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The Inapplicability of the Concept of the “Sidney Gravel” to the Ogallala Group (Late Tertiary) in Part of Southern Banner County, Nebraska

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A series of geologic maps of counties in western Nebraska was prepared for the Nebraska Geological Survey during the mid-1930s. These maps showed the distribution of rock units of Tertiary age including a formation designated as the “Sidney.” The Sidney Gravel was described as a widespread sheetlike complex of channel deposits, but with small areas where it is not developed. In southern Banner County, Nebraska, there are several channels filled with sand and gravel that were mapped as Sidney in this series. Recently one of these channel fills has been observed to cut across the other. The fills are separated from one another by an opaline siltcrete bed. In places these deposits directly overlie beds mapped previously as parts of the younger Kimball Formation.

While the local Ogallala lithostratigraphic relationships can be worked out, the exact relationship between the fills in Banner County and the type Sidney could not be precisely determined in the 1930s and cannot be worked out today. The concept of a gravel sheet does not apply to the study area in Banner County.

† † †

INTRODUCTION

In the mid-1930s Gilbert C. Lueninghoener and A. L. Lugn prepared a series of undated geologic maps of several counties in western Nebraska at a scale of 1:63,360. According to Lueninghoener (1983, personal communication) the geologic map for Banner County, Nebraska, was prepared by him probably during 1933 or 1934 using the county soil survey report and map prepared by Hayes and Bedell (1921) as a guide. Lueninghoener followed the existing roads in the area

and drew in contacts between several geologic formations on a county base map. After this preliminary preparation of the map, Lugn toured the county with Lueninghoener and checked the map. The final product [Lueninghoener and Lugn, 1933(?)] was drafted and is on file at the Nebraska Geological Survey, University of Nebraska-Lincoln. The formations shown on the map from youngest to oldest are the Kimball, Sidney, Ash Hollow-Valentine, Harrison, Monroe Creek, Gering, and Brule. Lugn (1939: Plate 1) lumped the Kimball and Sidney, and the Monroe Creek and Gering on his geologic map of the Nebraska panhandle. The formation contacts drawn on the 1939 map (prepared in 1938) in Banner County closely conform to those shown on the earlier geologic map of the county by Lueninghoener and Lugn and seem to indicate that Lugn's view of the relationships between formations was probably unchanged from the mid to the late 1930s.

There are many interesting aspects of the Lueninghoener and Lugn geologic map of Banner County, but perhaps the most interesting is the differentiation of the Ogallala Group into three map units: the Kimball, Sidney, and Ash Hollow-Valentine. The part of the map where these three units are shown to occur in the study area has been reproduced in modified form (Fig. 1A) for this report and will be referred to again later, but for the moment all that should be noted is that the authors of the map believed that separate formations in the Ogallala could be mapped in the county.

