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THE RUSH CREEK-LISCO STRUCTURAL BASIN, GARDEN AND MORRILL COUNTIES, NEBRASKA

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Detailed field mapping of outcrops in southern Garden and Morrill counties, Nebraska, has revealed a drop of more than 60 m (200 ft) in 4.8 km (3 mi) in the elevation of the contact between the Brule Formation and the Ogallala Group as exposed on the east side of Rush Creek. Beds of silt, sand, siltstone, and volcanic ash locally dip to the northwest at angles up to 8.5°. The contact between the two formations cannot be seen on the west side of Rush Creek but beds in the Ogallala Group there dip to the north and northeast. Rocks north of the North Platte River in the vicinity of Lisco dip to the south, completing the outcrop belt of the Rush Creek-Lisco Structural Basin.

The unusually long valley of Rush Creek runs along the axis of a north plunging synclinal fold within the structural basin, which probably controls the position of springs in the Ogallala Group feeding the only large perennial stream on the south side of the North Platte River in Garden County. The occurrence of Ogallala outcrops at river level along the south bank of the North Platte River just southeast of Lisco, Nebraska, is also related to this structural basin.

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INTRODUCTION

The author has participated in the geologic-mapping program of the Conservation and Survey Division of the University of Nebraska-Lincoln during summers since 1975. In those five summers rock outcrops and geologic contacts have been located in Lincoln, Keith, Garden, and Morrill counties, and the areas of exposure as well as the positions and elevations of the contacts have been plotted on 7.5-minute topographic maps. The author first observed surface indications of deformation in the summer of 1977 while mapping in Garden County, Nebraska, in the vicinity of Rush Creek, a southern tributary of the North Platte River.

PREVIOUS WORK

A few observations have been made over the years about the unusual nature of the geology in the area on either side of the North Platte River from the vicinity of the Rush Creek Drainage Basin to Pussy Spring in Garden and Morrill counties, Nebraska. Stansbury (1852) wrote one of the earliest descriptions of the general geography from Ash Hollow west during his expedition of 1850. He commented on July 5, 1850:

> We commenced our journey today up the north fork of the Platte. The road winds along the bottom under the cliffs. The lower stratum consists of yellow clay, capped by cliffs of sandstone and siliceous limestone, about two hundred feet in height. The formation was traced uninterruptedly for about twenty miles. The limestone appeared to contain no fossils – at least, none were discovered. Toward the end of the day's march the clay was left uncovered by the limestone, presenting bald eminences destitute of the least vegetation, which, from the action of the weather, had been worn into various curious and isolated peaks, of forms extremely picturesque (Stansbury, 1852:44).

On July 6, 1850, Stansbury continued:

> The banks on this side of the river have presented little of interest, the surface generally consisting of rolling prairie, gradually rising to the summit of the hills, which are at a considerable distance from the stream. On the opposite side, the cliffs are precipitous, displaying sections of horizontal beds of apparently the same rock already noticed. About two miles from our noon halt the rock was exposed close to the river and but little above its level (Stansbury, 1852:48).

This account places the Stansbury Expedition on the south side of the North Platte in the area where Lisco, Nebraska, is presently located and clearly shows that Stansbury saw that the rocks now included in the Ogallala Group[1] in

[1]The Ogallala Group has been assigned to the Miocene in this report (Fig. 1), following the radiometric age-determinations of Boellstorff (1978), but other authors (*see* Schultz and Stout, 1945; Stout, 1971) consider it to be Pliocene.

this area had dropped rapidly from a position high in the hills to the banks of the river.

Lugn (1935:169, Fig. 26) briefly described the geology of the North Platte Valley at Lisco and drew a geologic-profile section north-south across the river showing the Brule-Ogallala contact. According to Lugn's profile the Brule Formation occurs above the level of the North Platte River on the south bank of the river at the Lisco Bridge. This profile also indicates that the apparent slope of the contact is to the south at about 1.9 m to 2.3 m per km (10 ft to 12 ft per mi).

Schultz and Stout (1945:235, Text-fig. 2) also drew a north-south profile through the Lisco area. While the main purpose of this figure was to illustrate the terrace sequences along the North Platte River, the Brule-Ogallala contact is inferred by the authors to be nearly horizontal along a north-south line through their Lisco Locality C about 8 km (5 mi) east of Lisco.

