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Inherited Morphologies of Two Large Basins in Clay County, Nebraska

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INHERITED MORPHOLOGIES OF TWO LARGE BASINS IN CLAY COUNTY, NEBRASKA

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Abstract. *The Rainbasin area of south-central Nebraska is an important component of the central flyway of migratory waterfowl. Little is known or has been reported about the morphology of large basins in the Rainbasin. A subsurface investigation was conducted to determine the morphology of two basins in Clay County, Nebraska. Transects were located across two sample areas, and seventeen test holes were drilled to determine loess thickness and stratigraphy. Radiocarbon dates were obtained from buried paleosols. The modern basin landscape was determined to be a direct result of 2.5 to 8 m of loess deposition on an older basin landscape. The modern landscape generally mirrors the paleolandscape except that the modern basin ridges seem to have less relief than the paleoridges. The paleobasins were formed prior to the Early Wisconsinan deposition of the Gilman Canyon Formation. It is likely that other large basins within the eastern Rainbasin are underlain by paleobasins and are the result of prior basin-forming processes.*

Along the United States central flyway of migratory waterfowl lies a loess-mantled plain in south-central Nebraska. Parts of that plain are characterized by large basins that are wetlands during wet periods and dry basins at other times. These basins have a silty clay subsoil with a very low rate of hydraulic conductivity. This subsoil causes water to perch above it and eventually pond at the surface. The ponding of rainwater in the basins has led to the area being called the "Rainwater Basin," or more succinctly, the "Rainbasin." The Rainbasin contains essential wetland resources along the central flyway. Each spring, 90% of the mid-continental population of white-fronted geese, 50% of its breeding mallards and 30% of its breeding pintails gather there (Farrar 1989).

Relatively little documentation and some misconceptions surround the numerous wetlands and basins of the Rainbasin. Field surveyors in the 1850s provided the first written evidence pertaining to the basins, but did not establish section corners at certain points along their traverses because of wetlands (Branan et al. 1859). At these points the surveyors simply placed "Xs" on the maps. Although McMurtrey et al. (1972) published an inventory of the wetlands within the Rainbasin, little is known about its origin. The scientific literature dealing with the Rainbasin is sparse. Patrick Starks (1984), developed a basic geography of the depressions in Clay County. In addition to a map of the basins, the cartographic and quantitative analysis recognized that some of the basins in the county are "breached," (i.e., they exhibit external drainage). In addition, Starks focused on the many "lunettes," crescent-shaped ridges found on the south and east sides of 51 of the 120 depressions studied. He found that the pattern of lunettes extends diagonally from the northwestern corner to the southeastern corner of the county. The large depressions tend to be elliptical in shape while the small ones have varied shapes, and the surface area and volume of the depressions and lunettes are linked statistically. James Krueger (1986) focused upon the origin of the depressions based on the stratigraphy of a basin located in central York County, Nebraska. Sediments collected from 16 test holes indicated that the basin was formed during the Wisconsinan period. In addition, Krueger concluded that the shape of the basin was modified by strong prevailing winds and lake currents during a moist phase of the Wisconsinan.

Basins of similar form occur in many areas of the Great Plains, but their origins appear to differ from one region to another. Basins in west Texas and eastern New Mexico formed in Quaternary, Pleistocene, and Pliocene deposits by either "cap rock" leaching and deflation (Judson 1950; Havens 1961; Reeves 1966) or by deflation alone in locations where calcrete caprock was absent (Wood et al. 1992). Large basins in western Kansas formed as a result of solution of salt, gypsum, or chalk, while the small depressions formed by wind scour, differential compaction, and differential silt infiltration (Frye 1950).

Materials and Methods

Objective

Basins within the Rainbasin are important wetland resources, however, little is known about their morphology. The objective of this study was to determine the morphology of two basins in Clay County, Nebraska, by conducting subsurface investigations to obtain stratigraphic control. This stratigraphic information should provide insight into the origin of the basins and basic data that is essential for the proper management of the Rainbasin.

