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ABSTRACT

Medial Pleistocene Fossil Vertebrate Localities in Nebraska

C. Bertrand Schultz *Lloyd G. Tanner*

The accurate geologic dating of Pleistocene vertebrate localities which occur outside the glaciated regions has always been difficult. Several new fossil localities in Nebraska now provide data for a better understanding of the paleoecology and faunal evidence of the medial Pleistocene of the Great Plains region.

A fossil quarry, containing the remains of both vertebrates and invertebrates, has been discovered in south-central Nebraska (1½ miles south and west of Angus in Nuckolls County). The fossils are preserved in Sappa silts in a lime concentration zone (C horizon) of a Yarmouth paleosol. The calcium carbonate appears to have been responsible for the preservation of fragile invertebrate as well as vertebrate fossils. The mammalian remains range from small rodents to large proboscideans. Fossilized specimens of fish, reptiles, amphibians, and birds also are present in the deposit. The importance of this locality is emphasized because of its nearness to the glacial till border (less than forty miles), thus enabling a more definite geologic dating of the fossils. A second fossil quarry, with a similar faunal assemblage and also associated with a Yarmouth paleosol, has been located twenty-six miles north of Lincoln in Saunders County, Nebraska. This locality is within the Kansan till border and is definitely post-Kansan and pre-Illinoian. The faunas from both localities compare favorably with the well-known "*Equus* beds" fauna from Sheridan County, Nebraska, thus confirming the medial Pleistocene dating for the latter faunal assemblage.

The geomorphologic and stratigraphic evidence at the above mentioned localities (Nuckolls, Saunders, and Sheridan counties) demonstrates that these fossil deposits are medial Pleistocene in age and occur in the lower part of the Terrace-4 fill.

CONTRIBUTION OF *the Department of Geology, College of Arts and Sciences, and the Division of Vertebrate Paleontology of the Museum.*

Schultz[1] *Tanner*[2]

Medial Pleistocene Fossil Vertebrate Localities in Nebraska [3]

Introduction

One of the problems which has confronted vertebrate paleontologists for many years is the dating of the various fossiliferous deposits of the Pleistocene. Practically all of the important fossil vertebrate localities are situated many hundreds of miles from glacial till and intertill deposits of known age (see Fig. 1 for Nebraska localities). During the first thirty years of the present century there was a tendency among paleontologists and geologists (Calvin, 1909, 1910, 1911; Shimek, 1909, 1910; Hay, 1924; Matthew, 1918; and others) to consider most of the fossil localities in central North America to be Aftonian in age. However, since 1930 it has been demonstrated that most of these fossil sites are much more recent than Aftonian, especially those in the Nebraska-Iowa region (Lugn, 1934, 1935; Schultz, 1934; Barbour and Schultz, 1937a, 1937b). These changes in age assignments are due, of course, to the fact that the Pleistocene deposits of this region are much better understood as a result of more intensive study during the past

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[3] This paper was presented in part at three meetings: Lincoln (1955, Proc. Nebr. Acad. Sci., 65 Ann. Meeting, abstract: 16), New Orleans (1955, Bul. Geol. Soc. Amer. 66 [12] Pt. 2, abstract: 1612), and Denver (1956, U. S. Geol. Surv. "Colloquium," March 26-28, mimeographed abstract: 2 pages).

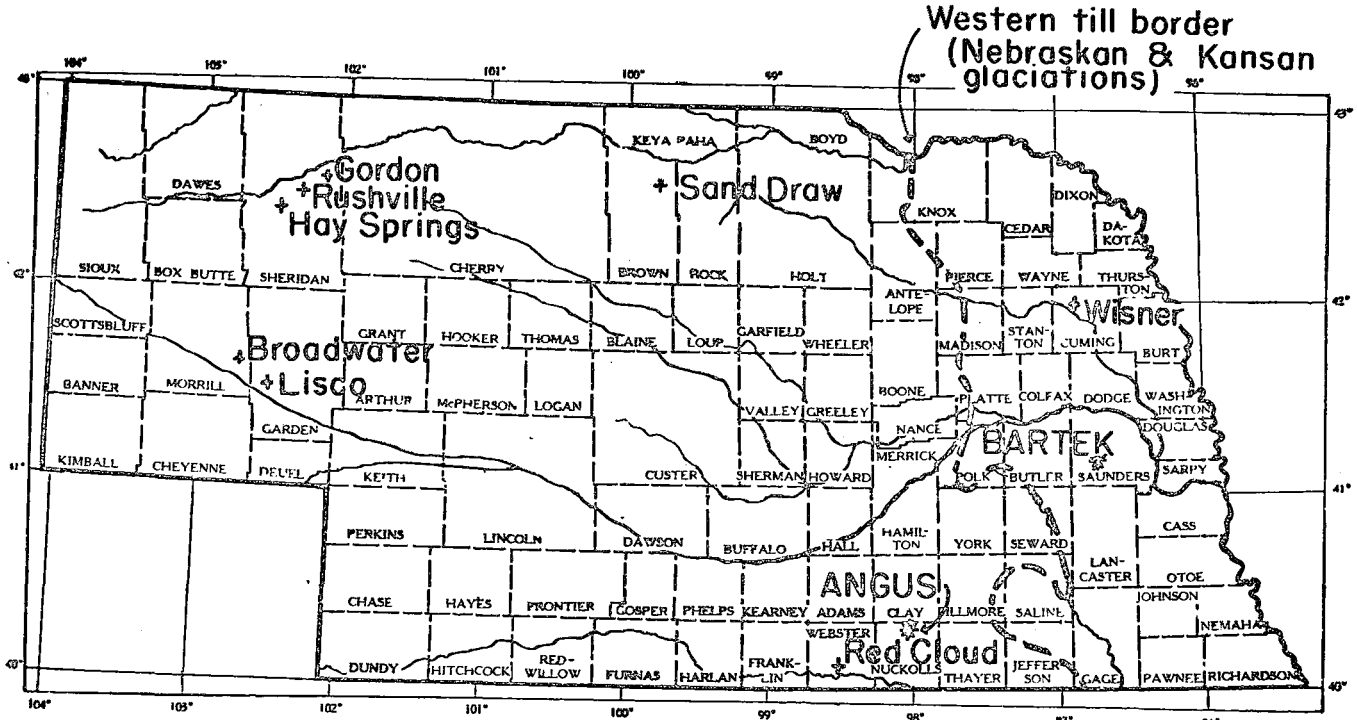

FIG. 1—Map of Nebraska showing important early and medial Pleistocene fossil localities. Early Pleistocene: Broadwater and Lisco (Barbour and Schultz, 1937a, 1937b; Schultz and Stout, 1941, 1945, 1948), Sand Draw (McGrew, 1944), Wisner (Frankforter, 1950), Red Cloud (Schultz, Reed, and Lugn, 1951). Medial Pleistocene: Sheridan County—Hay Springs, Rushville, and Gordon (Scott, 1897; Matthew, 1902, 1918; Frick, 1930, 1937; Lugn, 1934, 1935; Schultz, 1934; Barbour and Schultz, 1937a, 1937b; Schultz and Stout, 1941, 1945, 1948).

twenty-five years. The first extensive Pleistocene research in the Great Plains was done during the early 1930's by William C. Alden (1932, pp. 1-133) of the United States Geological Survey in the Montana region and by A. L. Lugn (1934, pp. 319-356; 1935, pp. 1-223) of the University of Nebraska in the state of Nebraska.

