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Gully, scour hole, and pothole development at the base of the Gering Formation (Miocene?), southeastern Banner County, Nebraska

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ABSTRACT

Several sediment-filled paleovalleys belonging to the Arikaree Group of Miocene (?) age occur in southeastern Banner County, Nebraska. One gully and a main paleovalley exhibit, respectively, erosional features like those in modern gullies in the area and like those on the bedrock floors of modern straight streams carrying an appreciable sediment load. Scour holes and a pothole on the valley floor of the main paleovalley are similar to those produced experimentally on the bed of a straight stream.

INTRODUCTION

The Gering Formation of the Arikaree Group (Miocene?), a predominantly fluvial deposit (Vondra, 1967), is exposed in many places in western Nebraska. In these places the Gering Formation rests unconformably upon rocks of the Brule Formation of the White River Group of Oligocene age. Lugn (1939, p. 1251) reported on the geology of the Arikaree and described the contact surface between the two groups as a pronounced erosional unconformity, yet evidence of pronounced erosion can be viewed in only a few places. Previous studies (Vondra, 1963; Schultz, Falkenbach, and Vondra, 1967) of the Arikaree report over one hundred meters of erosional relief on the top of the Brule Formation, but none of the studies made in Nebraska describes the nature of the erosional surface or the type of stream that produced it. Indeed, most visitors to the Pine Ridge or to the North Platte Valley, both in the Nebraska Panhandle, see from a distance a contact between the White River and the Arikaree groups that looks almost, if not totally, conformable.

The purposes of this report are to describe the unconformity between the basal Gering Formation of the Arikaree Group and the underlying Brule Formation at three sites in Banner County, Nebraska (Fig. 1), to suggest something about the nature of the streams that produced the unconformity at these places, and to describe the depositional history of the Gering Formation at these sites where an unconformity between the Gering and the Brule can be easily demonstrated.

PREVIOUS WORK ON THE BASAL ARIKAREE

The Gering Formation, accepted as the basal formation of the Arikaree Group in Nebraska since its inclusion in the group by Schultz (1938, p. 443 and 1941, p. 123) and by Lugn (1939, p. 1251), was described originally by Darton (1899). More detailed descriptions of the Gering Formation are given in theses by Vondra (1963) on the Wildcat Hills, by Wellman (1964) on the Pine Ridge, by Bart (1974) on parts of Wyoming and Nebraska, and by Swinehart (1979) along part of the valley side of the North Platte Valley. Papers by Schultz, Falkenbach, and Vondra (1967) and by Vondra, Schultz, and Stout (1969) have added to the developing picture of the formation.

The workers cited above have designated the age of the Gering Formation as Miocene. Renpenning and Tedford (1977, Table 1) have placed time-equivalent strata in the Oligocene. I have tentatively placed the Gering within the Miocene following the work of Vondra, Schultz, and Stout (1969), but caution the reader that the formation may be Oligocene in age.

At many places in western Nebraska the Gering Formation is predominantly a sandy fluvialite unit resting disconformably on siltstones of the Whitney Member of the Brule Formation. However, in some places lateral to Gering sandstones, sandy siltstones occur which may be either part of the Gering or part of the Brule. Darton (1903, p. 29) could not decide to which formation he should assign these beds when he originally looked at them and no interpretation since that time has been generally accepted. [For an appreciation of the varying
views expressed on this problem see Schultz (1941), Vondra (1963), Schultz, Falkenbach, and Vondra (1967), Vondra, Schultz, and Stout (1969), Bart (1974), Swinehart (1979), and Swinehart and Souders (1979).]

Figure 2A. Basal Gering Formation (Tmg) sediments filling a steep-walled gully carved into the Brule Formation (Tob). Gully is about 10 m wide.

Figure 2B. Steeply inclined gravel bed within sediments shown in Fig. 2A. Fossil turtle shell (T) lies just below gravel bed.

DESCRIPTION OF ARIKAREE SITES

Site 1

At site 1 (NE¼ SE¼ SW¼ sec. 16, T. 17 N., R. 53 W.) a steep-sided gully was carved into the Whitney Member of the Brule Formation (Fig. 2A) and later was filled with a basal fine sand rich in volcanically derived material, overlain by trough-crossbedded gray sands containing concentrations of heavy minerals, chaotic deposits containing a heterogeneous mixture of locally derived clasts and broken fossil turtle shells, and horizontal to steeply inclined beds of gravel derived by local stream erosion of Brule siltstones and concretions (Fig. 2B). These gully-fill deposits are considered to be part of the Gering Formation. Within the study area similar gullies occur

Figure 3. Map showing distribution of basal Gering Formation (dark gray) and overlying (medium gray) strata of Arikaree Group at sites 2 and 3. Probable channel trend is shown by dashed lines and light gray color. Base map is composite from U.S. Geological Survey Lone Pine Butte and Singleton Ranch 7.5' topographic maps.