Setting

The Rainbasin covers all or part of 16 counties, approximately 10,880 km^2 (Fig. 1), and is in the Central Loess Plains Major Land Resource Area (Soil Conservation Service 1981). Nearly level uplands, containing numerous small pothole depressions and less numerous large basins, characterize the Rainbasin. Potholes are small and irregular in shape and range from about 0.1 to 30 ha in area and are generally less than 1 m below the surrounding land at their lowest point. The basins are oval and elongate in shape and range from about 0.4 to 10 km^2 in area. The floors of the basins are generally 2 to 5 m below the surrounding upland. Because the potholes are shallow, they are not discernable on topographic maps with contour intervals of 1.5 m or greater. The potholes and basins are easily recognizable on soil maps (Fig. 2) because these landforms are represented by one or more soil map units.

The Platte River was the regional source of the Peoria Loess (Miller et al. 1964), which is the dominant surficial material of the Rainbasin. Robert Ruhe (1984) noted that there were probably numerous episodes of loess deposition throughout the midwestern United States. Loess has been shown to have a smoothing effect on the topography on which it was deposited (Hock et al. 1973), but a modern loess-mantled surface can be a reflection of a paleolandscape (Norton 1984). The material on which the modern soils in the eastern Rainbasin have formed is probably a combination of Bignell and Peoria loess units (Dreeszen 1970). Bignell Loess is younger than Peoria Loess and is generally separated from Peoria Loess by the Brady Soil (Schultz and Stout 1948). In the eastern Rainbasin, the Brady soil is normally not present and the Bignell Loess is not thick enough to be easily distinguished from Peoria Loess. Kuzila and Lewis (1993) suggested that Bignell Loess can be distinguished from Peoria Loess in the laboratory by using particle size analysis and clay mineralogy. The Gilman Canyon Formation generally underlies the Peoria Loess (Reed and Dreeszen 1965) and separates it from the underlying strata. The Gilman Canyon Formation can be variably composed of loess, eolian sand, and alluvium (May and Souders 1988).

Field Study

Soil and topographic maps were surveyed to locate breached basins in Clay County, Nebraska. Two sample areas (Fig. 3) were selected on the basis of landowner cooperation and soil and landscape characteristics typical of basins in the eastern Rainbasin. Breached basins, those that have been