The Great Plains and adjacent areas provide an ideal region for the study of the Pleistocene (Fig. 2). During parts of the "Ice Age" a large area of continental glaciation was located along the northeastern border of the Plains, while along the western edge there were extensive tracts of mountain glaciation. The sequences of glacial deposits of the Rocky Mountains and those to the east of the Plains usually are studied separately without any reference to each other, and two independent sets of data often result, which at present can not be correlated with each other with any degree of certainty. It is frequently assumed that identical sequences must be present in both the mountain areas and the continental glaciated regions, and hypothetical age assignments are attached to the various glacial stages and substages. The solution to the correlation of these two important glaciated regions appears to be found in the periglacial area along the northeastern margin of the Great Plains. If these periglacial sediments can be definitely correlated or tied in with the continental glacial deposits, then the correlations can gradually be extended to the west and south and eventually the ages of the various formations in outlying areas, as well as in the mountains, may be established with greater accuracy. Even within the glaciated region to the northeast of the Great Plains there are certain localities where the geological assignments of deposits are controversial. Some outcrops which are assigned to the various substages of the Wisconsin should be more critically studied and the evidence at hand re-evaluated in order to work out better correlations and precise datings. Fortunately studies concerning these correlations in both the glacial and periglacial regions are under way on a greater scale than heretofore by numerous individuals representing various institutions and organizations. The increased impetus is undoubtedly due in part to the fact that Pleistocene formations contain much of the usable groundwater supplies, commercial sands and gravels, and other ma-

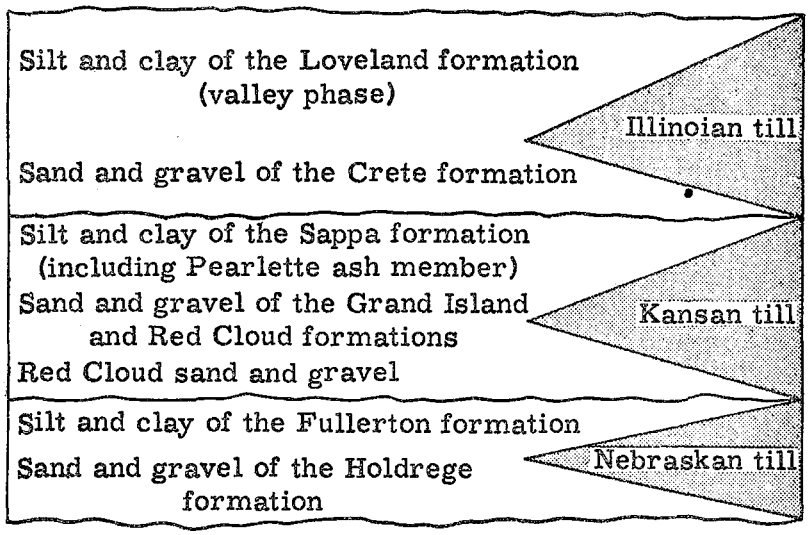

FIG. 2—Chart showing generalized stratigraphic relations of pre-Wisconsin Pleistocene deposits in Nebraska. Based on Condra, Reed, and Gordon, 1950, p. 12, and modified by Schultz, Reed, and Lugn, 1951, p. 547. From Flint, 1955, p. 42.

terials of economic value to the citizens of the Plains and adjacent areas.

STRATIGRAPHIC APPROACH

The stratigraphy of the Pleistocene of the Great Plains region is very complex and can not be accurately interpreted without the use of geomorphology. Some workers (Bryan and Ray, 1940; Bryan, 1941, 1950; Schultz and Stout, 1945, 1948; Lueninghoener, 1947; Frankforter, 1950; Schultz, Lueninghoener, and Frankforter, 1951) have considered that geomorphology is the key to the solution of Pleistocene correlations, but they also recognized that stratigraphic, petrographic, and paleontologic evidence must not be overlooked. The value of terraces in the correlations of river valley deposits still is not fully understood, nor are terraces used as extensively in geologic studies of the Pleistocene as they might be. Since there is such a duplication of sequences in the various terrace-fills, one must always be alert for geomorphologic evidence in order to be sure that the gravels, or the soils, or the loesses

are correctly identified. The lithology and stratigraphic sequence of several different terrace-fills in a single locality may be very similar, and extreme caution must be used in correlations. The color sequence found in one terrace-fill may be essentially the same as found in another fill of a different age, thus resulting in erroneous conclusions if colors are used as a basis for correlations and mapping. For example, the reddish to moderate brownish color of the Loveland (Illinoian) loess may be duplicated in other terrace-fills. Geomorphology, however, frequently furnishes the necessary clues for correct interpretations.

Within the Great Plains region there are five primary terraces (T-1 through T-5) and a complex secondary one (T-0), all of which appear to be regional in extent and are developed in various river valleys from Texas northward to Canada (see Schultz and Stout, 1948; Schultz, Lueninghoener, and Frankforter, 1951). Fortunately vertebrate fossils occur in all of these terrace-fills, thus providing a fairly complete stratigraphic faunal sequence from early to late Pleistocene.

Vertebrate Paleontology

Perhaps one of the most important problems in relation to Pleistocene paleontology is the dating of the well-known Sheridan County and Middle Loup River fossil localities in Nebraska. These concentrations of bones were called the "*Equus* beds" or Sheridan beds by W. B. Scott (1897), and are located approximately 200 miles west of the glacial till border near the towns of Hay Springs, Rushville, and Gordon, south of the Niobrara River (see locality map, Fig. 1). Two new fossil localities in Nebraska now provide data for a better understanding of the dating of these Sheridan County deposits. Both are located in the southeastern part of the State and are associated with glacial and periglacial deposits which have been satisfactorily dated. The Bartek Brothers Farm locality (Figs. 1 and 3) is located in Saunders County and the Angus locality (Figs. 1 and 4) in Nuckolls County.