Later, Condra and Reed (1940) produced a geologic map

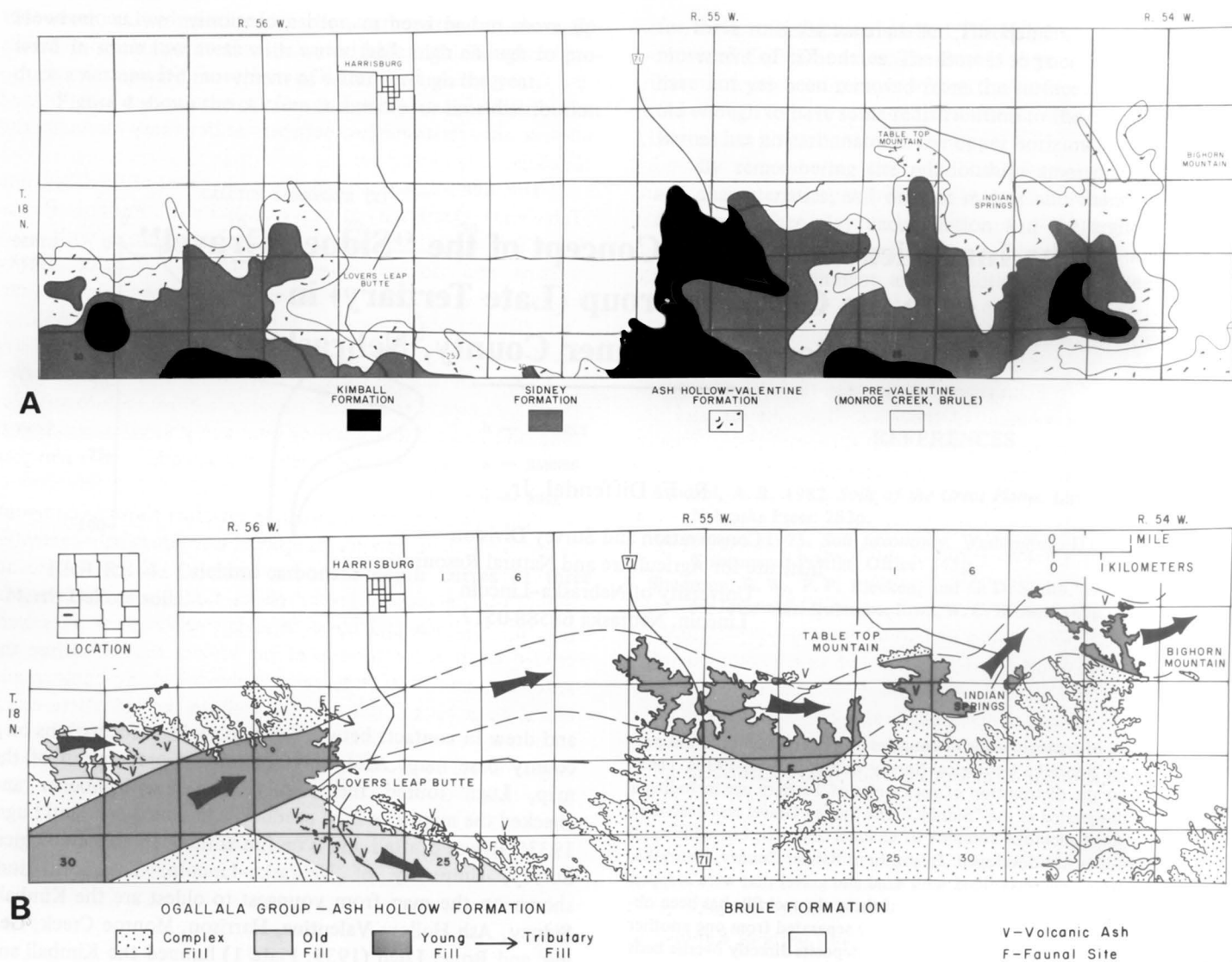


FIGURE 1. Geologic maps of the study area. A. Lueninghoener and Lugn map (slightly modified) prepared in mid-1930s. B. Map prepared for this report. Some parts of complex fill overlying older fill not shown so that older fill trend can be emphasized.

of Nebraska at a scale of about 1:500,000. The part of this map for Banner County is a reasonably faithful reproduction of Lugn's map prepared in 1938. The accompanying legend shows the conceptual subdivisions of the Ogallala defined by Lugn in 1938 and 1939. A revised edition of the state map completed by Condra and Reed (1950) has no significant change in the distribution or subdivision of the Ogallala in Banner County.

Between 1950 and 1969, the views of geologists on the staff of the Nebraska Geological Survey seem to have changed regarding subdivision of the Ogallala. The Ogallala was reduced to formation rank and is shown unsubdivided on an edition of the state geologic map compiled by R. R. Burchett (1969).

Published descriptions and discussions of the Ogallala and the Sidney also vary greatly. The heterogeneous nature of the Ogallala was recognized even in the early descriptions by Stansbury (1852) and Engelmann (1876). The first geologic reports containing maps showing the distribution of the Ogallala in Banner County were prepared by Darton (1899, 1903a, 1903b, 1903c) and by Adams (1902). As indicated previously, later mapping resulted first in attempts at subdivision of the Ogallala and still later in a return to a single map unit.

