84.0	85.0	39.5	72.4	20.4	84.2
Granitic	71.0	57.0	47.0	50.2	69.0	60.0	72.0	29.2	56.0	18.7	67.0
Graphic granite	----	0.8	0.5	0.3	0.2	----	----	----	0.6	----	----
ANORTHOSITE	1.8	----	8.0	6.1	----	----	----	----	1.8	----	1.2
Orthoclase	10.3	18.8	18.6	12.4	10.0	24.0	13.0	10.3	14.0	1.7	16.0
METAMORPHIC CLASTS	4.5	6.5	5.0	8.7	2.2	3.8	3.6	----	4.3	9.9	1.2
Gneiss	1.8	1.9	4.4	4.4	1.2	1.8	2.6	----	2.1	4.1	0.6
Schist	1.7	4.6	0.5	3.1	1.0	0.5	0.5	----	1.2	1.2	----
Amphibolite	1.0	----	0.1	1.2	----	1.4	0.5	----	1.0	----	----
Epidote	Tr.	Tr.	----	----	----	0.1	----	----	----	----	----
SIOUX QUARTZITE	----	----	----	----	----	----	----	----	----	4.6	0.6
SEDIMENTARY CLASTS	1.0	----	4.3	5.6	1.8	4.1	1.5	34.0	0.7	58.9	4.8
Chert	0.5	----	3.2	2.8	0.2	3.5	1.5	34.0	0.6	5.0	1.8
Sandstone	0.5	----	1.1	2.8	1.6	0.6	----	----	0.1	20.0	0.3
Carbonate	----	----	----	----	----	----	----	----	----	29.4	2.2
Shale	----	----	----	----	----	----	----	----	----	4.5	1.0
VOLCANIC CLASTS	1.8	3.4	0.1	0.5	----	1.1	----	----	1.2	----	0.3
UNKNOWNS	0.6	6.2	0.5	5.6	3.4	2.3	0.9	5.7	6.4	5.8	1.1

1=Ogallala anorthosite-bearing gravel, Kimball, Nebr.; 2=Ogallala granitic gravel, Greenwood Canyon (Stop 2); 3=Pleistocene anorthosite-bearing gravel, Broadwater, Nebr. (Stop 3); 4=Pleistocene anorthosite-bearing gravel, Lisco, Nebr. (Stop 4); 5=Pleistocene granitic gravel, Paxton, Nebr. (Stop 7); 6=Ogallala granitic gravel, Oshkosh, Nebr. (Stop 5); 7=Ogallala granitic gravel, Cambridge, Nebr. (Stop 8); 8=Ogallala granitic gravel, Red Cloud, Nebr.; 9=Pleistocene anorthosite-bearing gravel, Red Cloud, Nebr. (Stop 12); 10=Outwash gravel near Seward, Nebr.; and 11=admixed gravel (inwash - outwash gravel of Lugn, 1935).

portion of the state are composed of clasts derived from the Rocky Mountains with various proportions of glacial detritus admixed (figure 9). Such gravels could have formed marginal to continental ice sheets where eastward-flowing streams and proglacial streams coalesced; or in the glaciated area where tills left by retreating continental ice sheets were eroded by eastward-flowing streams, the till clasts would have been combined with detritus derived from the Rocky Mountains.

GEOLOGIC SECTIONS

by T. M. Stout

The numbered geologic sections that follow are those at which stops are to be made, whereas the lettered sections are supplementary and inserted in the same route order. All are shown as graphic sections on two illustrations (Figs. 10 and 11), and detailed to some extent below. This method of presentation should enable the reader to evaluate the evidence more clearly than if the sections were unrelated, but no effort has been made to present elaborate descriptions of lithology. Many of these geologic sections have been published upon before, but new descriptions and measurements are presented for nearly every one. The nomenclature adopted differs in many respects from that presently used by the Nebraska Geological Survey, and the principal departures are noted. However, no "official" commitment on the terms utilized or the ideas developed has been sought, even though it is hoped that a reasonably consistent and better correlation net will result.

Columnar Section 1
(Figs. 1, 10-1)

Stop 1: This first stop is to examine the principal volcanic ash bed in the Kimball, north of Dalton, Nebraska. Measured by Stout and H. M. DeGraw, November 28, 1970.

Location: About 3 miles north of Dalton along the Dalton-Bridgeport highway (Route 385), at about the center of the line separating Sections 16 and 17, T. 17 N., R. 49 W., and about 0.5 mile north of the Cheyenne-Morrill County boundary (unmarked), Morrill County, Nebraska.

	Thickness in feet
Ogallala (Group or/and Stage)[1]:	
Kimball Formation[2], Upper Member:	
4. Talus	2
3. Sand-siltstone ("grit") ledge, 0.7 feet, underlain by fine sand in talus, 5.5 feet	6
2. Volcanic ash, top is harder, base irregular, 3.5 to 3.6 feet	3.5
1. Fine sand in upper part, about 4.5 feet, underlain by a poorly-exposed sand-siltstone ("grit") ledge, about 2 feet, and talus at base, about 4.5 feet	11

(Note that the Sidney Sand and Gravel should occur near the base or top of the ledge in the middle of bed 1).

Columnar Section 2
(Figs. 1, 10-2)

Stop 2: This is one of the finest Ogallala sections to be found in western Nebraska. It has been the subject of much study, particularly by Lueninghoener (MS. of 1934, p. 26-29, pl. 3, Geologic Section 8) and by Schultz and Stout (1948, p. 555-559). Measured by Stout in 1935, with later additions, up the Greenwood Canyon, northwest of Dalton.

Location: This was Stop 9-1 of the 1965 INQUA Excursion "D" (Stout, Dreeszen, and Caldwell, 1965, p. 63) at the head of the Greenwood Canyon, which is in the center of the E. 1/2 of Section 10, T. 17 N., R. 50 W., 1.5 miles north of the boundary of Cheyenne and Morrill Counties, in Morrill County, Nebraska (no modern quadrangle map). This section begins about two miles down-canyon.

	Thickness in feet
Ogallala (Group or/and Stage)[1]:	
Kimball Formation[2], Upper Member:	
26. Talus	12
25. Sand-siltstone ("grit") ledge, 1.5 feet, underlain by gray sandstone, 4 feet, containing clay lenses and probably volcanic ash; the latter may be Lueninghoener's (MS. of 1934, pl. 3, Geologic Section 8) volcanic ash bed	5.5
24. Talus	27.5
23. Sand-siltstone ("grit") ledge, 1.5 feet, underlain by talus, 3 feet	4.5
22. Sand-siltstone ("grit") and ash ledges, usually covered, with pure volcanic ash, 0.5 foot, at base	12.5
21. Gray sandstone, 2.5 to 3.0 feet, underlain by light gray to white sandy clay and sandstone, 1.0 to 1.5 feet, with buff to red sandstone at base	4.5
Sidney Sand and Gravel Member:	
20. Granitic sand and gravel, elsewhere talus interval	14
Ash Hollow Formation[2]:	
19. Massive gray sandstone, gradational from underlying bed	5.5

	Thickness in feet
18. Reddish buff and gray sandstone, mottled in places	6
17. Lens of honeycombed sandstone with many root fibers, 0 to 4 feet, underlain by sandstone, 14 feet, containing granitic pebbles, coarser toward base; numerous nodular concretions	14
16. Yellowish gray fine sandstone, weathering gray, with red to buff lenses and numerous granitic pebbles up to 2 inches in diameter; coarser above	8
15. Talus interval at top, 11 feet, underlain by light gray, hard, honeycombed sandstone, 1.5 feet, containing red clay pebbles that weather more easily than the matrix; at base, gray sandstone ("grit") ledge more buff toward bottom, 3 feet	15.5
14. Talus	33
13. Massive sandstone ("grit") ledge at top, nodular on top surface, grading downwardly into buff sandy clay with other ledges that contain many root fibers; in places contains granitic gravel lenses	17
12. Massive sandstone ("grit") ledge, 3 to 5 feet, weathers so prominently that over-hangs and "rock shelters" are produced; at base many root fibers in a silt matrix, 3 to 5 feet	11
11. Hard sandstone ("grit") ledge, 1 foot, at top, underlain by buff silt and clay that is obscured by talus, 12.5 feet	13.5
10. Granitic sand and gravel channel-fill, 11 feet at maximum, cut into an interval with a hard sandstone ("grit") ledge, 1.5 feet, at top, underlain by talus, 7.5 feet; below that, a clay-siltstone ledge, 0.7 feet, with a talus interval, 4 feet, at the base	11
9. Prominent ledge of sandy claystone, weathers light gray, partly talus covered	6 to 8
8. Buff sandy clay, 7 feet, softer than the ledge above, with a buff clay, 0.2 to 0.4 feet, at base	7.5

	Thickness in feet
7. Prominent buff to reddish buff fine sand	4
6. Moderately hard sandy claystone ledge, 1.5 feet, at top, underlain by a talus interval, 4 feet	5.5
5. Hard sandstone ("grit") ledge, 3 feet, at top, usually buried in talus, underlain by a massive gray sandstone ("grit") ledge, 4 to 5.5 feet	8.5
4. Buff sandy clay, 4 feet, at top, underlain by partially-cemented fine sand and silty clay, with scattered granitic pebbles, becoming a ledge in places, 7 to 9 feet; contains sand and gravel lenses throughout	13
3. Buff sandy clay near top, but most of bed is obscured by talus; granitic gravels seem to be present in some places, and there are some poorly developed sandstone ("grit") ledges	44
2. Hard sandstone ("grit") ledge, 3.0 feet, at top, weathering prominently as large blocks, underlain by a talus interval, 7.0 feet, and with a basal hard sandstone ("grit") ledge, 3.0 to 4.5 feet, containing a few locally-derived nodules	13

White River (Group or/and Stage):

Brule Formation, Whitney Member:

1. Pinkish buff silty and sandy clay, becoming sandier toward top	52.5

(Note that the base of this Geologic Section is 250 yards south of the center of the north line of the N.E. 1/4 of Section 33, T. 17 N., R. 50 W., and 300 yards south of ranch house owned in 1935 by Carl Muse).

Columnar Section 3
(Figs. 1, 10-3)

Stop 3: This is the important quarry area of the University of Nebraska State museum known as the Broadwater Quarries ("Locality A"), east of Broadwater, Morrill County, Nebraska (Schultz and Stout, 1945, 1948, 1961; Stout, Dreeszen, and Caldwell, 1965, p. 63-73, figs. 9-36 to 9-43; Schultz and Martin, 1970a). A diatomaceous marl and peat bed situated between two sheets of sand and gravel yields most of the fossils. Collectively, these sediments

constitute the Broadwater Formation, and the marl and peat bed is the Lisco Member (correlated as "Afton"); see Schultz and Stout (1945, 1948). The relations between this Geologic Section and the preceding ones allow the definition of the Pliocene-Pleistocene boundary.

Location: This is Stop 9-2 of the 1965 INQUA Excursion "D" (Stout, Dreeszen, and Caldwell, 1965, p. 63-68, figs. 9-36 to 9-39). The quarries are situated about 5 miles east and 0.7 mile north of Broadwater, in the N.E. 1/4 of Section 20, and the W. 1/2 of the N.W. 1/4 of Section 21, T. 19 N., R. 47 W., Morrill County, Nebraska (Browns Creek Quadrangle).

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Broadwater Formation[4]:	
Upper Gravel Member[5]:	
4. Talus	20
3. Granitic sand and gravel; the skeleton of *Stegomastodon mirificus* (Leidy) on display in the University of Nebraska State Museum came from a "pocket" of sand and gravel there cut into the underlying marl and peat bed	15
Lisco Member[6]:	
2. Diatomaceous marl and peat (most of the fossils are from this bed)	9
Lower Gravel Member[7]:	
1. Granitic sand and gravel	45 to 48

Columnar Section A
(Figs. 1, 10-A)

This is the site near Lisco, Nebraska, where the first important specimen of a giant camel was found in this region (Schultz and Stout, 1945, p. 234-236, fig. 2, pl. 1, fig. 1), in loess within the Lisco Member. At this locality, the loess attains excellent development, and there are traces of a thin caliche that seems to have been eroded extensively before mantling of the loess. The Lower and Upper Gravels of the Broadwater sandwich the Lisco Member, as everywhere. This is the Lisco Locality "A" of the University of Nebraska State museum.

Location: Center of the W. 1/2 of the S.W. 1/4 of the N.E. 1/4 of Section 14, T. 18 N., R. 46 W., northeast of Lisco, Garden County, Nebraska (see map, Schultz and Stout, 1948, fig. 1, reproduced in Stout, Dreeszen, and Caldwell, 1965, p. 65, fig. 9-38).

Remarks: The section here is essentially like the one at the preceding site, except that the remants of a caliche locally replace the marl and peat. This bed was eroded before deposition of about 20 feet of the Lisco loess. Bed 2 is caliche, and bed 3 is the loess.

Columnar Section 4
(Figs. 1, 10-4)

Stop 4: Still farther east, the giant camels were found in great abundance in colluvial and alluvial silts, unconformably replacing the thick diatomaceous marl and peat bed. This is the Lisco Locality "C" of the University of Nebraska State Museum, and a brief stop is planned to observe these relations (it is much more difficult to visit the preceding section containing the Lisco loess).

Location: N. 1/2 of the N.W. 1/4 of the S.W. 1/4 of Section 21, T. 18 N., R. 45 W., east-northeast of Lisco, Garden County, Nebraska (see map referred to above).

Remarks: It seems unnecessary to give a formal section here. The Lower and Upper Gravels are beds 1 and 4, respectively. The thick diatomite (about 11 feet) of the Lisco Member is replaced at the quarry sites by colluvial and alluvial silt and sand (at least 20 feet thick). For discussion, see the literature cited above for the preceding section.

Columnar Section 5
(Figs. 1, 10-5)

Stop 5: These are the Oshkosh Quarries, worked for many years by field parties from the University of Nebraska State Museum. The fossil mammals are coming from a sand and gravel correlated with the Sidney Member of the Kimball Formation, and thus are of the same age as the mammals from the main productive horizon (Ft-40) at the Cambridge Quarries (Geologic Section 8). For discussion, see Schultz and Stout (1948; 1961) and Stout, Dreeszen, and Caldwell (1965).

Location: The Oshkosh Quarries constitute Stop 9-3 of the 1965 INQUA Excursion "D" (Stout, Dreeszen, and Caldwell, 1965, p. 68). They are situated about 6.5 miles south-southwest of Oshkosh, in the S.E. 1/4 of the N.E. 1/4 of Section 29, T. 16 N., R. 44 W. Garden County, Nebraska (Chappell Quadrangle).

	Thickness in feet
Ogallala (Group or/and Stage)[1]:	
Kimball Formation[2], Upper Member:	
15. Talus; capping caliche was found years ago on the tableland southwest of the Oshkosh Quarries without an appreciable loess mantle, but it is believed that a Broadwater valley-fill cuts across northwest-southeast not far above the quarries	15

	Thickness in feet
14. Uppermost exposed ledge; consists of very white clay and silt that appears to be ashy	7.5
13. Talus	12
12. Massive sand-siltstone ("grit") ledge, about 3 feet, at top, underlain by pinkish buff silt with occasional granitic pebbles; it is possible that this bed is also part of the Sidney Member	11
Sidney Sand and Gravel Member:	
11. Granitic sand and gravel, apparently representing the top over-riding portion of the Sidney Channel here, which is interpreted as cutting at least 50 feet to the quarry-level, and perhaps as much as 83 feet at the new workings south of the present quarry-sites. The Sidney thus may have a total thickness of 88 feet	5
Ash Hollow Formation[2]:	
10. Prominent sand-siltstone ("grit") ledges, with softer silt and clay interbeds	11.5
9. Talus; the quarries occur at this position in the Sidney channel.	47
8. Prominent sand-siltstone ("grit") ledge complex underlying the quarries, with soft silt and clay interbeds; this bed levels in toward the north as one of the lower main ledges of the Ogallala	11.5
7. Covered interval, estimated at about 8 feet; base of upper part of section	8
(Lower part of this section was measured in 1935 at at a butte known as "Sugar Loaf," situated near the center of Section 1, T. 16 N., R. 45 W., 5 miles west of the old Oshkosh Bridge across the North Platte River, also on the south side of the river, but about 5 miles north and 2.5 miles west of the Oshkosh Quarries).	
6. Capping sand-siltstone ("grit") ledge on "Sugar Loaf Butte"	7
Arikaree (?) (Group or/and Stage), Gering Formation:	
5. Sandy silt and clay, with many rows of nodules (these are interpreted as mostly due to lime	

accumulation associated with miniature soil development, for under certain light and moisture conditions, each row is seen to be overlain by a dark band) 12

4. Hard claystone ledge, 0.5 to 1 foot, at top, underlain by the same sandy silt and clay, containing nodules, with another hard claystone ledge in the upper third, 25 feet 26

3. Hard claystone ledge, 0.5 to 1 foot, at top, underlain by sandy clay and nodules, 9 feet (the base of the lowest nodules is about 48 feet below contact with the Ogallala) 10

2. Sandy clay, somewhat darker and sandier than the underlying Brule with a few scattered nodules in the lower 10 feet 90

White River (Group or/and Stage), Brule Formation, Whitney Member:

Thickness in feet

1. Light pink silt and clayey silt. (The main mass of the Whitney is interpreted here, as at many places elsewhere, to be an ancient loess; the same explanation is proposed for beds 2 to 5 that are regarded as Gering). 50

Literature: Engelmann (1876, p. 262-263) observed in the late 1850's the nodular silts such as those referred above to the Gering. Following the old trail on the south side of the North Plätte River, he would have passed near the "Sugar Loaf Butte" and perhaps gone up some of the canyons. The literature to 1965 is to be found listed in the Guidebook "D" of the 1965 INQUA Excursion (Stout, Dreeszen, and Caldwell, 1965, p. 68), but an earlier discussion (Schultz and Stout, 1948) will provide background for understanding the problems of the Pliocene-Pleistocene boundary.