Bartek Brothers Fossil Quarry

In Saunders County, Nebraska, there is a fossil vertebrate locality (Bartek Brothers Fossil Quarry, U.N.S.M. Coll. Loc. Sd-15) of particular significance since it is within the Kansan

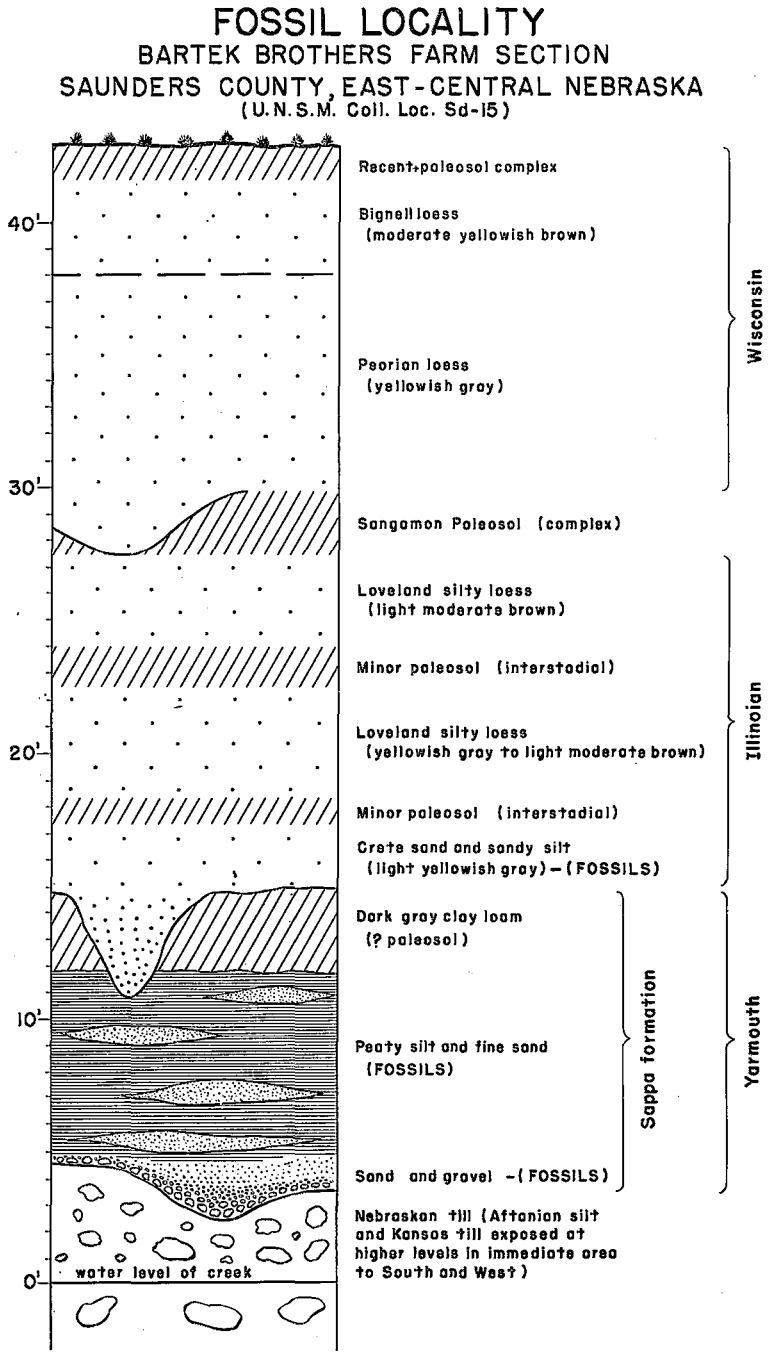

FIG. 3—See legend on opposite page.

till border and appears to be definitely post-Kansan in age. The Sappa silt and sand deposits, in which the fossils are preserved, are in the lower portion of a Terrace-4 fill (see Fig. 3 of present paper; also Lueninghoener, 1947, pp. 54-58, Figs. 19-20). The Kansan till and Aftonian silt deposits, which are exposed in the adjacent hills, are not present at the fossil quarry, but appear to have been eroded away, probably during the final retreatal stage of the Kansan glacier. The Nebraska State Geological Survey, under the direction of E. C. Reed, brought drilling equipment to the quarry site and made a series of drill tests in order to work out the detailed subsurface geology of the immediate area. The data obtained from this project clearly demonstrated that the fossils were in a post-Kansan valley fill. The writers appreciate the cooperation of the staff of the Nebraska State Geological Survey in working out the solution to this dating problem. The subsurface data agreed very well with the geomorphologic and paleontologic information.

The following mammals have been identified from the Sappa deposits at the Bartek Brothers Fossil Quarry:[4] *Paramylodon* sp.—Ground Sloth; *Mammut* sp.—Mastodont; *Mammuthus* sp.—Mammoth; *Equus* sp.—Horse; *Camelops kansanus* Leidy—Camel; *Tanupolama* sp.—Llama; *Cervus* sp.—Wapiti; *Bison* sp.—Giant Bison.

In addition, a microfauna represented by both vertebrates and invertebrates[5] is under study. Two partial bison skulls with horncores (U.N.S.M. 30356 and 30358) of *Bison alleni* also were obtained from the site (Schultz and Frankforter, 1946, p. 5), but these have been considered to have been derived from the Crete sand and sandy silt, which immediately overlie the Sappa deposits. The main fossiliferous zone (see Fig. 3) is associated with the peaty silt and fine sand and with the basal

[4] Named in honor of the owners of the property where the fossils occur.

[5] Larry Frankel, Dept. of Geol., Univ. of Conn., is studying the gastropods and other fossil invertebrates from this locality (Frankel, 1956, 1957).

FIG. 3—Bartek Brothers Farm section, U.N.S.M. Coll. Loc. Sd-15, 26 miles N. of Lincoln, center of NE ¼, sec. 12, T.14N., R.5E., Saunders County, Nebraska. (See Lueninghoener, 1947, Fig. 19.)