Diffendal (1978) reported on the Rush Creek Structure south of Lisco. Stimulated by this report, Souders (1978) prepared an unpublished geologic-profile section from southwestern Garden County to northeastern Cheyenne County which shows the Brule-Ogallala contact to be sloping toward the North Platte River Valley. Swinehart (1979) prepared a geologic-profile section along a generally north-northeast to south-southwest line less than 0.8 km (0.5 mi) east of Lisco depicting a more steeply sloping contact than previously illustrated by either Lugn or by Schultz and Stout.

DeGraw (1969, 1971) has described the general structural geology of western Nebraska and defined a number of structures in the area. Those structures located near the Rush Creek-Lisco area are the northwest-to-southeast trending Oshkosh-Lewellen anticline in southern Garden and northwestern Keith counties and the northeast-to-southwest trending "Sidney Fairway" folds in eastern Cheyenne County. DeGraw (1971:14-15) indicates that the "Sidney Fairway" is structurally complex, with the northeasternmost extension as two synclines approaching southwestern Garden County. DeGraw (1969:34) briefly referred to the "Lisco Anticline," a structure in the Ogallala Group northeast of Lisco, and attributed the name to T. M. Stout. Stout and DeGraw (1971:76) also referred to the "Lisco Anticline" on the basis of an extensive survey of the structure in 1938 and in that and other years with other members of field parties from the University of Nebraska State Museum (Stout, personal communication).

The Rush Creek-Lisco area is shown on bedrock geologic maps of western Nebraska prepared by Darton (1903), Lugn (1935), and Burchett (1969). Darton's (1903) map shows an outcrop-belt of the Brule 16 km (10 mi) wide beneath and on either side of the North Platte River at Lisco. Burchett's map indicates a belt of Brule about 12.8 km (8 mi) wide, whereas Lugn's map indicates Brule in an outcrop a little more than 1.6 km (1 mi) wide.

RESULTS OF PRESENT STUDY

The Rush Creek-Lisco Structural Basin

The basal Ogallala contact gradually rises to the west along the south side of the North Platte River Valley at an average rate of about 4 m per km (22 ft per mi) from the mouth of Ash Hollow to 3.2 km (2 mi) west of Sugar Loaf Butte in Garden County. From the area west of Sugar Loaf Butte to Coumbe Bluff (Fig. 1) the contact slopes to the northwest at a rate of about 18.8 m per km (100 ft per mi). At the south end of the Lisco Bridge, outcrops at river level belong to the Ogallala Group, and thus the Brule-Ogallala contact must continue to slope to the northwest from Coumbe Bluff to Lisco.

About 1.6 km (1 mi) southwest of Coumbe Bluff apparent dips on beds within the Ogallala Group increase to a maximum of 8.5° to the northwest. Approximately 24 km (15 mi) to the west-northwest of Coumbe Bluff similar angles of dip occur in these beds but the dip directions are toward the northeast. Beds between these two sites rarely dip more than 4° but vary in dip direction, producing small-scale folds with axes only a few kilometers apart. Figure 1, a revised geologic map of the Rush Creek-Lisco area based on field mapping and test- and irrigation-well data from the Conservation and Survey Division of the University of Nebraska-Lincoln, illustrates the relationships just described and includes strike-and-dip measurements on individual beds at selected sites.

It might be argued that the Rush Creek-Lisco area is simply underlain by a filled paleovalley; it is therefore instructive to examine a generally-recognized, large, complex filled-valley of Ogallala age as a model for comparison. Such a filled paleovalley occurs in the vicinity of Greenwood Canyon in southwestern Morrill County (Breyer, 1975:5-6; Stout, 1971). Greenwood Canyon trends north-south approximately normal to the trend of the paleovalley passing through the area while some tributaries to the canyon are nearly parallel to the paleovalley axis. While it is true that the Brule-Ogallala contact at Greenwood Canyon slopes to the south at a rate of 8.4 m to 9.4 m per km (45 ft to 50 ft per mi), the beds within the Ogallala Group remain nearly horizontal both normal and parallel to the axis of the paleovalley. Bedding and concretionary zones in the underlying Brule Formation are also nearly horizontal. Furthermore, at Greenwood Canyon there is a sand-and-gravel filled channel-complex in the Ogallala Group nearly 45 m (150 ft) thick and more than 1.6 km (1 mi) wide marking the position of a major stream which existed for a