Columnar Sections B-B'-B"
(Figs. 1, 10-B-B'-B")

These three geologic sections may be taken as generally representative for the type locality of the Ash Hollow Formation, although some workers (Lueninghoener, MS. of 1934, pl. 2, Geologic Section 12, for example, who was assisted by Stout in measuring his section) have calculated somewhat greater total thickness than given here. This is because of the length of the traverse required in order to tie in the ash and "*Yucca*" beds and the mastodont site, none of which are included here, for more work remains to be done on these details. The first geological study of importance was by Engelmann (1876), reporting on observations made in the late 1850's

but not published until long after the Civil War. Even then his work was ignored, until Stout rediscovered it at about the time Lugn happened to choose this locality and name for the Ash Hollow Formation, thus duplicating Engelmann; this was partially acknowledged by Lugn in several papers. The historical background of this locality is well presented by Mattes (1969), and the plans for developing Ash Hollow are now being realized through the cooperation of many State agencies and interested individuals. The Nebraska Geological Society has approved and sponsored the placement of a suitable marker on the promontory overlooking the North Platte River at the east side of Ash Hollow. New excavations and roads are making great changes in Ash Hollow. The measurements and the description given here were made in 1935 by Stout. Therefore, the results are to be considered tentative, for some problems are still unresolved: exact positions of all known ash and "Yucca" beds; the correlation of the "Caprock Member" of northern Nebraska; the age of the basal Ogallala sediments below the "Caprock Member"; and the restudy of the fossils from this area, especially those of the basal sediments and from the Pre-Ogallala deposits.

Location: The principal geologic section presented (lettered B), was mostly measured by hand-level up the main Ash Hollow, which is along the present Highway 26 between Lewellen and Ogallala, Nebraska. This traverse begins 1 mile east and 1.5 miles south of Lewellen, and passes through parts or all of Sections 3, 10-11, 22-23, and 26-27, T. 15 N., R. 42 W., mostly in the Ash Hollow State Park but also on some private land, Garden County, Nebraska (Chappell Quadrangle). The first supplementary section (lettered B') was measured in the N.E. 1/4 of the N.W. 1/4 of Section 4, T. 15 N., R. 42 W., 1.5 miles south of Lewellen and 0.2 mile east of the site of the old bridge across the North Platte River; this is west of the entrance to Ash Hollow. The second supplementary section (lettered B'') was measured a short distance farther west, 0.25 mile west of the site of the old bridge, on the east side near the mouth of a large canyon, in the N.E. 1/4 of the N.E. 1/4 of Section 5, T. 15 N., R. 42 W., in Garden County, Nebraska (Chappell Quadrangle).

	Thickness in feet
Ogallala (Group or/and Stage)[1]:	
Kimball Formation[2], Upper Member:	
19. Talus; occasionally ashy silt is exposed above the sand and gravel (bed 18) which may correlate with the volcanic ash bed already seen in Geologic Sections 1 and 2 (it is known as far east as Cedar Point, Geologic Section E). To the southeast of Ash Hollow, on the road from Lewellen to Big Springs, the High Plains Surface is unusually well developed, but in road cuts and fields the capping caliche of the Ogallala may be exposed. These exposures show very little loess mantling, so this talus interval	

	Thickness in feet
(where bedrock is still intact) would be mostly covering the Upper Member of the Kimball. However, a Broadwater valley locally has cut out much of this interval	>15
Sidney Sand and Gravel Member:	
18. Granitic sand and gravel, presently well exposed	15
Ash Hollow Formation[2]:	
17. Sand-siltstone ("grit") ledge, 2 feet, at top, underlain by buff to pink sand and silt, about 6 feet; then an intermediate sand-siltstone ("grit") ledge, 3.5 feet, underlain by talus, 2 feet; and at the base a hard sand-siltstone ("grit") ledge, with many root fibers, 2 feet	17
16. Talus, 13.5 feet, with sand-siltstone ("grit") ledge, 1.5 feet, at base; the latter contains the root casts of the cactus (<u>Yucca</u>)	15
15. Buff to pink sandy silt and sand	6
14. Massive sand-siltstone ("grit") ledge, may be white or elsewhere pink and green, 3 to 5 feet, at top, underlain by buff to pink silt and sand, 2 to 5 feet, and at the base a sand-siltstone ("grit") double-ledge, 3 feet	11
13. Buff to pink sandy silt and sand	11
12. Sand-siltstone ("grit") ledge, white to gray, 2 feet, underlain by pink to light pink and gray sandy silt and sand, 10 to 11 feet	13
11. Sand-siltstone ("grit") ledge, 2 to 4 feet, at top, underlain by light pink sandy silt and sand, 4 feet; then an intermediate sand-siltstone ("grit") ledge, 2 feet, underlain by massive buff sandy silt and sand, 3 feet; at the base, another sand-siltstone ("grit") ledge, 2 feet	14 to 15
10. Massive buff sandy silt and sand	10
9. Sand-siltstone ("grit") ledge, hard, sometimes white, 1.5 feet, at top, underlain by buff to gray sandy silt and sand, about 1 foot; at base, a poorly-cemented sand-siltstone ("grit") ledge, 1.5 feet	7

	Thickness in feet
8. Hard gray sandy silt and sand, but does not make ledge, about 5 feet exposed; talus at base, about 10 feet	13.5
7. Massive sand-siltstone ("grit") ledge, with granitic pebbles, 3 to 6 feet, underlain by brick-red coarse sand and sandy silt, in places making a ledge, 1 foot; then below, very hard gray sandstone, only rarely making a ledge, 4 feet, underlain by a hard sand-siltstone ("grit") ledge, 1 foot; in lower third, buff sandy silt and sand, 4 feet, underlain by a sand-siltstone ("grit") ledge, 1 foot, below which there is buff sandy silt and sand, 4 feet	25
6. Tentatively considered to be a double-caliche, and to correlate with the "Cap Rock Member" of Skinner, Skinner, and Gooris (1968, p. 406, 409; *see also* Schultz, Schultz, and Martin, 1970, fig. 8, and Schultz and Stout, 1961, p. 9, fig. 3, as the "Cap Rock Bed" of F. W. Johnson) in northern Nebraska: Sand-siltstone ("grit") ledge, about 4 feet, underlain by green silt and sand, 0.5 feet, and pink sandy silt with nodules, 4.5 feet, laterally including a sand-and-gravel channel, at least 4 feet; at base, the basal sand-siltstone ("grit") ledge, 4 feet, constituting the bottom caliche ledge of this escarpment	12

(Note that bed 4 in the supplementary section, B', includes a 2-foot hard ledge at the top, underlain by white sandy silt, 5.5 feet. Farther up that canyon, a 3- to 10-foot sand-siltstone ledge inserts within the lower part of bed 4, or at its base, and this is correlated as the basal caliche above. It is in this massive ledge that the seeds of *Krynitzkia* have been found, as elsewhere in the "Cap Rock Member"; *see* chart of Frye and Leonard, 1959, p. 23, fig. 3, reproduced *in* Schultz, Schultz, and Martin, 1970, fig. 13. In supplementary section B", bed 4 attains 19 feet in thickness and forms the bold escarpment that can be followed for many miles on both sides of the North Platte Valley from Ash Hollow westward to at least Lisco, Nebraska).

Valentine Formation[2]:

5 and 4. Massive white sandy silt and sand, base

	Thickness in feet
irregular, 16 feet, overlying a pebble conglomerate, 11 to 17 feet, that consists of locally-derived pebbles (not granitic pebbles) and rests with unconformity on bed 3 below. This interval is most variable to the west of Ash Hollow, including some pink and buff sandy silts in which many fossil mammals have been found. The basal conglomerate in Ash Hollow weathers as an over-hang to form a shelter known as the Ash Hollow Cave (Champe, 1946) and long utilized by Man. The conglomerate is shown as bed 3 on supplementary section B' and as bed 2 on supplementary section B''.	25 to 35

Arikaree or White River Groups (?), undifferentiated:

3. Light buff silt and clayey silt; this may be the interval that yields Gering fossils across the North Platte River and northwest of Lewellen, Nebraska, and it surely correlates with beds 2 to 5 at Oshkosh. The concretions that occur just below the basal conglomerate of the Ogallala have not been explained. They may be secondary, and thus related to the Ogallala channeling and groundwater movements, or they may be part of the history of the loessic silt that encloses them. To the west, in supplementary sections B' and B'', several rows of the nodules are present, but not as many as at Oshkosh. Also, at Oshkosh the rows of nodules have ledge separations, but these have not been noted near Ash Hollow.	32 to 40
2. Two dark silt bands, interpreted as possible soils; the lower, which has a sharp basal contact, measures 2 feet, and is separated from the thinner upper one by light-colored silt	5
1. Light buff silt and clayey silt, darker than above; toward the base of the exposure there are some other dark and light streaks. It is supposed that this is Brule (Whitney), which can be followed along the North Platte Valley from the Wyoming border eastward to near Cedar Point, northeast of Ogallala, Nebraska (see Geologic Sections D and E).	15

Columnar Section 6
(Figs. 1, 10-6)

Stop 6: This seems to be an important Pleistocene section, partly because it allows correlation with southwestern Kansas (Stout in Stout, Dreeszen, and Caldwell, 1965, p. 68-71, figs. 9-41, 9-43)

and gives completeness to the records at Broadwater and Lisco (Geologic Sections 3, A, and 4). This is just east of the head of Ash Hollow.

Location: This was Stop 9-4 of the 1965 INQUA Excursion "D" (Stout, Dreeszen, and Caldwell, 1965, p. 68, fig. 9-42b-1). It seems to be in an ancient "hanging" valley (see the old quadrangle maps for the Chappell and Ogallala Quadrangles) known as Brule Canyon, but the modern drainage is shown as Dankworth Canyon. It is situated about 6.5 miles south and 4 miles east of Lewellen, and 0.4 mile east of the road junction (to Big Springs) on Highway 26 (Lewellen-Ogallala) after leaving the head of Ash Hollow, in the center of Section 30, T. 15 N., R. 41 W., Garden County, Nebraska (Chappell Quadrangle).

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Loess-and-Other Mantling Sediments on Broadwater Formation[4]; these thus embrace equivalents of the Sheridan, Todd, Kersey, Kuner, and Floodplain valley-fills of Stout's nomenclature:	
Post-Bignell Soil Complex and Bignell Loess (post-Todd equivalents):	
7. Capping soil complex, 2.5 feet, which formerly was better exposed than now, allowed separation of three modern soils, overlying Bignell gray loess, 8 feet, with a distinct soil, 0.5 feet in the middle of the Bignell	10
Brady Soil and Peoria Loess (Todd Valley-fill equivalent):	
6. Brady Soil ("X")[8], about 2 feet, underlain by Peoria Loess of usual buff type, 122 feet, with the minor soils near the base of the loess (in the "*Citellus* Zone")[11] not readily distinguishable in a dark silt, 2.5 feet	125±
Equivalents of the Sheridan Valley-fill (Sheridan Formation)[9]:	
Sangamon Soils and Loveland Loess:	
5. Soil Complex ("S" and "T"[10], here not differentiated) consisting of dark soil, 2 feet, and the "B" and "C" horizons by the underlying 3.5 feet, developed on Loveland Loess, 12 feet. In the Loveland, when light and moisture conditions are best, one can distinguish the soil couplet of the mid-Loveland ("O" and "P")	17.5

	Thickness in feet
Sappa Member[11] (formerly "Upland"), upper part:	
4. Soil (?"N"), 1.5 to 2 feet, resting on white silt, 1 to 3 feet; the base of the white silt is an unconformity	3 to 5
Sappa Member[11] (formerly "Upland"), lower part:	
3. Caliche, developed with concretions on grayish buff fine sand and silt, and buff silt, occurs on the unconformity at the base of this bed	17
Broadwater Formation[4]:	
"True" Yarmouth Caliche (Soil "K" of Stout's classification):	
2. Caliche developed with large concretions on silt and sand, 8.5 feet; at the top is orange and reddish brown silt, with brown to brownish buff silt and sand below. The caliche concretions are from 2 to 6 inches in diameter and about 1 foot long; some may be root casts of the cactus (*Yucca*)	8.5
Upper Gravel Member[5]:	
1. Granitic sand and gravel (resting on Ash Hollow Formation)	30

Literature: Stout (1955, 1956) and papers cited above above and in the Selected References.

Columnar Section C
(Figs. 1, 10-C)

This is a supplementary section to Geologic Section 6, and somewhat more complete. This area is very difficult to reach, requiring much walking. It is in the next "hanging" valley east of the Brule Canyon, named on the maps the "Chase Canyon" (*see* old maps of the Chappell and Ogallala Quadrangles).

Location: N.W. 1/4 of Section 1 and N.E. 1/4 of Section 2, T. 13 N., R. 40 W.; and S.E. 1/4 of Section 35, and S.W. 1/4 of Section 36, T. 14 N., R. 40 W., about 2.5 to 3.5 miles north and 0.5 to 1.5 miles east of Brule, Keith County, Nebraska (old Ogallala Quadrangle).

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Loess-and-Other Mantling Sediments on Broadwater Formation[4]; these thus include equivalents of the	

	Thickness in feet
Sheridan, Todd, Kersey, Kuner, and Floodplain valley-fills of Stout's nomenclature:	
Post-Bignell Soil Complex and Bignell Loess (post-Todd equivalents):	
9. Capping Soil Complex not clearly distinguishable, overlying Bignell gray loess	1 to 3
Brady Soil and Peoria Loess (Todd Valley-fill equivalent):	
8. Brady Soil ("X")[8], about 0.5 feet, underlain by Peoria Loess of usual buff type, 98 feet, with distinct minor soil (?"V"), 0.5 feet, 5 feet above the base of the Peoria (this 5.5-foot interval would correspond to the upper part of the "*Citellus* Zone")[12]	100±
Equivalents of the Sheridan Valley-fill (Sheridan Formation)[9]:	
Sangamon Soils and Loveland Loess:	
7. Soil Complex ("S" and "T"[10], here not differentiated) overlying and developed on Loveland Loess. In the Loveland, one can distinguish the soil-couplet ("O" and "P"), about 2 to 3 feet above the base	9
Sappa Member[11] (formerly "Upland"), upper part:	
6. Soil ("N"), 2.5 to 3 feet, developed with nodules on buff loessic silt that becomes buff laminated and soft silt, or even white silt and fine sand, in the lower half; an unconformity with relief up to 10 feet marks the base of this bed	8 to 16
Sappa Member[11] (formerly "Upland"), lower part:	
5. Caliche, developed with concretions on buff to brown silt; sand and pebbles on unconformity at base	1.5 to 7.5
Broadwater Formation[4]:	
"True" Yarmouth Caliche (Soil "K" of Stout's classification):	
4. Caliche developed with concretions on buff silt or blocky sand	4.5 to 5

Upper Gravel Member[5]:	Thickness in feet
3. Granitic sand and gravel, limonitic and carbonaceous at top	43
Lisco Member[6]:	
2. Sand and silty sand, 12 to 14 feet, or elsewhere pinkish buff loess, resting unconformably on the calichified lower part of the Lisco; the latter consists of pinkish to grayish buff silt, with numerous white limy concretions, totaling 4 feet in thickness. This caliche at the top of the lower portion of the Lisco is taken as Soil "J" and correlated as the "Afton"	12 to 14
Lower Gravel Member[7]:	
1. Granitic sand and gravel, only partly exposed	11

Columnar Section D
(Figs. 1, 10-D)

Section in the vicinity of Cedar Point, about 5 miles north and 4 miles east of Ogallala, Nebraska. Measured by Stout in 1935, accompanied by B. L. Gainsforth.

<u>Location</u>: S.E. 1/4 of Section 2, T. 14 N., R. 38 W., Keith County (Ogallala Quadrangle).

Ogallala (Group or/and Stage)[1]:	Thickness in feet
Kimball Formation[2], Upper Member:	
14. Talus, presumably covering bed rock	12
13. Sand-siltstone ("grit") ledge, 2 feet, underlain by softer sand-siltstone, 3 feet; elevation of top surface of ledge estimated at about 3290 feet	5
12. Sand-siltstone ("grit") ledge, underlain by softer sand-siltstone, 1 foot, and with a basal hard sand-siltstone ("grit") ledge, 3 feet	5
11. Soft pink sand-siltstone, usually as talus	4.5
10. Prominent "<u>Yucca</u>" bed; sand-siltstone ("grit") ledge characterized by very large root casts. These root casts were assembled in the masonry of the entrance gate of the Gainsforth Ranch many years ago by B. L. Gainsforth. The elevation of the base of this bed is determined as about 3268 feet	7

(Note that the Sidney Sand and Gravel would normally occur at about this position, but it has not been recognized in the Ogallala area).

Ash Hollow Formation[2]:	Thickness in feet
9. Soft pink sand-siltstone, mostly covered	28
8. Sand-siltstone ("grit") ledge, 2 feet, underlain by softer pink sand-siltstone containing many root casts, 5 feet	7
7. Sand-siltstone ("grit") ledge, 1 foot, underlain by softer pink sand-siltstone, 8 feet	9
6. Hard sand-siltstone ("grit") ledge; elevation of the base of this bed is estimated as about 3219 feet	5
5. Soft pink to red sand-siltstone as lenses in gray and buff sand-siltstone	10
4. Sand-siltstone ("grit") ledge, 1 foot, underlain by covered interval, 15 feet	16
3. Hard, irregular and discontinuous, sand-siltstone ("grit") ledges, intercalated with softer pink sand-siltstone	11
Pre-Ogallala (?), Arikaree or White River Groups (?):	
2. Pink to buff sandy and silty clay with numerous "potato-like" concretions in upper half, particularly near the top	53
1. Talus	22

(From temporary surveyor's stakes in position at the time of measurement and description of this section, the base of bed 1 is taken as 3112 feet; the estimates of higher elevations are by hand-level from this datum. A change in lithology was said to have been noted in local drilling at a depth of about 25 feet; this may or may not be the top of the Whitney Member of the Brule Formation).