The subdivision of the Ogallala into formations including the Sidney Gravel was proposed originally by Lugn (1938). He (1939) expanded his descriptions of these formations and described the Sidney as "... a quite widespread sheet-like

complex of channel deposits, but there are small areas where it is not developed; and, in such places, the Kimball formation rests directly on the Ash Hollow formation commonly with apparent lithologic continuity." Lugn (1939:1,262) went on in the same paragraph to report similar, but less widespread, gravel deposits in the Ash Hollow Formation. In the first edition of *The Geological Section of Nebraska*, Condra and Reed (1943:10) continued to recognize a formation called the Sidney Gravel. Their condensed description after Lugn (1939) of the Sidney is of a "... channel or basin deposit in southwestern Nebraska, northeastern Colorado, and at places in northwestern Kansas, but not widely persistent, yellowish to dark brownish, fine to coarse, with some pebbles, thickness variable, 0-50'." Schultz and Stout (1948:555) designated the Sidney as a member of the Kimball Formation and described it as a basal "... gravel and silt member ... locally unconformable on other beds, but generally affording a transition from the latest Ash Hollow sand and gravel channels." By 1959 the concept of the Sidney Gravel had reached the point where E. C. Reed (Condra and Reed, 1959: first of four unnumbered pages inserted between page ii and page iii) called the Ogallala a formation consisting of three members (Kimball, Ash Hollow, and Valentine) and did not mention the Sidney at all. Since the publication of this less-than-helpful redefinition, reference to the Sidney has appeared from time to time (see Stout, 1965, 1971), and the concept has been attacked by Breyer (1975, 1981), who concluded that the Sidney and Kimball formations are not valid rock-stratigraphic units. Through all of this work one fact remains true. There can be no doubt that there was a gravel at the type area designated for the Sidney by Lugn (1939) at Sidney, Nebraska. What was and is still in doubt is the extension of this unit over large areas of the southern panhandle of Nebraska, adjacent areas of southwestern Nebraska, and parts of Kansas and Colorado.

RESULTS OF STUDY

The author has been mapping recognizable lithostratigraphic units in western Nebraska since 1975 following the advice and counsel of several geologists and paleontologists to "keep an open mind" on stratigraphic problems in the area. By 1980 the author had reached eastern Banner County and had decided to test further the concept of the Sidney Gravel Formation to see whether such a clearly defined mappable unit occurred in the area. What follows are the results of that test.

Any spot that had been mapped in detail by Lugn could be taken for examination of the Sidney question. The area south of Harrisburg, Banner County, Nebraska, was selected for four reasons. First, it had been mapped topographically and the map published in 1895 at a scale of 1:125,000.

Second, it had been mapped geologically by Lueninghoener and Lugn. Third, it had been the scene of excavation of fossils by field parties from the University of Nebraska State Museum. And fourth, it had excellent exposures which showed clearly the relationships between sedimentary units in the Ogallala.

The area selected is along the escarpment of the Cheyenne Tablelands. Quaternary stream erosion by tributaries to Pumpkin Creek (north of the study area), combined with mass wasting and downslope movement, has produced deeply incised draws cut into the rocks beneath the tablelands surface. The remaining Ogallala beds exposed along the walls of the draws and on remnant divides between the draws, are easy to observe and map. Figure 1B is the map of the area prepared for this report. The Ogallala has been subdivided into an older sand and gravel fill, a younger sand and gravel fill which cuts across the older fill, some small tributary fills, and a complex fill of great age range.

The older fill, disconformable on older rocks, is conglomeratic at the base and grades upward into irregularly cemented sand and gravel. A volcanic ash bed up to 3 m thick occurs within this deposit. In several places along the outcrop belt of the fill, this ash and older Ogallala pebbly sandstones were eroded later in the history of the stream that deposited the sediment, and fragments were redeposited as boulder and block megaclasts (Figs. 2 and 3) within the fill. These megaclasts may be more than an order of magnitude larger than the largest clasts in the unit derived from erosion of the Rocky Mountains in north-central Colorado. One ash block is 2.0 x 3.4 x 9.1 m.

The maximum outcrop thickness of the older fill is about 20 m. The unit is capped by a prominent opal horizon, overlain

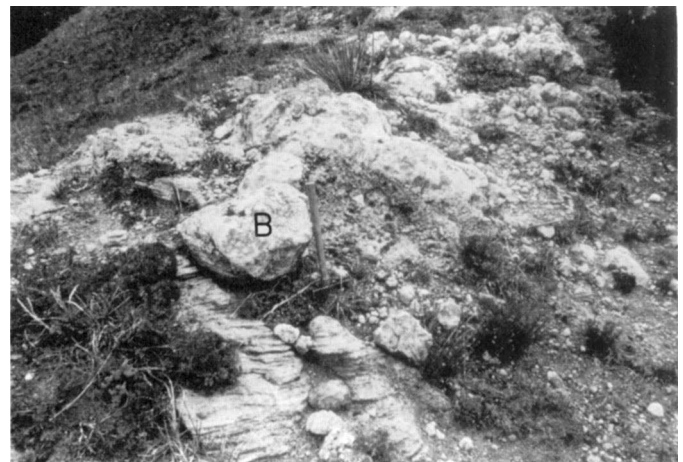


FIGURE 2. Locally derived Ogallala boulder (B) megaclast in older Ogallala conglomerate fill. Hammer is 40.6 cm long.