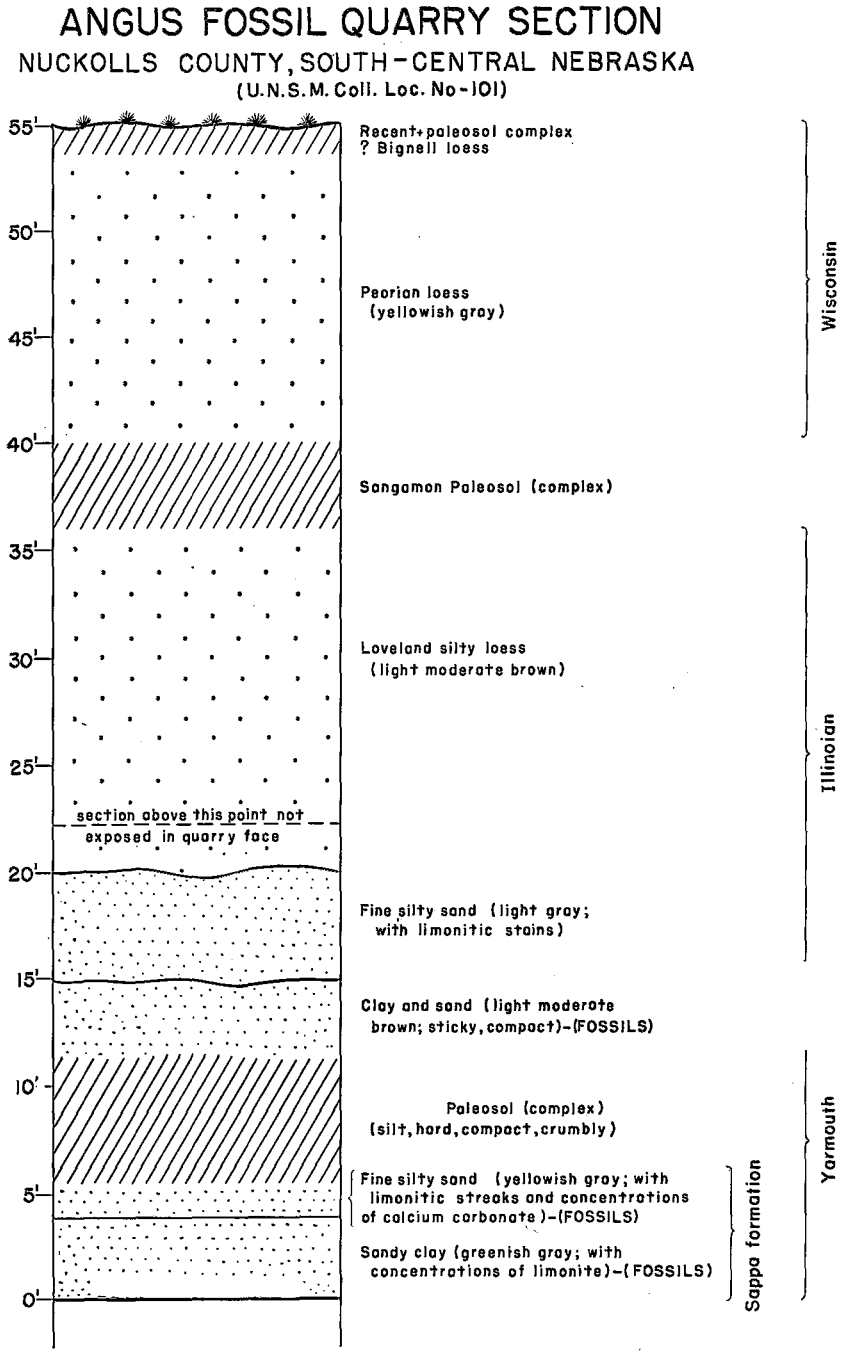

FIG. 4—See legend on opposite page.

sand and gravel, all of which are considered to be typical of the Sappa (Yarmouth interglacial in age). Further excavations are planned for all fossiliferous levels in the quarry.

Angus Fossil Quarry

The geologic evidence at the Angus Fossil Quarry (U.N.S.M. Coll. Loc. No-101, see Figs. 1 and 4) indicates that a well-developed paleosol complex occurs on top of the Sappa silt and sand in the base of a Terrace-4 fill. The fossils are found most abundantly in lime concentration zones, which may be attributed to C horizons of ancient soils. The calcium carbonate appears to have been responsible for the preservation of the bones as well as of the fragile shells of invertebrates. The various faunal elements indicate that the sediments containing the fossils were deposited during an interglacial period which was warm, not too different from that of today in the same area. The following mammals have been identified from the Angus Fossil Quarry thus far: *Lepus* sp.—Jack Rabbit; *Silvilagus* sp.—Cottontail; *Cynomys niobrarius* Hay—Prairie Dog; *Geomys* sp.—Eastern Pocket Gopher; *Castor* sp.—Beaver; *Ondatra nebrascensis* Hollister—Muskrat; *Microtus?* sp.—Meadow Mouse; *Canis latrans* Say—Coyote; *Mammuthus* (*Archidiskodon*) *imperator* (Leidy)—Mammoth; *Equus excelsus* Leidy—Horse; *Mylohyus browni* Gidley—Peccary; *Camelops kansanus* Leidy—Camel; *Odocoileus sheridanus* Frick—Deer; *?Stockoceros* sp.—Four-horned Antelope.

In addition, the remains of reptiles, amphibians, birds, and fish were recovered. The diagnostic mammalian remains indicate that all of the forms were at approximately the same stage of evolution or development as those from the Sheridan beds in northwestern Nebraska and from the Sappa deposits at the Bartek Brothers Fossil Quarry in Saunders County. This certainly gives added proof that the 1934 Yarmouth assignment for dating the Sheridan beds still holds (Lugn, 1934; Schultz, 1934). In stratigraphic paleontology, workers are more concerned with the stage of development of the fossil rather than the specific identification. Taxonomic studies are definitely

FIG 4—Angus Fossil Quarry section, U.N.S.M. Coll. Loc. No-101, 1½ mi. SW of Angus, SW ¼ of NE ¼, sec. 33, T.4N., R.6W., Nuckolls County, Nebraska.

dependent upon stratigraphic data, and it is now evident that most of the Pleistocene mammalian groups are in dire need of revision because of new stratigraphic evidence. The evolution of certain Pleistocene vertebrates took place at a very rapid rate and as a result some of the forms prove to be splendid index fossils. The development of the bison is an excellent example of rapid development (Schultz and Frankforter, 1946; Schultz and Stout, 1948, p. 568). Continued research work on the bison problem during the past ten years has given additional support to the earlier stratigraphic evidence that the bison migrated into the Great Plains during the late Kansan and diminished in size at a rather constant rate until historic times (from *Bison latifrons* of the late Kansan and early Yarmouth to *Bison bison* of the Recent).