Literature: Lueninghoener (MS. of 1934, p. 36 and pl. 7, Geologic Section 13, with somewhat more detailed description and analysis of this section). Lugn *in* Wenzel and Waite (1941, p. 31, with a different description; see also their geologic map, pl. 1). This may be about the location of the graphic section prepared by E. C. Reed *in* Frye and Leonard (1959, fig. 1, Geologic Section 23).

Remarks: Fossil seeds characteristic of the Ogallala were reported in bed 2 by Lugn in Wenzel and Waite, (1941, p. 31), but after subsequent investigation by Stout and Gainsforth, the conclusion was reached that these seeds were not in place. They were probably derived from above.

This geologic section is margined a mile or so to the west by a prominent Broadwater Valley-fill. Its value here is that the High Plains Surface can be so clearly related to the pre-Broadwater incision, and the correlation with the Geologic Sections 1 and 2 is made positive by the presence of the prominent "*Yucca*" bed (bed 10 above) overlying the volcanic ash bed in the supplementary section that follows.

Columnar Section E
(Figs. 1, 10-E)

Supplementary section to Geologic Section D, measured by Stout in 1935, accompanied by B. L. Gainsforth, in a small tributary canyon situated a short distance southwest.

Location: Northeast corner of the N.W. 1/4 of Section 11, T. 14 N., R. 38 W., southwest of Cedar Point, Keith County, Nebraska (also Ogallala Quadrangle).

	Thickness in feet
Ogallala (Group or/and Stage)[1]:	
Kimball Formation[2]:	
12. Talus	14
11. Sand-siltstone ("grit") ledge, thickness from 2 to 7 feet	7
10. Softer buff to gray sand-siltstone	9
9. Prominent "*Yucca*" bed, same as bed 10 of preceding section; the very large root casts of the cactus are perhaps best seen here	5.5
8. Volcanic ash lens, 0-2 feet, at top, underlain by buff to gray sand-siltstone, 5 feet	5
(Note again that the Sidney Sand and Gravel would normally occur at about this position, but it is not known in the immediate area).	
Ash Hollow Formation[2]:	
7. Hard sand-siltstone ("grit") ledge at top, 1 foot, underlain by softer pink to buff sand-siltstone, 12 feet	13
6. Hard sand-siltstone ("grit") ledge, 5 feet, in	

	Thickness in feet
upper part, with white silt at base of ledge, underlain next by softer pink sand-siltstone, 1.5 feet, with another sand-siltstone ("grit") ledge, 8 feet, at base of bed	14.5
5. Softer buff to pink sand-siltstone, with brick-red sand and silt lenses and many hard ledges	16
4. Sand-siltstone ("grit") ledge, 4 feet, underlain by gray sandstone, 5 feet	9
3. Sand-siltstone ("grit") ledge, 1.5 feet, at top, underlain by pink and gray sand-siltstone, 8.5 feet	10
2. Sand-siltstone ("grit") ledge, 1.5 feet, at top, underlain directly by softer brick-red sand-siltstone, 1.5 feet, with grayish green sandstone, 6 feet, next below, and a sand-siltstone ("grit") ledge, 1.5 feet, at the base. The elevation of the basal contact is estimated as 3185 feet	10.5
Pre-Ogallala (?), Arikaree or White River Groups (?):	
1. Massive buff to pink sandy and clayey silt, with many small nodular concretions at the top	59

(Note that the base of the section was taken at a temporary surveyor's stake with an elevation of 3126 feet; the higher elevations were computed by hand-level measurements from this datum).

Literature: Lugn (*in* Wenzel and Waite, 1941, p. 31, Cedar Point Section) refers to volcanic ash below the "*Yucca*" bed, not known elsewhere in this area.

Remarks: Geologic Sections D and E, taken together, define the High Plains Surface with respect to the Broadwater Valley-fill to be seen at the Paxton Cut.

Columnar Section 7
(Figs. 1, 10-7)

Stop 7: Section at the west side of the Paxton Cut, a diversion canal excavated through the divide ridge separating the North Platte and South Platte Rivers in order to take the excess impounded water from Lake McConaughy to the siphon at Paxton. This siphon carries the water under the nearly dry bed of the South Platte River to other canals and reservoirs down-valley. Because the basal gravels floor the Paxton Cut, extending below water level in the canal, it proved necessary to cement the bottom of the canal. Measured by Stout in June, 1955.

Location: The Paxton Cut is just north of Paxton, Nebraska, and 14 miles east and 4 miles south of the preceding sections. Center of the S.E. 1/4 of Section 32, T. 14 N., R. 35 W., Keith County, Nebraska (Paxton Quadrangle).

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Broadwater Formation[4]:	
Upper Gravel Member[5]:	
7. Talus	15
6. Granitic sand and gravel	5
5. Lens of gray sand and sandy silt, 3-5 feet	5
4. Granitic sand and gravel	15
Lisco Member[6]:	
3. Blocky gray sand and silt, with limonite stain at top, containing numerous root casts of the cactus (*Yucca*), 2 to 3 feet	3
2. Grayish buff fine sand and silt, 3 to 4 feet	3
Lower Gravel Member[7]:	
1. Granitic sand and gravel	102

Literature: Schultz and Stout (1941, p. 9-11). Stout *in* Stout, Dreeszen, and Caldwell (1965, p. 68-73, figs. 9-42a-b, 9-43).

Remarks: The close similarity of this section to Geologic Sections 6 and C leaves no doubt as to the correlation locally with the Broadwater Formation. The discovery long ago of a skull of *Stegomastodon mirificus* (Leidy), during the excavation of the Paxton Cut (Schultz and Stout, 1941, p. 11), but of which only a tooth fragment is preserved in the University of Nebraska State Museum, further substantiates the stratigraphic and geomorphic evidence.

Columnar Section F
(Figs. 1, 11-F)

This is the now well-known section at Bignell Hill, in the loess-canyon area south of Bignell and the Platte River, and southeast of North Platte, Nebraska. Measured by Stout, accompanied at times by C. B. Schultz, in 1936, 1939, 1940, and 1955.

Location: Composite of the base and top of Bignell Hill Section

(Stout, Dreeszen, and Caldwell, 1965, p. 75-77, figs. 10-44A, 10-45), which constituted Stops 10-1 and 10-2 of the 1965 INQUA Excursion "D". The base of the section is about 1.2 miles south of Bignell, in the N.E. 1/4 of the N.W. 1/4 of Section 3, T. 12 N., R. 29 W., whereas the top is about 0.5 mile farther south, in the N. 1/2 of the SE 1/4 of Section 3, same township and range, Lincoln County, Nebraska (North Platte Quadrangle).

Quaternary (Group or/and Stage)[3]:	Thickness in feet
Loess Mantle on Probable Sheridan Formation[9]; it thus embraces equivalents of the Todd, Kersey, Kuner, and Floodplain valley-fills of Stout's usage:	
Post-Bignell Soil Complex and Bignell Loess (post-Todd equivalents):	
5. Capping soil complex (Schultz and Stout, 1945, fig. 3, reproduced *in* Stout, Dreeszen, and Caldwell, 1965, fig. 10-44), 1.5 to 2 feet, underlain by Bignell Loess, about 8 feet	10
Brady Soil and Peoria Loess (Todd Valley-fill equivalent):	
4. Brady Soil ("X")[8], 1.5 feet, underlain by about 168 feet of Peoria Loess; minor soils ("U", "V", "V'") near base of loess	177
Sheridan Formation[9]:	
Sangamon Soil Complex:	
3. Soil Complex ("S" and "T")[10]	3
Loveland Loess and Sand Member[13]:	
2. Light pink loessic silt (Loveland)	15
1. Soil (possibly "R"), about 1 foot, developed on pinkish buff fine sand, about 13 feet exposed	14

<u>Literature</u>: Schultz and Stout (1941, p. 9-11; 1945; 1948, p. 567-570, 573, fig. 4; 1961, p. 53). Thorp, Johnson, and Reed (1950, p. 8-9, 14, pl. 2-A). Reed and Dreeszen (1965, p. 43). Stout, Dreeszen, and Caldwell (1965, p. 75-77, fig. 10-44) Frye, Willman, and Glass, *in* Schultz and Frye (1965, p. 17-18). Schultz (1968, fig. 8-5, where the Soil "X" or Brady Soil is misidentified in the valley-fill of Terrace 2-B). Dreeszen (1970, p. 19). Schultz and Martin (1970b, p. 344-345, fig. 1, where Soil

"YY" is incorrectly identified as the Brady Soil, since the name Brady Soil was proposed originally only as a substitute name for the Soil "X").

Columnar Section G
(Figs. 1, 11-G)

This is perhaps the most important of the Loveland Loess sections in Nebraska and in the United States as well. Noted briefly following its discovery by Schultz and Stout (1945, p. 238, 240), this locality came to be known both as Buzzard's Roost and Gilman Canyon (Schultz and Tanner, 1957, p. 76-77, fig. 7; Stout, Dreeszen, and Caldwell, 1965, p. 72-73, 78-82, figs. 9-43-5, 10-47 to 10-50; Reed and Dreeszen, 1965, p. 40-41, 62-63; Schultz and Martin, 1970b, p. 343-345, fig. 2, table 1). The section given here was measured by Stout in 1955, with later additions.

Location: Composite of two sections (Stops 10-6 and 10-5 of the 1965 INQUA Excursion "D"). The volcanic ash site is situated in a branch of Gilman Canyon, in the center of the W. 1/2 of N.E. 1/4 of Section 17, T. 10 N., R. 26 W., whereas the remainder of the section is found about a mile farther west, in the W. 1/2 of the S.W. 1/4 of the S.E. 1/4 of Section 7, T. 10 N., R. 26 W., Lincoln County, Nebraska (Gothenburg Quadrangle). The upper part of the section is situated about 13 miles south and 2.5 miles east of Brady, Nebraska.

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Loess Mantle on Probable Sheridan Formation[9]; it thus embraces equivalents of the Todd, Kersey, Kuner, and Floodplain valley-fills of Stout's nomenclature:	
Post-Bignell Soil Complex and Bignell Loess (post-Todd equivalents):	
8. Capping soil complex (not clearly differentiated here), underlain by the typical gray Bignell Loess	15
Brady Soil and Peoria Loess (Todd valley-fill equivalent):	
7. Brady Soil ("X")[8], about 1.5 feet, underlain by Peoria Loess of usual buff type, about 68 feet; minor soils near the base of the loess (in the "Citellus Zone")[12] are not as clearly developed as elsewhere	70
Sheridan Formation[9]:	
Sangamon Soil Complex:	

	Thickness in feet
6. Soil Complex ("S" and "T")[10]	5
Loveland Loess and Sand Member[13]:	
5. Pinkish buff loess, comprising the interval from the top down to the top of Soil "P",[14] and including Soils "R", "Q", and "P'"	25
4. Distinctive soil-couplet (Soils "O" and "P")[15], slightly more than 4 feet, underlain by pinkish buff loess, 31 feet	35
Sappa Member[11] (formerly "Upland"), upper part:	
3. Distinctive, thick soil (Soil "N")[16], about 3 feet, overlying pinkish buff loess, about 33 to 36 feet, with a weak soil ("M"), 2 feet, in places at the base	35
2. Pearlette Ash Bed, about 6 to 12 feet, evidencing slump features such as would result from deposition in a gully, and reworked in places at its top	11
Sappa Member[11] (formerly "Upland"), lower part:	
1. Pinkish buff loess, as above, with weak soil development (Soil "L") and accompanying small nodular concretions in lower part	19±

Literature: Much as cited in the introductory paragraph and for the preceding section. *See* also Stout and de Heinzelin *in* de Heinzelin (1957, p. 118, Geologic Section 25).

Columnar Section H
(Figs. 1, 11-H)

This section, measured also by Stout in 1955 and 1957 (except for the ash thickness), nearly duplicates the preceding section. However, it is noteworthy for the unusual thickness of the volcanic ash, measured by Lugn (1935, p. 132, 201) and by Schultz and Stout (1945, p. 238, 240, pl. 1, fig. 3) at the time of active work as about 50 feet thick.

Location: Near the center of the W. 1/2 of the W. 1/2 of Section 20, T. 8 N., R. 24 W., 2.5 miles west and 1 mile south of Eustis, Frontier County, Nebraska (no quadrangle map available). Reached from excursion route *via* Curtis, Nebraska.

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Loess Mantle on Probable Sheridan Formation[8]; it embraces equivalents at least of the Todd Valley-fill of Stout's nomenclature:	
Soil Complex and Peoria Loess (Todd Valley-fill equivalent):	
7. Soil complex of indefinite age, about 1 foot, underlain by the typical Peoria loess, about 49 feet	50
Sheridan Formation[9]:	
Sangamon Soil Complex:	
6. Soil Complex ("S" and "T")[10]. These are splendidly represented here, with Soil "S" the heavier profile of the two, and separated from Soil "T" by light-colored loess.	5.5±
Loveland Loess and Sand Member[13]:	
5. Typical pink to pinkish buff loess, comprising the interval from the top of the Loveland down to the top of Soil "P"[14], and including Soils "R", "Q", and "P'"	20
4. Distinctive soil-couplet (Soils "O" and "P")[15], about 3 feet, underlain by pinkish buff loess, about 9 feet	12
Sappa Member[11] (formerly "Upland"), upper part:	
3. Distinctive soil (Soil "N")[16] about 1 foot, overlying pinkish buff loess, about 18 feet, with slumped masses of volcanic ash reworked in lower part, and at the base an important soil (Soil "M"), 1 foot	20
2. Laminated silt and ash bands, with much reworked volcanic ash (<u>see</u> Schultz and Stout, 1945, p. 240, pl. 1, fig. 3) resting on a somewhat disconformable surface of truncation of the main ash	13.5
1. Main volcanic ash bed (Pearlette Volcanic Ash Bed); when actively worked about 50 feet of pure ash was exposed (Schultz and Stout, 1945, p. 238, 240, pl. 1, fig. 3; Lugn, 1935, p. 132), and much slumping in the upper part suggests very rapid deposition in a gully (canyon)	50±

Literature: Lugn (1935, p. 132, 201). Schultz and Stout (1945, p. 238, 240, pl. 1, fig. 3). Stout and de Heinzelin *in* de Heinzelin (1957, p. 117, Geologic Section 23). Stout *in* Stout, Dreeszen, and Caldwell (1965, p. 79-82).

Columnar Section 8
(Figs. 1, 11-8)

Stop 8: This significant Late Pliocene locality, with its magnificient fossil mammals (especially *Dipoides stirtoni* Wilson, *Amebelodon fricki* Barbour, and *Barbourofelis fricki* Schultz, Schultz, and Martin), when compared with the Broadwater localities and their fossils, allows not only the definition of the Pliocene-Quaternary boundary in North America but correlation as well with the rich records in Asia and Europe (Schultz and Stout, 1948, with discussions). There are Late Pliocene (Sidney and Upper Members of the Kimball) as well as Medial Pliocene (Ash Hollow) quarries here northwest of Cambridge, Nebraska, that have been actively worked by field parties from the University of Nebraska State Museum since 1927. Measurements given here were taken by Stout over many years, usually with C. B. Schultz and L. G. Tanner.

Location: This is Stop 11-1 of the 1965 INQUA Excursion "D" (Stout, Dreeszen, and Caldwell, 1965, p. 83-84, fig. 11-51). The higher quarry (Ft-40) is situated about 7.5 miles north and 5 miles west of Cambridge, northwest of the Medicine Creek Dam, in the E. 1/2 of the E. 1/2 of the S.W. 1/4 of the S.E. 1/4 of Section 15, T. 5 N., R. 26 W., Frontier County, Nebraska (Freedom Quadrangle). The older quarry is across the canyon to the west (Ft-43), in the W. 1/2 of the E. 1/2 of the S.E. 1/4 of the S.W. 1/4 of Section 15.

	Thickness in feet
Ogallala (Group or/and Stage)[1]:	
Kimball Formation[2], Upper Member:	
4. Talus	>25
3. Sandstone and siltstone ("grit") ledges, with only rare fossil mammals; a few clams have been found in the lower part	25±
Sidney Sand and Gravel Member:	
2. Granitic fine sand and gravel, containing many vertebrate fossils, especially in fine sand and silt lenses; some clay seams	25±
Ash Hollow Formation[2]; much of the formation was formerly exposed here:	
1. Granitic sand and gravel channel-fill at adjacent Ft-43 site	15 to 25

Literature: Schultz and Stout (1945; 1948; 1961). Stout, Dreeszen, and Caldwell (1965, p. 83-84, fig. 11-51). Tanner (1967). Schultz, Schultz, and Martin (1970). Also much earlier literature; see Selected References.

Columnar Section I
(Figs. 1, 11-I)

Supplementary section to Geologic Section 8; at the west end of the Medicine Creek Dam, southeast of the quarry sites mentioned above, and northwest of Cambridge, Nebraska.

Location: Center of Section 26, T. 5 N., R. 26 W., Frontier County, Nebraska (Cambridge Quadrangle, but consult also adjacent Medicine Creek Dam Quadrangle). To reach these high Ogallala beds, now greatly slumped (Schultz and Stout, 1961, p. 34, 53, fig. 29 for Stop 38 of 1961 Conference Trip), leave the route of the excursion at the west end of the Medicine Creek Dam, taking trail east, then southwest and west, to abandoned quarry site.

(Note that Quaternary Peoria Loess, Sangamon Soils, and Loveland Loess, once mantled these high Ogallala sediments, but presently this mantle is mostly in talus; compare with Schultz and Stout, 1961, fig. 29 on p. 34).

Ogallala (Group or/and Stage)[1]:

Kimball Formation[2], Upper Member:

6. Talus	35±
5. Sand-siltstone ("grit") ledge, about 1 foot, underlain by light greenish gray silt and sand, about 11 feet	12
4. Sand-siltstone ("grit") ledges at top, about 7 feet, underlain by light greenish gray silt and sand, about 11 feet	18

Sidney Sand and Gravel Member:

3. Light pink cross-bedded fine sand and silt	15
2. Talus	10±

Ash Hollow Formation (?)[2]; much of the formation is exposed just below the dam, to the east of this section:

1. Large green sandstone concretions, about 3 feet, at top, underlain by 5 feet of fine sand and concretionary masses	8

Columnar Section 9
(Figs. 1, 11-9)

Stop 9: This is an easily accessible volcanic ash site. Measured by Stout and H. M. DeGraw, November 29, 1970.

