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Duer Ranch, Morrill County, Nebraska: Contrast between Cenozoic Fluvial and Eolian Deposition

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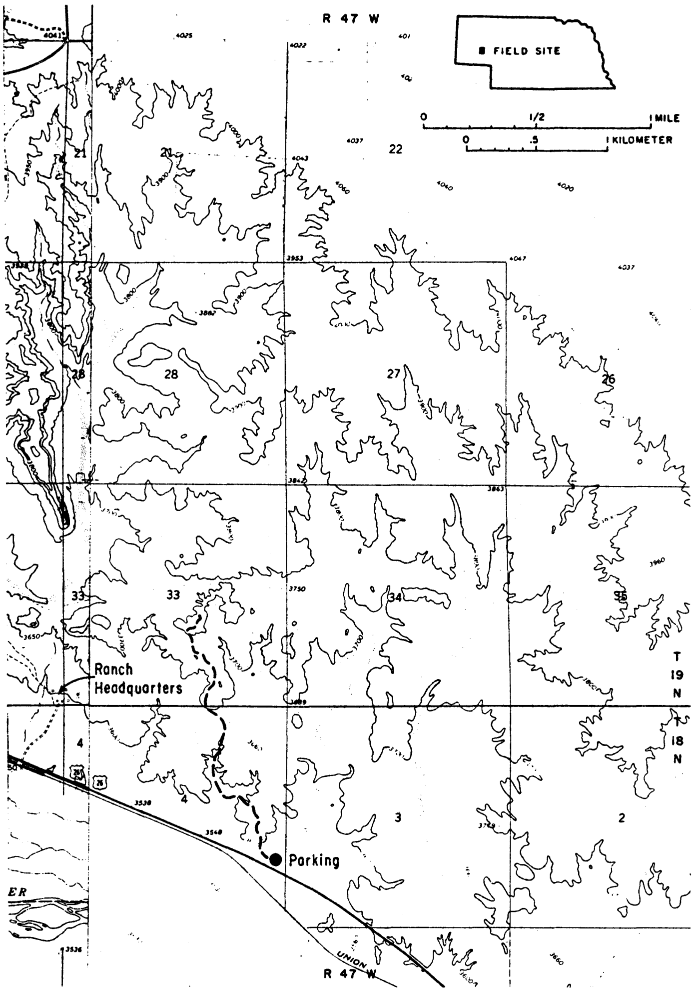

Figure 1. Map showing location of Duer Ranch locality. Base is from Tar Valley SW (contour interval of 20 ft) and Broadwater (contour interval of 10 ft) 7½-minute Quadrangles; scale 1:24,000. Dashed line is a suggested initial travel route that traverses many of the interesting features of this locality.

LOCATION AND ACCESSIBILITY

The Duer Ranch locality is situated on either side of U.S. 26 in southeastern Morrill County, Nebraska, halfway between the villages of Lisco and Broadwater and about 54 mi (90 km) southeast of Scottsbluff, Nebraska. The Rush Creek Land and Livestock Company currently owns all of sections 28, 29, 33, 34, and 35 of T.19N.,R.47W., as well as parts of sections 2, 3, 4, 10, and 11 of T.18N.,R.47W. (Broadwater and Tar Valley SW, 7½-minute Quadrangles; Fig. 1). The owners have allowed geologists to study the exposures on ranch property provided that visitors stop at the ranch headquarters (Fig. 1) and obtain permission from the ranch foreman. Vehicles should be parked inside the gate on the north side of U.S. 26 in the SW¼Sec.3,T.18N., R47.W. (Fig. 1), and all study of the site should be done on foot. Be certain to close any gates that you open, and do not smoke on the property. Rattlesnakes are found on the ranch. If you have a small group and wish to examine the exposures in the southeast corner of the locality, two vehicles can park safely along the north side of the road cut on U.S. 26 in the NE¼ NW¼ sec. 10, T.18N.,R.47W.

SIGNIFICANCE OF THE LOCALITY

The Duer Ranch locality contains some of the finest and most easily accessible examples of different styles of alluvial cuts and fills in the Cenozoic rocks of Nebraska. It offers a unique area in which to examine the geometries and alluvial fills of several Miocene and Pliocene age paleovalleys and paleo-gullies. Good exposures of eolian volcaniclastic siltstones and a regionally important volcanic ash of the Oligocene age Brule Formation are also present at the Duer Ranch locality. In addition, Quaternary ephemeral stream development and deposits can be studied.

