GENERAL STRATIGRAPHY OF THE FORT UNION FORMATION
NEAR EKALAKA, SOUTHEASTERN MONTANA

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INTRODUCTION

The Paleocene Fort Union Formation fills the intramontane Powder River Basin. In southeastern Montana, the Fort Union Formation is fluvial. In western North Dakota, however, the lower half grades into the Cannonball Formation, which is marine. The Southeastern Montana Keck group focused on the Fort Union Formation where it outcrops around Ekalaka, Montana (Fig.1).

THE FORT UNION FORMATION NEAR EKALAKA

In outcrops around Ekalaka, two members make up the Fort Union Formation: the Ludlow and the Tongue River. The Ludlow consists of dull-colored fine-grained sands, muds, coals, and carbonaceous shales. The muds are high in smectite. The Tongue River sediments are medium grained gold or tan sands. The Tongue River sediments are lower in smectite compared to the Ludlow. The boundary between the two members is where the smectite muds end and the lighter colored sands begin. I examined outcrops of the Fort Union Formation around Ekalaka to determine the local stratigraphic sequence.

FIELD AND LABORATORY METHODS

I examined the stratigraphic sequence at two sites: Herrington Ranch and Williams Ranch. At each outcrop, I measured lithostratigraphic units using a Jacob Staff. I chose outcrops with distinctive sedimentary beds that could be traced from section to section. I recorded the grain size, color and sedimentary structures in each lithostratigraphic unit. I traced the beds from outcrop to outcrop to determine their lateral extent. From this data I drew a series of vertically scaled stratigraphic columns, one for each outcrop measured.

I drew correlations between similar lithologic units in the stratigraphic columns at each site. When the thickness of the units or their order varied from outcrop to outcrop, I used marker beds such as coals as reference points. I developed generalizations about the depositional history of the area using these correlations.

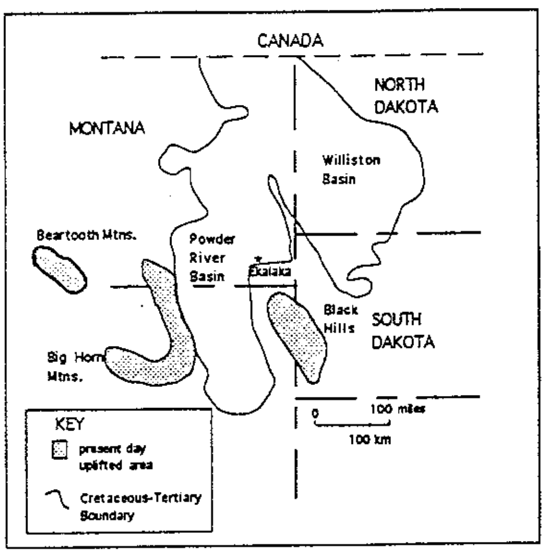


Figure 1. Regional setting of the study area showing the location of the Williston and Powder River Basins and the Cretaceous -Tertiary boundary (Belt et al., 1992)

GENERAL STRATIGRAPHY NEAR EKALAKA

The Williams Ranch and the Herrington Ranch sites have similar stratigraphic sequences (Fig.2,3). Both sites have sediment sequences typical of the Ludlow and the Tongue River. The generalized stratigraphic sections of the two sites are characteristic of the stratigraphy of the area around Ekalaka.

The base of the stratigraphy in the area around Ekalaka starts in the middle or upper Ludlow. Around Ekalaka, the Ludlow contains units of grey, brown or yellow mud, silt, and medium and fine-grained sand. The clay units are 2 to 5 meters thick. They have a popcorn-like texture when dry. The mud units are 0.5 to 2 meters thick. Some of the mud units are unconsolidated . Others are consolidated and filled with root casts. The silt and fine-grained sands are 1 to 5 meters thick and usually grade into each other. They are unconsolidated. The medium-grained sand units are 3 to 8 meters thick. They contain trough cross-beds. Paleocurrent directions recorded from these trough crossbeds average northeast.

A zone of dirty coals and carbonaceous shales lies near the top of the Ludlow. The coals range from several centimeters to a meter thick. Some coal beds pinch to thin lenses in carbonaceous shale. Others, however, are purer and contain chunks of wood. Palynological analyses of two coals in this zone place their age at the early Paleocene (Belt, personal communication).

Almost immediately overlying the top-most Ludlow sand is a unit of ripple-bedded sand and silt. The unit is 5 to 17 meters thick. Each ripple bed is 1 or 2 centimeters thick. The sand beds are tan and medium-grained. The silt layers are paler and generally whitish, although in some places the silt has a greenish tint. Leaf fossils, root casts and burrows are also found in this lithology.