Figure 4. View of site 2 showing unconformities (1-4) at the base of and within the Arikaree Group.
EROSIONAL FEATURES AT BASE OF GERING FORMATION

Figure 5. Unconformity (1) exhibiting scour holes at base of the Gering Formation at site 2. Second unconformity (2) above truncates unconformity 1. The man is 1.83 m tall.

Figure 6. Scour hole carved in Brule Formation and filled with basal sand and gravel of the Gering Formation. Depth of hole is about 3.3 m.

in other paleovalleys as well as along the sides of major presently existing valleys (Diffendal, in press, and Vondra, 1963).

Site 2 and Site 3

These two sites include cuts through all (site 2-NW ¼ NW ¼ NE ¼ SW ¼ NE ¼ NW ¼ sec. 36, T. 17 N., R. 54 W.) and most (site 3-SE ¼ NE ¼ NE ¼ sec. 27, T. 17 N., R. 54 W.) of the Arikaree sediments in a paleovalley that was carved into the Whitney Member of the Brule Formation (Fig. 3). The paleovalley floor is exposed along a prominent cut-bank on the north side of Rocky Hollow at site 2 (Fig. 4). In addition to this unusual basal Arikaree unconformity, this exposure also includes two, or possibly three, other unconformities.

One of the more frustrating facets of the study of Cenozoic fluvial systems in western Nebraska is the rarity of exposed paleovalley floors. Shepherd and Schumm (1974, p.256) pointed out:

"Moreover, the alluvial fill found in nearly all valleys obscures the configuration of the bedrock-alluvium interface that constitutes the valley floor."

Thanks to their experimental work on river incision, however, we do know what types of bed-scour features to expect in both straight and meandering stream systems if we find an exhumed ancient valley floor.

Contributions to Geology, University of Wyoming, v. 21, no. 1, p. 1-6, 8 figs., September, 1982.
Recent erosion has cut obliquely across the axis of the paleovalley at site 2 to reveal a portion of the Arikaree valley floor (Fig. 5). Scour holes present here are like those described by Picard and High (1973, p. 18-23) for recent ephemeral streams and similar to the features experimentally produced by Shepherd and Schumm (1974) in straight channels. These scour holes have very steep or even undercut surfaces (Fig. 6) and are filled with horizontally-and cross-stratified sands. Cobble and boulders derived locally from the Brule Formation occur in some of these holes. One of these scour features at this site (Fig. 7) was illustrated by Darton (1903, p. 31).

The most interesting feature present at site 2 is a basal Arikaree pothole about 2.5 m deep and about 1.2 m wide at the top (Fig. 8) which is filled with Gering Formation gravel having long axes up to 30 cm long. The gravel clasts are composed of Brule siltstone and of carbonate-cemented concretions from the Brule. The pothole fill becomes less indurated and coarser grained upward. The surface of the fill bears the impressions of the spiral grooves on the pothole surface and of the irregular surface at the bottom of the pothole.

Most papers describing potholes, particularly those written before 1940, consist of only a few pages. Those by Brögger and Reusch (1874), Elston (1917), Elston (1918), Ives (1948), and Gjessing (1967) are among the longer, more important ones. Experimental work on pothole origin was reported by Alexander (1932), by Shepherd and Schumm (1974), and by Schumm (1977). Allen (1971, p. 183) summed up the origin of potholes.
EROSIONAL FEATURES AT BASE OF GERING FORMATION

After the incision of the valley floor and the subsequent filling of the bed-scour features, a second stream truncated the scour features (Fig. 4). This second period of erosion was followed by deposition of a pale-olive thin-bedded, fine-to-medium-grained volcanioclastic sand up to 12 m thick containing vertebrate and plant fossils. This Gering sand body is overlain by at least 30 m of more typical grayish brown fine-to-medium-grained Arikaree sands containing abundant heavy minerals and calcareous concretions. Both sand sequences are burrowed. Possibly the base of the grayish brown unit also is an unconformity. Disconformably overlying the Arikaree Group sequence at sites 2 and 3 are sediments and rocks of the Ogallala Group.

CONCLUSIONS

The base of the Gering Formation in most places in western Nebraska does not show scour features because, as Shepherd and Schumm suggest for other streams (1974, p. 266), such features probably were eliminated by lateral planation. However, at three sites in southeastern Banner County, Nebraska, bed-scour features at the base of the formation are well exposed. These features are similar to those developed on younger rocks as well as to those developed experimentally on valley floors cut by straight streams. During the incision phase of the Gering paleovalleys in Banner County, gullies were cut into the paleovalley sides and the scour holes and potholes typical of fast flowing, sediment-laden streams were formed on the floor of the main paleovalley. The sediments of the Gering Formation at these sites do not grade laterally into finer grained units, but are separated from them by prominent well-exposed erosion surfaces.

The geometry of the filled gully at site 1 and of the filled paleovalley at sites 2 and 3 illustrates the necessity of careful examination of both surface and subsurface data when working out the geology of Cenozoic continental deposits on the Great Plains. Such narrow features can be easily missed during a drilling program and even during surface study, but are probably more common in all of the Cenozoic groups of rocks in the region than previous geologic work indicates.

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