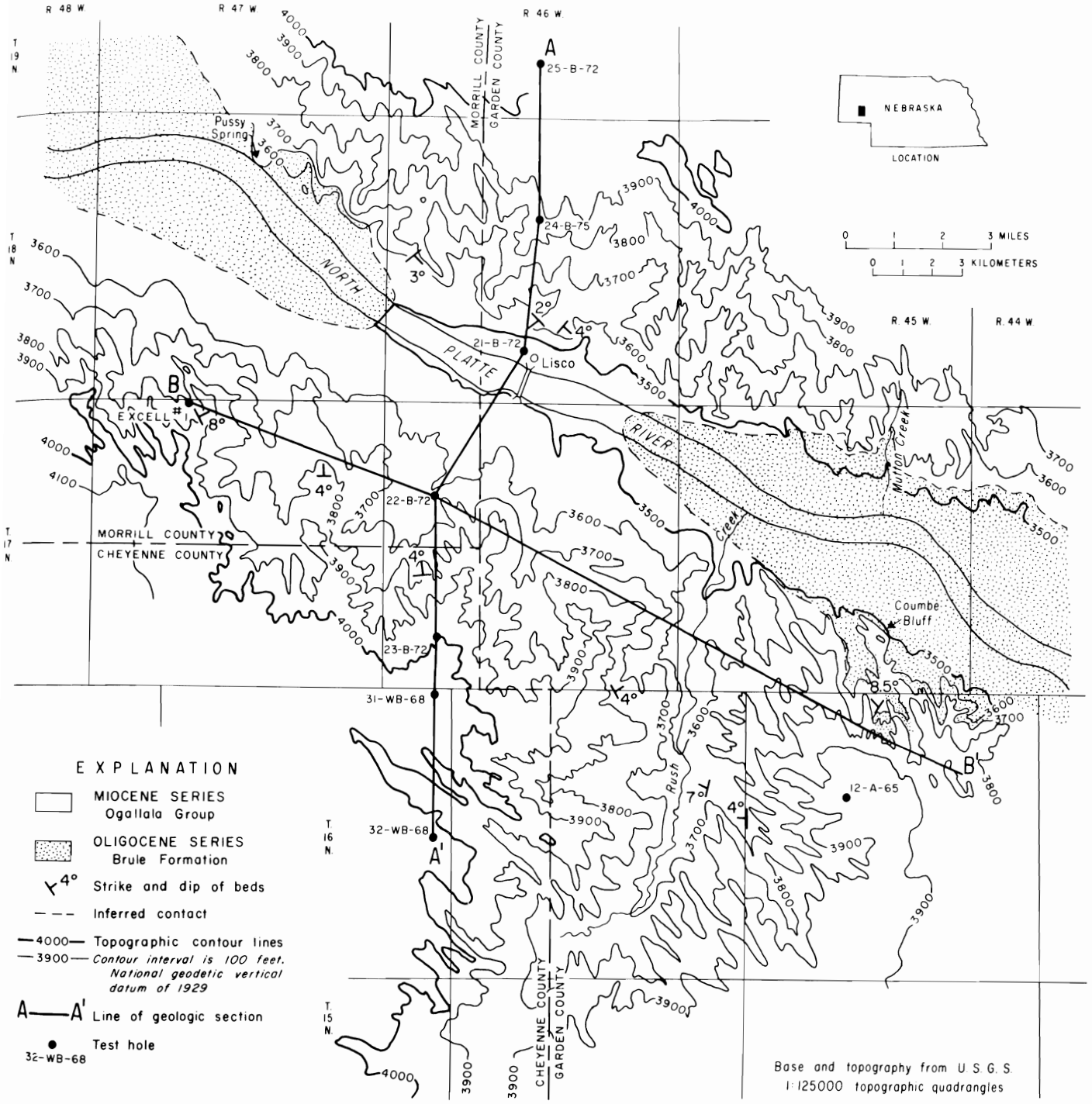

FIGURE 1. Geologic map of the Rush Creek-Lisco Structural Basin. The northwest portion of the map is after Swinehart (1979).

long period of time during aggradation of the Ogallala sediments. This type of channel deposit is typical of a lithologically-diverse valley-fill of Ogallala type.

Having studied the Greenwood Canyon exposures, the author returned to the Rush Creek–Lisco area. The rock types in the Ogallala Group there are diverse and include beds of silt, very fine-to-medium sand, sandstone, pebbly sand, limey silt, and volcanic ash (tephra). Even in areas exhibiting the highest dips, these beds generally maintain their thicknesses and relative spacings both parallel to strike and in down-dip direction in some cases for more than 0.8 km (0.5 mi) (Fig. 2a). In two townships (T. 17–18 N., R. 47 W., Morrill County) many key beds, such as volcanic-ash beds, can be traced for even greater distances while exhibiting little facies-variation even though they are folded into broad, low, plunging anticlines and synclines. These relationships strongly suggest that the dip of the beds is structural rather than depositional.