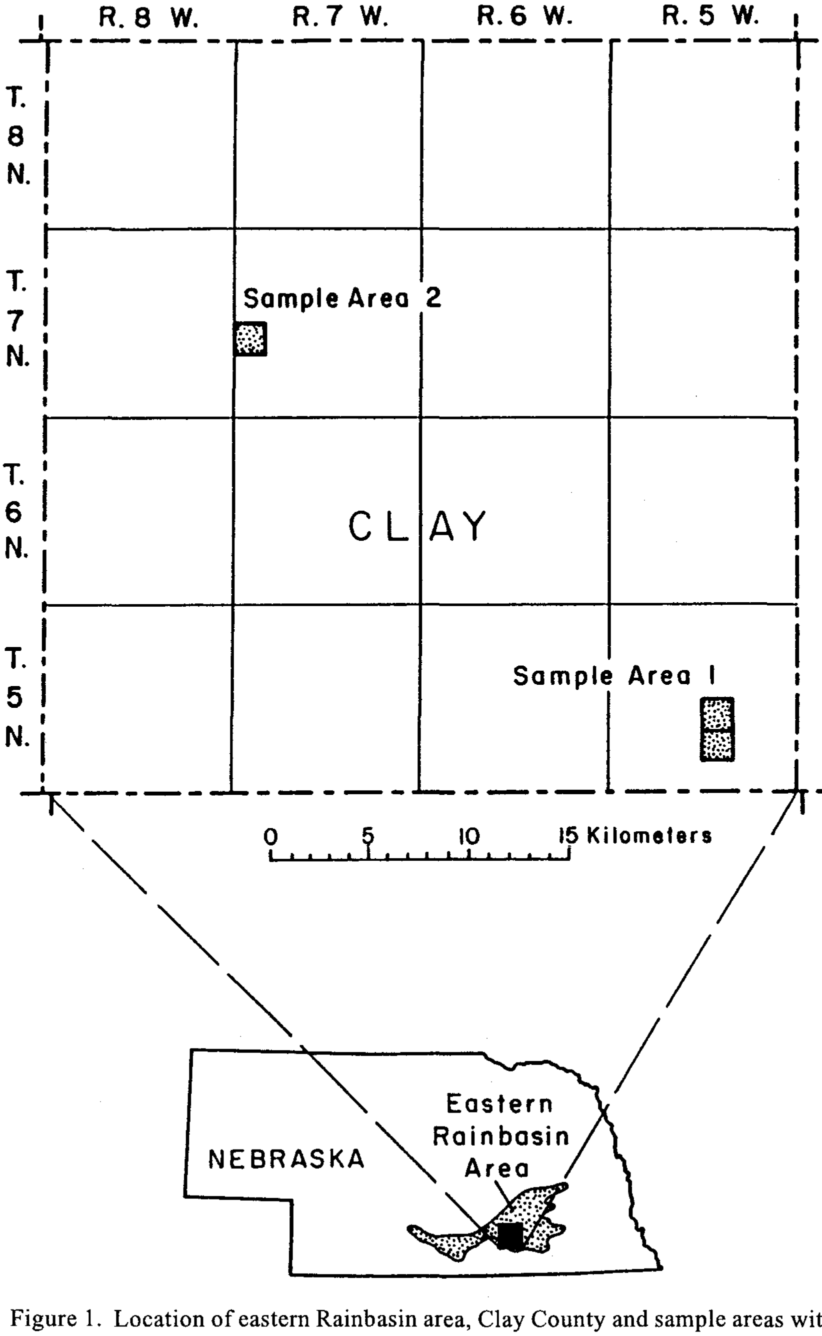

Figure 1. Location of eastern Rainbasin area, Clay County and sample areas within Nebraska.