This lithology has been deformed at most places it crops out. The beds have been faulted, microfaulted, and tilted. Bedding attitudes range from horizontal to nearly vertical. In some places deformation consists only of microfaults. Structural data indicate that the unit is deformed brittley. In places where the unit has been deformed, blocks of deformed material are interspersed with flat-lying sandstones. No outcrops with these sandstones had both upper and lower boundaries. However, the units appear to be at least 13 meters thick. The sands contain conglomerates of matrix-supported chunks of the light-colored deformed material.

On top of the deformed unit lie Tongue River sands. The sands are tan and medium grained. Where the section is complete, the sands fine upward and grade into several meters of ripple-bedded silt. Chunks of silcrete, or petrified soil, cap the ripple beds. At most places, however, the section is incomplete. The sandstone contains cross-beds and has rip clasts of shale and sand at the base. There are no lateral accretion beds. The Tongue River sands appear to have no lateral boundaries at the Herrington or Williams Ranch sites. Fossils found in the channel sands date the lower Tongue River sands at the late Torrejonian (Belt, personal communication).

FACIES INTERPRETATION

There are four groups of sediments at Herrington Ranch and Williams Ranch. From oldest to youngest, the first is the fine to medium-grained sands, silts, muds, and clays found in the Ludlow. The second is the coal and carbonaceous shale zone near the top of the Ludlow. The third is the ripple bedded sand and silt unit. The youngest is the cross-stratified, fining up, medium grained sandstone of the Tongue River member.

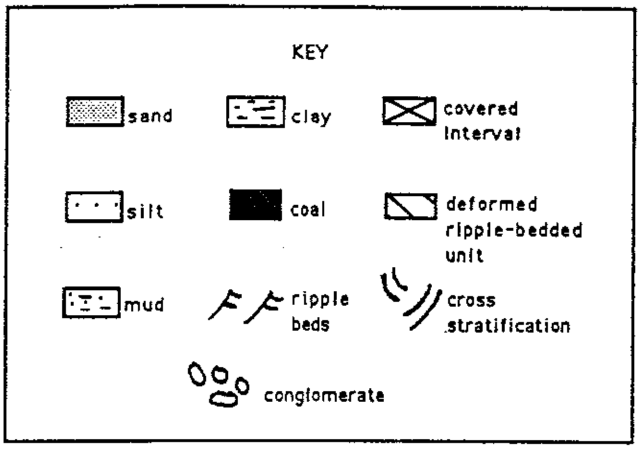
Interbedded Silts, Muds, and Medium to Fine-grained Sands

Alternating muds and fine grained sands like those in the Ludlow can be found on the floodplain of a river. Fine-grained sands are deposited at the edge of the river as it overflows. Finer sediment is deposited further away from the edge of the river. Thus, a change in the sediment size indicates that the edge of the river has gradually moved closer or further from the point in question. At the Herrington and Williams sites, mud often grades into fine-grained sand and back again. This indicates that the edge of the river was migrating closer to and then further from the floodplain. Root casts show that part of the flood plain was vegetated.

The medium-grained sandstone bodies present in the Ludlow represent the river channels which provided sediment for the floodplain. Paleocurrent data indicate that around Ekalaka the drainage direction was to the southeast.

Coal

Coal deposition represents swamping. At the Williams and Herrington sites, the coal beds pinch and swell laterally. The coals grade to dirty carbonaceous shales and back to coal. Thus, the swampy



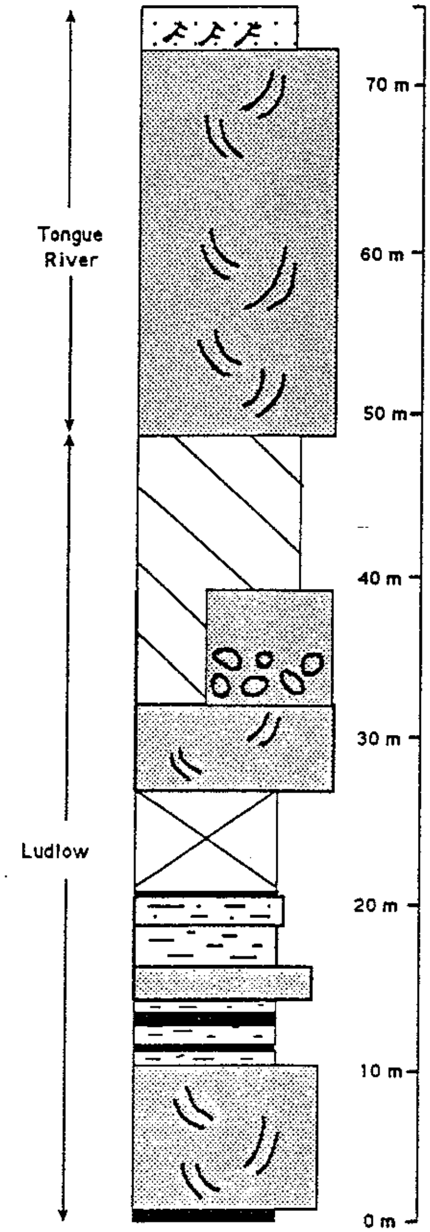


Figure 2. Generalized stratigraphy at Herrington Ranch (Lambert, Abel and Cole, unpublished data).