There is an example of trough cross-bedding in an easily-traceable sand-and-gravel body outcropping near the divide that trends southeast from Coumbe Bluff that seems to clarify the relation. This sand and gravel slopes to the northwest, but in several discontinuous areas, where it is cemented, trough cross-beds plunge southeast at angles up to 20°. If deformation has not occurred then the stream depositing this sand and gravel must have flowed up hill!

There are indications of deformation affecting the underlying Brule Formation in the Coumbe Bluff area, too. An ash bed in the Brule Formation at the base of Coumbe Bluff has an apparent dip to the northwest of about 18.8 m per km (100 ft per mi). At an exposure about 1.6 km (1 mi) southwest of Coumbe Bluff (Fig. 2b), concretionary zones like those reported above in the Brule at Greenwood Canyon, are inclined to the northwest at nearly the same angle of dip as for the overlying beds of the Ogallala Group. Other concretionary zones, some in beds of uncertain age, occur from Sugar Loaf Butte eastward to Ash Hollow Canyon, also along Blue Creek and at Cedar Point in Keith County, and they maintain a nearly horizontal orientation just as at Greenwood Canyon.

Kellison (1979) has produced an unpublished structural-configuration map drawn on an upper chalk unit of the Niobrara Formation in the southern Nebraska panhandle as part of his Master's-thesis research. This map, although based in part on relatively few data-points, shows folding in the chalk in the area of the Rush Creek–Lisco Structural Basin.

All of the evidence cited above strongly supports the conclusion that the Rush Creek–Lisco area is in a structural basin rather than in just a filled paleovalley. The area affected extends at least from the springs that are the source of Rush Creek northward about 24 km (15 mi) to the vicinity of a test-hole of the Conservation and Survey Division (24-B-72),

FIGURE 2. a. View from south of Coumbe Bluff looking west at strata of the Ogallala Group dipping toward the northwest. b. View from the same point looking east at a part of the Whitney Member of the Brule Formation containing concretions and at the overlying basal portion of the Ogallala Group. The strata and contact are dipping toward the northwest.

and from Coumbe Bluff northwestward at least to the Hansen Brothers Ranch, a distance of approximately 24 km. Figure 3 shows north-south and east-west structural sections across the basin. It also shows the development of smaller-scale folding of the rocks within the basin.

Age of the Structure

The deformation that produced the Rush Creek-Lisco Structural Basin affected all of the rocks up through the Ogallala Group. This includes both the Ash Hollow and Kimball formations recognized by earlier workers. The deformation, therefore, had to have occurred after the Ogallala Group was deposited. During a part of the 1978 field season, James B. Swinehart and the author collaborated on mapping from the Lisco area west to Broadwater, Nebraska. That mapping included part of a basal channel-system that had been examined earlier by Breyer (1975), filled with very coarse gravel probably belonging to the Broadwater Formation of Quaternary age. This coarse sand and gravel descends from 48 m (160 ft) above the North Platte River at Pussy Spring to a position only about 24 m (80 ft) above river level 4.8 km (3 mi) east of Lisco (Schultz and Stout, 1945:235, Text-fig. 2). It is probable that the distribution pattern of this sand and gravel deposit is related to the Rush Creek-Lisco Structural Basin. Because the Broadwater Formation has been tentatively estimated to be about 2.8 m.y. old (Boellstorff, 1978:46), and since the youngest dates given by Boellstorff (1978:46) for Ogallala Group rocks in Garden and Morrill counties are about 7 m.y. before present, the deformation producing the basin probably occurred more recently than 7 m.y. ago and may have occurred, at least in part, within the last 2.8 m.y.

There is also a possibility that deformation occurred more than once in the basin area. The incision of the Broadwater valleys may have been the result of renewed downfolding in

