

SOME OBSERVATIONS ON DISTURBED SEDIMENTARY STRATA FORT UNION FORMATION, EKALAKA, MT

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Introduction

The Fort Union Formation (Paleocene) dominates the geology of southeastern Montana, in the vicinity of Ekalaka. The Fort Union is most commonly identified as a fluvial formation marked by single and multi-storied sandstone bodies and vast muddy floodplain muds and sands (Diemer, 1991). Widespread coals and carbonaceous shales characterize the floodplain deposits of the Fort Union, except in the Ekalaka area, where only the older member, the Ludlow shows the development of such deposits. The younger member, the Tongue River, is characterized by sandstone without floodbasin deposits. The topography of the study area is dominated by butte-like features capped by 20-30 m thick units of the Medicine Rocks Sandstone, which is part of the Tongue River Member. The underlying Ludlow Member consists of unlithified mud, and lithified sandstone. Thin, lignite coal beds are common.

During the time of deposition of the Fort Union, paleo-drainage directions changed from the northeast (Ludlow) to the southeast (Tongue River). These changes might be associated with a gentle uplift of the Miles City arch, an northwestern extension of the Black Hills (for further details, see articles by Cole and Abel, this volume). If the uplift took place it would have diverted drainage to the Cannonball Sea.

In the vicinity of Ekalaka there are disturbed sedimentary beds of unknown origin bounded in many places by flat-lying strata above and below. The disturbed blocks show well preserved bedding lineation and micro-faults within the blocks. Similar structures have been documented by H. L. Garret (1963), which he has called Angela dips. The primary locations of his observations were between the Cedar Creek Anticline and the Porcupine Dome within the Lebo shale of east-central Montana. Lebo in this area is younger than Ludlow in the Ekalaka area (see notes on the January workshop by Belt). Angela dips are generally steeply dipping, vertical to overturned, appear normal or thrust faulted, lie between flat-lying strata. They are associated with sandstone channels of the Fort Union Formation (Garret, 1963). Other slumped blocks were observed by Dane (1978) in the Cave Hills area of NW South Dakota. These occur at the base of the F-Sandstone of the Cannonball Member, and may be the same age as the Lebo slumps reported by Garrett (1963). The disturbed strata in Ekalaka has many of the same characteristics as the younger slump structures in east-central Montana and in northwestern South Dakota.

Understanding the rheology of the unconsolidated Ludlow deposits in the Ekalaka area may be important in this study if these weak units acted as slip surfaces for basal failure of over-lying semi-lithified sandstones. The large slump features would not have occurred so dramatically without the presence of the underlying coals and shales, but because slump blocks without any association with Ludlow coals and shales were also observed, other aspects need to be considered.

Field Descriptions

At each field site bedding and fault strike and dip measurements were recorded. Also any unusual geometries observed were sketched and described. The faults observed were usually either micro fault scale or what I will call medium scale faults. Medium faults are characterized by lengths of 2-3 meters which cross erosional or slip surfaces or show some type of structure produced by movement. Large scale regional faults were not observed in my field area. All disturbed strata was of a similar lithology and hypothesized to be lacustrine deposits from a shallow lake in a fluvial system which was referred to last summer as the Mystery Lithology, but which on the charts in the reports of other workers, is now referred to as "Un-named Sandstone". This lithology has been observed by others to reach 20 to 25 m thick where it is undisturbed and conformable with the underlying Ludlow Member. Mystery Lithology is always unconformably overlain by the Medicine Rock Sandstone, whether or not that lithology is deformed by slump blocks. The different structural features described in this section have been selected to show the varied styles and scales of the observed disturbed beds. At the time of slumping, the Mystery Lithology was lithified or semi-lithified. The evidence for this is that channel sands, which came in contact with those slumped blocks, and were presumably syn-slumping river deposits, contain discrete pebbles, cobbles and boulders of Mystery Lithology. If the M. L. were not consolidated, the cohesionless sand of the blocks would have been dispersed and not been recognizable as discrete blocks within the normal cross-bedded sand of the river deposits. Too many blocks of too

many sizes are found throughout these cross-bedded sand deposits, to which Belt and others used the field-term "rumble beds".

Large Scale - Butte

Walter's Ranch is a butte capped by a large sandstone deposit, shown in Figure 1. Immediately below the cap there are many outcrops of disturbed bedding in contact with the sandstone. These outcrops of disturbed strata have orientations of bedding which are irregular, switching back and forth in no apparent pattern. The surface is irregular and often small channel ledges seem to cut down into the mystery lithology. One medium fault cuts across this erosional contact, from upper sandstone cap down into Mystery Lithology, and follows the bedding lineation of the disturbed strata. This medium fault may have been produced by compaction of the massive sandstone above.

There are also other disturbed bedding below several sandstone bodies which are spaced out across the butte at a lower stratigraphic level. These sandstone bodies were referred to as the intermediate sandstones on this butte. Below the lower disturbed strata there is flat-lying upper Ludlow deposits recorded in vertical sections done by Beth Lambert, Carleton College. A coal and lignite were found immediately below some disturbed strata, shown in Figure 1. Also disturbed strata was found above the intermediate sandstones. Another intermediate fault, approximately 2 meters, produced a drag like structure on a sandstone block as another sandstone block rotated listrically down the fault. Well preserved slickenlines were found along the fault surface.