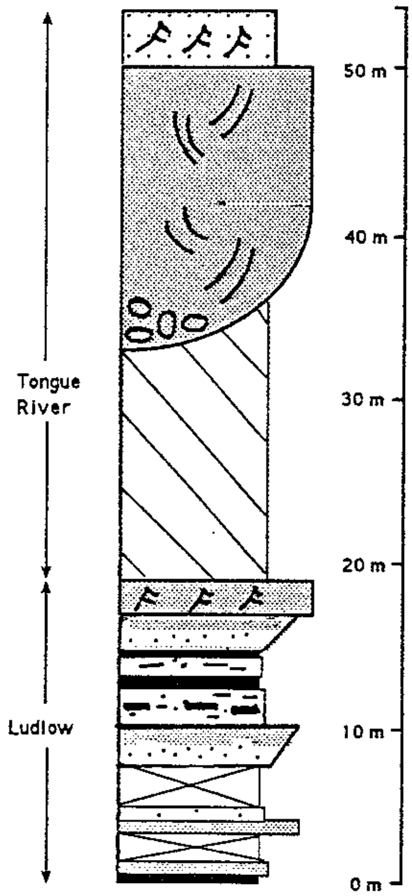


Figure 3. Generalized stratigraphy at Williams Ranch (Lambert, Roberts and Belt, unpublished data).

environment was discontinuous and was affected by influxes of sediment from the river. The swamps were probably located on the floodplain of the river since the sediment into which they grade is silt.

Ripple-bedded Sand and Silt

The ripple-bedded sand and silt unit indicates shallow water with periodic changes in energy level. The ripple-beds that the water was shallow. The alternation of silt and sand layers shows that the water energy level changed periodically. The water energy was stronger during the sand deposition, and weaker during deposition of the silt. The water was never stagnant, however; clay stayed in suspension. Leaf fossils have been preserved in the unit. This shows that the environment was either vegetated or near areas of vegetation.

Small cross-bedded sandstone bodies can be found at the same stratigraphic level as the ripple-bedded unit. The small sandstone bodies represent river channels. The combination of sandstone bodies at the same stratigraphic level as interbedded sands and silt represents an environment of small river channels with shallow, slow-moving channels on the floodplains. The channels periodically received influxes of water. This changed the water energy which in turn changed the grain sizes deposited. Even during the slow -moving periods, however, the water moved enough to keep clay in suspension.

Structural data indicate that rotational slumping caused the deformation of this unit. The data also indicate that deformation was brittle rather than ductile. The brittleness shows that the sand and silt must have lithified prior to deformation.

The geologic record is missing the event which created the conditions for rotational slumping. Steep-sided landforms are needed for rotational slumping to occur. The small river channels with associated floodplain channels would have had low-relief topography. Therefore, the missing event was one which created the relief necessary for slumping.

This missing event may have been a series of rivers incising the flat-lying, ripple-bedded unit. The rivers created canyons. Eventually the sides of the canyons slumped into the river bed. The small sandstone bodies interspersed with slump blocks support this hypothesis. The sand bodies show that the blocks slumped into a fluvial environment. The sands may be the remnants of the canyon-cutting channels. This sequence of lithification, incision. and bank slumping created the deformation of the ripple-bedded unit preserved in the geologic record.

Medium-grained, Fining Upwards Sands

The youngest unit at both sites is medium-grained, fining-upwards sandstone of the Tongue River. The sandstone represent a river channel migrating across the area. There are no lateral accretion beds or channel edges at either site, so the lateral extent of the channel is not known. Paleocurrent analysis shows that the channels at both sites were flowing northeast. The channel fines up to silt ripple beds at the top, showing that eventually the river migrated away.

GEOLOGIC HISTORY OF THE FORT UNION FORMATION NEAR EKALAKA

During the deposition of the Ludlow, the area near Ekalaka was part of a fluvial system that included meandering channels and floodplains. The rivers supplying the sediment to the floodplains periodically migrated across them. During the early Paleocene, the floodplains developed coal swamps. The swamps received occasional influxes of sediment from the river channels. Next shallow channels developed on the floodplain. The shallow channel sediments lithified. After lithification, rivers incised into the lithified unit, creating canyons. The sides of the canyons slumped into the river bed. The river flowed over the slump blocks. During the late Torrejonian, a river channel migrated across the slump unit. Finally, the channel migrated away.

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