Location: Along Highway 46, 2 miles south of the junction in Oxford of Routes 46 and 136, on the slope leading up from the south bank of the Republican River, just north of the prominent microwave tower, in the center of the S. 1/2 of Section 13, T. 3 N., R. 21 W., Furnas County, Nebraska (Hollinger Quadrangle).

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Sheridan Formation[9]:	
Sappa Member[11] (formerly "Upland"), upper part:	
3. Talus	4
2. White silty marl, 2 feet, underlain by a hard ledge, slightly less than 1 foot thick, of which the basal 2 inches is volcanic ash (Pearlette Ash Bed)	3
Sappa Member[11] (formerly "Upland"), lower part:	
1. White marl and silt, partly in talus	4

Columnar Section 10
(Figs. 1, 11-10)

Stop 10: This is the well known type locality of the Sappa (formerly "Upland"), at the former workings of the volcanic ash mines (Barbour, 1916; Lugn, 1935, p. 125, 133-134; Reed, 1948b; Frye, Leonard, and Swineford, 1948, p. 503-505, pl. 2-C, table 1, sample 9; Dreeszen and Souders in Stout, Dreeszen, and Caldwell, 1965, p. 89-94, fig. 11-5; table 11-4) near Orleans, Nebraska. The present section was measured by Stout, 1971.

Location: This is Stop 11-3 of the 1965 INQUA Excursion "D", situated about 3.5 miles west and 2 miles north of Orleans, in the N.W. 1/4 of the S.W. 1/4 of the S.E. 1/4 of the N.E. 1/4 of Section 11, T. 2 N., R. 20 W. (Sappa Township), Harlan County, Nebraska (Stamford Quadrangle).

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Loess Mantle on Probable Sheridan Formation[9]; it thus embraces equivalents at least of the Todd Valley-fill of Stout's nomenclature:	

	Thickness in feet
Soil Complex and Peoria Loess (Todd Valley-fill equivalent):	
8. Soil complex of indefinite age, about 1 foot, underlain by the usual Peoria Loess, about 20 feet	21
Sheridan Formation[9]:	
Sangamon Soil Complex:	
7. Soil Complex ("S" and "T"[10], not differentiated here), about 2.5 to 3 feet	3
Loveland Loess and Sand Member[13]:	
6. Typical brownish buff Loveland Loess, with sand at base (the latter correlated with the Crete by Dreeszen and Souders *in* Stout, Dreeszen, and Caldwell, 1965, p. 90-92, fig. 11-55, which is certainly a possible correlation)	10±
Sappa Member[11] (formerly "Upland") upper part (this is the Sappa type locality, but note the discussions of Dreeszen and Souders *in* Stout, Dreeszen, and Caldwell, 1965, p. 90-94, fig. 11-55, and of Reed and Dreeszen, 1965, concerning a possible correlation of beds 5 and 4 with the Grafton):	
5. Green silt and sand, a little darker than below, 2 to 2.7 feet	2.7
4. Massive light greenish gray sand and silt, becoming more silty toward the top and with some pink sand toward the base; the much weathered 4 to 6-inch uppermost part of this bed is provisionally correlated with Soil "N"[16]	18±
3. Pearlette Ash Bed, truncated at top, and with several silt partings just above the middle; of variable thickness, about 6.3 to 7 feet. There may be some slight relief at the base of the ash bed here	7
Sappa Member[11] (formerly "Upland"), lower part:	
2. Light greenish gray sandy silt with a slight suggestion of soil development in places at the top (possibly Soil "L"?); the silt becomes very sandy toward the base	1.5
Grand Island Sand and Gravel Member[17]:	
1. Fine sand and gravel, formerly better exposed	>5

Literature: See Stout, Dreeszen, and Caldwell, 1965, p. 89, for literature to 1965. Other references are noted in the opening paragraph for this geologic section, and many other references listed at the back of this guide discuss the problems of regional correlation.

Columnar Section 11
(Figs. 1, 11-11)

Stop 11: The route of the excursion passes by an interesting volcanic ash site that overlies a soil here correlated with the prominent one at the type "Upland" exposures (Geologic Section K). This site was studied by Morgan (MS. of 1962, Geologic Section H-7), but the geologic section given here was prepared by Stout in 1963.

Location: Center of the N.E. 1/4 of Section 35, T. 2 N., R. 17 W.; the reference point is 0.9 mile east of the east edge and 1.1 mile east of the water tower in the present (rebuilt) Republican City, 1.2 mile west of the Harlan-Franklin County boundary; on the west but also east side of the west fork of what Morgan calls "Eureka Creek". Go on foot about one-fourth mile south of Highway 136 from the flagged position at a culvert; situated in Harlan County, Nebraska (old Holdrege Quadrangle).

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Sheridan Formation[9]:	
Loveland Loess and Sand Member (?)[13]:	
6. Light buff loessic silt	2
Crete Sand and Gravel Member[18]:	
5. Granitic sand and gravel, only about 1 foot well exposed on west side	1
Sappa Member[11] (formerly "Upland"), upper part:	
4. Prominent dark soil (correlated as Soil "N")[16], 2.5 feet, exposed only on east side, underlain by dark pinkish buff silt, 8.5 feet, that on the west side displays much lime concentration and a few rodent burrows in the upper half, with laminated and nodular ashy silts at the base	11
3. Pearlette Ash Bed, very thin, only 0.5 to 3 inches	0.3
Sappa Member[11] (formerly "Upland"), lower part:	
2. Prominent dark soil at top (correlated with the "Upland" Soil or Soil "L" at the type	

	Thickness in feet
"Upland" exposures, Geologic Section K), 1.5 feet, exposed only on the west side of the gully, resting on grayish buff silt, about 10 feet	11
Grand Island Sand and Gravel Member[17]:	
1. Granitic sand and gravel, about 5 feet well exposed	5

Literature: See Morgan (MS. of 1962, Geologic Section H-7).

Columnar Section J
(Figs. 1, 11-J)

Another spot along the route of the excursion is likewise given attention, even though no stop is planned. Here, a soil that has not yet been correlated yielded a skull fragment (to be brought along on the trip). A loop of wire, flagged on the south side of Highway 136, only 3.1 miles east of the preceding section (Geologic Section 11) allows identification of the exposure; the fossil was found on the north side of the road, at the west end. The section is by Stout, 1971.

Location: About 5.1 miles east of the east margin of the present (relocated) Republican City, and about 5.3 miles east of the water tower there, just west of the southeast corner of Section 28, T. 2 N., R. 16 W., Franklin County, Nebraska (old Holdrege Quadrangle). This site is 4.5 miles west of the west margin of Bloomington, Nebraska.

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Sheridan Formation[9]:	
Sappa Member[11] or Loveland Loess and Sand Member[13]:	
4. Talus	5
3. Pinkish buff nodular loess	5.5
2. Dark soil, weathers light gray, about 3 feet exposed; not yet correlated	3
1. Talus	2

Columnar Section K
(Figs. 1, 11-K)

Although not visited as frequently now as in earlier years of Pleistocene study in Nebraska, these type "Upland" (later renamed as Sappa) exposures (see Lugn, 1935, p. 119-121, fig. 17; Reed,

1948b) are still of great importance in understanding the regional correlations and in deciding upon a proper nomenclature, as well as in developing a classification. Measured by Stout, in 1955, 1957, and 1971.

Location: The exposures are situated along Highway 10, 14.6 miles north of the junction of Highways 10 and 136, and about 1.5 miles north of the junction of Highways 4 and 10. These exposures are just east of the highway in the south bank of the West Branch of Thompson Creek and in a small gully just below the highway. This is near the center of the west line of Section 18, T. 4 N., R. 14 W., 2.7 miles west and 0.5 mile south of the village of Upland, Franklin County, Nebraska (old Red Cloud Quadrangle).

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Sheridan Formation[9]:	
Loveland Loess and Sand Member[13]:	
5. Beneath a capping soil complex of indefinite age, 0.5 to 1 foot, is an interval of several brown fine sand beds, each with some loess and a soil above it (Soils "O" and "P",[15] together with the younger Soils "Q" and "R", are believed to be identifiable – see Stout and de Heinzelin in de Heinzelin, 1957, p. 114, Section 19), about 17 feet	18
Sappa Member[11] (formerly "Upland"), upper part:	
4. Soil at top (correlated as Soil "N"[16], see Stout and de Heinzelin in de Heinzelin, 1957, p. 114, Section 19), about 1 foot, is underlain by dark brown fine sand, 5.5 feet	6.5
3. Soil at top (correlated as Soil "M"), about 3 inches, with a rodent burrow once found to cut down from its upper surface, is underlain by sand and silt, 1 inch to more than 2 feet thick, developed upon the soil below (bed 2)as a lens	2
Sappa Member[11] (formerly "Upland"), lower part (this bed 2 constituted Lugn's type "Upland", whereas beds 3 and 4 were placed in the Loveland by him):	
2. Soil at top, heavy and thick (considered to be Soil "L" of Stout's nomenclature, for which the name "Upland" Soil may have to be utilized if the term "Sappa Soil" proves to be ambiguous), 2 to 3 feet thick and well described by Lugn (1935, p. 120, also by de Heinzelin (1957,	

	Thickness in feet
p. 114, Section 19); underlain in some places by several feet of greenish gray silt and sand	5 to 7
Grand Island Sand and Gravel Member[17]:	
1. Granitic sand and gravel, about 2 to 3 feet exposed	3

Literature: Lugn (1935, p. 119-121, fig. 17). Reed (1948b). Stout and de Heinzelin *in* de Heinzelin (1957, p. 114, Section 19, from a visit here August 13, 1957). *See* also the Selected References at the back of this guide.

Columnar Section L
(Figs. 1, 11-L)

This is the last of the supplementary sections to be introduced formally for consideration during the excursion. The measurements are by Stout, 1971. It is very near a site mentioned as of importance by Schultz and Stout (1945, p. 238) because the volcanic ash bed occurs between two sheets of sand and gravel which up to that time had been collectively assigned to the "Grand Island" by Lugn. Later, some workers came to regard the basal gravels at this locality as correlating with the Red Cloud, named (*see* Geologic Section 12, following) from only a few miles distant. However, the relations that can be observed at a stop on the 1965 INQUA Excursion "D" (Stop 12-1 of that excursion, situated about 3 miles north of Inavale), show that the gravels are definitely younger than Red Cloud. (*See* discussion *in* Stout, Dreeszen, and Caldwell, 1965, p. 96-97).

Location: This site is northwest of Inavale, Nebraska, about 3.2 miles west of the east boundary of Inavale and 2.2 miles north. The point of turn-off from Highway 136 is a county road 1 mile east of the Webster-Franklin County line, and about 12.6 miles east of the east boundary of Franklin, Nebraska. It is situated 0.2 miles north of the southeast corner of Section 19, T. 2 N., R. 12 W., Webster County, Nebraska (Red Cloud Quadrangle).

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Sheridan Formation[9]:	
Crete Sand and Gravel Member[18]:	
3. Granitic sand and gravel	3±
Sappa Member[11] (formerly "Upland"), upper part:	

Thickness in feet

2. Pearlette Ash Bed, consisting of somewhat silty volcanic ash — 1.6

Grand Island Sand and Gravel Member[17]:

1. Granitic sand and gravel — 5±

Columnar Section 12
(Figs. 1, 11-12)

Stop 12: This is a site just west of the type locality of the Red Cloud (Schultz, Reed, and Lugn, 1951), but recently a "substitute type locality", which must be considered simply as a reference section that amplifies the original description, has been proposed for a subsurface record (Reed and Dreeszen, 1965, p. 29, 31-32, 53-54, fig. 9). However, this new information may aid greatly in tying in the Red Cloud with sediments farther east, approaching the till border. The present section is within sight of the original exposure upon which the Red Cloud (Stop 12-2 of the 1965 INQUA Excursion "D"; Stout, Dreeszen, and Caldwell, 1965, p. 96-97) was defined, and the Pearlette Volcanic Ash Bed occurs in demonstrable relation above it. Measured by Stout, 1970 and 1971, accompanied by C. B. Schultz, H. M. DeGraw, and others.

Location: N.E. 1/4 of the N.E. 1/4 of Section 29, T. 2 N., R. 11 W. Webster County, Nebraska (Red Cloud Quadrangle); this is a site about 100 yards west from a reference and parking spot along a north-south road, 4.0 miles east and 1.7 miles north of Inavale, Nebraska (Red Cloud Quadrangle).

Thickness in feet

Quaternary (Group or/and Stage)[3]

Loess-and-Ash Mantling Sediments on Broadwater Formation[4]; these embrace equivalents at least of the Sheridan Valley-fill:

4. Talus — >10

Sappa Member[11] (formerly "Upland"), upper part:

3. Pearlette Volcanic Ash Bed (thickness uncertain) — 1.5

Presumably Sappa Member[11] (formerly "Upland"), lower part, is to be expected below:

2. Talus interval — 5.5

Broadwater Formation[4]:

Upper Gravel Member[5]:

	Thickness in feet
1. Granitic sand and gravel (at the type pits the thickness of sand and gravel is reported by Schultz, Reed, and Lugn, p. 549, to be at least 33 feet). In many exposures in this region, there appear to be traces of a soil, even of caliche locally, at the top of these gravels	15

Columnar Section 13
(Figs. 1, 11-13)

Stop 13: The volcanic ash at this site was correlated recently by Izett, Wilcox, Powers, and Desborough (1970, p. 131, locality 10, Sample No. 66W8) as the "Bishop ash bed".

Location: N.E. 1/4 of the S.E. 1/4 of Section 26, T. 3 N., R. 8 W., Nuckolls County, Nebraska; the reference point for parking is just south of the road junction 5.7 miles west of the west margin of Nelson. From this point, one walks due west along the fence at the north side of a field to the main drainage; the volcanic ash bed is exposed in a west-facing low cliff just north of a concrete spillway. This site is reached on the excursion from Mont Clare by taking the east-west road 0.6 mile south of the Mont Clare elevator, going east 2.0 miles and north 1.4 miles to the reference point mentioned above.

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Sheridan Formation[9]:	
Sappa Member[11] (formerly "Upland"), upper part:	
2. Volcanic ash bed (appears to be stratigraphically in the correct position for the Pearlette Volcanic Ash Bed); the lower 16 inches consists of pure white ash, whereas the upper 10 inches is laminated (six laminae) and very silty toward the top. There is a slight disconformity at the base, with relief of about 5 inches. The ash bed is overlain by about 6 feet of talus. The maximum thickness of the ash is about	2.2
Sappa Member[11] (formerly "Upland"), lower part:	
1. Soil at top, about 2 feet. This soil is correlated provisionally with Soil "L" underlying the ash at Geologic Section 11 (which seems to be that of the type "Upland" exposures, Geologic Section K, except no ash is present there). The soil here is underlain by pink silts which are poorly exposed. The interval from the bottom of the gully to the base of the ash is about 19 feet, of which much is in talus	19

Literature: See also Miller, Van Horn, Dobrovolny, and Buck (1964, p. 79, Geologic Section 7, unit 3).

Columnar Section 14
(Figs. 1, 11-14)

Stop 14: This is the Indian Creek Ash Site, giving one last opportunity on the excursion to see the volcanic ash bed of the Sappa, this time in clear relation (just as at Geologic Section 11 east of Republican City) to Crete Sand and Gravel. This is only one of many ash sites in eastern Nebraska.

Location: This was a stop on the 1965 INQUA Excursion "D" (Stop 14-5, in Stout, Dreeszen, and Caldwell, 1965, p. 110-114, fig. 14-62). It is located near the center of the W. 1/2 of the N.E. 1/4 of Section 17, T. 9 N., R. 1 E., about 3 miles west and 1.5 miles south of Beaver Crossing, Seward County, Nebraska (Utica Quadrangle).

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Sheridan Formation[9]:	
Crete Sand and Gravel Member[18]:	
5. Granitic sand and gravel	4±
Sappa Member[11] (formerly "Upland"), upper part:	
4. Greenish gray clayey silt; green sandy lens at base	5.3
3. Green silt	8.3
2. Pearlette Volcanic Ash Bed; upper part silty ash (1 foot 1 inch), with a humic parting separating it from the lower part (2 feet 5 inches) of pure ash	3.5
Sappa Member[11] (formerly "Upland"), lower part:	
1. Dark greenish gray, slightly humic-stained, silt at top, 4 inches, underlain by greenish gray silt, about 1.6 feet; much obscured by talus	2±

(Note that sand and gravel, here referred to the Grand Island, is to be expected at moderate depth. Dreeszen and Souders in Stout, Dreeszen, and Caldwell, 1965, fig. 14-62, assign bed 5 of this section questionably to the Beaver Creek, whereas beds 2-4 are correlated by them with the Sappa, and bed 1 is regarded as Walnut Creek).

Literature: See also Goll (MS. of 1961), who makes first mention of this site in a thesis prepared under Stout's direction and sponsored by the Nebraska Geological Survey.

Columnar Section 15
(Figs. 1, 11-15)

This is the last stop of the excursion, planned to carry the correlations into the glaciated region of eastern Nebraska. The site selected was discovered by Carroll Goll and Stout, as representative of many of the higher knobs in eastern Seward County, Nebraska, where the Kansan till (referred to the Cedar Bluffs Till and to a possible moraine along this high ridge, by Reed and Dreeszen, 1965, p. 32, 54-55, fig. 5-A) appears to be breaking up into sand and gravel intercalated with till. This condition seems to be expectable where stagnant ice is melting and collapsing as outwash sand and gravel may be released. A similar situation has been described recently in two papers by Boulton (1970a-b), entitled respectively: "On the origin and transport of englacial debris in Svalbard glaciers", and "On the deposition of subglacial and melt-out tills at the margins of certain Svalbard glaciers". The process envisioned was indeed not greatly different from that expressed in two early papers by Barbour (1913, 1914) describing a "minor" phenomenon of the "Kansan drift in Nebraska". The suggestion is made (see also the illustration in Goll, MS. of 1961, pl. 15, especially profile C-C') that the Red Cloud sand and gravel may be in places the outwash-equivalent of such stagnating Kansan ice. Further, the next younger valley-fill in the glaciated as well as periglacial regions, seems to be post-Kansan; this is the Sheridan Valley-fill relationship mentioned throughout these discussions, and such valley-fills (as at Indian Creek, Geologic Section 14) are generally floored with the sand and gravel best termed "Grand Island". In any case, we hope that you will find this site as interesting as it has been to some of us.