Block Sequence

One location investigated in more detail was called Walt's Surprise (near L-7 on Cole's cross-section, this volume). This is an outstanding outcrop which shows an almost complete sequence of blocks with different orientations, shown in Figure 2 as a diagrammatic sketch. Walt's Surprise got its name from the unbelievable outcrop quality, and from Prof. Coppinger's unerring ability to surprise us with new, important outcrops. Along the side of a butte the disturbed blocks could be traced along almost continuously. Contacts between blocks could be observed. However no basal contacts with flat-lying strata could be detected. Talus and vegetation cover inhibited any effort to find a contact or possible slip surface. A nearby vertical section done by Beth Lambert (see her report, this volume) indicated that Walt's Surprise was underlain by flat-lying upper Ludlow deposits. As a large scale slump feature the outcrop must have originally been thick flat-lying Mystery Lithology. The scarp of such a feature was not observed in the vicinity. Overall free walls and scarps were not found associated with any of the disturbed strata, this is thought to be because of erosion or reworking by the fluvial systems above.

Drape Features

The drape feature has been included in this section because it may be a small scale area of the margin between a stable bank and a collapse area. In the diagram, Figure 3, reproduced from field notes, we see that flat-lying strata of Mystery Lithology drapes over an edge. This is not Holocene erosion or slump, but is preserved in a lithified sequence of disturbed formation. The outcrop of disturbed strata is only about 2 meters thick and made up of white, grey, and green clay interbeds. A massive sandstone to the right, not in the sketch, is stratigraphically above the disturbed strata. There is also sandstone deposits below this outcrop.

Average Field Outcrop

Figure 4 was included to represent most of the outcrops of disturbed bedding found in the area of study which were relatively small when compared to the butte along Mill Iron road at the Walters Ranch and at Walt's Surprise. Simple relationships were observed in these isolated outcrops such as the two Mystery Lithology deposits lying almost perpendicular to each other. The absence of continuity and direct contact with flat-lying deposits made these outcrops difficult to analyze with respect to sequence or events and origin. At these sites bedding and micro fault data was collected to be processed for regional analysis. Ian Clark (see article, this volume), has been working with all the data to find regional trends and principal stress directions.

Micro faults

Micro faults were usually extensional, few were found to be contractional. Micro faults were often found as conjugate pairs. Offsets could range from 5 cm to 20 cm in one disturbed block. Figure 5 is an example of a micro fault taken from a block in the Walt's Surprise sequence. Microfault data is being used for regional analysis of extensional directions.

Discussion

The semi-consolidation or complete lithification of the Mystery Lithology has some important implications. The lithification must have come prior to the slumping. Hence, if river bank undercutting was responsible for the slumping that took place, the rivers must have been incised. Incised meanders, such as those commonly shown in beginning textbooks for the San Juan river, are very rare. The usual river pattern is one of wandering, rather than tight bends. Still, undercutting at those bends can take place.

The geologic record holds few examples of slope failure associated with terrestrial fluvial systems (Laury, 1971). Preservation in an active fluvial system is difficult because most slope failure sediment is washed away and reworked into the system. Laury states that base failure and rotational slump which occurs below the stream level are more likely to be preserved as they should remain untouched by water flowing above. If the features described in Ekalaka are like those that Laury has described as base, shear failure it is possible that the plane of failure could somehow be related to the upper Ludlow coal and lignite beds. We saw disturbed beds immediately on top of lignites and coals in the Walters Ranch diagrammatic cross-section. However how do we explain the disturbed beds which are stratigraphically higher, below the sandstone cap which are not associated with any coal or lignite?

The relationship presented in the Walters Ranch diagram raises some important questions. What ever caused the disturbance occurred more than once. Is the cause of failure related to some inherent characteristic of the Mystery Lithology, which was triggered periodically by river bank undercutting of the semi-lithified M. L. sandstone, or was it triggered regionally all at once by an earthquake? The analysis being done by Ian Clark hopefully may answer some of these questions.

References

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- Diemer, John A. and Edward S. Belt, 1991, Sedimentology and paleohydraulics of the meandering river systems of the Fort Union Formation, southeastern Montana: *Sedimentary Geology*, v.75, p 85-108.
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DIAGRAMMATIC SKETCHES

