THE MARSHALL LAMBERT SYMPOSIUM ROAD LOG CONTRIBUTIONS

Road Log to
THE TYPE AREAS OF THE PALEOCENE SLOPE FORMATION AND INTERCALATED TONGUES OF THE CANNONBALL FORMATION,
SLOPE COUNTY, NORTH DAKOTA

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Introduction

The Slope Formation was named by Clayton and others (1977) for strata previously included in the upper part of the Ludlow Formation and lowermost portion of the Tongue River Formation (although usage has been inconsistent). Two marginal marine tongues of the Cannonball Formation intercalate with the Ludlow (restricted usage) and Slope formational sequence. In redefining the upper contact of the Slope Formation, Clayton and others (1977) also introduced the Bullion Creek Formation for strata between the Slope and Sentinel Butte Formations previously reported as the Tongue River Formation. The purpose of this road log is to guide the interested geologist and paleontologist to the type area of the Slope and tongues of the Cannonball Formations. The value or validity of the use of the Slope Formation, as a replacement for the upper portion of the Ludlow Formation, will be discussed in a contribution by Hartman and Cvancara (in prep.). That work will provide justification for the introduction of new names for the tongues of the Cannonball Formation. The lithostratigraphic nomenclature employed here follows that of the North Dakota Geological Survey (but see also Carlson, 1983). In contrast, the U.S. Geological Survey recognizes the Ludlow and Tongue River Members of the Fort Union Formation for the same stratigraphic sequence.

To those visiting the area described in this report, please contact appropriate landowners for permission to access property. In addition, please limit the collection of macrofossils (specifically brackish-water shell pods) of the tongues of the Cannonball Formation. These occurrences are very limited, particularly in the Boyce Tongue, and are needed for in situ field examination. The trail portion of the route will be considered by most travelers to be accessible in a pickup. All maps referred to are U.S. Geological Survey 7.5-minute series topographic quadrangles at a scale of 1:24,000. The writer wishes to acknowledge the cooperation and hospitality of the families of Clyde and John Brown, the patience of Ms. Carol Edwards of the U.S. Geological Survey Field Records Library, and the support of the National Science Foundation, U.S. Department of Energy, and U.S. Bureau of Mines in this research. I also wish to thank Dr. David W. Krause (State University of New York at Stony Brook) for his thoughtful comments on this and other contributions by the writer.

General Access

To access the type area of the Slope Formation from Beach, travel south to Golva on ND 16 and continue south about 11 km (7 mi) to a T-intersection. Travel west for 1.7 km (1 mi) and follow the curve in the road to the south. Continue south for 11 km (7 mi) to the Golden
Valley-Billings County line. Access from Marmarth to the same county line intersection should be considered only under dry road conditions. On a wet day, numerous soft spots and a few creek fordings can cast a shadow on an otherwise pleasant undertaking. From U.S. 12, go north on the first road west of the Little Missouri River (about 1.6 km, 1 mi), for about 28.8 km (18 mi), to the Slope-Golden Valley county line. There are essentially no possible turnoffs. The route takes the traveler past Pretty Butte, which is truly stunning in certain lighting situations, about 11 km (7 mi) north of U.S. 12. Pretty Butte, and much of the surrounding strata, is of the uppermost Cretaceous Hell Creek Formation. Pretty Butte is capped by a thick clinker, representing the baking of strata from the burn of an underlying coal bed. The route includes crossing the contact between the drab-colored Hell Creek and lighter-colored Ludlow Formations. This contact is frequently marked by a lignite and is closely correlated with the Cretaceous-Tertiary boundary.

To the Type Slope Formation

The intersection on the Slope-Golden Valley County line is located in the northwest corner of sec. 4, T. 135 N., R. 106 W., on the Ollie, Mont.-N. Dak. Quadrangle (1981), in the headwaters area of Horse Creek (Hartman, this volume, Figure 1). Travel east (following a number of south-directed curves) for about 7.5 km (4.7 mi) to a section line fence and cattle guard indicating the entrance to the Brown Ranch. The juncture of the road to Brown Ranch (to the southeast) and the trail to the stratotype of the Slope Formation occurs just east of the cattle guard in the northwest corner of sec. 7, T. 135 N., R. 105 W., on the Williams Lake Quadrangle (1979), Slope County, North Dakota. Follow the trail east on a steep, rutted road, for about 2.1 km (1.3 mi), across a valley of a tributary of Deer Creek. On reaching the trail juncture on an upland bench in the NW¼ NW¼ of sec. 8, take the southeast trail for about 2.2 km (1.4 mi) to the edge of Three V Crossing Quadrangle (1979) in the E½ SE¼ NE¼ SW¼ sec. 9. The highly dissected badlands to the south are formed primarily in the Slope Formation, with flat-bottomed tributaries exposing the uppermost part of the Ludlow Formation. The drainage was informally referred to as School Section Creek by Moore (1976). Numerous surface-measured sections, one subsurface geophysical and mud-sampled section, and other geologic observations, dating back to the studies of Leonard (1908), have been made in this area. Follow the somewhat twisting road around an embayment of School Section Creek. The stratotype of the upper part of the Slope Formation can be viewed to the east at a few high-ground vantages along this route. Good views can be obtained of the type Slope from a platform overlooking the breaks south of the section line gate (to private land) separating sections 9 and 10. A bearing of 126° transects the top of the slightly dome-shaped butte forming the top of the stratotype. In this view, the upper Slope Formation is exposed on dissected south-facing bluffs (Figures 1 and 2). The north side of the butte is a broad, grass-covered slope. Lenses of brackish-water fossils occur in the lower portion of the bluff, forming the upper portion of the type Slope section, and can be traced intermittently to this vantage.