Location: Just south of center of the west line of Section 20, T. 12 N., R. 4 E., 3.4 miles north and 1 mile west of Garland, Seward County, Nebraska (Seward Quadrangle).

	Thickness in feet
Quaternary (Group or/and Stage)[3]:	
Broadwater Formation[4]:	
Upper Gravel Member[5]: (It should be recalled also that the name Atchison has been proposed from time to time for the supposed Red Cloud-equivalent within the till border; see Schultz, Reed, and Lugn, 1951, p. 547-549).	
2. Talus	3

	Thickness in feet
1. Sand and gravel "outwash", intercalated with till. In some places near this site there have been instances of soil development directly on the till or outwash. (Can this be part of a "True" Yarmouth profile, Soil "K"?). An outcrop of volcanic ash on the till plain, in a small depression, was found by Goll (MS. of 1961, pl. 5-B, as exposed 0.3 mile west of the northeast corner of Section 30, T. 12 N., R. 4 E., Seward County, Nebraska), but this exposure has not yet been re-located.	7

Notations on Geologic Sections

[1]Ogallala (Group or/and Stage):
regarded as a formation by the Nebraska Geological Survey; see Reed in Condra and Reed (1943, as reprinted with preface, 1959).

[2]Kimball, Ash Hollow, and Valentine Formations:
regarded as members by the Nebraska Geological Survey; see Reed in Condra and Reed (1943, as reprinted with preface, 1959).

[3]Quaternary (Group or/and Stage):
regarded as the Pleistocene Period or System by Lugn (1935, table A, opposite p. 30), and by Condra and Reed (1943, p. 4; reprinted with preface, 1959).

[4]Broadwater Formation:
not formally recognized, and apparently in part miscorrelated, by the Nebraska Geological Survey; see Reed, Dreeszen, Bayne, and Schultz (1965, p. 187-202, especially fig. 4).

[5]Upper Gravel Member (Broadwater Formation):
correlated with the Red Cloud by Stout and Schultz in Stout, Dreeszen, and Caldwell (1965, p. 18, 63-73, 96, fig. 3-8), but a different correlation is proposed by Reed and Dreeszen (1965, p. 29, 32, 53-54, fig. 9), that involves re-interpretation of the Red Cloud. The Red Cloud is treated as a formation by the last-cited authors. The Upper Gravel Member is not formally recognized by the Nebraska Geological Survey.

[6]Lisco Member (Broadwater Formation):
correlated with the "Afton" and also with the "Kansan" in part by Stout in Stout, Dreeszen and Caldwell (1965, p. 18, 67, fig. 3-8), but not formally recognized by the Nebraska Geological Survey.

[7]Lower Gravel Member (Broadwater Formation):
correlated with the "Nebraskan" and with the Holdrege by Stout in Stout, Dreeszen, and Caldwell (1965, p. 18, 67-68, figs. 3-7, 3-8). Although the type Holdrege is considered to be Ogallala, elsewhere the Holdrege is regarded as a member of the Fullerton Formation by Reed and Dreeszen (1965, p. 18, 29). The Lower Gravel Member is not formally recognized by the Nebraska Geological Survey.

[8]Brady Soil ("X"), at Top of Peoria Loess (Loess-equivalent of Todd Formation): This was the Soil "X" of Schultz and Stout (1945, fig. 3), for which the name Brady was proposed by Schultz and Stout (1948, p. 570).

[9]Sheridan Formation:
not currently recognized by the Nebraska Geological Survey, but see Lugn (1935).

[10]Sangamon Soil Complex (Soils "S" and "T"),(Sheridan Formation): this is the lower part of the Gilman Canyon Formation of Reed and Dreeszen, (1965, p. 40-41, 62-63), exclusive of the "*Citellus* Zone"; also *see* Dreeszen and Souders *in* Stout, Dreeszen, and Caldwell (1965, p. 78-81, 89-94, figs. 10-49 and 11-55).

[11]Sappa Member (Sheridan Formation): ranked as a formation by the Nebraska Geological Survey; *see* Reed and Dreeszen (1965, p. 35).

[12]"*Citellus* Zone" at Base of Peoria Loess (Loess-equivalent of Todd Formation): renamed as the upper part of the Gilman Canyon Formation by Reed and Dreeszen (1965, p. 40-41, 62-63), and *in* Stout, Dreeszen, and Caldwell (1965, p. 78-81, fig. 10-49).

[13]Loveland Loess and Sand Member (Sheridan Formation): considered as a formation by the Nebraska Geological Survey, *see* Reed and Dreeszen (1965, p. 4, fig. 3), and Dreeszen and Souders *in* Stout, Dreeszen and Caldwell (1965, p. 90-92, fig. 11-55; also p. 12, fig. 3-3).

[14]Upper part of the Loveland Loess and Sand Member (Sheridan Formation): this is the interval from the top of the Loveland Loess and Sand Member down to the top of Soil "P", including Soils "R", "Q" and "P'"of Stout's classification. It is the unit recently named by Schultz and Martin (1970b, p. 343-345, fig. 2, table 1) as the *Gothenburg Member* of the Loveland.

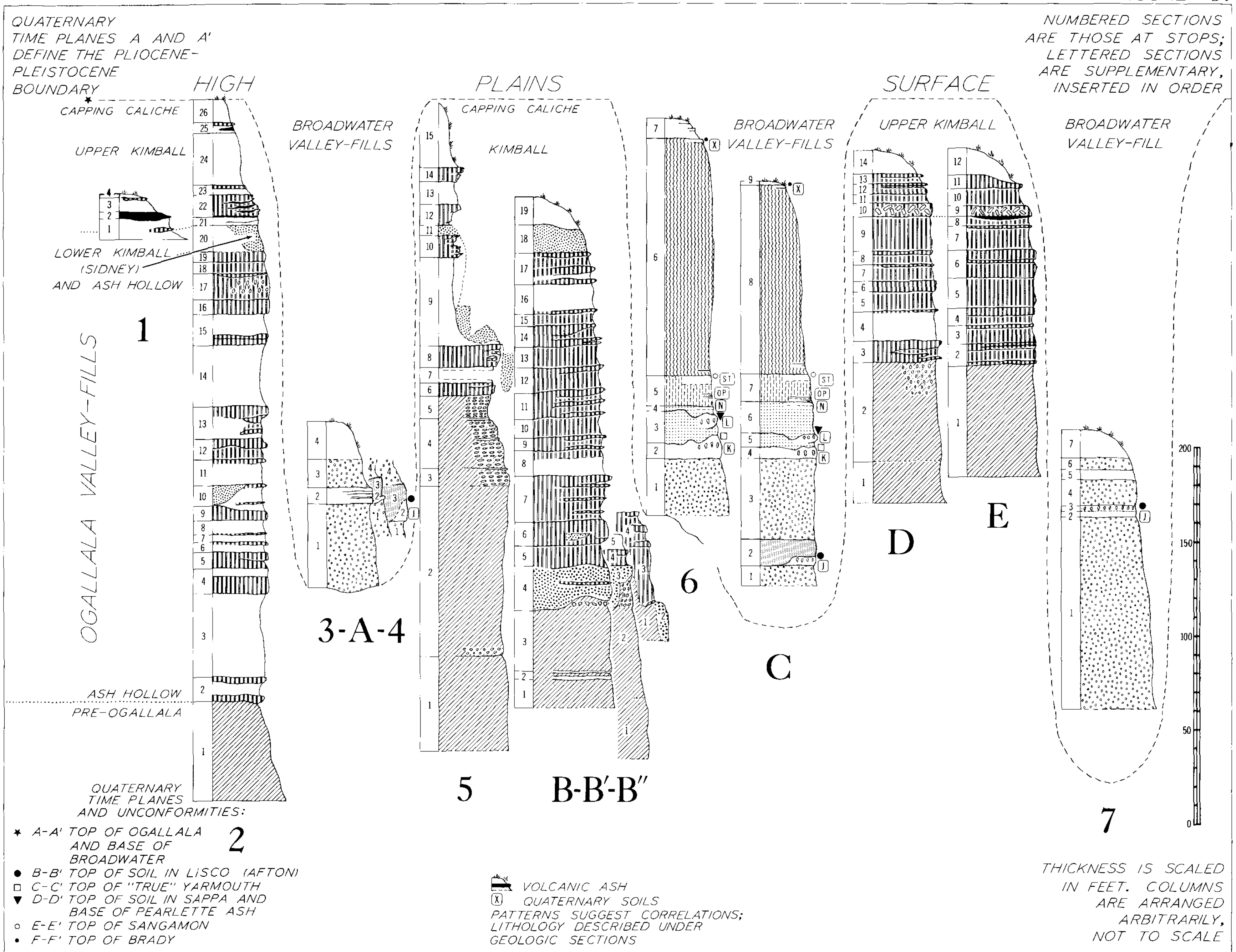
[15]Soils "O" and "P" of the Loveland Loess and Sand Member (Sheridan Formation): named the *Buzzard's Roost Paleosol Complex* by Schultz and Martin (1970b, p. 343-345, fig. 2, table 1).

[16]Soil "N" of the Sappa Member (Sheridan Formation): recently named the *Ingham Paleosol* by Schultz and Martin, (1970b, p. 343-345, fig. 2, table 1).

[17]Grand Island Sand and Gravel Member (Sheridan Formation): ranked as a member of the Sappa Formation by the Nebraska Geological Survey; *see* Reed and Dreeszen (1965, p. 4, fig. 3 and p. 34).

[18]Crete Sand and Gravel Member (Sheridan Formation): considered to be a member of the Loveland Formation by the Nebraska Geological Survey; *see* Reed and Dreeszen (1965, p. 4, fig. 3, and p. 40).

FIGURE 10.



PLIOCENE AND QUATERNARY IN WESTERN NEBRASKA

ROAD LOG FOR FIRST DAY

by T. M. Stout and H. M. DeGraw
(with arrangements by L. G. Tanner)

April 27, 1971
Departure, 8:00 A.M. MDST
Distance, 227 Miles

Mileage

0.0 (0.3) Sidney, Nebraska: Line up cars along U.S. Highway 30 (the Lincoln Highway) opposite and east of the post office, headed east. This is south of the municipal water tower, just west of the base of which is the type locality for the Sidney Sand and Gravel (Lugn, 1939a). The top of the escarpment is somewhat below the High Plains Surface (to be seen several miles north of Sidney, as well as on the road to Peetz, Colorado, south of Sidney). In the lower part of the escarpment a few blocks west of this starting point, north of the underpass and railroad, the Whitney Member of the Brule Formation (White River Group, Oligocene) is well exposed below the Ogallala. The Whitney is best exposed, however, along the railroad 1.5 miles west and 1.5 miles south of Sidney (just south of post 78, at the corner formed by Sections 1-2 and 11-12, T. 13 N., R. 50 W., in Cheyenne County, Nebraska). A geologic section measured by Stout in 1940 there shows 73 feet of Whitney overlain by 7.5 feet of possible Gering Formation (Arikaree Group, Early Miocene), capped by a thin basal conglomeratic sandstone, composed of granitic pebbles, totaling 1 to 6 inches in thickness and massive caliche ledges of the Ogallala (probably Ash Hollow). A geologic section measured by Lueninghoener (MS. of 1934, p. 40, pl. 12, Geologic Section 11) near this same spot differs in that greater thicknesses of Brule and "Arikaree-like" sediment were obtained, whereas the conglomeratic channel-fill was recorded as about 10 feet thick and the capping ledges were noted to range in thickness from 14 to 30 feet. The unconformity at the base of the Ogallala there displays relief of at least 11 feet. An attempt at mapping the relief on top of the "Brule" in Cheyenne County, using primarily subsurface data, is to be found in the recent report of Smith (1969, pl. 1). Lacking the conspicuous volcanic ash beds of the Whitney as datum horizons (Schultz and Stout,

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Explanation of Figure 10 (opposite): Pliocene and Quaternary of Western Nebraska. Numbers refer to the Geologic Sections at Stops; letters refer to the Supplementary Geologic Sections (described under Geologic Sections).

1955, 1961; Vondra, Schultz, and Stout, 1969; DeGraw, MS. of 1969), the Whitney in the outcrop belt near Sidney is difficult to correlate. Nevertheless, work was undertaken by Stout and associates on several occasions (particularly in 1940 and 1957, recorded in Stout, 1960a) to re-correlate the Whitney south of Sidney, near Peetz, Colorado (Galbreath, 1953). The most critical section was found to be situated 4 miles south and 3 miles west of Peetz (in the S.W. 1/4 of Section 22, T. 11 N., R. 52 W., Logan County, Colorado), where both the Lower and Upper Ash Layers are clearly developed in the Whitney. The Upper Ash Layer proves to be the "white marker bed" at the base of the Vista of Galbreath (1953; Stout, 1960a). Thus, the Whitney in northeastern Colorado is nearly identical with the Whitney of the Wildcat Ridge north of Sidney (Schultz and Stout, 1955; Vondra, Schultz, and Stout, 1969). Further, there is also a thin "Arikaree" unit southwest of Peetz, like that near Sidney, which suggests that the Whitney near Sidney correlates with the upper part of the Whitney (Whitney C). The Upper Ash Layer of the Whitney is to be expected in the lower reaches of the exposures west of Sidney, and there is some suggestion of light-colored silts at about that horizon. It may be of interest to recall that the Whitney in most places is an ancient loess (Schultz and Stout, 1955), not very different from the Peoria loess of the Quaternary, confirming at least in part the prediction of Matthew (1899).

0.3 (0.3) Proceed east, crossing the railroad.

0.6 (0.1) Underpass.

0.7 (0.9) Junction of Routes 19 (to Peetz, Colorado) and 30; continue east.

1.6 (5.1) Leave U.S. Highway 30, turning north toward Bridgeport on Route 385.

6.7 (0.3) We are now on the High Plains Surface, essentially on the top of the Kimball (top of the Ogallala). It is possible that in some places, as south of Kimball and just south of the Nebraska-Colorado boundary, the capping caliche of the Kimball may be developed on truncated Ash Hollow rather than on the Kimball. However, in the absence of any information to the contrary, it usually is assumed that the beds below the caliche are the upper part of the Kimball (fluviatile and lacustrine sediments). It should be noted also that there may be a complex history recorded above the capping caliche that can seldom be deciphered. There is some evidence of the Lisco Caliche above the capping caliche

in a few places east and northeast of Chappell, and there may be a thin loess mantle above that on the south flanks of major valleys. Thus, the evolution of the High Plains Surface, where undissected, is a matter of some speculation. Where erosion below the High Plains Surface has occurred, as will be noted occasionally for the next 16 miles, there may be gravels of several ages exposed: Sidney or Ash Hollow, or Broadwater, or even post-Broadwater. Some of the Broadwater sand and gravel in this region was considered by earlier workers to be Sidney. A study of the Kimball through Cheyenne and Morrill Counties has been prepared by Kent (MS. of 1963), under the direction of C. B. Schultz and T. M. Stout and generalized maps of the Ogallala relations are to be found in Smith (1969).

7.0 (2.7) Pass the sign giving directions for reaching the High Plains Agricultural Laboratory of the University of Nebraska. This is one of several laboratories maintained by the University, and it has as one of its projects the improvement of wheat production on the High Plains Surface of western Nebraska, for which the region has long been famous. The terms "Table" and "Tableland" are locally employed to designate the remarkable farming areas of this Surface.

9.7 (2.8) Historical marker, commemorating the discovery oil well (Mary Egging #1) of western Nebraska by the Marathon Oil Company. This well came in on August 9, 1949. We are situated structurally in the northeastern part of the Denver Basin (DeGraw, MS. of 1969, 1970).

12.5 (1.2) Gurley Cemetery.

13.7 (0.7) Enter Gurley.

14.4 (0.9) Typical High Plains Surface. Note the presence of occasional deflation depressions, which are not as prominent as some in the southern part of the High Plains. These depressions become ponds after melting of snow or after heavy rains, but most are dry during much of the year. There are also some northwest-southeast valleys, at least some of which are probably filled with Broadwater (Early Pleistocene) sand and gravel.

15.3 (1.8) Note the caliche exposed in the field at the right (east).

17.1 (1.7) Tower.

18.8 (1.0) Oil pump, separator, and tanks.

19.8 (1.6) Enter Dalton.

21.4 (0.4) First glimpse of breaks to the northwest.

21.8 (0.5) Caliche in the field at left. Approximate boundary of Cheyenne and Morrill Counties.

22.3 (0.2) STOP 1 (Geologic Section 1, Figs. 1, 10-1, described under Geologic Sections): volcanic ash bed in the Kimball (Ogallala, Late Pliocene). This ash bed resembles in some ways that illustrated by Barbour (1916, p. 385-386, figs. 45-46) as a 10-foot bed "owned by J. C. Wolfe, near Lodge Pole, Cheyenne County," but it has not been re-located. Continue north.

22.5 (0.4) Pump and tanks to right.

22.9 (0.2) Road junction and section corner; continue north.

23.1 (1.0) Caliche ledges with much rootlet material. From this point one obtains a glimpse of the North Platte River Valley to the northeast, toward Broadwater.

24.1 (0.5) Tanks at left.

24.6 (0.3) Gravels and ledges of the Ash Hollow (Ogallala). First glimpse of Courthouse and Jail Rocks (see cover of this guidebook), at the east end of the Wildcat Ridge, to the northwest.

24.9 (1.2) Leave Highway 385, and go west on gravelled road. Sign points out that the Mud Springs Pony Express Monument is ahead. This junction is "Reference Point a," to which we return shortly.