LOCALITY INFORMATION

Deposits of Oligocene through Quaternary age are exposed along the deeply incised, intermittent stream valleys on the Duer Ranch (Fig. 2 and measured sections I-IV). The oldest of these units is the Whitney Member of the Brule Formation, White River Group. The Whitney is usually considered the uppermost of the two Brule members recognized in western Nebraska (the other being the Orella). However, recently Souders and others (1980) and Swinehart and others (1985) have presented evidence that another unit, informally named the Brown Siltstone beds, can be recognized above the Whitney in many places in western Nebraska.

The Whitney Member is a massive to crudely bedded volcaniclastic siltstone containing abundant smectite and carbonate cement. There are at least two prominent vitric ash beds (tuffs) exposed in the Whitney (Fig. 2 and measured section III). The lowest of these ashes, easily visible from U.S. 26 in the NE¼ Sec.10,T.18N.,R.47W., is the Upper Ash of the Whitney, a regional marker bed for much of the Nebraska panhandle. The Lower Ash of the Whitney (Figs. 2 and 3), an even more extensive marker bed, was identified in test hole 24-A-53.

Siltstones of the Whitney Member are very well sorted and contain an average of 50 percent relatively unaltered rhyolitic

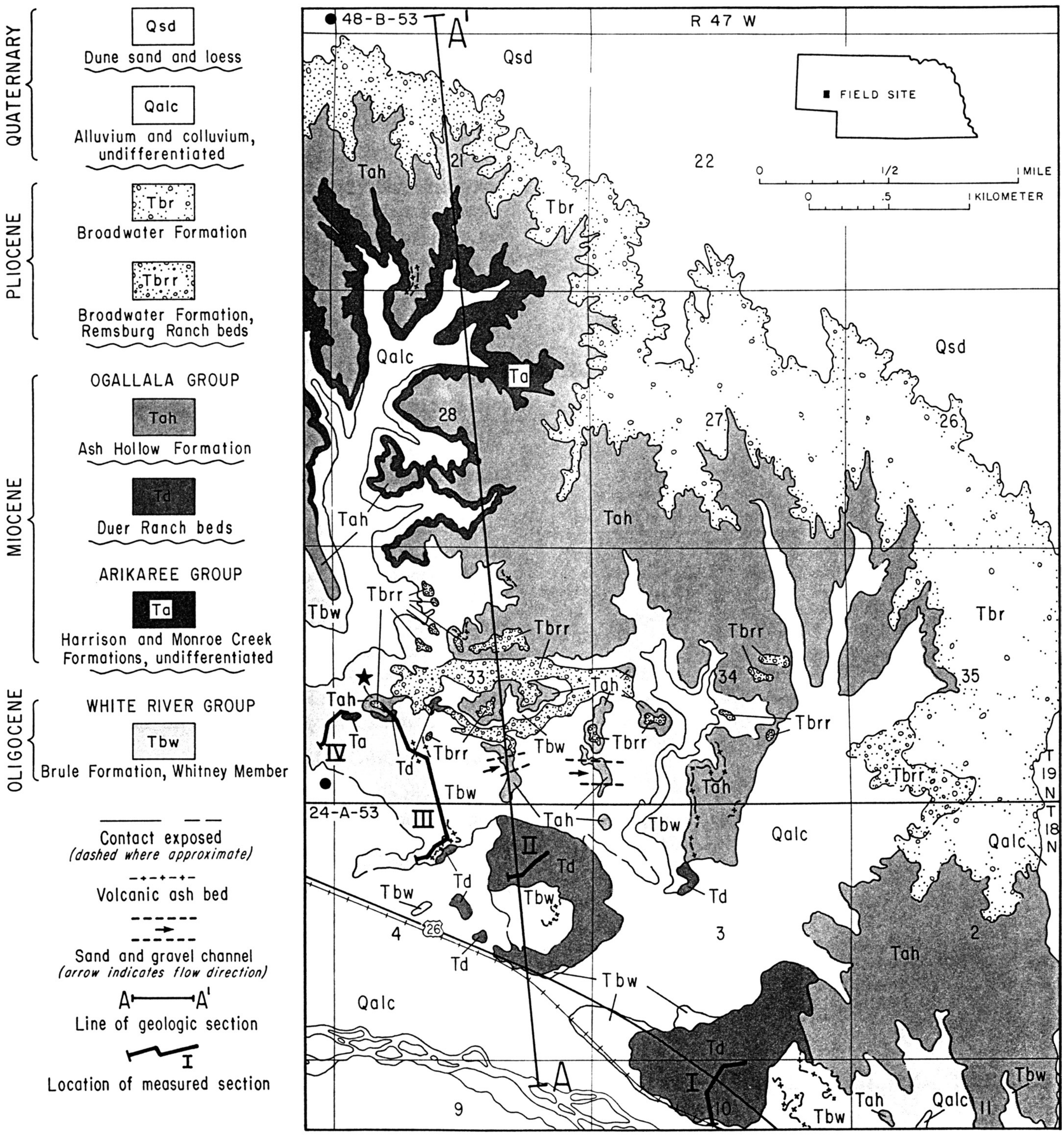

Figure 2. Geologic map of the Duer Ranch locality.