Sheridan County Fossil Localities

The Pleistocene fossil localities south of Hay Springs in Sheridan County, Nebraska (see Fig. 1) were first visited in 1857 by the F. V. Hayden expedition, which was under the direction of Lt. G. K. Warren of the U. S. Army Engineers (see Schultz and Stout, 1948, p. 562 for brief history of these localities). In 1880 a field party from Harvard University under the leadership of Samuel Garman collected the holotype of the ground sloth, "*Mylodon garmani*" (=*Paramylodon nebrascensis*) in the Sheridan County region. Two Princeton University expeditions, led by John Bell Hatcher, also collected in the same area in 1886 and 1893. American Museum of Natural History field parties did some collecting in the Hay Springs region in 1893, 1897, and 1916. In 1915 a Yale Peabody Museum party opened up a small quarry and obtained some material. The Frick Laboratory, American Museum of Natural History, did the first extensive excavating at the locality when Charles H. Falkenbach opened quarries there during 1928-1930 (Frick, 1930).

The University of Nebraska State Museum obtained fossils from the area first in 1901 and then later in 1917, when Dr. E. H. Barbour sent expeditions to the Niobrara valley south of Hay Springs. The Museum made some large-scale excavations there in 1940, when a quantity of fine specimens was collected; also some work was done there in 1956 and 1957. Deposits of the same age and also containing medial Pleistocene fossils were located farther east on the south side of the Niobrara

River in Sheridan County near Rushville and Gordon (see Fig. 1).

The main Rushville Fossil Quarry (U.N.S.M. Coll. Loc. Sh-3) had been discovered by C. H. Falkenbach of the Frick Laboratory in 1930 and was worked by University of Nebraska parties in 1932, 1933, 1937, 1938, 1940, 1956, and 1957. The quarries south of Gordon (U.N.S.M. Coll. Loc. Sh-5 and 6) were worked on a large scale in 1937, 1938, 1939, and 1941.

As a result of all of the collecting in Sheridan County during the century from 1857 to 1957, there is a vast amount of fossil material, as well as stratigraphic data, available. Unfortunately the chief fossil-producing zones represent more than one stratigraphic level and appear to range in age from late Kansan (or early Yarmouth) to early Illinoian. The largest concentrations of bones, however, appear to be coming from the Sappa sand and silt, and are pre-Illinoian in age (see Fig. 5). The Hay Springs Fossil Quarry (U.N.S.M. Coll. Loc. Sh-1) and the Rushville Fossil Quarry (U.N.S.M. Coll. Loc. Sh-3) were both reopened in 1956 in order to obtain more detailed information concerning the stratigraphic occurrence of the fossils (see Fig. 5). Fortunately most of the material collected since 1928 has been recorded stratigraphically and can be tied into the stratigraphic section. It is evident that a small amount of the material comes from the Crete sand and silt above the typical Sappa, and therefore is early Illinoian in age. There is no conclusive evidence that any of the main Sheridan County fossiliferous zones are late Illinoian or Sangamon in age as Hibbard (1956) has suggested. Hibbard based his conclusions on three partial rami and two left incisors of *Microtus pennsylvanicus* from a Hay Springs fossil locality which was worked by an American Museum of Natural History Expedition of 1897. Neither the exact location of this collecting locality nor the stratigraphic data can be determined for these specimens. All of the evidence at hand to the writers conclusively shows that the Sheridan County Fossil Quarries are in the base of the Terrace-4 fill and are pre-Sangamon in age and most of the specimens can be attributed to the late Kansan and Yarmouth.

The following mammals have been identified from the Hay Springs Quarries (U.N.S.M. Coll. Loc. Sh-1 and 9); *Paramylodon nebrascensis* Brown—Ground Sloth; *Megalonyx leidyi* Lindahl—Ground Sloth; *Cynomys niobrarius* Hay—Prairie Dog;

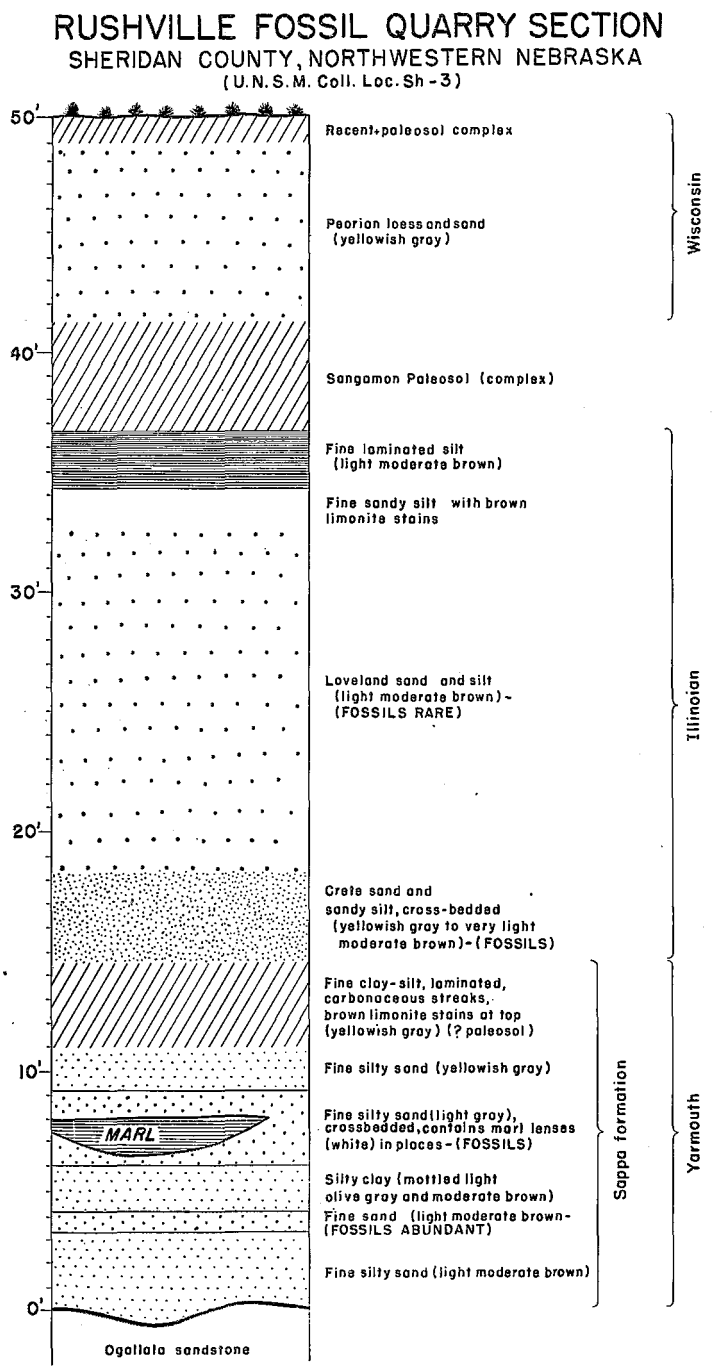

FIG. 5—See legend on opposite page.