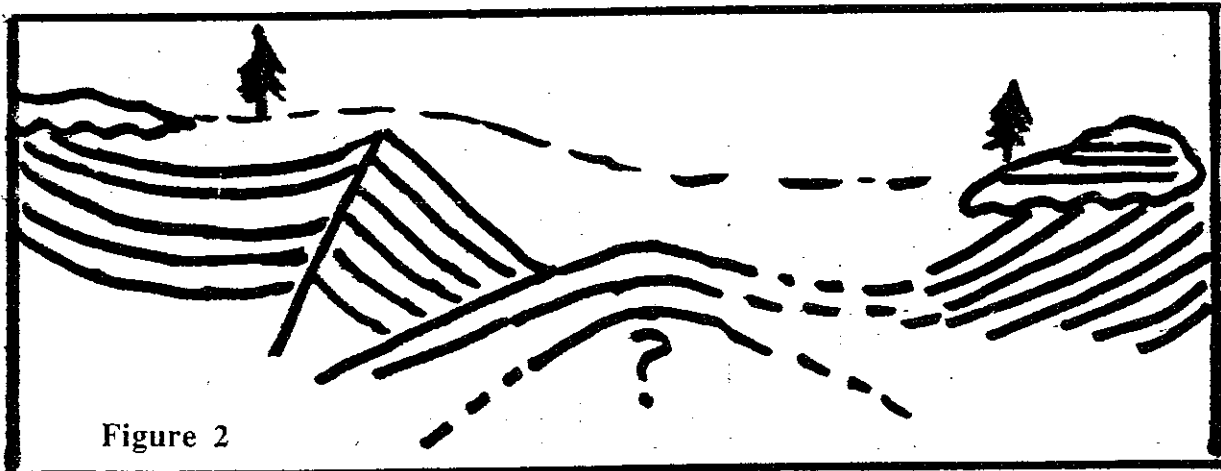
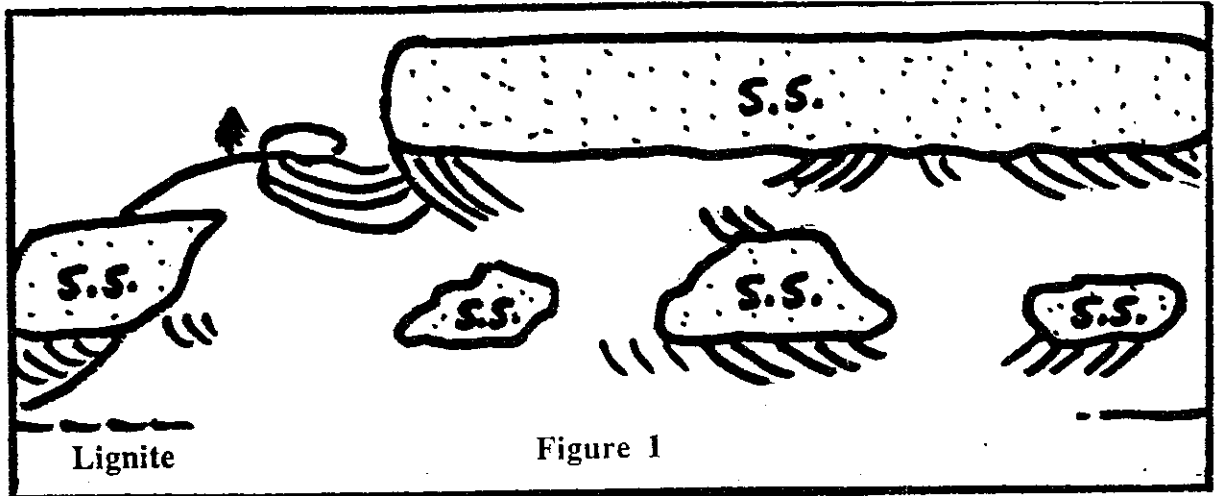


Figure 2

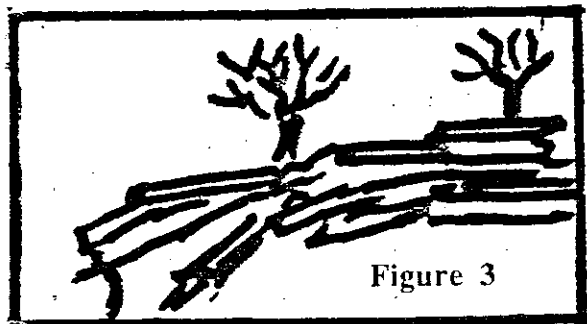


Figure 3

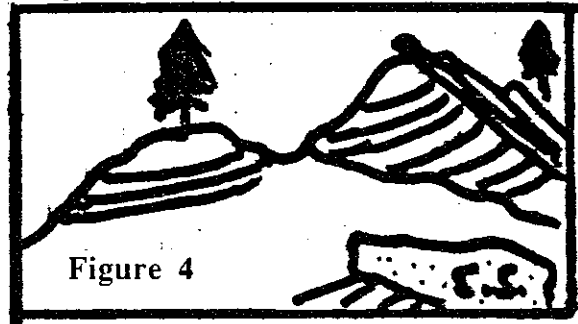


Figure 4

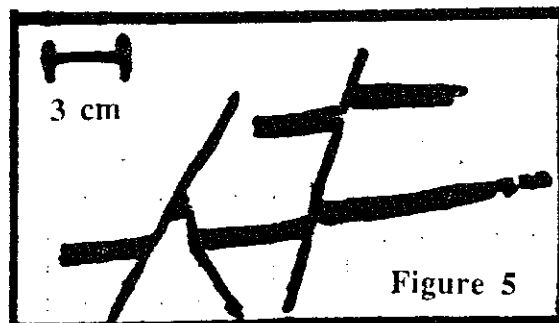


Figure 5