PALEOMAGNETIC STUDY OF THE LOWER FORT UNION FORMATION (EARLY PALEOCENE), EASTERN MONTANA

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The technique of magnetostratigraphy makes use of the fact that the Earth's magnetic field has reversed polarity many times in the past and that these reversals are recorded in strata. My study presents the results of reconnaissance work in a sedimentary sequence from the Lebo and Tongue River Members of the Fort Union Formation.

Results now emerging from the studies by Wong and Hayden (this volume) and earlier by Belt and Rockwell (in press) and Belt and others (1984) indicate that a major change in composition (both sand and clay mineralogy) and depositional style occcurred across the Lebo - Tongue River boundary. This boundary can be seen as a profound color change visible at great disances from outcrops. That color change can be traced across the entire western Williston Basin through parts of four western states. The boundary has been widely assumed (e.g. Bluemle et al., 1981) to be synchronous over this entire region. Whether the boundary is time-transgressive or synchronous effects the conclusions on the timing of the earliest uplift of the ancestral rockies and the periods of quiescence that followed. It is now believed the boundary records the transition from uplift (Lebo Member) followed by a period of quiescence (Tongue River Member) (see Wong report, this volume).

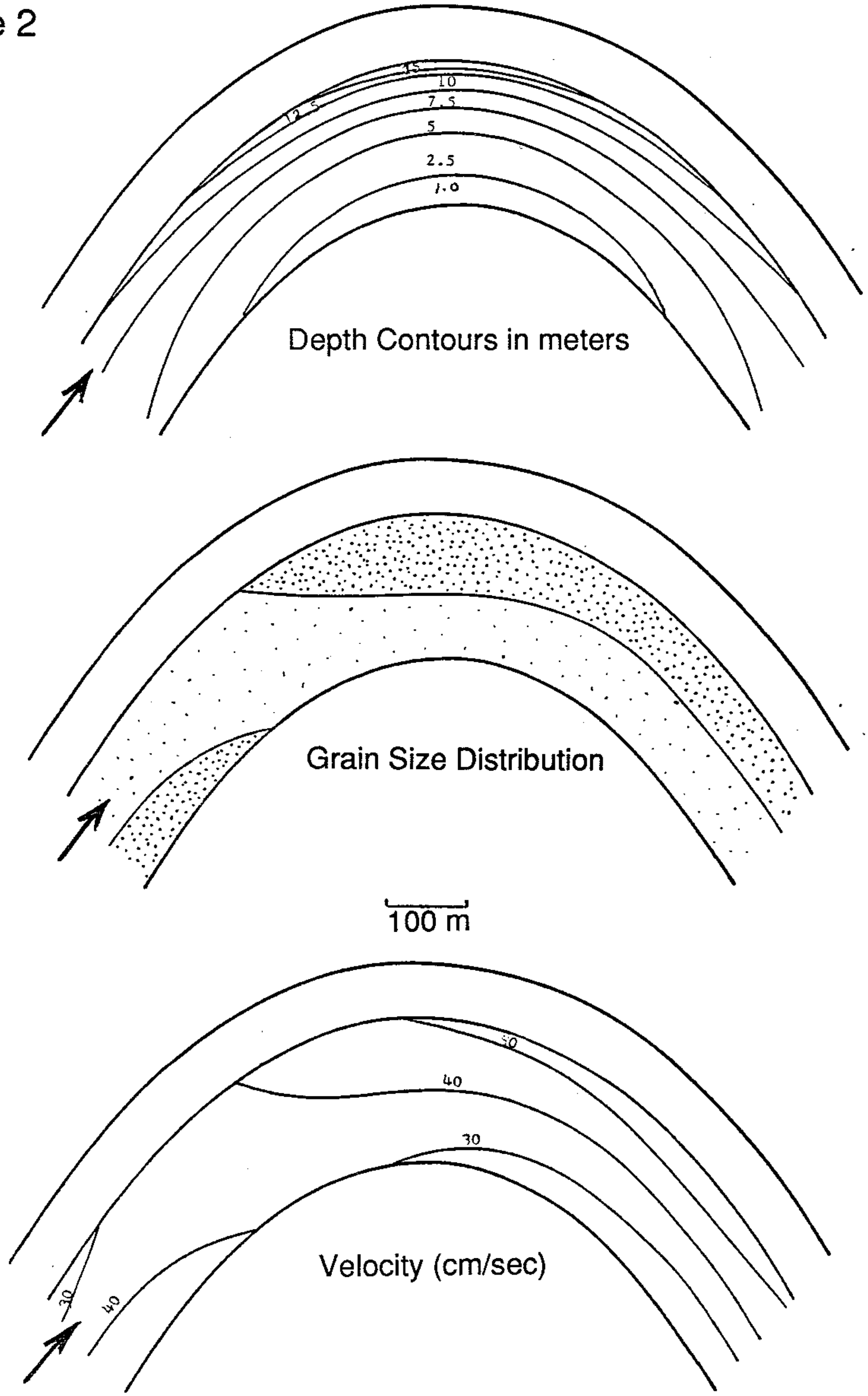
This project set out to establish a type section based on magnetostratigraphy from eastern Montana area so that in subsequent summers additional type sections could be made in western North Dakota and in northeastern Wyoming. Because of the difficulties encountered in sample preparation and measurement, not all of the objectives were achieved. The results reported here deal with the sources of magnetism in the sediment and the techniques by which future work will have to be conducted. Emphasis is on methodology, as results are just now appearing.