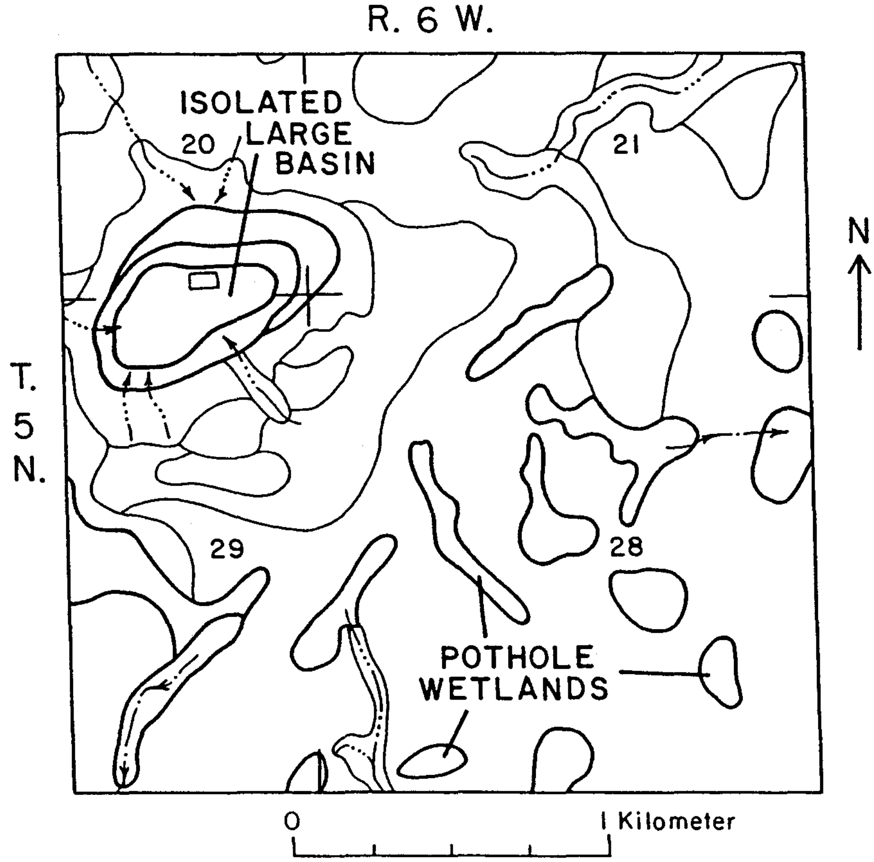

Figure 2. Soil map showing potholes and an isolated large basin. SE 1/4 Sec. 20, S 1/2 Sec. 21, E 1/2 Sec. 29, and Sec. 28 Township 5 N., Range 6 W. (Hammer et al. 1981)

naturally drained, were used as study sites to facilitate drilling and sampling operations. Transects were located across the basin in order to obtain stratigraphic information from the three landscape positions: upland, basin-rim, and basin-floor (Fig. 3). The transect at area 1 ran across the entire basin. The transect at area 2 ran across only a portion of the basin because the basin-floor at area 2 is artificially flooded as part of a wildlife management program.

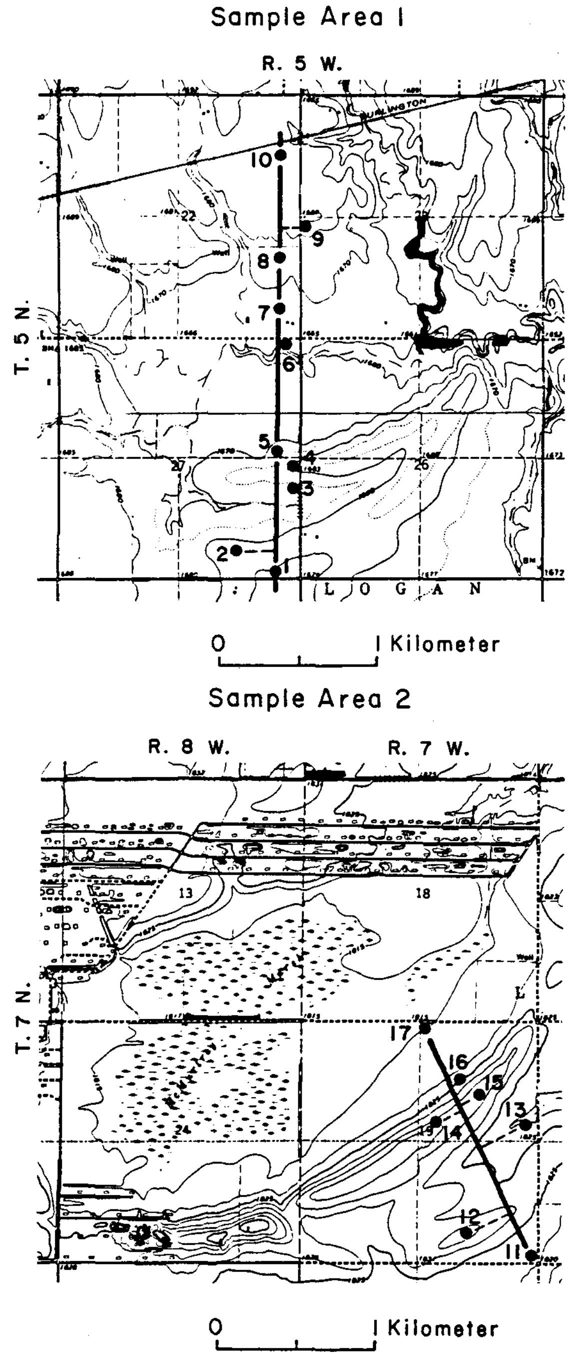

Figure 3. Location of transects and test holes within sample areas.

Along the transects, 17 test holes (Fig. 3), 10 at area 1 and seven at area 2, were cored to depths as great as 22 m to determine loess thickness and stratigraphy. Cores were taken with a hollow stem auger and split-tube core barrel by a Central Mining Company model 75 drill rig. The color, texture, and thickness of the stratigraphic layers were described by the Soil Survey Staff (1991). A description of representative testholes are found in Table 1.