26.1 (0.3) Ash Hollow at the rise.

26.1 (0.2) Turn north.

26.6 (0.3) Schoolhouse, built in 1901. The road to the Mud Springs Pony Express Station is at the south side of this school house. Our route from east of Sidney has been parallel the Pony Express Route (Mattes, 1969). Continue north.

26.9 (0.5) Autogate. Note young valley-fills to right. Go northwest and west.

27.4 (0.5) Two autogates (one abandoned) and railroad crossing.

27.9 (0.5) Pass entrance to the Greenwood Ranch.

28.4 (0.4) Courthouse and Jail Rocks, composed of Arikaree on White River like most of the rest of the Wildcat Ridge (Vondra, Schultz, and Stout, 1969), may be seen to the

northwest. These represent the Arikaree and White River Valley-fills.

28.8 (1.1) Autogate.

29.9 (1.0) The Ogallala (Pliocene) escarpment looms ahead. Note that the Ogallala Valley cuts progressively deeper to the south, in contrast to the Arikaree Valley of the Wildcat Ridge to the north (Vondra, Schultz, and Stout, 1969, figs. 1-8, geologic map).

30.9 (0.2) Junction with oiled road just south of the Ranch in Greenwood Canyon; turn left (south) up the Greenwood Canyon Road (not oiled).

31.1 (1.0) Jog west, then south along a grove.

32.1 (0.4) Autogate. The base of the Greenwood Canyon Geologic Section begins with the Brule Formation (Whitney Member) exposed at the bottom of the Greenwood Canyon to the right, ahead.

32.5 (0.3) Narrow bridge and autogate; note the young valley-fills to the right (west). The contact of the Ogallala on Whitney can be seen better now, to the northwest.

32.8 (1.2) Ash Hollow "grit" (or "mortar beds") ledges are exposed opposite the ranch house and mail box. The trace of the Greenwood Canyon Geologic Section is on both sides of the road, as one proceeds up the main road (left fork of the Greenwood Canyon).

34.0 (0.6) Windmill at right (south), opposite gravels in the Ash Hollow. The section builds rapidly as we ascend the canyon road, and the Kimball caps the hills. Turn right at top of hill and park only a short distance beyond.

34.6 (9.8) <u>STOP</u> 2 (Geologic Section 2, Figs. 1, 10-2, described under Geologic Sections): volcanic ash bed above Sidney Sand and Gravel, with a fossiliferous horizon between, and the complete upper part of the Kimball above. This is the Greenwood Canyon Section, one of the thickest Ogallala sections in western Nebraska; it was Stop 9-1 of the 1965 INQUA Excursion "D". After walking out to the point and back, turn around and return by the same route to "Reference Point *a*" (*see* mileage log 24.9).

44.4 (8.2) Reach Route 385 again, turn left (north) on the Sidney-Bridgeport oiled road, and proceed to the junction with the Broadwater road. Note the sand dunes *en route*.

52.6 (4.5) Turn right (east) on Route 92, toward Broadwater. The young valley-fills related to the present North Platte River are beautifully displayed for many miles.

57.1 (3.6) Artesian well on the right (south). The water is derived from the Chadron Formation, at the base of the White River Valley-fill (Oligocene). Continue east to Broadwater, crossing the North Platte River just south of there.

60.7 (2.9) Junction of Routes 92 and 26 (the Yellowstone Highway). This junction is "Reference Point b" to which we return after visiting the Broadwater Quarries of the University of Nebraska State Museum. Go left on Route 26, then abruptly right at the Conoco Station, and again right at the schoolhouse a block farther north. Take the road east from Broadwater, on the north side of the Union Pacific Railroad (North Platte Valley route). The road is oiled only for the first mile, gravel thereafter.

63.6 (0.4) Keeping on the main road, turn northeast and north. The Whitney Member of the Brule Formation (Late Oligocene, White River Group) is exposed along the escarpment to the east, with some Arikaree in places, capped with Ogallala at the top of the hill.

64.0 (0.8) Excellent example of the "pseudo-pipy" concretions characteristic of the Gering Formation (Arikaree Group) at many localities. As one proceeds up this road, higher Arikaree (probably Monroe Creek or Harrison) with "true-pipy" concretions is exposed, but the Miocene is truncated by Ogallala at the top of the hill.

64.8 (1.6) Top of "Breakneck Hill," with Ash Hollow exposed for about a quarter of a mile along the road and on the slopes nearby. These beds contain considerable volcanic ash in places here, and there are channel-fills of granitic sand and gravel. A large turtle was collected at the first sand exposure coming up to the top of the Breakneck Hill. Continue on the winding road to higher slopes, to a point opposite the Broadwater fossil quarries; park there and walk over to the pits.

66.4 (6.5) STOP 3 (Geologic Section 3, Figs. 1, 10-3, described under Geologic Sections): Early Pleistocene Broadwater Valley-fill, and the Broadwater fossil quarries of the University of Nebraska State Museum. The fossils come from the diatomaceous marl and peat bed (equivalent to Soil "J" or the "Afton" Soil) and from the overlying sand and gravel (Upper Gravel, correlated with the Red Cloud). The basal sand and gravel (Lower Gravel) is unfossiliferous. This is Stop 9-2 of the

1965 INQUA Excursion "D" (see discussions in that guidebook, and in Schultz and Stout, 1945, 1948, as well as in Schultz and Martin, 1970a). This is the type locality for both the Broadwater Formation and the Lisco Member (the diatomaceous marl and peat bed). Go on to road junction at top of hill and turn around, returning by the same route to Broadwater and to "Reference Point b" (see mileage 60.7).

72.9 (5.2) Reach Route 26 at junction with Route 92, and continue southeast on Highway 26. As one proceeds, the same escarpment previously described occurs north of the highway.

78.1 (0.8) Ranch house to the north of the highway is at the base of the escarpment. The Whitney occurs in the deep gullies both west and east of the ranch house, with Gering exposed above, and with the Ogallala (Ash Hollow) at the top of the escarpment.

78.9 (0.4) A deep Ogallala channel-fill occurs in the bottoms of two gullies, just north of the highway. This channel probably cuts down to near the present level of the North Platte River, demonstrating the considerable relief at the base of the Ogallala here east of Broadwater. The age of these sands is uncertain, but they may be Valentine.

79.3 (0.3) At the west side of the gully, near the culvert, there is another channel-fill incised into the Whitney; it may be of the same age as the preceding ones, or it may be Miocene.

79.6 (1.5) The Whitney is exposed on both sides of the road here for nearly a mile. The Lower and Upper Ash Layers of the Whitney (Schultz and Stout, 1955; Vondra, Schultz, and Stout, 1969) are clearly distinguishable in these exposures, although the interval between them is less than farther west in the Wildcat Ridge. Along some of the large valleys, there is Ash Hollow sand and gravel, but it is generally poorly exposed.

81.1 (1.0) Gravels on ridge just north of road are probably related to the Terrace-3 Valley-fill (Todd).

82.1 (0.5) Ducklore Lodge, a private hunting lodge is to the right.

82.6 (1.0) Entrance to Connor's Ranch.

83.6 (3.3) As we approach Lisco, the escarpment just north of the road is chiefly Ash Hollow, but there is the possibility of some Sidney Sand and Gravel at the top of the escarpment here. Several "*Yucca*" beds, containing

root casts of the cactus, may be observed.

86.9 (4.5) Lisco. This is "Reference Point c," representing the turn if one was to go north and northeast of Lisco to visit the Supplementary Section A (Figs. 1, 10-A, described under Geologic Sections): this is the area where the Lisco loess is well developed (Lisco Locality A of the University of Nebraska State Museum; see Schultz and Stout, 1945, pl. 1, fig. 1; 1948). However, time does not allow a visit to this locality, so continue east. Just northeast of Lisco, one can observe the "Lisco Anticline," one of several well known structures in the Ogallala of western Nebraska.

91.4 (1.6) Leave Highway 26, and turn north on country road. There is a small roadside park, with a pump near a large tree at this turn. This is "Reference Point d," to which we will return shortly. As we go north from the highway, we are following the trace of a geologic profile published by Schultz and Stout (1945, p. 235, fig. 2, profile for Lisco Locality C). This begins at the North Platte River and proceeds north over the young valley-fills (Floodplain, Kuner, Kersey and Todd) finally coming up on a great surface (Terrace-4) that can be traced up and down the North Platte River Valley for many miles. A mammoth tooth was found in the Terrace-3 fill (Todd) along the road.

93.0 (1.0) Turn east. Notice the exposure of the Grand Island Sand and Gravel at the turn. Then, continuing east, one almost immediately rises again to the top of the Terrace-4 Surface (top of the Sheridan Valley-fill).

94.0 (1.5) Turn north. Again note the Grand Island at this turn. Continuing north, one comes up on the slopes leading to the Broadwater Valley-fill, exposed below the ranch house at the top of the escarpment.

95.5 (4.1) STOP 4 (Geologic Section 4, Figs. 1, 10-4, described under Geologic Sections): Early Pleistocene Broadwater Valley-fill (Lisco Locality C), much as seen at the Broadwater fossil quarries (Geologic Section 3), but it is here that a large accumulation of giant camels (*Gigantocamelus fricki* Barbour and Schultz, 1939) has been found by field parties of the University of Nebraska State Museum. A thick diatomaceous marl and peat bed (at least 11 feet thick) is exposed south of the quarries, but the fossils are mostly found in colluvial and alluvial silt and sand that replace the marl and peat bed to the north. Since these sediments occur between the two gravel sheets of the Broadwater, the Lisco here exhibits two of its three principal "facies" (Schultz and Stout, 1945, 1948; Stout,

Dreeszen, and Caldwell, 1965, p. 63-68, fig. 9-40). Return to Highway 26 at "reference Point d" (see mileage 91.4).

99.6 (11.5) Reach Highway 26, and turn southeast toward Oshkosh.

111.1 (1.5) Oshkosh, at junction of Routes 27 and 26. This is "Reference Point e." We are scheduled to have our lunch at the Johnson's Cafe in Oshkosh, and our visit to the Oshkosh Quarries may be before or after lunch. In either case, we turn south at this reference point, on Route 27, the Oshkosh-Chappell road. (No mileage is recorded for the lunch stop in Oshkosh).

112.6 (1.3) Cross the North Platte River.

113.9 (3.1) Leave the oiled road (Route 27), and take the west canyon road at the fork. Numerous sand dunes occur on the lower valley-fills at the mouth of this canyon. In the valley walls, there are numerous rows of small "potato-like" concretions that are interpreted here as probably being the "B" and "C" accumulation horizons of miniature soils in the Gering loess (Arikaree Group). The Whitney Member of the Brule Formation, as usual along the North Platte River Valley, comprises the basal, loessic silts. Up canyon, the Ogallala (Ash Hollow) is in sharp contact with the Gering. Continue south and southwest on the winding canyon road to the top of the hill.

117.0 (0.4) Leave the west canyon road, and turn west and northwest on a trail that leads past a windmill to the Oshkosh Quarries.

117.4 (6.4) STOP 5 (Geologic Section 5, Figs. 1, 10-5, described under Geologic Sections): Late Pliocene Oshkosh fossil quarries of the University of Nebraska State Museum. These pits, which occur in a deep channel-fill of the Sidney Sand and Gravel, were Stop 9-3 of the 1965 INQUA Excursion "D" (Stout, Dreeszen, and Caldwell, 1965, p. 68; Schultz and Stout, 1948, p. 555-557; 1961). The lower part of the columnar section (Fig. 10-5) used here is from an isolated butte west of the south approach to the Oshkosh Bridge. After visiting some new pits just south of the main workings, return to "Reference Point e" (see mileage 111.1).

123.8 (10.0) Again reach Highway 26. Turn southeast and proceed toward Lewellen. On this traverse, notice the sand dunes mantling the surfaces of the younger valley-fills along this north side of the North Platte River.

133.8 (1.4) Cross Blue Creek, an important tributary to the North

Platte River that seems to have re-excavated an old Broadwater Valley-fill. The Battle of Ash Hollow was fought in 1855 up the valley of this beautiful stream. Continue southeast.

135.2 (2.0) Lewellen. Continue southeast and south.

137.2 (0.7) Cross North Platte River opposite the mouth of the Ash Hollow.

137.9 (3.9) Ash Hollow Cemetery, at the entrance to Ash Hollow. This area is now mostly a part of the historic Ash Hollow State Park (Mattes, 1969). This is "Reference Point f," from which begins the Supplementary Geologic Sections B, B', and B'' (Figs. 1, 10-B, B', B'', described under Geologic Sections). As one goes up the Ash Hollow, probably the most interesting spot along the old Oregon Trail, one can follow fairly well the traverse of the Supplementary Section B (Fig. 10-B). Nearly at the head of the Ash Hollow, one can see the tracks where the immigrants let down their wagons into the Hollow. The outcrop of sand and gravel near the top of the Ash Hollow road is regarded here as probably Sidney Sand and Gravel.

141.8 (2.4) Probably Sidney Sand and Gravel. Continue southeast.

144.2 (0.4) Junction with road to Big Springs. Continue east on Route 26, toward Ogallala.

144.6 (0.6) STOP 6 (Geologic Section 6, Figs. 1, 10-6, described under Geologic Sections): Broadwater Valley-fill, east of the head of Ash Hollow, apparently part of the ancient hanging-valley known as "Brule Canyon" (see old Chappell and Ogallala Quadrangle maps), but in present Dankworth Canyon. This was Stop 9-4 of the 1965 INQUA Excursion "D" (Stout, Dreeszen, and Caldwell, 1965, p. 68-73, figs. 9-41 to 9-43; Stout, 1955, 1956). Walk down into the canyon. Return to cars and continue east.

145.2 (9.2) Boundary of Garden-Keith Counties; enter Keith County. As one continues east toward Ogallala, notice the great "hanging-valleys" (see old Chappell and Ogallala Quadrangle maps; and Stout, Dreeszen, and Caldwell, fig. 9-42a on p. 70).

154.4 (10.3) Junction with road to Brule. This is "Reference Point g" from which one would go to near Brule, and then east and north, to reach the area of Supplementary Geologic Section C (Figs. 1, 10-C, described under Geologic Sections), the Chase Canyon Section (Stout, Dreeszen, and Caldwell, 1965, p. 68-73, figs. 9-41 to 9-43;

Stout, 1955, 1956). Since time will not permit a visit there, continue east on Route 26, toward Ogallala.

164.7 (2.9) Junction with Route 61 that would lead to the Kingsley Dam, northeast of Ogallala on the Ogallala-Arthur road. The Kingsley Dam impounds the water of the North Platte River to form the Lake McConaughy. The distance to the dam from this road junction ("Reference Point h") is 6.4 miles. Several miles farther east is the Cedar Point, near which the Supplementary Geologic Sections D and E (Figs. 1, 10-D,-E, described under Geologic Sections) were measured. Time does not allow visits to the dam site or to the Cedar Point Area, so continue south along Route 26 into Ogallala.

167.6(19.8) Ogallala: turn east at main junction with Highway 30, taking Route 30 for less than a block, then turning right (from right lane) onto the overpass that leads to the Interstate (Route 80). Follow the Interstate to the Paxton Exit.

187.4 (0.3) Leave Interstate (Route 80) at the Paxton Exit. This is "Reference Point i," to which we return shortly.

187.7 (0.4) Stop sign; go left (north).

188.1 (0.5) Cross the South Platte River (one-lane bridge). Notice the siphon and gravel pit to the right (east). The siphon is utilized to carry North Platte River water from Lake McConaughy under the nearly dry bed of the South Platte River into canals and reservoirs before being returned to the Platte River below the city of North Platte.

188.6 (0.1) Cross railroad at the edge of Paxton.

188.7 (0.4) Reach junction with Highway 30 (the Lincoln Highway, once the great transcontinental highway); go right (east) for a short distance on Route 30, through part of Paxton.

189.1 (1.3) Turn left (north) in Paxton at a point nearly in line with the siphon, and take a trail north into the Paxton Cut, turning onto the trail at the west side of the Canal, just above the Canal.

190.4 (4.4) STOP 7 (Geologic Section 7, Figs. 1, 10-7, described under Geologic Sections): Paxton Cut, a Broadwater Valley-fill. Notice the "*Yucca*" root casts and other concretions in the Lisco Member (Soil "J", correlated with the "Afton" Soil). Return to the Paxton Entrance to the Interstate (Route 80), "Reference Point i" (see mileage 187.4).

194.8(31.3) Reach the Interstate (Route 80) at the Paxton Entrance, and proceed to the North Platte Exit. Notice on this route, if it is not too dark, the beautiful development of the younger valley-fills along the South Platte River. We also cross into the Central Standard Time Zone.