The trail from the section line gate (secs. 9-10) trends southeast for about 0.6 km (0.4 mi), at which point the traveler has reached the stratotypes of the Slope Formation and the Three V Tongue of the Cannonball Formation. The type area was originally reported by Clayton and others (1977, p. 7) as "in the south-facing exposure in the northwest corner of section 15 and the southwest corner of section 10, T105N, R135W." The cited township and range is in error,
representing a transposition of the numbers. The lower portion of the stratotype of the Slope Formation is located in south-facing exposures, which also bear the Boyce Tongue, in the N\(\frac{1}{2}\) NW\(\frac{1}{4}\) sec. 15, T. 135 N., R. 105 W., while the upper portion of the Slope Formation and the stratotype of the Three V Tongue of the Cannonball Formation are on southwest-facing exposures in the S\(\frac{1}{2}\) SW\(\frac{1}{4}\) SW\(\frac{1}{4}\) sec. 10, T. 135 N., R. 105 W. (Figure 1; Hartman, this volume, Figure 1, Location A).

The Slope Formation and Three V Tongue Stratotypes

The Slope Formation is not fully represented in its type section (Figures 2 and 3). The nearest outcrop of the "white bed"-silcrete horizon used to demarcate the contact between the Slope Formation from the overlying Bullion Creek Formation is located about 8.8 km (5.5 mi) to the northeast and outside the scope of the present report. At the stratotype, the Slope Formation is about 68.7 m (225 ft) thick. Clayton and others (1977) reported a total thickness of about 90 m (295 ft) for the Slope Formation in its type area, which is confirmed by current studies. The base of the Slope Formation was defined by Clayton and others (1977) at the top of a coal and carbonaceous claystone sequence identified as the T Cross bed. As they did not nomenclaturally distinguish or treat as significant the occurrence of the brackish-water beds in this section, the base of the Slope Formation consisted, where locally observed, of sediments deposited in environments related to the Cannonball Sea, here corresponding to the "T Cross clay" (Figures 3 and 5). As presented by Moore (1976), in reference to his upper Ludlow Formation, and discussed by Carlson (1983), the T Cross lignite (of Moore) represented the basal unit of the Slope Formation. Correlation of the thick T Cross lignite, in its reference area in the SW\(\frac{1}{4}\) sec. 20, T. 133 N., R. 105 W., Marmarth SE Quadrangle (1979), in southern Slope County, into the type area of the Slope Formation (in T. 135 N., R. 105 W.) is uncertain and was not documented by previous studies (see Hartman, 1989). With the inclusion of the T Cross lignite (of Moore) in the basal Slope Formation, the lower tongue, referred to here as the Boyce Tongue, of the Cannonball Formation is intercalated within the lowermost part of the Slope Formation. As defined by Clayton and others (1977), the Boyce Tongue represents a lithostratigraphic unit between the Ludlow and overlying Slope Formation (Figure 5).

The brackish-water sediments occurring above the Boyce Tongue are herein referred to as the Three V Tongue of the Cannonball Formation (Figures 2 and 3; Hartman and Cvancara, in prep.). Fossils from this horizon were probably first recognized by A.G. Leonard in 1907 (Leonard, 1908). The bed containing these fossils has been called the upper or U tongue (e.g., Van Alstine, 1974) and Oyster tongue (e.g., Brown, 1948; Belt and others, 1984). The Three V Tongue is largely coincident with the "Oyster clay" unit reported by Moore (1976) and is noted for its lenses of brackish-water macrofossils that occur in the south-facing exposures along the north rim of the School Section Creek (of Moore) drainage. The lenses are composed of bivalve taxa from the families Ostreidae, Corbiculidae, and Corbulidae (Van Alstine, 1974; Hartman and Cvancara, in prep.). The palynomorph studies of Timothy J. Kroeger, as part of his dissertation studies at the University of North Dakota, will provide additional interpretation on the environments of deposition represented by the Slope Formation in its type area.
To the Boyce Tongue