Sedimentary rocks acquire a natural remanent magnetization, NRM, during deposition, while igneous rocks acquire a NRM during cooling of constituent minerals through their respective Curie temperatures. It would be expected that the NRM of the rocks in my field area would be a DRM, detrital remanent magnetization, caused primarily by the orientation of remanence-bearing minerals in the Earth's magnetic field at the time of deposition or soon thereafter. Subsequently, such rocks may acquire secondary magnetizations, CRM (chemical remanent magnetization) from iron oxides which formed during diagenesis or as products of weathering, and VRM (viscous remanent magnetization) from the effects of subsequent and present magnetic fields. Most serious is the potential for secondary chemical changes that destroy preexisting magnetic particles and result in the growth of the new ones, thereby producing a CRM more resistant to demagnetization procedures than the primary remanence. Critical, therefore, to all paleomagnetic studies is an identification of the minerals carrying the remanence as this can provide direct evidence of the likely age of the magnetization and also the mechanism by which such magnetization was acquired. For additional information see Tarling (1983).

Two stratigraphic sections sampled for this study are located 25 miles east of Miles City, Custer County Montana. Three to five samples were taken from each of thirty-four sites along sections which traverse the boundary between the Lebo and Tongue River Members of the Early Paleocene Fort Union Formation. Sediments are unconsolidated and poorly lithified, and the coarsest clastic material in the sections is fine-grained sand. This range of grain sizes is ideal for paleomagnetic study, as sediments undergo major chemical changes during lithification. Fine sediments are the most magnetically stable and are more likely to reflect accurately the geomagnetic field direction, while larger grains may demonstrate a depositional anisotropy. Lithologies sampled were therefore silt size or finer, and ranged from well-consolidated, but friable, carbonaceous shales to less well-consolidated clays, silty clays, clayey silts. Muddy fine sands were avoided whenever possible.

Rocks exhibiting several features thought to indicate a greater potential for secondary magnetism or from analytical problems were avoided whenever possible. In carbonaceous shales, these features included extremely friable nature, and high organic content (leaf fossils) which can provide a source for secondary sulfide minerals. Iron-stained sands and silts, interpreted as recent pyritic or hematitic weathering, was

Figure 2


15
10
12.5
7.5
5
2.5
1.0
Depth Contours in meters
Grain Size Distribution
100 m
50
40
30
30
40
Velocity (cm/sec)

avoided by sampling at least a foot below the weathering surface, or deeper, if the stain persisted. Likewise sediment containing roots of modern plants, authigenic crystals of gypsum, gypsum or calcite-filled fractures in the sediment, and ferroandolomite (ironstone) and other carbonate nodular horizons were also avoided. Horizons that included sufficient swelling clay (smectite) could be recognized easily in the field because of the popcorn-weathered textures. Clay units that are moist or that were high in smectite were avoided because after removal from the outcrop, desiccation might shift the orientation of the grains carrying the remanence.

Fist-sized samples for paleomagnetic analysis were marked on the outcrop with reference lines to indicate their orientation. The present attitude of samples in space must be considered in order to achieve a correct paleomagnetic direction. Bulk samples for mineralogical analysis as well as oriented samples for polished thin-section preparation were also collected.

Initial preparation of paleomagnetic samples was carried out at the paleomagnetic facilities at Dartmount College under the instruction of Dr. Jamees Reynolds of Norwich University. Samples were cut to a reasonable size using a press saw usually used for slicing concrete, and ground into cubes on a corundum grinding wheel. This technique eliminates the possibility of contamination as samples are not in contact with metal tools. Reference marks were carefully transferred onto the final samples. Samples were then placed in standard (2.34 cm per side) plastic boxes for paleomagnetic measurement. Preliminary analysis at Dartmouth was supplemented by further analysis at the University of Massachusetts where Dr. Laurie Brown supervised. The samples were shown to carry very weak remanence, and hence a more powerful magnetometer was sought. A cryogenic magnetometer was necessary for measurements, especially for alternating field demagnetization procedures, in which remanence is removed in successive stages of increasing magnitude. Preliminary measurements of NRM were carried out at the paleomagnetic laboratory of Professor John King, University of Rhode Island, School of Oceanography. These measurements produced a median magnetic moment of 0.000005 emu. The cryogenic magnetometer at URI was sent to the manufacturer for repair immediately after these measurements were made, so further analyses might use the cryogenic magnetometer at Lamont-Doherty Geological Observatory.

X-ray diffraction analysis of magnetic-mineral separates is underway at Smith College. Magnetic separates were obtained using a method developed by me after equipment designed by Butler and Lindsay (1985). Bulk samples are dissaggregated in water to which calgon has been added to prevent flocculation of clays. A slurry of sediment and calgonated water is pumped through tygon tubing which passes between the pole caps of a Frantz electromagnet. A second pump is employed to keep the sediment in suspension.

Remanence-bearing minerals respond to the magnetic field graident and remain in the portion of the tube in contact with the Frantz, while nonmagnetic sediment passes through. The identities of remanence-carrying minerals are determined by x-ray diffraction. A monochronometer was installed to prevent iron fluorescence which masks the signal of the copper x-ray tube thereby yielding a poor peak-to-noise ratio. Standards of typical remanence-bearing minerals were analysed in order to compare their powder patterns with those of magnetic separates of the twelve bulk samples. The results from x-ray diffraction analysis and perhaps also results from energy dispersive micropobe analysis, will be presented at the conference in mid-April.

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