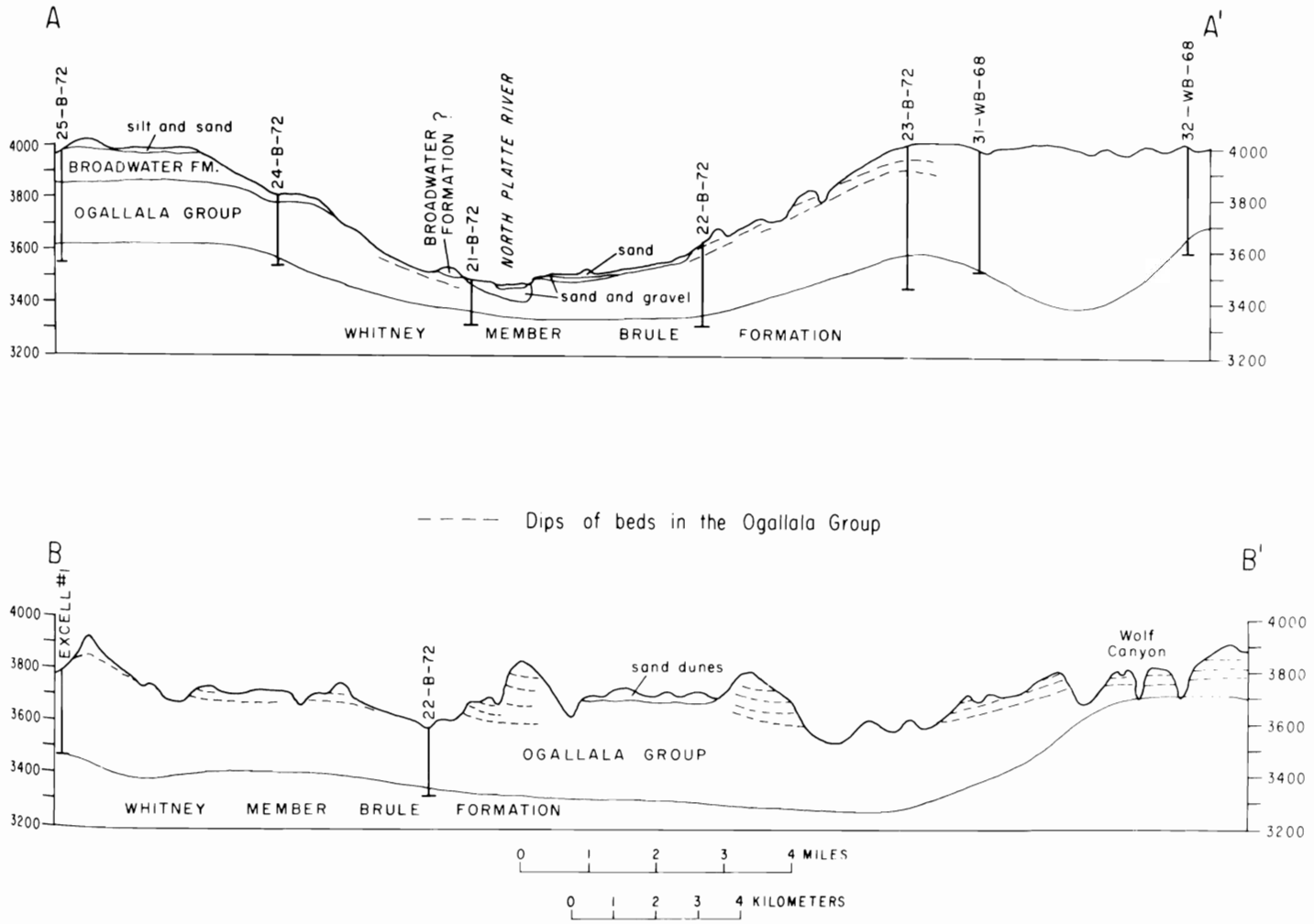

FIGURE 3. Geologic structure sections along lines A-A′ and B-B′ of Figure 1.

the Quaternary. The post-Niobrara folding affecting the Niobrara (and perhaps older rocks in the area) could also have been a separate, older event.

Relationship to other Structures

It seems clear that the Rush Creek–Lisco Structural Basin is an extension of the "Sidney Fairway" of DeGraw (1969, 1971). Whether or not the two structures are related is not known, and the cause is also unknown at this time. The "Lisco Anticline" is a small-scale structure developed within the larger Rush Creek–Lisco Structural Basin. The rocks of the basin may be draped over faults recognized in other localities that might extend into the study area, but this cannot now be demonstrated.

DeGraw (1971:20) has commented that Rush Creek flows on top of both pre-Ogallala and pre-Oligocene drainageways. The evidence presented earlier suggests that much, if not all, of this development is due to structure rather than simply by stream incision and filling.