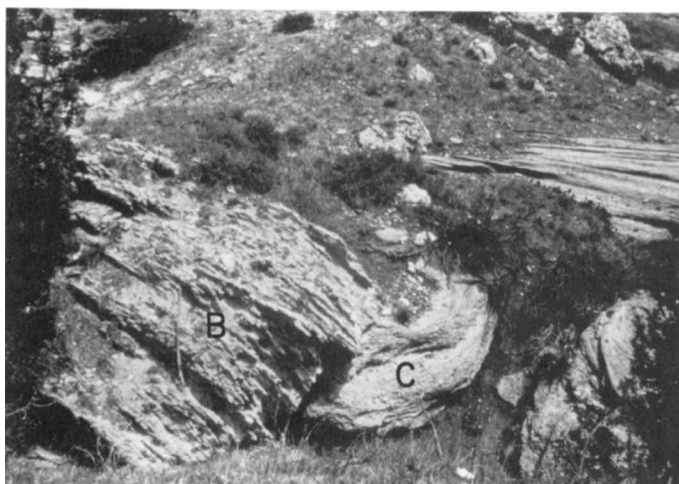


FIGURE 3. Megaclast block (B) of indurated volcanic ash in trough cross-bedded conglomerate (C) of older fill.

by pebbly sands, pebbly sandstones, calcretes, and other beds, all of which form a part of a complex fill which is less easily differentiated than other parts of the Ogallala.

A younger fill unconformably cuts across the older fill, and in places east of Nebraska Highway 71 occupies an anastomosing channel that a river eroded through older Ogallala beds and into pre-Ogallala siltstones. This younger deposit is cemented basally in many outcrops. Up to 5 m of the basal sediment is composed of locally derived gravel and sand clasts. The majority of the fill is dominantly granitic sand and gravel apparently derived from the same source area in north-central Colorado as the sediment in the older fill. The maximum diameters of these distantly derived clasts are up to five times greater than those of the same types of clasts in the older fill. Locally derived megaclasts, both blocks and boulders, occur in this unit. Opal cobbles and boulders occur in the young fill and probably were derived, at least in part, from erosion of the opal horizon capping the older fill.

Volcanic ash occurs in the younger fill on the flanks of the paleovalley on the Brown and Van Pelt ranches (SE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 4, T. 18 N., R. 54 W. and NW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 13, T. 18 N., R. 55 W.). At both sites the ash occurs above a massive pebbly sandstone (Fig. 4) resembling some types of recent colluvium in the area.

Several small tributary fills have been identified in the map area. They occupy such small paleodrainages that they do not show up well on maps even at a scale of 1:24,000. The positions of these fills are shown on Figure 1B. Their relationships to one another and to the larger units described earlier are not clear in most cases because the tributaries are isolated features. In all cases the coarser sediments in these tributary fills were derived by stream erosion of older rocks near the fill.

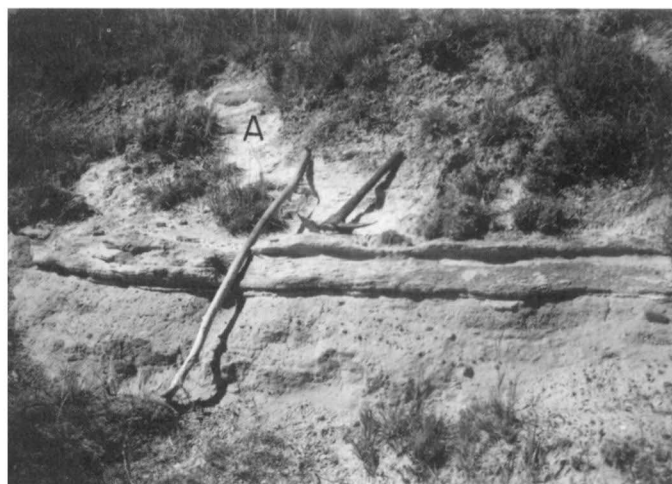


FIGURE 4. Volcanic ash bed (A) about 1.5 m thick deposited along side of tributary to younger sand and gravel fill. Ash and underlying pebbly sandstone bed have primary dips toward paleovalley.