glass shards (Fig. 4) and an estimated 30 percent volcanically derived plagioclase and rock fragments in the coarse silt and very fine sand fractions. These characteristics, combined with the general lack of stratification and scarcity of fluvial sequences, suggest that most of the Whitney was deposited by the wind and accumulated on upland surfaces where organisms and pedogenic processes destroyed most stratification. The pyroclastic material was derived from volcanic vents in the western United States with the San Juan volcanic field of southwestern Colorado one of the most probable sources. Regional studies of the Whitney

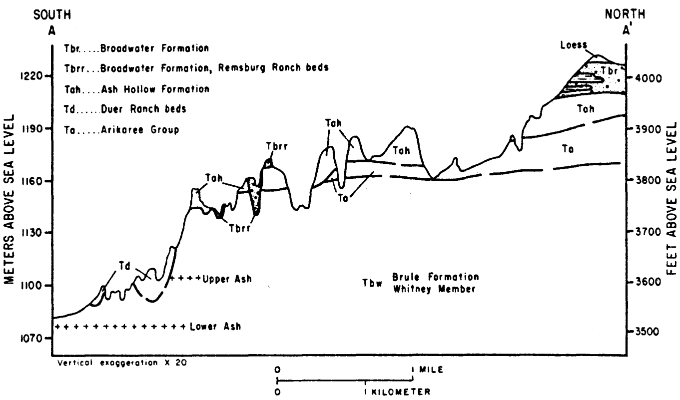

Figure 3A. Geologic section along line A-A′. Lower Ash of Whitney projected from Conservation and Survey Division test hole 24-A-53, 0.75 mi (1.2 km) west of section.

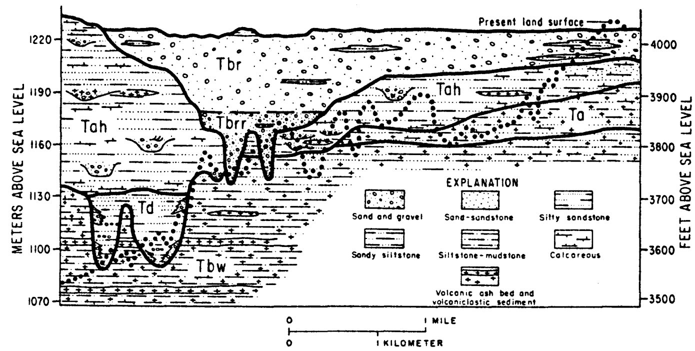

Figure 3B. Restored geologic section.

(Souders and others, 1980; and Swinehart and others, 1985) indicate that it is a blanket deposit with the Upper and Lower ash beds present over thousands of square kilometers of western Nebraska. These studies add additional strength to the concept of a primarily loessic upland origin for the Whitney.

The Arikaree Group is represented by the undifferentiated Harrison and Monroe Creek Formations that disconformably overlie the Brule Formation. These yellow brown to yellow gray, massive, very well-sorted volcaniclastic silty sands with calcareous "pipy" concretions occur only in the northwestern part of the locality (Fig. 2). Poorly defined horizontal bedding and locally abundant vertical tubules (burrows?) are the only common structures present in the Arikaree. The mineralogy of the Arikaree, like that of the Brule, is dominated by volcanically derived grains (Fig. 4). The Arikaree at the Duer Ranch locality is interpreted to be primarily an eolian deposit.

Unconformably overlying both the Arikaree and Brule is a fluvial sequence informally called the Duer Ranch beds (Figs. 2 and 3) and included within the Ogallala Group. The Duer Ranch beds consist of rock types ranging from claystones to coarse conglomerates. Brown, silty, very fine to medium-grained sands are the most common lithology (refer to measured sections I-III). These materials fill several paleogullies cut a minimum of 50 ft (15 m) below the Upper Ash of the Whitney Member and 165 ft (50 m) below the base of the Ash Hollow Formation. In the NE¼Sec.4,T.18N.,R.47W. (Fig. 2), the Duer Ranch paleogullies trend easterly, but less than 0.6 mi (1 km) east they trend southerly.