Hydrologic Considerations

It is seemingly no accident that the springs that feed Rush Creek, as well as Mutton Creek and other smaller tributaries to the North Platte River east of Lisco, occur where they do. The rocks beneath the valley of Rush Creek, in particular, are deformed into a trough plunging generally northward toward the North Platte River. Ground water probably tends to flow eastward, following the regional slope and the direction of inclination of the permeable Ogallala Group rocks west of Rush Creek. This ground water flow is probably largely prevented from travelling farther east than Rush Creek because the water encounters the rapidly rising Brule–Ogallala contact and the relatively impermeable Brule Formation beneath the contact. From this point both ground and surface water tends to flow along the axis of this trough toward the north.

The springs at Mutton Creek, about 6.4 km (4 mi) northeast of the mouth of Rush Creek, occur along the Brule–Ogallala contact and are controlled, at least in part, by the southward tilt of the contact and beds.

CONCLUSIONS

The Rush Creek–Lisco area is underlain by a structural basin of moderate size. The basin is relatively young but may have been influenced in its development by older structural movements in the area. Whether the folding at the surface is simple or draped over older faulted rocks is unknown.

The Rush Creek–Lisco Structural Basin controls much of the ground water movement beneath the area. The folding may also be responsible for the path taken, at least locally, by the Broadwater and post-Broadwater streams as they crossed this part of Morrill and Garden counties.

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REFERENCES

Boellstorff, J. 1978. Chronology of some Late Cenozoic deposits from the central United States and the Ice Ages. *Transactions of the Nebraska Academy of Sciences*, 6:35–49.

Breyer, J. 1975. The classification of the Ogallala sediments in western Nebraska. *University of Michigan Museum of Paleontology Papers in Paleontology*, 12:1-8.

Burchett, R. R. 1969. Geologic bedrock map of Nebraska. *Publication of the University of Nebraska-Lincoln, Conservation and Survey Division.*

Darton, N. H. 1903. Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian. *United States Geological Survey Professional Paper*, 17:69p.

DeGraw, H. M. 1969. Subsurface relations of the Cretaceous and Tertiary in western Nebraska. Master of Science Thesis, University of Nebraska-Lincoln:137p.

_____. 1971. The pre-Oligocene surface in western Nebraka–its relation to structure and subsequent topographies. *In* T. M. Stout, H. M. DeGraw, L. G. Tanner, K. O. Stanley, W. J. Wayne, and J. B. Swinehart, *Guidebook to the Late Pliocene and Early Pleistocene of Nebraska.* Lincoln, Nebraska, The University of Nebraska Conservation and Survey Division, Nebraska Geological Survey: 12–21.

Diffendal, R. F., Jr. 1978. The Rush Creek Structure, Garden County, Nebraska. *Proceedings of the Nebraska Academy of Sciences, 88th Annual Meeting*: 41. (Abstract).

Kellison, L. 1979. Structural configuration of the upper chalk unit, Niobrara Formation. Unpublished map. University of Nebraska-Lincoln, Conservation and Survey Division.

Lugn, A. L. 1935. The Pleistocene geology of Nebraska. *Bulletin of the Nebraska Geological Survey,* Series 2, 10: 233p.

Schultz, C. B., and T. M. Stout. 1945. Pleistocene loess deposits of Nebraska. *American Journal of Science,* 243: 231-244.

Souders, V. 1978. Cross section from test well 31-B-72 to test well WPP 32-68. Unpublished cross section, University of Nebraska-Lincoln, Conservation and Survey Division.

Stansbury, H. 1852. *Exploration and survey of the valley of the Great Salt Lake of Utah, including a reconnaissance of a new route through the Rocky Mountains.* Philadelphia, Lippincott, Gambo and Company:487p.

Stout, T. M. 1971. Geologic sections. *In* T. M. Stout, H. M. DeGraw, L. G. Tanner, K. O. Stanley, W. J. Wayne, and J. B. Swinehart, *Guidebook to the Late Pliocene and Early Pleistocene of Nebraska.* Lincoln, Nebraska, The University of Nebraska Conservation and Survey Division, Nebraska Geological Survey:29-67.

____, and H. M. DeGraw. 1971. Road log for first day. *In* T. M. Stout, H. M. DeGraw, L. G. Tanner, K. O. Stanley, W. J. Wayne, and J. B. Swinehart, *Guidebook to the Late Pliocene and Early Pleistocene of Nebraska.* Lincoln, Nebraska, The University of Nebraska Conservation and Survey Division, Nebraska Geological Survey:68-81.

Swinehart, J. B., II. 1979. Cenozoic geology of the North Platte River Valley, Morrill and Garden counties, Nebraska. Master of Science Thesis, University of Nebraska-Lincoln:127p.