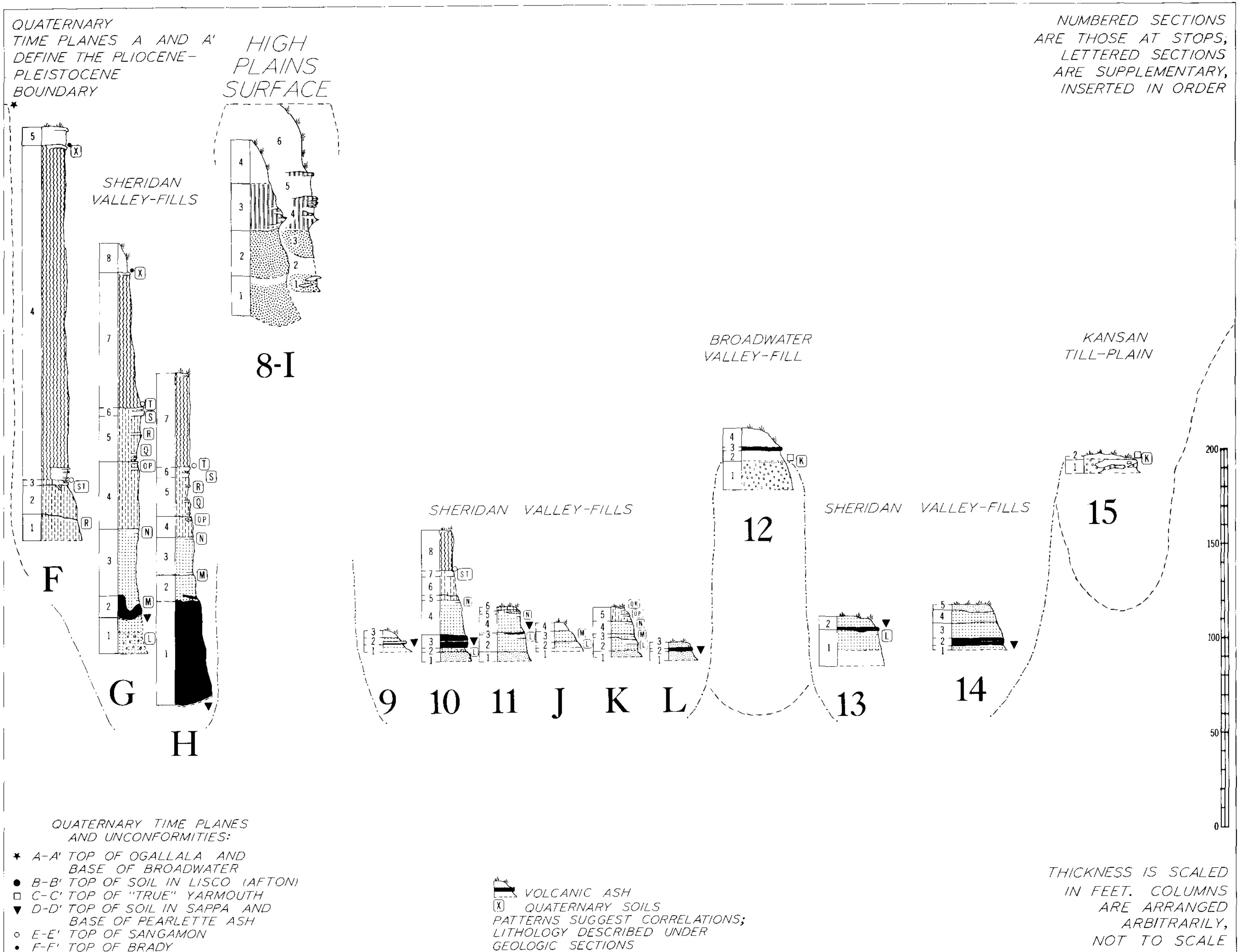
226.1 (0.4) Leave the Interstate (Route 80) at the North Platte Exit.

226.5 (0.4) Stop sign; go left (north), keeping left in inside lane.

226.9 (0.1) Turn left into the parking area of the Holiday Inn of North Platte.

227.0 Night Stop. This is "Reference Point j," for assembly at 7:00 A.M. (Central Daylight Saving Time!) tomorrow, to continue the trip.

FIGURE 11.



PLIOCENE AND QUATERNARY IN SOUTHERN NEBRASKA

ROAD LOG FOR SECOND DAY

by T. M. Stout and H. M. DeGraw
(with arrangements by L. G. Tanner)

April 28, 1971
Departure, 7:00 A.M. CDST
Distance, 395 Miles

Mileage

0.0 (1.9) North Platte, Nebraska: Line up cars in parking lot of the Holiday Inn of North Platte ("Reference Point j"; see mileage 227.5 for yesterday). Turn right (east) out of parking lot, then right again (south) onto Highway 83 (North Platte-McCook road). Take the overpass over the Interstate (Route 80), proceeding south on Route 83 toward Wellfleet and Maywood.

1.9 (2.1) Road junction; this is "Reference Point k," for it is from here that one would take the road along the south side of the South Platte and combined Platte Rivers in order to reach Bignell and the Bignell Hill Section (Supplementary Geologic Section F, Figs. 1, 11-F, described under Geologic Sections). The North Platte Experimental Station of the University of Nebraska is at this road junction. Continue south on Route 83.

4.0 (1.2) Pass the Dry Land Research Farm of the University of Nebraska.

5.2 (1.3) Pass sign for the Lincoln County Wildlife Club and the entrance to the Lake Maloney Area.

6.5 (0.7) Lake Maloney at right (west).

7.2 (0.5) South entrance to the Lake Maloney Area.

7.7 (9.8) Sand dunes begin.

17.5 (2.5) Enter Frontier County Conservation District (still in Lincoln County).

20.0 (0.6) Tower at left.

20.6 (3.1) Junction with Route 23 (road to Grant). Grant is situated on the High Plains Surface. Notice that we are entering a northwest-southeast valley with a marginal ridge on its south side.

Explanation of Figure 11 (opposite): Pliocene and Quaternary of Southern Nebraska. Numbers refer to the Geologic Sections at Stops; letters refer to the Supplementary Geologic Sections (described under Geologic Sections).

23.7 (1.9) Route 83 now turns southeast, parallel with the ridge.

25.6 (0.6) Pass entrance to Wellfleet Special Use Recreation Area.

26.2 (0.4) Entrance to Wellfleet, after passing a church.

26.6 (0.5) Railroad. Note that the road ahead ascends the loess-mantled ridge, and that we leave the ancient valley-fill.

27.1 (0.9) Medicine Creek.

28.0 (1.1) Notice the characteristic flat-floored valley-forms of the loess area.

29.1 (0.7) Excellent example of erosional and depositional topography of the loess-canyon area.

29.8 (0.6) Summit of loess ridge, with good example of canyon at right.

30.4 (3.0) Boundary of Lincoln and Frontier Counties; enter Frontier County.

33.4 (1.0) High-level surface, with valley-fill at left.

34.4 (0.9) Leave Route 83 at junction with Route 23; take Route 23 east and southeast toward Maywood and Curtis. Enter the filled-valley, marginal to Medicine Creek.

35.3 (0.4) Enter Maywood.

35.7 (2.2) Leave Maywood.

37.9 (0.9) Note the young valley-fills at the left.

38.8 (0.4) Railroad.

39.2 (1.0) Cross Medicine Creek.

40.2 (1.2) Notice the valley-fills at left.

41.4 (0.2) Well Canyon.

41.6 (0.3) Enter Curtis. An Agricultural School is maintained here by the University of Nebraska.

41.9 (0.3) Junction of Routes 23 and 23-S at stop sign in Curtis. This is "Reference Point 1," from which one would depart from the excursion route to visit the Buzzard's Roost and Eustis Sections (Supplementary Geologic Sections G and H, Figs. 1, 11-G, described under Geologic Sections). This would be also the point of departure to visit two additional sites of great interest

but not otherwise mentioned. The first is the Cut Canyon Section, situated 6.3 miles north and 1.4 miles west of Curtis (in the N.W. 1/4 of the N.E. 1/4 of Section 29, T. 9 N., R. 28 W., Lincoln County, Nebraska; Curtis Quadrangle), with evidence proving that the principal ancient valley-fill system in this area is the Sheridan. The second site noted is that from which the greater part of the skeleton of the Lincoln County Mammoth, holotype of *Mammuthus maibeni* (Barbour, 1925a-b) was obtained. This is the featured display in Elephant Hall at the University of Nebraska State Museum in Lincoln. It was found in the Sangamon Soils ("*Citellus* Zone"), 11.2 miles north and 5.2 miles west of Curtis, in Well Canyon (in the N.E. 1/4 of Section 34, T. 10 N., R. 29 W., Lincoln County, Nebraska; Wellfleet Southeast Quadrangle). *Leave Route 23 and take Route 23-S here, toward Stockville.*

42.2 (0.2) Railroad. Continue on Highway 23-S, toward Stockville.

42.4 (0.7) Cross Medicine Creek.

43.1 (1.6) Excellent loess-canyon topography at left.

44.7 (5.6) Summit divide, giving good view of the loess canyons.

50.3 (1.1) Valley-fills.

51.4 (0.5) Historical marker for Frontier County and Stockville.

51.9 (0.4) Enter Stockville.

52.3 (0.4) Oiled road ends. Continue east toward Elwood, still on Route 23-S.

52.7 (0.5) Medicine Creek.

53.2 (0.9) Bridge and good example of a dissected young valley-fill.

54.1 (0.6) Turn right.

54.7 (0.2) Turn left.

54.9 (0.1) Turn right (slow!).

55.0 (0.5) Good examples of flat valley-floors (tops of valley-fills; *see* Schultz and Stout, 1945, fig. 4).

55.5 (1.3) Summit surface.

56.8 (0.9) Mitchell Creek.

57.7 (0.4) Narrow bridge.

58.1 (1.9) Curve. This is on a summit surface.

60.0 (0.1) One-lane bridge across Deer Creek.

60.1 (0.5) Junction with road to Farnam. Continue east on Route 23-S.

60.6 (1.1) Turn right (south).

61.7 (1.0) Irrigation well.

62.7 (0.3) Road junction. Leave Route 23-S, continuing south toward Orafino and Medicine Creek Dam.

63.0 (0.8) Bridge and young valley-fill.

63.8 (3.0) Orafino (church and school). Continue south, again on summit surface.

66.8 (1.0) Turn left (east), still on summit surface (probably the High Plains Surface).

67.8 (2.3) Turn right (south).

70.1 (0.9) First glimpse at right (west) of the Harry Strunk Lake (the Medicine Creek Reservoir).

71.0 (1.9) Summit surface, rather certainly the High Plains Surface here, but the thickness of the loess mantle is not known. Ogallala (Kimball) is to be expected at an unknown depth.

72.9 (0.6) Store: a well-known landmark. Turn right (west) toward the Medicine Creek Dam. This is "Reference Point *m*," to which we return.

73.5 (0.6) East end of the Medicine Creek Dam. Notice the Ogallala (Ash Hollow) exposures below the dam. A volcanic ash bed was once found in a gully just below the approach to the dam, at the top of the bedrock, or in the mantling sediments. The reservoir has flooded many of the Early Man sites excavated by the University of Nebraska State Museum field parties in this area; some of these sites can be seen from here. Cross over the dam.

74.1 (1.5) West end of the dam. This is "Reference Point *n*," to which we also return, but to be discussed later (mileage 82.7). Proceed on the main and winding road, past the sign for the Medicine Creek Recreational Area, and continue west.

75.6 (0.5) Turn right (north) at road junction, on road that trends west of northwest.

76.1 (0.2) Turn left (west) at sign "Trail No. 5".

76.3 (0.3) Go northwest.

76.6 (0.1) Go west.

76.7 (0.7) Possible point for the stop, from which one can walk to sites. But if road conditions permit, we will drive directly to them. Continue west and northwest.

77.4 (1.0) Pass through gate, taking the quarry trail back to the other side of the fence from the preceding spot, then north to the quarry sites.

78.4 (4.3) STOP 8 (Geologic Section 8, Figs. 1, 11-8, described under Geologic Sections): Cambridge fossil quarries (Ft-40 and Ft-41, as well as the Early Man Sites adjacent), worked by parties of the University of Nebraska State Museum. The fossils are found in the Sidney Sand and Gravel and overlying upper part of the Kimball (Ft-40), and across the gully (Ft-41) in the upper part of the Ash Hollow. The best known fossil mammals from the Ft-40 site are: Amebelodon fricki Barbour (1927, 1929a-b, and Osborn, 1936, v. 1); Barbourofelis fricki Schultz, Schultz, and Martin (1970); and Dipoides stirtoni Wilson. The latter genus allows correlation with the type Pliocene of Europe and Asia (Schultz and Stout, 1948; Stout, unpublished studies), allowing precise projection of the Pliocene-Pleistocene boundary throughout much of the Northern Hemisphere. This is Stop 11-1 (and also Stop 11-2) of the 1965 INQUA Excursion "D" (Stout, Dreeszen, and Caldwell, 1965, p. 83-89, figs. 11-51 to 11-54). Return to the gate, by the same quarry trail, then back to the west end of the Medicine Creek Dam ("Reference Point n," mileage 74.1).

82.7 (1.2) West end of the Medicine Creek Dam again (Medicine Creek Dam and adjacent Cambridge, Freedom, and Bartley Quadrangle maps); this is the "Reference Point n," (see mileage 74.1). From this point, one can take a trail south and southeast, then west, for a distance of about 0.6 mile, to the abandoned quarry where one can see the upper part of the Kimball, and possibly also the Sidney Sand and Gravel. The face is now badly slumped from what it once was (see photograph in Schultz and Stout, 1961, p. 34, 53, fig. 29, for Stop 38 of the 1961 field trip). This constitutes Supplementary Geologic Section I (Figs. 1, 11-I, described under Geologic Sections). Continue across the dam and back to the store.

83.9 (7.9) Reach store again ("Reference Point m"; see mileage

72.9). Turn right (south) on the oiled road toward Cambridge.

91.8 (0.8) Junction with Route 6-34. Turn left (east) on Highway 6-34. Note just to the northeast the prominent exposure (Sheridan Valley-fill)with the Sangamon Soils developed on Loveland Loess and overlain by Peorian Loess. The exposure is inscribed "Jesus Saves".

92.6 (0.8) Boundary of Red Willow and Furnas Counties; enter Furnas County.

93.4 (1.4) Enter Cambridge.

94.8 (1.4) Cross Medicine Creek at east edge of Cambridge.

96.2 (3.2) The Sangamon Soils on Loveland Loess, with the Peoria Loess above, are exposed in the Sheridan (Terrace-4) Valley-fill. These exposures extend for about 2.3 miles.

99.4 (1.1) Good exposures of the Sheridan (Terrace-4), Todd (Terrace-3), and Kersey (Terrace-2) Valley-fills, for a distance of 0.8 mile.

100.5 (2.2) Rise to the top of the Sheridan (Terrace-4) Valley-fill. Notice that the High Plains Surface seems to be present on the other (south) side of the Republican River Valley.

102.7 (0.2) Enter Holbrook.

102.9 (0.4) Historical marker (Burton's Bend) at left, in Holbrook.

103.3 (1.6) Cross Deer Creek at the east edge of Holbrook.

104.9 (3.4) Notice the broad top surface of this valley-fill (terrace).

108.3 (0.2) Muddy Creek.

108.5 (0.3) Enter Arapahoe.

108.8 (0.6) Lady of Fatima Shrine at left.

109.4 (0.6) Leave Arapahoe.

110.0 (1.2) Cross Elk Creek. Notice the Terrace-2 (Kersey) and younger valley-fills, with the Terrace-3 (Todd) ahead.

111.2 (0.6) Terrace-3 (Todd) Surface.

111.8 (1.1) Terrace-4 (Sheridan) Surface.

112.9 (0.8) Higher surface.

113.7 (0.8) Cross Big Antelope Creek.

114.5 (0.8) Higher surface again.

115.3 (0.8) Junction of Route 6-34 with Route 136. Leave Highway 6-34, and go southeast on Route 136 toward Edison and Oxford.

116.1 (0.7) Notice edge of terrace just below.

116.8 (0.4) Sharp turn left (east), then right (south).

117.2 (0.2) Enter Edison. The Edison Volcanic Ash Mines are located near here (Barbour, 1916, p. 374-377, figs. 24-26). Barbour recorded that the ash here is in a bed ranging in thickness from 8 to 17 feet, and at one face he noted a 9-foot bed "riddled with old burrows filled with black dirt."

117.4 (0.1) Railroad.

117.5 (0.3) Turn left (east).

117.8 (0.3) Leave Edison.

118.1 (1.8) Road along railroad is on a valley-fill (terrace) surface.

119.9 (1.7) Narrow bridge: Turkey Creek.

121.6 (1.1) Narrow bridge: Swartz Creek.

122.7 (0.7) Bridge. Notice the broad farming surface developed on the top of the low valley-fill to the right (south).

123.4 (0.4) Historical marker for the Republican River.

123.8 (1.2) Narrow bridge.

125.0 (0.9) Enter Oxford, crossing railroad 0.2 mile farther.

125.9 (0.7) Junction of Routes 136 and 46. Leave Highway 136 here turning right (south) on Route 46, toward Stamford. As we leave Oxford, notice the edge of the Terrace-1 (Kuner Valley-fill), as well as the Floodplain (Terrace-0 and -00) Valley-fill.

126.6 (1.3) Cross the Republican River.

127.9 (5.6) <u>STOP</u> 9 (Geologic Section 9, Figs. 1, 11-9, described under Geologic Sections): volcanic ash bed along the

road, just south of Oxford. This is in the Terrace-4 (Sheridan Valley-fill). Continue south.

133.5 (0.6) Junction of Routes 46 and 89. Turn left (east) on Route 89, toward Stamford.

134.1 (2.0) Boundary between Furnas and Harlan Counties; enter Harlan County.

136.1 (0.4) Enter Stamford.

136.5 (1.9) Leave Stamford.

138.4 (1.6) Leave Route 89, and turn left (north) on country road. This is "Reference Point o," to which we will return after our visit to the ash mines.

140.0 (0.4) Cross power line. The stop is at the highest pole along this line to the east, but it is a difficult site now to reach.

140.4 (0.2) Turn in on road to the Jerry Bose Farm.

140.6 (2.2) Jerry Bose Farm. From here, transportation is planned for taking the group to the site; otherwise, it is a short walk. There is an alternative route.

STOP 10 (Geologic Section 10, Figs. 1, 11-10, described under Geologic Sections): Orleans Volcanic Ash Mines (no longer active), as described by Barbour (1916, p. 368-370, 372, figs. 13-18); later used as the type locality for the Sappa (Reed, 1948b; Dreeszen and Souders *in* Stout, Dreeszen, and Caldwell, 1965, p. 89-94, fig. 11-55, table 11-4), replacement name for the "Upland" of Lugn (1935). This was Stop 11-3 on the 1965 INQUA Excursion "D". Lunch is planned to be at this stop, but otherwise at Vicker's Cafe in Alma. Return to "Reference Point o" (see mileage 138.4).

142.8 (2.0) Again reach Route 89 ("Reference Point o"), and turn left (east).

144.8 (0.5) Pass trail, leading north, the alternative route to Stop 10. Continue on east.

145.3 (1.1) Cross railroad complex (Flynn Junction).