Coarse sediments, mostly colluvial deposits, are more common in the lower 50 ft (15 m) of the Duer Ranch and also near the edges of the gullies (Fig. 3B), where clasts of Brule siltstone and Arikaree sandstone up to 2 ft (0.6 m) in diameter are locally abundant. Pebbly lenses are generally less than 1 ft (30 cm) thick and are very limited in extent. Indistinct horizontal stratification is the most common sedimentary structure in the Duer Ranch, although some crossbed sets up to 1.5 ft (0.5 m) thick are present. Crossbed orientations essentially agree with the gully trends defined by gully boundaries. At some sites near these boundaries, Duer Ranch strata have primary dips of up to 7°, and the gully sides dip as steeply as 20°. Gradients up to 100 ft per mi (20 m/km) occur along some of the paleogullies (measured section III) tributary to the main complex.

The fine-grained sediments in the Duer Ranch beds are similar in color and general appearance to the sandy silts of the Brule Formation, but the two units are very distinct mineralogically (Fig. 4).

The Duer Ranch beds represent a significant change from the eolian-dominated environments of the Brule and Arikaree. The complex probably represents a combination of fluvial and mass-wasting processes. The absence of pedogenic structures (pa-

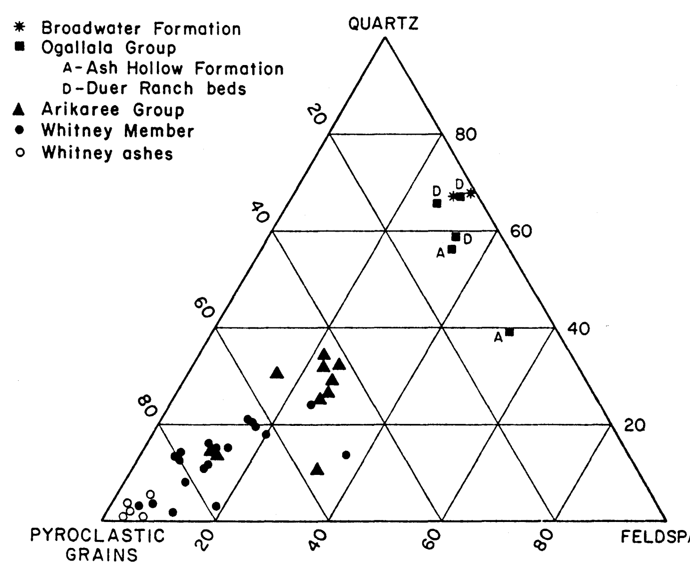

Figure 4. Ternary plot of quartz, feldspar, and pyroclastic grains in the very fine sand fraction of selected samples from the Duer Ranch locality. Pyroclastic grains include glass shards, rhyolitic to andesitic volcanic rock fragments and glass-mantled quartz, plagioclase, and heavy minerals. This class represents the minimum amount of volcanically derived material in any sample. Samples were sieved and treated with 10 percent HCl to remove carbonates and with 3 percent HF to remove authigenic clay (smectite) grain coatings.

leosol horizons) and unconformities within the fills suggests rapid sedimentation, and the Duer Ranch beds are interpreted to have been deposited by ephemeral streams.

Vertebrate fossils collected from the Duer Ranch beds place their deposition during the early part of the Clarendonian Land Mammal Age (about 10 to 12 Ma). These fossils include two horses, *Pseudhipparion* and a primitive *Pliohippus,* a camel, cf. *Protolabis,* and an antilocaprid, *Cosoryx.*

The Ash Hollow Formation rests disconformably on the Duer Ranch beds and is characterized by a hetereogeneous assemblage of sands, sandstones, sandy siltstones, sands and gravels, calcretes, silts and clays, and volcanic ashes. The typical carbonate-cemented sandstones and siltstones ("mortar beds") of the type Ash Hollow (Diffendal, this volume) are common. Ash Hollow sandstones are arkoses to subarkoses, usually containing less than 15 percent volcanically derived grains (Fig. 4). The 16- to 32-mm-size clasts of gravels are characterized by 80 percent granitic (including feldspar and quartz) pebbles and 10 percent rhyolitic to andesitic volcanic pebbles. In this locality, the cuts and fills of the Ash Hollow, in contrast to the Duer Ranch beds, are not deeply incised into older beds and lack steep gradients (Figs. 2 and 3). There is an excellent exposure of a 32-ft (10-m)-thick, sand-and-gravel-filled Ash Hollow channel in the SW¼SE¼Sec.33,T.19N.,R.47W. A light gray volcanic ash bed (vitric tuff) up to 20 ft (6 m) thick occurs in the SE¼SW¼-Sec.34,T.19N.,R.47W. (Fig. 2) and forms the base of a prominent vertical face. The abundance of siliceous rhizolith (= root cast) horizons and calcretes (refer to measured section III) indicates a slower rate of deposition for the Ash Hollow than for the Duer Ranch beds.