Much of the Ogallala in the area is too complex to subdivide into smaller lithologic units at a scale of 1:24,000. This complex fill has been lumped as one unit because the author could find no good place to subdivide the sequence into smaller lithologic units.

INAPPLICABILITY OF THE SIDNEY COMPLEX

It is possible to map units within the Ogallala in the study area. Such units include major sand and gravel and/or conglomerate fills and volcanic ash lentils. Other lithostratigraphic units might be identified and mapped if enough time were devoted to the project.

None of the sand and gravel units has the geometry attributed to the Sidney by Lugin. These bodies are not "sheetlike" but rather fill valleys eroded by streams into older rocks. The valleys generally are less than 3 km wide and up to 60 m deep. They have low sinuosity and irregular bedrock floors with up to 20 m of relief.

It could be argued that the older and younger fills might all be the "Sidney." The opal horizon at the top of the older fill is evidence against this argument. Such opaline duricrusts, or silcretes, were described by Reeves (1976) and Wopfner (1978) as supergene and pedogenic in origin. Apparently they take considerable time to form and indicate a relatively stable environment during their development. Both the younger and older fills are discrete units and cannot be traced and connected with the deposits known to be Sidney at the type area. These factors argue against placing either fill in the Sidney.

Whatever their lithostratigraphic position within the Ogallala, the two sand and gravel fills were not recognized by Lueninghoener and Lugn. Their assignment of the younger fill to three lithostratigraphic units (*compare* Figs. 1A and 1B) indicates this lack of understanding started at the very beginning of the application of the idea of the Sidney Gravel to the Ogallala sequence in this part of Banner County.

CAUSES OF STRATIGRAPHIC PROBLEMS

Despite the problems in applying the concept of the Sidney Gravel, it might be asked why there are still disputes about the lithostratigraphic subdivision of the Ogallala Group after more than 80 years of study of this mass of rocks in Nebraska and adjacent states by many researchers. For that matter, why are there similar arguments still going on about the rock-stratigraphic boundaries between some of the formations in the Hemingford, Arikaree, and White River groups [e.g., *compare* Hunt (1981) and Schultz (1938) on the Hemingford-Arikaree]? The causes of these problems, in part, are due to the differences between authors over establishment of objective physical criteria for subdividing these rock units and to variations in adherence to the rules of an accepted stratigraphic code. Another cause may be the seemingly unconscious attempt by some to apply principles for subdivision of rock sequences deposited in marine environments to the subdivision of continental sequences. The assumption by some authors of the synchronicity of alluviation in all paleovalleys without adequate proof that synchronous events had actually occurred is yet another cause of difficulties. Finally, as Krauskopf (1968) pointed out, some questions may not have answers, and some of the questions asked about the Ogallala and other Tertiary units may be unanswerable ones.

The problem of developing objective criteria for subdividing the Ogallala can be illustrated by comparing some of the views of Schultz and Stout with those of this author. Schultz and Stout (1980) outlined their concept of Cenozoic cyclic sedimentation on the Great Plains and described the Ogallala cycles (p. 192, and Fig. 4). They recognized an "end-Ash Hollow soil," or caliche (best developed at Cedar Point in Keith County), containing many concretions, which they called root-casts of yucca. Above this soil there is supposed to be a minor unconformity separating the Ash Hollow from the overlying rocks of the Ogallala that Schultz and Stout assigned to the Kimball Formation. At the top of the sequence designated as Kimball, Schultz and Stout (1980: Fig. 4) noted an end-Ogallala caliche above which is a major unconformity. It is unclear from their discussion (p. 192) whether or not the caliche in their Figure 4 is the same as the "end-Ogallala soil-complex." It is also unclear whether or not the soil-complex is equivalent to the Kimball Formation, and whether or not the caliche in Figure 4 is the "High Plains Surface." [Schultz

(1981:59) cleared up one of these problems by showing the "High Plains Surface" at the top of the Kimball.] What seems clear from their writing is that each major depositional cycle of a group/stage is supposed to begin with drought and erosion, which produces a major unconformity, followed by alluviation. Minor cycles of the same style occur within groups, according to Schultz and Stout, and each cycle (major and minor) ends with development of a soil.