The journey to the type area of the Boyce Tongue of the Cannonball Formation requires the traveler to navigate a difficult (impassable to most) hairpin turn, which has been largely reclaimed by a back-cutting rivulet. Navigating the trail on foot from this point is prudent. Follow the trail south for about 0.1 km (0.06 mi) and then due east for about 0.8 km (0.5 mi) to where the trail turns to the northeast. At this juncture, a wide, flat river plain can be seen to the southeast, bounded by an exaggerated meander loop of the Little Missouri River. On a bearing of about 140°, descend the nose of the promontory to and across the flats for about 3 km (1.86 mi). This route parallels the south flank of the meander loop and brings the traveler to the bluffs that include the type area of the Boyce Tongue of the Cannonball Formation (Figure 4; Hartman, this volume, Figure 1, Location B). A wade across the Little Missouri River will be necessary for closer examination.

The Boyce Tongue Stratotype

The occurrence of brackish-water fossils at a horizon immediately above the T Cross lignite (of Moore) (Figure 4) was probably first noted by C.J. Hares in 1911 (Hares, 1911, Section 137). This report, however, went unreported, but was noted by Roland Brown, who rediscovered the occurrence in 1931 (Brown, 1948, 1962). His observations, and those to follow, were taken in the NE¼ NW¼ SW¼ of sec. 14, T. 135 N., R. 105 W., on the Three V Crossing Quadrangle. Brackish-water fossils at this level have been referred to as the lower or L tongue (e.g., Van Alstine, 1974), Corbula tongue (Brown, 1948), and Corbicula tongue (e.g., Belt and others, 1984), and is largely coincident with the "T Cross clay" of Moore (1976). The same molluscan families reported for the Three V Tongue are also present in the Boyce Tongue (Van Alstine, 1974; Hartman and Cuvancara, in prep.).

Figure Explanations

Figure 1. Type Area of the Slope Formation. A northeast view of the type area of the Slope Formation in sections 10 and 15, T. 135 N., R. 105 W. (Hartman, 1991; Hartman, 1993, this volume, Figure 1, Location A). The photo is from a bluff on the west side of the Little Missouri River in the SW¼ of sec. 16. Section M1721 is one of a number of sections measured in this area (M-numbers represent geological observations maintained in a catalog by the Energy & Environmental Research Center). The Boyce and Three V Tongues of the Cannonball Formation occur in the lower and upper bluff faces, respectively. The Boyce Tongue overlies the "T Cross lignite of Moore" (see also Figure 4) and the Three V Tongue occurs in the lower portion of exposures in the upper bluff (see Figure 2). The trail described in the text can be (barely) observed on the left edge of the photograph (on the west end of the exposures) and just below the exposures of the upper bluff.

Figure 2. Type area of the Three V Tongue. An easterly view of the upper portion of the Slope Formation exposed in its type area, including the stratotype of the Three V Tongue of the Cannonball Formation (Hartman, 1991). Note the presence of the trail (in foreground) described in the text.
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Figure 3. Stratotype of the Slope Formation. This geologic section is derived from the combined interpretation of Moore (1976), Belt and others (1984), T.J. Kroeger (University of North Dakota, unpublished observations, 1988), and Hartman (unpublished observations, 1990). In this section, the Boyce and Three V Tongues would have been identified by Moore (1976) as the T Cross clay and Oyster clay, respectively. The placement of the Ludlow-Slope formational contact is after Clayton and others (1977) (see Carlson, 1983; and text for discussion).

Figure 4. Type area of the Boyce Tongue. An easterly view primarily of the lower portion of the Slope Formation in its type area, including the stratotype of the Boyce Tongue of the Cannonball Formation immediately overlying the T Cross lignite (of Moore).

Figure 5. Chronostratigraphy of North Dakota Paleocene strata. This drawing illustrates the relative occurrence of the Boyce and Three V Tongues of the Cannonball Formation as interpreted from far-western North Dakota in the valley of the Little Missouri River.

References


Figure 1
Type Area of the Slope Formation

Figure 2
Type Area of the Three V Tongue
Figure 3

STRATOTYPE OF THE SLOPE FORMATION

- Fine-grained sandstone
- Clayey sandstone
- Mudstone
- Siltstone
- Alternating claystone, shale, and sandstone
- Lignitic clastic rock
- Lignitic shale
- Calcareous shale-claystone
- Carbonaceous shale-claystone
- Claystone
- Lignite
- Fossiliferous bed or lens
- Covered interval

named lignites
Figure 4
**Stratotype of the Boyce Tongue**

![Stratotype of the Boyce Tongue](image)

Figure 5
**Chronostratigraphy of North Dakota Paleocene Strata**

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<tr>
<th>Golden Valley Formation</th>
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*Substantially more text*
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