Diagnostic vertebrate fossils from the Ash Hollow Formation at this locality include two horses, *Dinohippus* and *Astrohippus,* and a rhinoceros, *Teleoceras.* These fossils allow assignment of an early Hemphillian Land Mammal Age (6 to 9 Ma) to this unit.

The Broadwater Formation of Pliocene age provides an example of a third style of alluvial deposition at the Duer Ranch locality. The formation consists primarily of sands and gravels within a major paleovalley that can be traced along the North Platte River valley for more than 95 mi (150 km).

The Broadwater Formation, as originally defined by Schultz and Stout (1945) from exposures in sections 20 and 21, T.19N.,R.47W., was composed of three members—a basal gravel, a middle finer-grained unit (the Lisco) and an upper gravel. Subsequent fieldwork and test drilling have demonstrated that there is more than one fine-grained unit in this part of the Broadwater (Fig. 3).

In this guide, the Broadwater Formation is divided into the lower Remsburg Ranch beds (a new informal name) and the upper, generally finer-grained alluvial fill originally described by Schultz and Stout (1945). The Remsburg Ranch beds were deposited primarily in the deep, narrow, anastomosing, bedrock-incised inner channels of the Broadwater paleovalley (Figs. 2, 3, 5, and 6). Breyer (1975) first suggested that these deposits were part of the Broadwater Formation but only used indirect evidence to support this idea. Superposition of the Remsburg Ranch beds and the main body of the Broadwater now can be demonstrated in the SW¼SW¼Sec.35,T.19N.,R.47W. The Broadwater increases in thickness from about 60 ft (18 m) in the northwestern corner of the study area to about 264 ft (80 m) in section 35 (Fig. 2). In sections 33 and 34, the Remsburg Ranch beds occur as remnants within inner channel 525 to 1,100 ft (160 to 330 m) wide and up to 150 ft (46 m) deep (Figs. 3, 5, and 6). During the incision of the inner channels, several bedrock islands were formed. The morphology of these deep, narrow cuts is clearly visible from the air (Fig. 6) and resembles closely the inner channels of valleys described by Shepherd and Schumm (1974).

The maximum size of western source clasts (primarily quartzite derived from the Medicine Bow Mountains of southeastern Wyoming) allows differentiation of the two parts of the Broadwater. The intermediate diameters of the ten largest clasts from local sites within the Remsburg beds average 4 to 5.5 in (11 to 14 cm) while the same value for the main body of the Broadwater Formation is 2.7 to 3 in (7 to 8 cm). In addition, the Remsburg Ranch beds locally contain more mafic

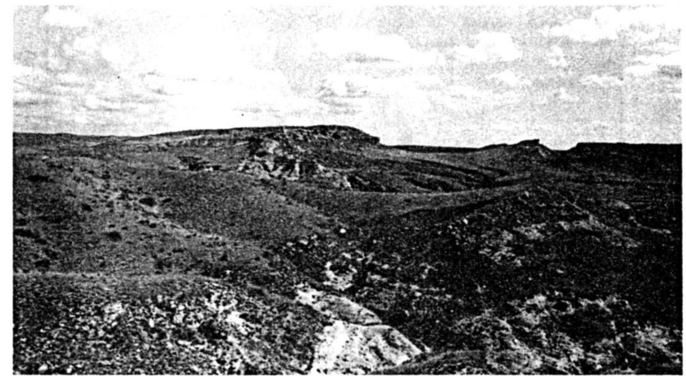

Figure 5A. Remsburg Ranch beds within partially exhumed Broadwater Formation inner channels cut into Ash Hollow and Brule Formations. View looking ESE from starred location on Figure 2 (NW¼SW¼Sec.33, T19N.,R.47W.).