These concepts of Schultz and Stout are interesting but cannot be applied unambiguously to the Ogallala sequence in the opinion of the writer. Their "end-Ash Hollow soil" cannot be traced for more than a few sections in the vicinity of Cedar Point on the south side of the North Platte Valley. At Cedar Point there are several exposures where more than one of these "root-cast" horizons occur, while at other places in adjacent drainages only one or none is present. In fact, similar caliches occur along the North Platte from Sarben to near Rush Creek, but they are discontinuous and variable in number. Demonstrable erosional unconformities which cut these beds have not been documented and Stout (1971:44) even placed the "Yucca bed" at Cedar Point in the Kimball, rather than the Ash Hollow, illustrating the difficulty of deciding where to make a formation break in this part of the Ogallala section.

This author will certainly agree that there is a major erosion surface at the top of the Ogallala in western Nebraska, but the "end-Ogallala soil-complex" or "end-Ogallala caliche" of Schultz and Stout that occurs beneath this surface in places cannot be shown unquestionably to have been the end of Ogallala deposition in the southern Nebraska panhandle. For that matter no one has shown that the uppermost caliche in the Ogallala sequence in Kimball County, Nebraska, is the same rock unit as the uppermost caliche in Banner County, Nebraska. The Sidney Gravel is supposed to occur just above the unconformity separating the Ash Hollow from the Kimball, but "the Sidney gravel" does not occur everywhere by Stout's own admission [see Ogallala measured sections in Stout (1971)]. I am certain that there is no way to prove that the discontinuous gravel units called Sidney by Stout were ever part of a single rock unit.

Both the *North American Stratigraphic Code* (Anonymous, 1983) and the *International Stratigraphic Guide* (Anonymous, 1976) are clear on the criteria to be used in subdivision of lithostratigraphic sequences, and to my view none of these criteria can be applied at this time in an unqualified manner to the Ogallala beds between the North Platte River and the Colorado-Nebraska border in the Nebraska panhandle. For example, no one has shown that the Ogallala is a gradational sequence. No key beds occur in the sequence across the region, and no unconformities other than those at the base and top of the Ogallala have been shown to be traceable for more than a few kilometers. As pointed out earlier in this paper, more than one local unconformity occurs in the Banner County study area, but these cannot be traced across the region. While

the cyclic concept of Schultz and Stout (1980) might allow subdivision, if such cycles could be delineated, each subdivision probably would yield so many local formations or members with questionable relationships to one another that understanding of the Ogallala would not be furthered by adding more units to the literature.

While not explicit it seems that Schultz, Stout, and their co-workers initially recognized the Kimball (and thus the Sidney) by the species of included fossil faunas and floras rather than by physical evidence of a regional formation break. If this is so, then they have mixed biostratigraphic and lithostratigraphic units with the result of producing the circular argument that these rocks are part of the Kimball Formation because they contain Kimball fossils and vice versa.

The author knows of no way of proving it, but I believe that Lugn's concept of the sheetlike Sidney Gravel may have been the result of applying one or both of two ideas to the problem of subdividing the Ogallala, that is, (1) at least some fluvial Tertiary formations were similar in geometry to marine units and (2) alluviation was synchronous in all pre-Ogallala paleovalleys during the deposition of the Ogallala. The fact that gravels called Sidney by Lugn in Banner County are not sheetlike has been demonstrated earlier in this paper. The idea of synchronicity of deposition has also been shown to be questionable, because time does not enter into separation of lithostratigraphic units if the stratigraphic codes are followed.

CONCLUSIONS

Given enough time and luck, an investigator of the Ogallala can identify some mappable units within the group and can trace them for some distance on the surface and in the subsurface. These units have complex cross-cutting relationships that are not easily worked out with precision except on a local basis. The lithostratigraphic correlations of parts of the Ogallala over broad areas made in the past are probably incorrect given the complexities viewed even in the small area just described. The dating of the volcanic ash beds found in association with the sand and gravel fills might help to establish more firmly correlations with other dated Ogallala sequences. Further careful faunal and floral collection might help to work out the regional biostratigraphy in greater detail, but precise lithologic correlations of units smaller than major fills from one Ogallala paleovalley to another may continue to elude us in the future. We can no more map a correlative Sidney Gravel in the study area in Banner County today than Lueninghoener and Lugn could in the 1930s.

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