Samples that ranged in weight from 500 to 750 g were collected from the top 15 to 20 cm of a buried soil from test holes 2, 6, and 10 (Fig. 3). For comparison, a buried soil, thought to represent the same stratigraphic layer as the buried soil found in test holes 2, 6, and 10 was sampled at the Spring Ranch roadcut, which is 32 km west and 5 km north of area 1 (300 m south of the northwest corner of sec. 4, T. 5 N., R. 8 W., Clay County, Nebraska). Radiocarbon dates of all samples were determined by Beta Analytic Inc., Miami, Florida.

Results and Discussion

The shape of the present land surface is a direct result of 2.5 to 8 m of loess deposition on an ancient landscape (Fig. 4). Norton (1984) found comparable results on a loess-mantled landscape in Ohio. The modern landscape generally mirrors the paleolandscape except that the modern lunettes have less relief than the paleolunettes. The modern landscape is slightly smoother than the original topography, similar to results found by Hock et al. (1973). The older landscape was usually identified by a dark-colored buried soil 0.5 to 2 m thick that resembled the Gilman Canyon Formation. Samples taken during this study yielded radiocarbon dates that ranged from 21,140 +/- 220 to 26,140 +/- 530 YBP (Table 2). Krueger (1986) obtained dates of 20,940 +/- 240, 23,740 +/- 220, and 28,350 +/- 610 YBP from the top, middle, and bottom, respectively, of a buried soil that underlies the Peoria Loess. Kitchen (1987) studied a location within 1.5 km of area 2 of this study and obtained a date of 20,220 +/- 330 YBP on the top of a buried soil that underlies the Peoria Loess. The dates obtained on the ancient landsurface underlying the Peoria Loess indicate that the buried soil is within the Gilman Canyon Formation (Dreeszen 1970).

The Gilman Canyon Formation lies above materials that may be Mid- or Early Wisconsinan and/or Illinoisan in age. These materials range from clay loam to coarse sand in texture (Table 1). The topography of the Gilman Canyon Formation is a direct result of the underlying stratigraphy. Basins and accompanying ridges were present prior to the deposition of the Gilman Canyon Formation. It is possible that the pre-Gilman Canyon surface was

TABLE 1

DESCRIPTION OF REPRESENTATIVE TESTHOLES FROM AREA 1

TEST HOLE 1

DEPTH (m) FROM	TO	DESCRIPTION	UNIT
0	0.3	silt loam very dark brown 10YR 2/2*	BIGNELL AND PEORIA LOESS
0.3	0.5	silt loam grayish brown 10YR 5/2	BIGNELL AND PEORIA LOESS
0.5	0.9	silty clay very dark grayish brown 10YR 3/2	BIGNELL AND PEORIA LOESS
0.9	1.3	silty clay loam dark grayish brown 10YR 4/2	BIGNELL AND PEORIA LOESS
1.3	1.8	silty clay loam grayish brown 2.5Y 5/2 CaCO3 concretions	BIGNELL AND PEORIA LOESS
1.8	3.8	silty clay loam light brownish gray 2.5Y 6/2 strong brown mottles 7.5YR 5/6	BIGNELL AND PEORIA LOESS
3.8	4.9	silt loam grayish brown 2.5Y 5/2 Fe/Mn concretions strong brown mottles 7.5YR 5/6	BIGNELL AND PEORIA LOESS
4.9	5.1	silty clay loam dark grayish brown 10YR 4/2	GILMAN CANYON FORMATION
5.1	5.9	silty clay loam very dark grayish brown 10YR 3/2	GILMAN CANYON FORMATION
5.9	6.2	silty clay loam dark gray 10YR 4/1	GILMAN CANYON FORMATION
6.2	6.7	silty clay loam grayish brown 10YR 5/2	GILMAN CANYON FORMATION
6.7	7.9	clay loam brown 10YR 5/3 Fe/Mn concretions strong brown mottles 7.5YR 5/6	MID-WISCONSINAN AND OLDER SEDIMENTS
7.9	9.1	silty clay loam light brownish gray 2.5Y 6/2	MID-WISCONSINAN AND OLDER SEDIMENTS
9.1	10.3	clay loam light yellowish brown 2.5Y 6/3	MID-WISCONSINAN AND OLDER SEDIMENTS
10.3	10.8	sandy clay loam grayish brown 2.5Y 5/2	MID-WISCONSINAN AND OLDER SEDIMENTS
10.8	TD	sand and coarse sand very pale brown 10YR 7/4	MID-WISCONSINAN AND OLDER SEDIMENTS