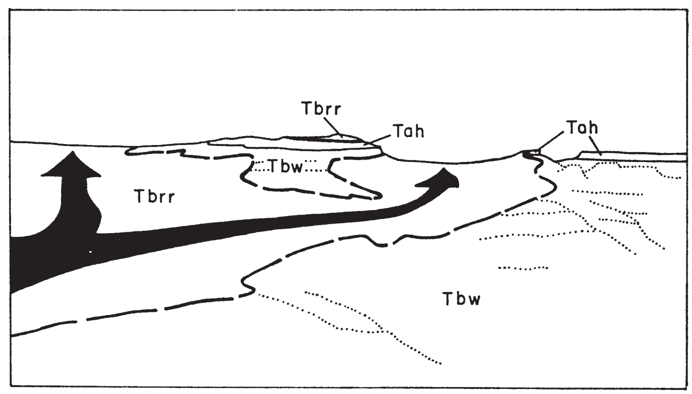

Figure 5B. Sketch of 5A with inner channel boundaries shown by heavy dashed line. Arrows indicate paleoflow direction.

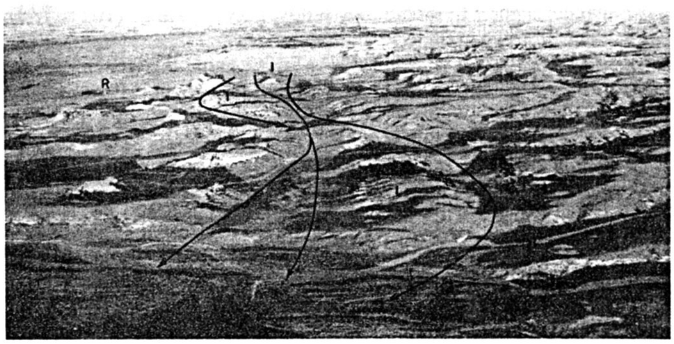

Figure 6. Oblique aerial view looking west at anastomosing inner channels filled with sand and gravel of Remsburg Ranch beds. Arrows indicate directions of flow. "I" is bedrock island, "R" is ranch headquarters.

plutonic clasts and fewer sandstone and siltstone clasts than the upper part of the Broadwater. The Broadwater Formation is interpreted to have been deposited by a major braided river system.

The age of the Broadwater Formation based on fossil vertebrates is early to middle Blancan (2.5–3.5 Ma). Fossils from sites along the outcrop belt of the Remsburg Ranch beds indicate that this unit is somewhat older than the original Broadwater Formation.

Quaternary deposits in the Duer Ranch area consist of colluvium, alluvium, thin sandy loess, and dune sand. These deposits are complex and are worth examination by themselves. Some Holocene stream cuts have also exposed sequences of Quaternary buried soils.

MEASURED SECTIONS

Section I: base at center of south line of SE¼NE¼NW¼Sec.10,T.18N., R.47W. (Fig. 2) in a gully 49.5 ft (15 m) north of railroad tracks at elevation of 3,540 ft (1,080 m).
WHITE RIVER GROUP
Brule Formation - Whitney Member
1. Siltstone, slightly clayey, massive; upper 10 ft (3 m) covered .... 16 ft (4.9 m)
OGALLALA GROUP
Duer Ranch beds
2. Sand, very fine to coarse, pebbly, poorly sorted; thick, indistinct stratification, some graded beds and low-angle (10°), large-scale cross-beds; abundant intraformational claystone cobbles and boulders (up to 18 in [45 cm] in diameter); a spring occurs at the Whitney/Duer Ranch contact .... 15 ft (4.6 m)
3. Sand, very fine to very coarse, with some fine gravel lenses; some cross-bedded strata with both trough and planar cross-bedding, southerly paleoflow direction; mostly granitic pebbles with 5 to 10 percent acidic volcanics .... 20 ft (6.1 m)
4. Siltstone, very sandy; pebbly, yellow-brown (10YR 6/4), laminated; thinly interbedded with sandstone, very fine to medium; local thin claystones .... 18 ft (5.5 m)
5. Siltstone to silt, very sandy, pebbly; interbedded with thin sand to sandstone, very fine to fine; beds usually less than 6 in (15 cm) thick .... 8 ft (2.4 m)
6. Sand, very fine to fine, very silty; interbedded with poorly sorted, pebbly, very fine to fine friable sandstone; local small fills of fine gravel; upper 24 ft (7.6 m) contains a few irregularly cemented sandstone ledges .... 52.5 ft (16 m)
7. Sand, very fine to medium, very silty, slightly clayey, locally pebbly; indistinct horizontal bedding; upper 13 ft (4 m) to hilltop are covered .... 24 ft (7.3 m)