Thomomys sp.—Western Pocket Gopher; *Castoroides? nebraskensis* Barbour—Giant Beaver; *Ondatra nebrascensis* (Hollister)—Muskrat; *Microtus* sp.—Vole; *Canis* sp.—Coyote; *Canis dirus nebrascensis* Frick—Wolf; *Arctodus simus nebrascensis* Frick—Giant Bear; *Mustela* sp.—Weasel; *Smilodon nebrascensis* Matthew—Sabre-tooth Tiger; *Mammuthus* (*Archidiskodon*) *imperator* (Leidy)—Mammoth; *Equus excelsus* Leidy—Horse; *Equus niobrarensis* Hay—Horse; *Equus calobatus nebrascensis* Frick—Stilt-legged Horse; *Platygonus vetus* Leidy—Peccary; *Camelops kansanus* Leidy—Camel; *Tanupolama americanus* (Wortman)—Llama; *Odocoileus sheridanus* Frick—Deer; *Capromeryx furcifer* Matthew—Subpronghorn; *Hayoceros falkenbachi* Frick—Falkenbach's Pronghorn.

The following mammals have been identified from the main fossil horizon below the marl bed (see Fig. 3) at the Rushville Fossil Quarry (U.N.S.M. Coll. Loc. Sh-3 and 4): *Sorex* sp.—Shrew; *Lepus* sp.—Jack Rabbit; Sciurid (*Citellus* group)—Ground Squirrel; *Cynomys niobrarius* Hay—Prairie Dog; *Dipodomys* sp.—Kangaroo Rat; *Geomys* sp.—Eastern Pocket Gopher; *Castoroides? nebraskensis* Barbour—Giant Beaver; *Castoroides* sp.—Giant Beaver; *Castor* sp.—Beaver; *Peromyscus* sp.—White-footed Mouse; *Ondatra nebrascensis* (Hollister)—Muskrat; Microtine, undetermined—Vole; *Canis* sp.—Coyote; *Canis dirus nebrascensis* Frick—Wolf; *Urocyon?* sp.—Fox; *Procyon* sp.—Raccoon; *Mustela* sp.—Weasel; *Smilodon nebrascensis* Matthew—Sabre-tooth Tiger; *Mammuthus* (*Archidiskodon*) *imperator* (Leidy)—Mammoth; *Equus excelsus* Leidy—Horse; *Equus niobrarensis* Hay—Horse; *Equus calobatus nebrascensis* Frick—Stilt-legged Horse; *Platygonus vetus* Leidy—Peccary; *Camelops kansanus* Leidy—Camel; *Tanupolama americanus* (Wortman)—Llama; *Odocoileus sheridanus* Frick—Deer; *Capromeryx furcifer* Matthew—Subpronghorn; *Hayoceros falkenbachi* Frick—Falkenbach's Pronghorn.

Middle Loup River Fossil Localities

It would be well to point out that the fossiliferous deposits ("Loup River Beds" of Meek and Hayden) along the Middle

FIG. 5—Rushville Fossil Quarry section, U.N.S.M. Coll. Loc. Sh-3, 14 mi. S. and 2 mi. W. of Rushville, NE ¼, NW ¼, sec. 9, T.29N., R.44W., Sheridan County, Nebraska.

Loup River do not appear to be exactly the same age as the fossil localities along the Niobrara River in Sheridan County. The Hayden expedition of 1857 collected fossils, including Leidy's fragmentary holotypes of *Mammuthus (Archidiskodon) imperator, Equus excelsus, Panthera augusta,* and *Stegomastodon mirificus,* from the Middle Loup region. The Yale College expeditions of 1870 and 1873 also obtained specimens (including Marsh's holotype of *Bison ferox*) from the same area on the Middle Loup. In 1916 an American Museum of Natural History Expedition collected some fossils from west of Seneca along the Middle Loup (Matthew, 1918). The University of Nebraska State Museum opened up several fossil quarries along the North Prong of the Middle Loup northwest of Mullen in Cherry County in 1930, and these (U.N.S.M. Coll. Loc. Cr-10 and Cr-11) have been worked from time to time since then (Schultz, 1934; Schultz and Stout, 1948). Extensive field work has been planned for the 1958 collecting season in this area.

The fossils from the main fossiliferous layers along the Middle Loup River near Mullen and Seneca appear to range in age from early to medial Pleistocene. A few specimens are similar to those from the Broadwater deposits, while some appear to have come from the Sappa near the base of the Terrace-4 fill, but the majority of the fossils are from the Crete sand and silt (early Illinoian in age), which is higher in the Terrace-4 fill than the Sappa deposits. Again careful stratigraphic collecting has helped to work out the correct sequence. The geomorphologic evidence is complex due to the movement of the sand dunes in the Sand Hills Region at various times during the latter part of the Pleistocene.

The stratigraphic information at hand, as well as the fossil material, indicates that there is some difference in age between the faunal assemblage found below the marl at the various Sheridan County fossil quarries (U.N.S.M. Coll. Loc. Sh-1, Sh-3, etc.) and the forms which occur above the marl in the Middle Loup River fossil quarries (U.N.S.M. Coll. Loc. Cr-10 and Cr-11). The Sappa deposits contain a typical interglacial faunal assemblage while the Crete has a glacial type.

Northeastern Nebraska Fossil Localities

It is gratifying to know that special stratigraphic studies in vertebrate paleontology are also being carried on in the glaci-

ated region of northeastern Nebraska and northwestern Iowa (Frankforter, 1950, 1957). Much is being learned about the stratigraphic sequence of the mammalian remains in this important area where the tills and intertill deposits can be definitely dated.

Pleistocene Problems

The use of paleosols in correlations has been increasing at a very rapid rate, but much is yet to be learned of their true value. Caution must always be exercised in order not to overemphasize the use of paleosols. One must remember that soils formed in the valleys differ from those that formed on the slopes of the valleys, or on the hilltops. Near the base of each terrace-fill a soil is to be found and this can be traced to higher levels and usually there are paleosol complexes in the upland areas where several soils of different ages are found one directly above the other.