TEST HOLE 8

DEPTH (m) FROM	TO	DESCRIPTION	UNIT
0	0.3	silt loam very dark brown 10YR 2/2	BIGNELL AND PEORIA LOESS
0.3	1.1	silty clay loam very dark grayish brown 10YR 3/2	BIGNELL AND PEORIA LOESS
1.1	1.4	silty clay loam dark grayish brown 10YR 4/2	BIGNELL AND PEORIA LOESS
1.4	1.8	silty clay loam grayish brown 10YR 5/2	BIGNELL AND PEORIA LOESS
1.8	4.6	silt loam light brownish gray 10YR 6/2 Fe/Mn concretions strong brown mottles 7.5YR 5/6	BIGNELL AND PEORIA LOESS
4.6	5.2	silt loam light yellowish brown 2.5Y 6/4 strong brown mottles 7.5YR 5/6	BIGNELL AND PEORIA LOESS
5.2	5.5	silt loam dark brown 10YR 3/3	GILMAN CANYON FORMATION
5.5	6.1	silty clay loam very dark grayish brown 10YR 3/2 contains some bleached grains	GILMAN CANYON FORMATION
6.1	6.2	silty clay loam very dark gray 10YR 3/1	GILMAN CANYON FORMATION
6.2	6.7	fine sandy loam brown 10YR 5/3	MID-WISCONSINAN AND OLDER SEDIMENTS
6.7	7.5	very fine sandy loam very pale brown 10YR 7/4 strong brown 7.5 YR 5/6 mottles	MID-WISCONSINAN AND OLDER SEDIMENTS
7.5	7.9	loamy fine sand pale brown 10YR 6/3	MID-WISCONSINAN AND OLDER SEDIMENTS
7.9	8.4	very fine sandy loam pale brown 10YR 6/3	MID-WISCONSINAN AND OLDER SEDIMENTS
8.4	TD	fine to coarse sand very pale brown 10YR 7/3 Fe/Mn concretions strong brown 7.5 YR 5/6 mottles	MID-WISCONSINAN AND OLDER SEDIMENTS

* moist color

TABLE 2

RADIOCARBON DATES OF TOP OF BURIED SOILS

Sample	Depth Below Surface	Date
	m	YBP*
Core 2	4.2	26,140 +/- 530 (Beta Analytic 23456)
Core 6	3.0	22,590 +/- 280 (Beta Analytic 24268)
Core 10	4.8	24,990 +/- 430 (Beta Analytic 23457)
Spring Ranch	5.6	21,140 +/- 220 (Beta Analytic 20105)
Spring Ranch	6.9	23,850 +/- 290 (Beta Analytic 20104)

* Years Before Present

altered by erosion and deflation, resulting in the formation of basins and accompanying ridges. The erosion and deflation processes may have been severe enough to expose and deflate sandy material similar to that found below the buried soils in this study (Table 1). Evidence of the deflation of these sands is suggested by soil surveys from the eastern Rainbasin that show the presence of sandy materials within lunettes (Hammer et al. 1981, 1986).