SECTION II: base at NE¼NE¼SE¼NE¼Sec.4,T.18N.,R.47W., (Fig. 2) about 1,980 ft (600 m) north of U.S. 26 at elevation of 3,575 ft (1,090 m).
OGALLALA GROUP
Duer Ranch beds
1. Sand, very fine to fine, moderately silty; moderate, yellowish-brown (10YR 5/4); thick bedded, massive; interbedded with sandy silt; local pebbly sand lesnes; some medium-scale cross-bedding; most stratification is indistinct .... 35 ft (10.7 m)
2. Gravel and sand, gravel clasts up to cobble size and mostly comosed of reworked Arikaree and Whitney concretions; granitic pebbles also present; fossil bone fragments common; unit is approximately 200 ft (60 m) wide and pinches out into sandy silts ..... 4 ft (1.2 m)
3. Sand, very fine to fine, very silty, poorly sorted; moderate yellowish-brown (10YR 5/4); indistinct, thick horizontal bedding, locally calcareous .... 16 ft (4.9 m)
4. Sand, very fine to fine, moderately silty, pebbly with local thin granitic gravel lenses; local cut and fill with a maximum of 12 inches (0.3 m) of relief .... 14 ft (4.3 m)
5. Sandstone, very fine to fine, moderately silty, calcareous, thin-bedded and cross-laminated; interbedded with thin clayey siltstones and claystones, yellowish-brown (10YR 6/2); some siltstones contain many small vertical tubules (burrows?) .... 35 ft (10.6 m)

SECTION III: base at center of south line SE¼NE¼NW¼Sec.4, T.18N.,R.47W. at elevation of 3,580 ft (1,092 m).
WHITE RIVER GROUP
Brule Formation - Whitney Member
1. Siltstone, moderately clayey; grayish orange (10YR 7/4) to moderate yellowish-brown (10YR 5/4); massive; compact; several thin 6- to 12-in (15- to 30-cm) mottled zones with irregular clumps of darker colored siltstone ("microbreccias" = reworked soil horizons?) containing small tubules and "vesicles;" small pods of barite crystals common in upper 10 ft (3 m) .... 32 ft (9.7 m)
2. Upper Ash bed, silt to siltstone, moderately sandy; very pale orange (10YR 8/2); 81 percent glass shards in very fine sand fraction; burrows common; gradational upper contact .... 4 ft (1.2 m)
3. Siltstone, slightly clayey; very slightly sandy; massive; several thin, lightly mottled zones or "microbreccias," as below ..... 46 ft (14 m)
4. Volcanic ash bed, siltstone to silt, moderately sandy; 88 percent glass shards in very fine sand fraction; unit pinches out to the east .... 4 ft (1.2 m)
5. Siltstone, slightly clayey; massive; small, irregular calcareous, cemented concretions in upper part; 3.3 ft (1 m) below top is a very silty, brecciated, white (N9) claystone; 3 to 7 in (8 to 17 cm) thick containing very small (<1 mm diameter) tubules ...... 25 ft (7.6 m)
6. Siltstone to silt, slightly sandy; yellow olive grey (5Y 6/2); massive; small, irregular, calcareous nodules; unit becomes sandier about 1,650 yards (500 m) east and contains carbonate-cemented, vertically oriented, and interconnected concretions; this unit may be equivalent to the base of the "Brown Siltstone beds" of Swinehart and others (1985) .... 5 ft (1.5 m)
7. Silt, very sandy; 71 percent glass shards in very fine sand fraction; fining upward; small tubules (burrows?) common; local oxidized zones; small, irregular concretions; gradational upper contact .... 8 ft (2.4 m)
8. Siltstone, very sandy, 68 percent glass shards in very fine

sand fraction; yellowish-gray (5Y 7/2); 1 cm thick indurated ledge at top .... 6 ft (1.8 m)
9. Siltstone, slightly sandy; moderate yellowish-brown (10YR 5/4); massive; a paleogully of the Duer Ranch beds (units 15-18) cuts almost to the base of this siltstone .... 21 ft (6.4 m)
10. Siltstone, slightly sandy; mottled yellowish-gray (5Y 7/2) and moderate yellowish-brown (10YR 5/4) "microbreccias" in upper 3.3 ft (1 m); small (1-mm) diameter vertically oriented tubules (burrows?) common .... 9 ft (2.7 m)
11. Siltstone, moderately sandy; yellowish-gray (5Y 7/2); massive .... 4 ft (1.2 m)
12. Siltstone, slightly to moderately sandy; white (N9) to pale greenish-yellow (10YR 8/2); many small burrows(?), as below ... 3.3 ft (1 m)
13. Siltstone, moderately sandy, fining upward, massive; small vertical burrows(?) common; 3 in (8 cm) white, calcareous siltstone at top .... 11 ft (3.4 m)
14. Siltstone, very sandy; 47 percent glass shards in very fine sand fraction; poorly defined horizontal laminations; abundant small (2-mm) diameter vertical tubules (burrows?) up to 24 in (60 cm) long, some siliceous rhizoliths in upper 24 in (60 cm); carbonate-cemented, vertically oriented, and interconnected concretions with indistinct boundaries .... 9 ft (2.7 m)