The diagrammatic sketch (Fig. 6) showing the relationship of minor paleosols and carbonaceous layers of a valley to the major paleosol complex in an upland situation demonstrates the necessity of using the utmost care in giving age assignments to paleosols. Frequently thick humic zones appearing in a geologic sequence impress workers in the field, but attention should be turned to the clay-enriched zones, which represent strong B horizons of ancient soils, and also to the lime-enriched zones (C horizons) occurring below. Too often the number of paleosols exposed in a locality is considered as very significant and each paleosol is tied in with a theoretical interglacial or interstadial period, when in reality several paleosols may have been formed within the locality during a single interglacial or interstadial period of time (note the double interstadial paleosol in the upper portion of the Loveland in Fig. 7). The Sangamon paleosol complex is frequently made up of several (as many as six) different paleosols each separated by silt or loess. There are always minor if not major fluctuations in climatic conditions during both glacial and interglacial times. Frequently the evidence of some of the paleosols has been obliterated by subsequent erosion. In places a paleosol may appear to be very mature, representing a long period of time, while in another nearby locality a soil which appears as the equivalent may represent only a short duration of time. During

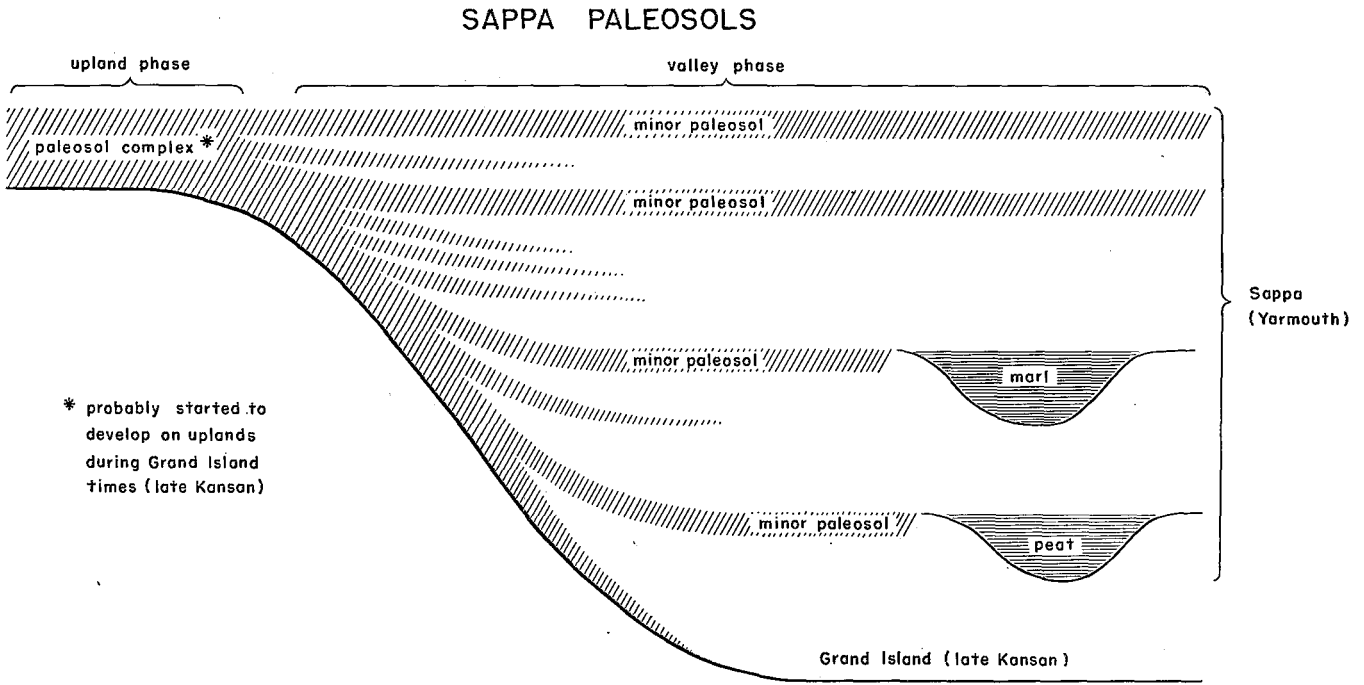

FIG. 6—Diagrammatic sketch showing relationship of minor paleosols and carbonaceous layers (in a valley fill) to the major Sappa paleosol (in an upland deposit).

Yarmouth times, for example, the soil formed on the higher surfaces during all of the interglacial period, while in the valleys the soils were buried intermittently by unusually heavy floods and slope wash (Fig. 6). Therefore, one must use extreme caution in considering a given paleosol as representing an entire interglacial period. As far as vertebrate paleontology is concerned, it should be pointed out that most of the fossils have been preserved in valley fills rather than in upland situations. Therefore a faunal assemblage could be considered as interglacial even though it may be found beneath a paleosol.

Extreme care should be exercised in the interpretations of paleoecological data. The staff members of the University of Nebraska State Museum and Department of Geology have been working with problems involved in paleoecology since 1939 (Schultz and Stout, 1939, p. 1967; 1948, pp. 560-562, Fig. 1) and recognize the difficulties which arise when a single species is used to demonstrate climatic conditions which existed at any given time. The entire faunal assemblage must be considered and special attention paid to the mammals which were forced to migrate when climatic conditions changed. The faunal studies must be extended to include fossil localities in all parts of the Great Plains region in order to get a regional picture of migrations, ecological and stratigraphic sequences, and extinctions. The University of Nebraska research program has included cave excavations in the Guadalupe Mountains of New Mexico and Texas, as well as in the Ozarks of Arkansas, and the northern Rockies in Wyoming. The Guadalupe caves have proven to be the best single cave region related to the Great Plains, since this area is adjacent to the chief migration routes of the mammals which were forced to migrate out of the northern and central Great Plains because of advancing glaciers and deteriorating climatic conditions. Cave faunas associated with both the Valders and Cary[6] glaciations are now known as a result of work in the caves in 1937-1940, 1946, and 1954-1955.

There seems to be little agreement about the paleoecological conditions under which loesses were deposited during the medial and late Pleistocene. There appear to be at least three major problems concerning the loess itself: *first,* the source;

[6] Carbon-14 tests by W. F. Libby, Institute of Nuclear Studies, Univ. of Chicago, and Meyer Rubin, Low Radiation Laboratory, U. S. Geol. Surv., Washington, D. C., have confirmed these age assignments.