146.4 (2.0) Cross the Republican River, just above its junction with Beaver Creek.

148.4 (1.1) Junction of Routes 89 and 136 (also railroad crossing), at the west edge of Orleans. Continue east on Highway

136, through Orleans.

149.5 (1.0) Cemetery.

150.5 (1.7) Rope Creek.

152.2 (1.7) Junction of Routes 136 and 89; turn right (south) on the combined route.

153.9 (0.2) Underpass.

154.1 (0.9) Enter Alma. Turn left (east) on Highway 136. The Vicker's Cafe (an alternate lunch stop) is at the northeast corner at this junction.

155.0 (0.9) Leave Alma.

155.9 (6.1) Overpass.

162.0 (0.2) Road junction entering present site of Republican City. Continue east on Route 136.

162.2 (0.9) Leave Republican City.

163.1 (1.2) STOP 11 (Geologic Section 11, Figs. 1, 11-11, described under Geologic Sections): East of Republican City Ash Site. The stop is along the highway, at a flagged position beside a culvert; walk south about 0.25 mile to the ash exposure. The face on the opposite (east) side of the drainage has been also included in the profile.

164.3 (1.6) Boundary of Harlan and Franklin Counties; enter Franklin County.

165.9 (0.4) Cross Turkey Creek.

166.3 (0.5) Junction with road to Naponee (State Spur 2136). Continue east.

166.8 (0.3) Junction with road to Pleasant View Christian Church. There is a red barn at the northeast corner. Continue east.

167.1 (3.9) Pass by without stopping the site of Supplementary Geologic Section J (Figs. 1, 11-J, described under Geologic Sections): buried soil not yet correlated, which yielded a fragment of a fossil mammal skull on the north side of the highway, at the west end. A flagged loop of wire at the south side of the exposure allows ready identification.

171.0 (0.8) Big Cottonwood Creek.

171.8 (0.7) Little Cottonwood Creek.

172.5 (0.4) Enter Bloomington.

172.9 (4.6) Leave Bloomington.

177.5 (0.6) Junction of Routes 136 and 10, at Franklin. This is "Reference Point p," from which one would proceed north 14.6 miles in order to visit the type "Upland" exposures (Supplementary Geologic Section K, Figs. 1, 11-K, described under Geologic Sections). Since time does not allow this side trip, continue east on Route 136.

178.1 (2.6) Leave Franklin.

180.7 (7.5) Note Sangamon Soils in roadcut to north.

188.2 (1.5) Riverton.

189.7 (1.0) Boundary of Franklin and Webster Counties; enter Webster County.

190.7 (3.2) Road junction 1 mile east of the boundary of Franklin and Webster Counties. This flagged position is "Reference Point q," from which one would go north 2.2 miles to visit a volcanic ash site where the ash is sandwiched between two sheets of sand and gravel (Supplementary Geologic Section L, Figs. 1, 11-L, described under Geologic Sections). Since it is evident that we cannot visit the site on this trip, continue east without stopping.

193.9 (0.3) Enter Inavale.

194.2 (4.0) Leave Inavale.

198.2 (1.7) Leave Highway 136 and turn left (north) on country road. This is "Reference Point r," to which we will return shortly.

199.9 (1.8) Go north 1.7 miles to parking spot alongside country road. Walk west to the exposure, up the gully.

STOP 12 (Geologic Section 12, Figs. 1, 11-12, described under Geologic Sections): volcanic ash above the type Red Cloud Sand and Gravel. Return to "Reference Point r" (see mileage 198.2).

201.7 (2.2) Again reach Highway 136 ("Reference Point r"). Turn left (east), toward Red Cloud.

203.9 (0.1) Enter Red Cloud.

203.9 (0.1) Enter Red Cloud.

204.0 (0.5) Webster County Historical Museum.

204.5 (0.3) Junction of Highways 136 and 281; continue east on Route 136.

204.8 (2.3) Leave Red Cloud.

207.1 (1.8) Cretaceous (probably Niobrara).

208.9 (3.3) Railroad.

212.2 (2.0) Republican Valley Wayside Area is to the right (south).

214.2 (0.2) Buried soil (probably Sangamon?) at meander about a mile north.

214.4 (3.1) Junction of Highways 136 and 78 (to Guide Rock); continue east.

217.5 (2.9) Boundary of Webster and Nuckolls Counties; enter Nuckolls County.

220.4 (3.0) Leave Highway 136, turning north at road junction with the sign for "Mt. Clare Elevator".

223.4 (1.5) Turn east at a point (flagged) about 0.6 mile south of Mt. Clare.

224.9 (0.6) Railroad; continue east.

225.5 (1.0) Turn left (north).

226.5 (0.3) Abandoned schoolhouse at road junction; continue north.

226.8 (0.2) Park 0.35 mile farther north, on line with fence at the north side of a cornfield. This is 0.2 mile south of a "T-junction" with the road from Nelson. Walk west, parallel with the fence into main gully. The exposure is only slightly south, near a concrete spillway, facing west.

STOP 13 (Geologic Section 13, Figs. 1, 11-13, described under Geologic Sections): volcanic ash exposure. Return to cars, and continue north.

227.0 (5.6) Turn right (east) on road leading to Nelson.

232.6 (0.2) Enter Nelson.

232.8 (0.5) Go north one block, then east to main paved highway.

233.3 (0.8) Junction with Highway 14; turn left (north) toward the Interstate.

234.1 (5.5) Leave Nelson.

239.6 (1.0) Junction with Route 4; continue north on combined Highway 14-4.

240.6 (1.7) Junction with Route 4 from east; continue north on Route 14. Note that the Angus Mammoth was found east-southeast of here and north of Angus (this site was Stop 12-4 of the 1965 INQUA Excursion "D"; see Stout, Dreeszen, and Caldwell, 1965, p. 97). Other sites occur southwest of Angus; see above-cited Guidebook, and Schultz and Tanner (1957, p. 66-68, fig. 4).

242.3 (1.2) Historical marker at creek crossing.

243.5 (0.4) Road curves northeast and east.

243.9 (0.7) Boundary of Nuckolls and Clay Counties; enter Clay County.

244.6 (1.0) Road turns north, soon after crossing railroad.

245.6 (10.7) Junction with Route 314 (to Deweese); continue north on Route 14.

256.3 (0.2) Junction with Route 41 in Clay Center; continue north on Route 14.

256.5 (3.8) Leave Clay Center, continuing north on Highway 14.

260.3 (3.0) Junction of Highways 14 and 6; turn right (east) on combined Highway 14-6.

263.3 (16.6) Second junction; turn left (north) on Route 14, leaving Highway 6.

279.9 (34.3) Aurora Entrance to the Interstate (Route 80); leave Route 14 and go east on the Interstate, but only about 34.3 miles.

314.2 (4.6) Leave Interstate (Route 80) at the Utica Exit; turn right (south) at stop sign, and go south 4.5 miles. This is "Reference Point s," to which we return shortly.

318.8 (0.7) Turn left (east) and proceed east 0.7 mile to park along road (or alternatively, to drive into the field to the south).

319.5 (5.4) STOP 14 (Geologic Section 14, Figs. 1, 11-14, described

under Geologic Sections): Indian Creek Volcanic Ash Exposure. Walk south into the bed of Indian Creek to site, which faces south at a meander. This site was Stop 14-5 of the 1965 INQUA Excursion "D" (see Stout, Dreeszen, and Caldwell, 1965, p. 113, fig. 14-62, Stop 14-5). Return to "Reference Point s" (see mileage 314.2).

324.9 (16.1) Utica Entrance to Interstate (Route 80), "Reference Point s." Proceed east on Interstate, but only to the Milford Exit, a distance of about 16 miles.

341.0 (5.7) Leave Interstate (Route 80) at the Milford Exit; turn left (north) at stop sign, and proceed north. This is "Reference Point t," to which we return after our last stop.

346.7 (3.0) Junction with Route 34. Continue north for 3 miles.

349.7 (2.0) Turn right (east) at the Merle J. Beckles Farm, and proceed 2 miles.

351.7 (3.5) Turn left (north) at a point 1 mile west of Garland; proceed 3.4 to 3.5 miles to site. (An alternative route will be used if roads are bad).

355.2 (14.2) STOP 15 (Geologic Section 15, Figs. 1, 11-15, described under Geologic Sections): Kansan till becoming outwash (probable equivalent of the Red Cloud). Return by same route to "Reference Point t" (see mileage 341.0).

369.4 (19.0) Milford Entrance to Interstate (Route 80); this is "Reference Point t." Go east on Interstate to the principal Downtown Exit for Lincoln.

388.4 (3.5) Junction of Routes 80 and 180 (Downtown Exit for Lincoln); turn right (south) on Route 180 and proceed to Downtown Lincoln.

391.9 (1.8) Downtown Lincoln at junction of 10th and "O" Streets, just south of the exit from Route 180; this is also the junction of Routes 2 and 34. Turn left (east) onto "O" Street and proceed east to 33rd Street.

393.7 (1.1) Leave "O" Street, and turn left (north) on 33rd Street. Go north to Holdrege Street.

394.8 (0.2) Reach 33rd and Holdrege Streets. The Nebraska Center for Continuing Education (the Kellogg Center) of the University of Nebraska is at the northeast corner. Go north and then turn east to the Center.

395.0 Reach the Nebraska Center (on East Campus of the University of Nebraska-Lincoln). End of Excursion!

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Explanation of Plates 1 and 2 (in pocket)

Plate 1. Geology of the Gangplank Area and Adjacent Region. (Reproduced, with permission, from Buffington, MS. of 1961, pl. 1. This study of Gangplank geology was made jointly by Buffington and Stout, after preliminary study of the problems and measurements of some geologic sections by Stout. The map was compiled chiefly by Buffington from the geologic maps of Colorado, Wyoming, and Nebraska, and from other available published or unpublished information.)

Plate 2. Great Plains Sedimentational Patterns. (Published previously by Stout *in* Schultz and Stout, 1961, as fig. 2, and *in* Stout, Dreeszen, and Caldwell, 1965, as fig. 3-6; *see* also Stout, 1960b).

GREAT PLAINS SEDIMENTATIONAL PATTERNS

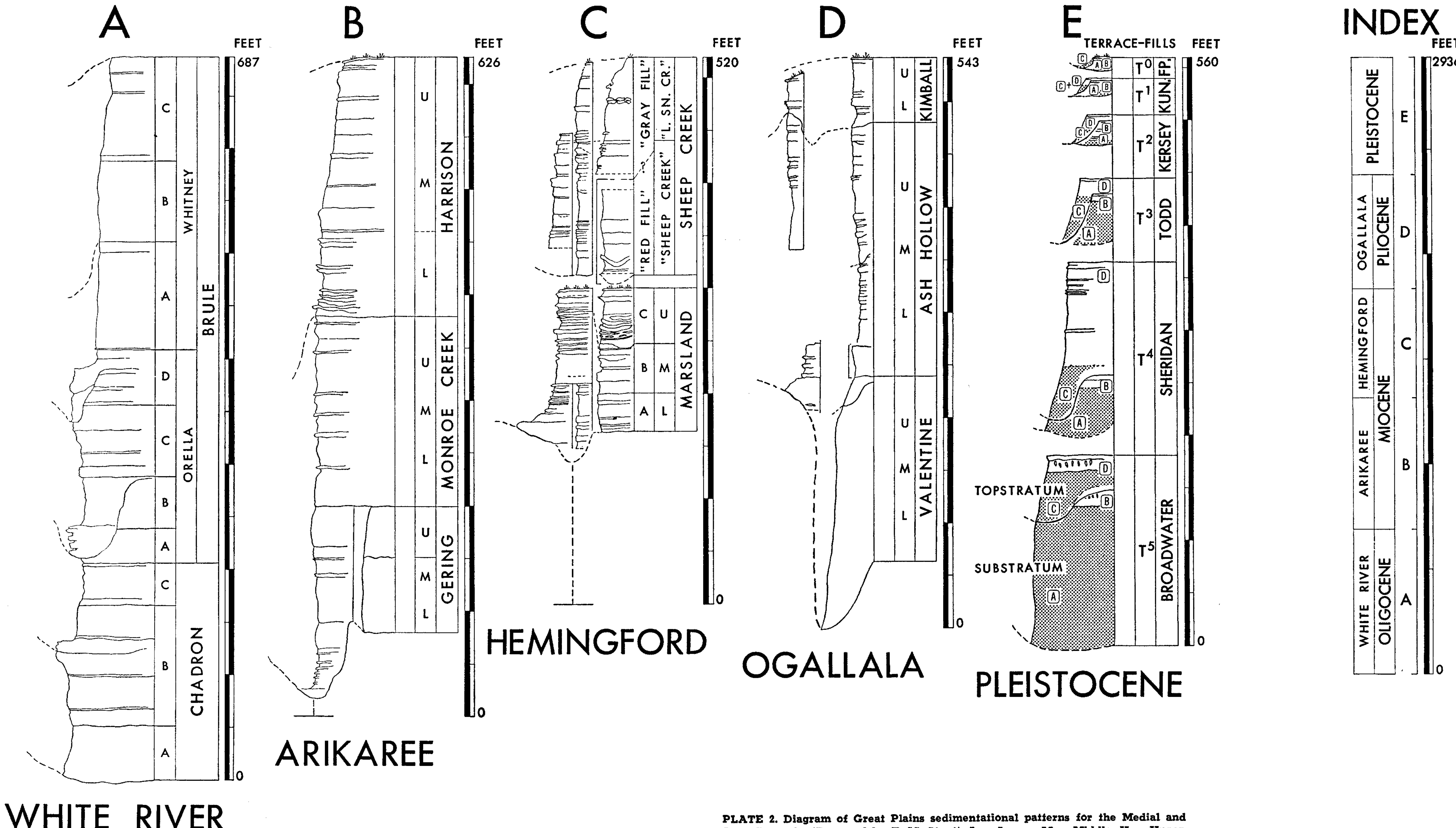

PLATE 2. Diagram of Great Plains sedimentational patterns for the Medial and Late Cenozoic. (Prepared by T. M. Stout). L = Lower, M = Middle, U = Upper, "L. SN. CR." = "Lower Snake Creek", KUN. = Kuner, and FP. = Floodplain.

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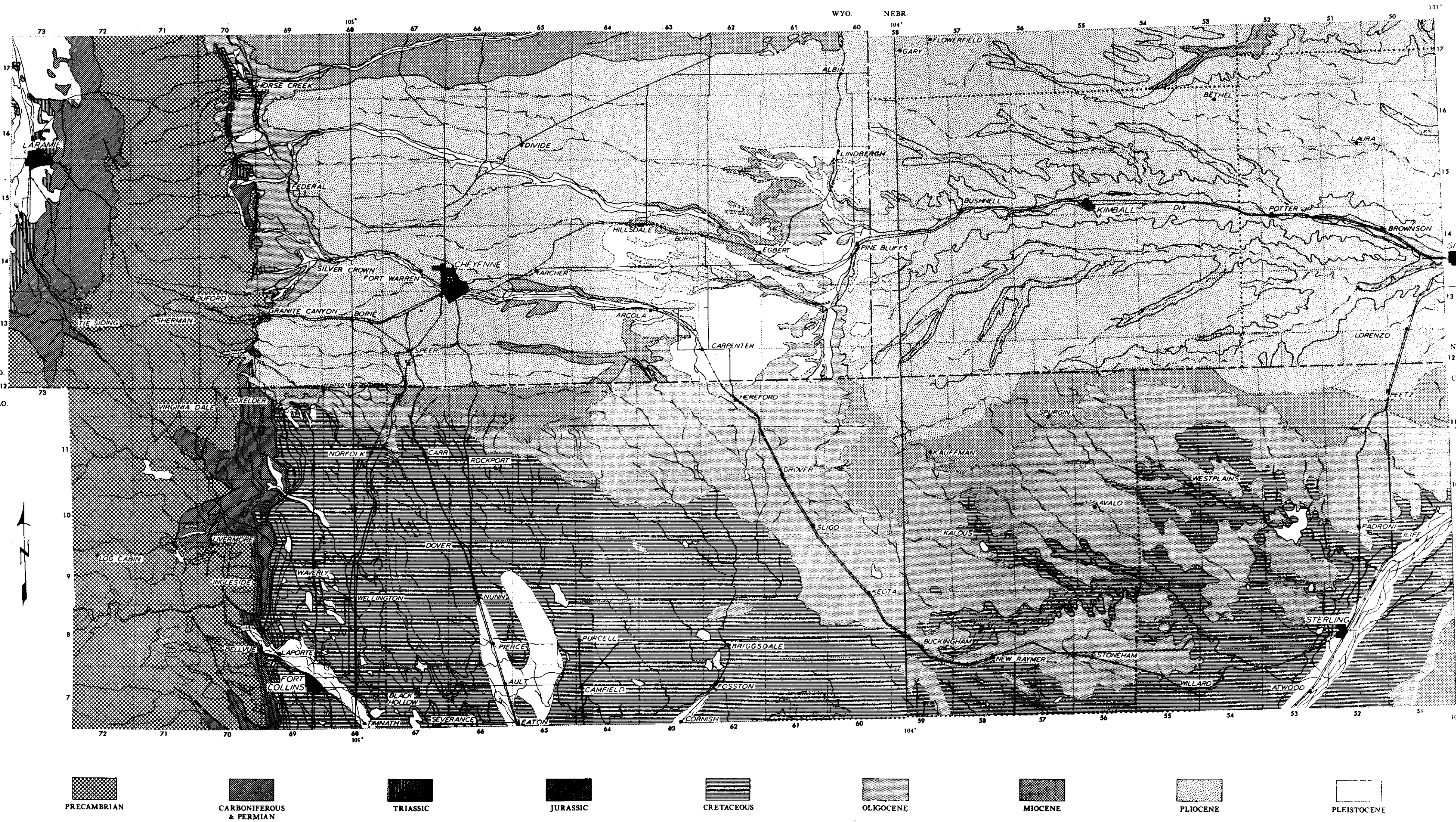

GEOLOGY OF THE GANGPLANK AREA AND ADJACENT REGION

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