Conclusions

The morphologies of the two basins investigated in this study were inherited from an ancient landscape. The modern landscape has evolved from the loessial burial of paleobasins formed prior to the Early Wisconsinan deposition of the Gilman Canyon Formation. The present landscape is

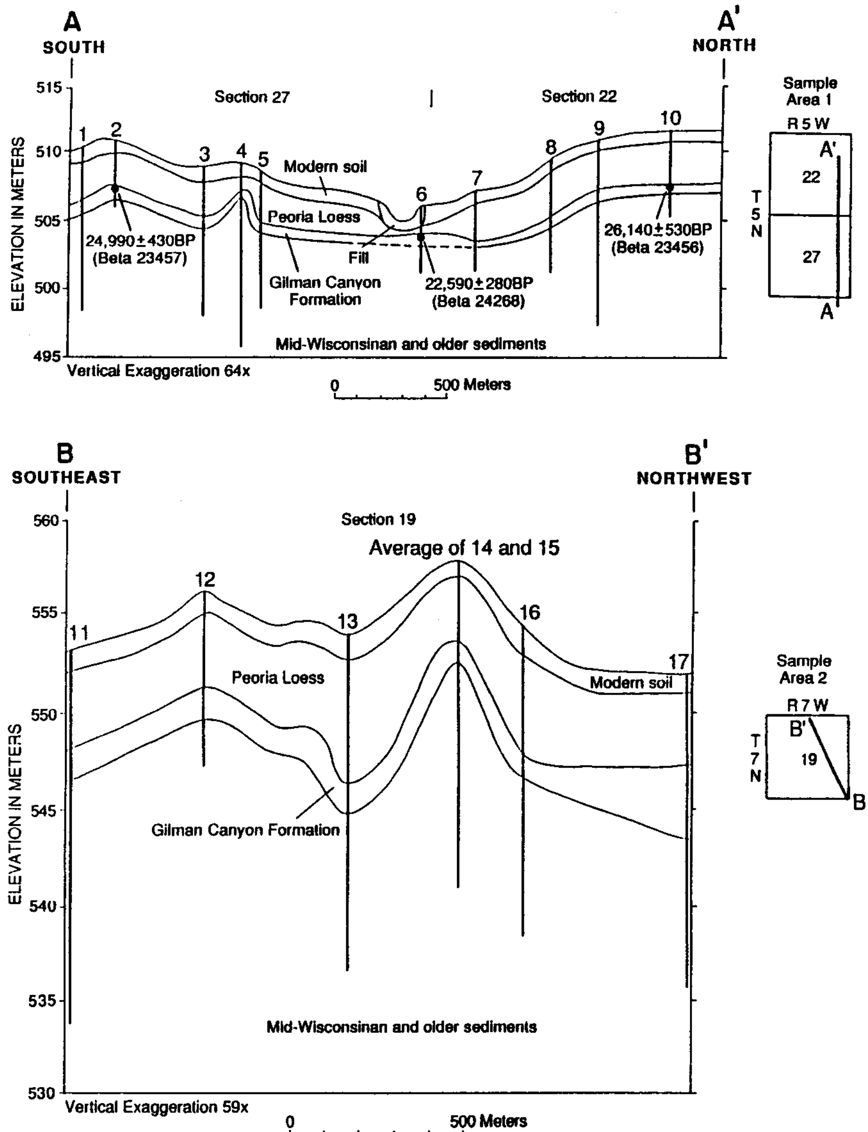

Figure 4. Cross sections along transects at area 1 (A - A', test holes 1 - 10) and area 2 (B - B', test holes 11 - 17). Radiocarbon dates are noted on cross section A - A'.

slightly smoother than the paleolandscape. The paleobasins probably formed as a result of erosion and the subsequent deflation of the eroded materials. The results of this study, coupled with those of Krueger (1986) indicate that it is likely that other large modern basins within the eastern Rainbasin are also underlain by paleobasins and are the result of similar basin-forming processes.

Results of this study may be applied to document the loss of wetlands by extreme physical modification of a modern basin landscape. During agricultural development, some basin wetlands may have been filled or reshaped to an extent that they are no longer recognized as basins. A stratigraphic investigation could provide evidence that a paleobasin exists below such a modified landscape. The presence of a paleobasin coupled with evidence of physical modification of the land surface could indicate that a modern basin wetland had existed at the site. In general, stratigraphic investigations within the eastern Rainbasin could provide baseline data on the extent of basin wetlands prior to agricultural development.

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