OGALLALA GROUP

Duer Ranch beds

15. Conglomerate, clasts up to 10 in (25 cm) in diameter, larger clasts composed of reworked Arikaree and Whitney calcareous concretions; this unit caps a small knob just south of the saddle where the main fill of a Duer Ranch paleogully (unit 16) is exposed. This conglomerate is not present in the fill and probably is a colluvial deposit at the gully edge .... 5 ft (1.5 m)
16. Silt to siltstone, very sandy with interbedded silty sand and pebbly sand lenses; moderate yellowish-brown (10YR 5/4); poorly defined horizontal bedding; this unit fills a narrow (330 ft [100 m]-wide) gully eroded into the Brule .... 69 ft (21 m)

Ash Hollow Formation

17. Sandstone, very fine to medium, slightly silty; calcareous; abundant siliceous rhizoliths .... 4 ft (1.2 m)
18. Sandstone, fine to coarse, locally pebbly, arkosic; interbedded with sandstone, very fine to fine, very silty; calcareous "mortar bed" ledges; several siliceous rhizolith horizons .... 35 ft (10.6 m)

Broadwater Formation—Remsburg Ranch beds

19. Gravel, sandy, larger clasts (maximum axis about 7.5 in [19 cm]) predominantly quartzite; mafic plutonic pebbles common, less than 1 percent anorthosite .... 8 ft (2.5 m)

SECTION IV: base of section in NE¼NE¼SE¼SE¼Sec.32,T.19N., R.47W. at elevation of 3,630 ft (1,106.4 m)

WHITE RIVER GROUP

Brule Formation—Whitney Member

1. Siltstone, moderately clayey, slightly sandy; pale yellowish-brown (10YR 6/4) to pale olive (10Y 6/2 in upper 8 in (20 cm); massive .... 8 ft (2.4 m)
2. Siltstone, moderately sandy; 74 percent glass shards in very fine sand fraction; mottled light grey (N7) to pale olive (10Y 6/2) "microbreccia;" abundant small tubules (burrows?) ..... 2 ft (0.6 m)
3. Siltstone, slightly to moderately sandy; grayish-orange (10YR 7/4) to yellowish-brown (10YR 5/4); massive; several thin, discontinuous "microbreccia" zones; 3.75-in (9.3-cm)-thick light gray (N7) to pale olive (10Y 6/2) siltstone occurs about 40 ft (12 m) above base of unit; mostly vertical exposures above this unit .... 81 ft (24.7 m)
4. Silt, very sandy; well sorted; 64 percent glass shards in very fine sand fraction, grayish-orange (10YR 7/4); massive, iron stain in upper 2 ft (60 cm); upper and lower contacts are indistinct; the base of this unit may be equivalent to the base of the Brown Siltstone beds of Swinehart and others (1985) .... 5 ft (1.5 m)
5. Siltstone, slightly sandy; pale olive (10Y 6/2) in upper 2-ft (60-cm) width; local staining; some small vertical tubules (burrows?) .... 17 ft (5.2 m)
6. Claystone; white (N9); brecciated, possible mud cracks .... 1 ft (0.3 m)
7. Siltstone, slightly sandy; massive; angular claystone clasts occur in basal 2 ft (60 cm); indistinct calcareous concretions .... 14 ft (4.3 m)
8. Siltstone, sandy; contains claystone fragments; 3-ft (90-cm) thick; a 6-inch (15-cm)-thick claystone; white (N9) at base and top of siltstone; 330 ft (100 m) east are 3 thin claystone beds in this unit; easily recognizable marker bed .... 4 ft (1.2 m)
9. Siltstone, very sandy; moderate yellowish-brown (10YR 5/4); the unit becomes slightly finer grained upward; small diameter burrows(?) common; a few thin calcareous ledges ..... 7 to 14 ft (2.1 to 4.3 m)

ARIKAREE GROUP (?)

Harrison and Monroe Creek formations, undifferentiated

10. Siltstone, very sandy at base grading up into very silty, very fine sandstone, 35 percent in very fine sand fraction; massive; locally abundant small vertical burrows(?), some siliceous rhizoliths; calcareous, vertically oriented concretions with indistinct boundaries; this unit could be interpreted to be part of the Brule Formation below .... 11 to 14 feet (3.4 to 4.3 m)

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