BUZZARDS ROOST SECTION

LINCOLN COUNTY, SOUTHWESTERN NEBRASKA

(U.N.S.M. Coll. Loc. Ln-103)

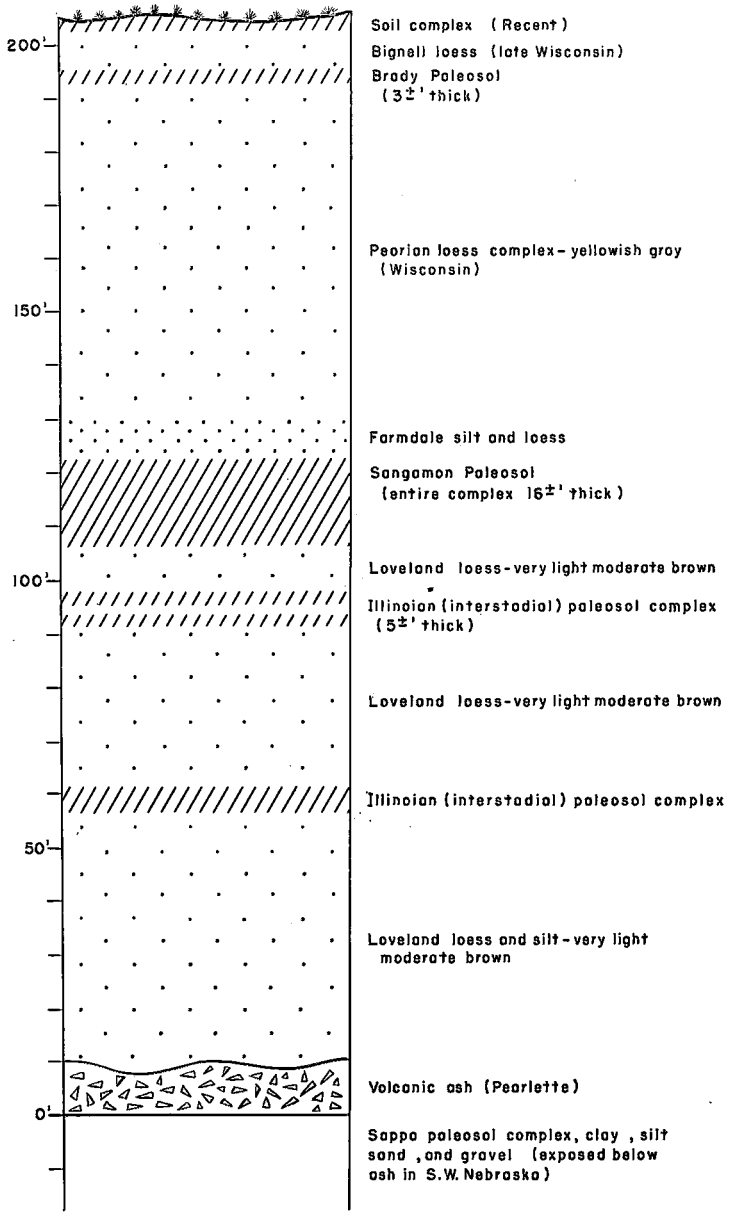

FIG. 7—See legend on opposite page.

second, time of deposition; and *third,* climatic conditions at time of deposition (Lugn, 1935, 1957; Leonard and Frye, 1954; Frye and Leonard, 1957).

Vertebrate fossils are rarely found in typical loess deposits but are frequently associated with the paleosols, usually in the carbonaceous zones (A horizons) and immediately above (see Fig. 7). The fossil gastropods, on the other hand, are found in the loess deposits between the paleosols (Frankel, 1956, 1957) where the vertebrates are absent. The shells appear to be absent in the paleosols due to the process of leaching. Certainly there is no evidence of extensive leaching during the time of deposition of the loess, since the shells of the pulmonate gastropods are so well preserved. The vertebrate remains are entirely absent, strongly suggesting that the climate deteriorated to such an extent during the heavy deposition of loess that the larger vertebrates, at least, could not exist. Why did the pulmonate gastropods survive if climatic conditions were not favorable? Seasonal fluctuations in weather may be the answer to the apparent contradictions of evidence. There may have been some part of the year when rainfall was abundant and it was comparatively cool, but the main part of each year must have been warm and dry. This undoubtedly would have permitted the migration of sands in the Sand Hills Region, the blowing of loess, and perhaps even the proper ecological conditions for the pulmonate gastropods to exist actively at least intermittently in the Plains area.

Moist conditions apparently prevailed over the Central Plains during the first half of the Pleistocene and there was very little loess deposited during this time, but during the latter half there was an ever-increasing amount of loess being deposited (Fig. 7). The accumulated uplift in the Rocky Mountain region and in the areas westward to the Pacific coast, from

FIG. 7—Buzzard's Roost section, Terrace-4 fill, U.N.S.M. Coll. Loc. Ln-103, 6 mi. S. and 8 mi. W. of Gothenburg, W ½, SE¼, sec. 7, T.10N., R.26W., Lincoln County, Nebraska. The Buzzard's Roost section shows more details of the lithology and paleosol occurrence than in the Nuckolls, Saunders, and Sheridan counties' sections because of the greater thickness of the deposits. A. L. Lugn (1935, 1957) attributes the thickness of the loess to the nearness to the source area ("Sand Hills Region") and the direction of prevailing winds at the time of deposition.

late Kansan to early Illinoian times, may well have produced a physiographic barrier or "rain shadow" effect (Schultz, Lueninghoener, and Frankforter, 1951, p. 26) on the Nebraska region, which could have resulted in deteriorating climatic conditions from Illinoian times to the present.

The value of Carbon-14 in dating geological and paleontological deposits can not be overemphasized, but again caution must be used in order not to jump to conclusions before an adequate number of tests have been made in connection with a given stratigraphic level.

Conclusions

The discovery of the new fossil vertebrate quarries of Yarmouth age in Terrace-4 fills in Saunders and Nuckolls counties, Nebraska, is aiding in confirming the dating of the Sheridan County fossil localities near Hay Springs, Rushville, and Gordon. The fossils from the latter quarries, which are located stratigraphically in Terrace-4 fills, vary in age fram late Kansan to early Illinoian but most of the forms (from Sappa deposits) appear to be Yarmouth in age. The fossil quarries along the Middle Loup River near Mullen, Nebraska, also are in a Terrace-4 fill, but a majority of the specimens appear to come from an early Illinoian deposit (Crete sand and silt).

It is evident that much future work will be required from a great number of people, all cooperating with each other and working in various related fields of geology and associated sciences, in order to solve the problems of the Pleistocene. Geologists and paleontologists have only "scratched the surface" in this vast undertaking, but it also should be noted that a great deal of progress is being made by a large number of participants.

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