Mudstone facies of the channel-dominated coastal plain to estuarine transition in the Campanian Dinosaur Park Formation, Alberta, Canada

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Summary

Mudstone facies of the Dinosaur Park Formation were characterized and distinguished in the field and laboratory to help determine their significance as they relate to the flooding events of the last major transgression of the Western Interior Seaway at ~75 million years ago. The Campanian Dinosaur Park Formation (76-75 Ma) is well exposed in Dinosaur Provincial Park in southern Alberta, and represents a transition from coastal plain to estuarine (Dinosaur Park Formation) to marine environments (Bearpaw Formation). The mudstones were categorized according to their visual characteristics (colour, type and orientation of organics present, size of organics, percentage of organics, and any structures present), and measured total organic content (T.O.C.). Six distinct facies are represented, and are interpreted as: (1) lacustrine or estuarine bays; (2) mud-filled incised channels or abandoned channels; (3) swamps; (4) overbank paleosols; (5) point bars; (6) and marine muds. Bentonite is also common throughout the Dinosaur Park Formation. The geometry of these mudstone facies and their lateral and vertical relationships will be determined in the field to improve interpretations of the depositional environments represented, as well as the stratigraphic significance of the different facies.

Mudstones interpreted as lacustrine and estuarine bay deposits are dominantly organic-rich, darker in colour, are laminated, and preserve transported organics. Those from mud-filled incised channels comprise fine-grained silt and clays, have transported organics as well as in situ roots, and are characterized by their conchoidal fractures. Mud-filled incised channels have incised lower contacts, and lenticular geometry in the field. Swamp deposits

consist of coaly muds, with abundant organics and no distinguishable roots. Paleosols, developed on overbank deposits, are massive and blocky with in situ roots. Point bar deposits are heterolithic, alternating between muds and very fine-grained sandstones with roots and small plant fragments on bedding planes. The marine muds are dark grey in color, with no preserved roots.

These analyses will help to determine if the Dinosaur Park Formation represents a freshwater coastal plain throughout the succession, or if there are also estuarine deposits distributed throughout the formation that can be mapped as flooding surfaces. If recognized, these surfaces can then be used for the stratigraphic prediction of overlying amalgamated channel sandstones that contain resources (gas) in the subsurface. Future research will be focused on mapping these mudstones facies in the field.

Introduction

The Campanian Dinosaur Park Formation (DPF) in southern Alberta (76-75 Ma) (Eberth, 1995; Eberth, 1996) represents a transition between coastal plain to estuarine to marine environments. Mudstones can be expected to be deposited in many different depositional environments in this transition. The mudstones within the Dinosaur Park Formation are generally interpreted as mud-filled incised valleys (Eberth, 1996) or paleosols developed on overbank deposits (Matson, 2010). Throughout the succession, numerous horizons with sharp-based contacts between the mudstones and the channel sands are present where inclined heterolithic strata are absent (Eberth and Brinkman, 1997). These mudstones may instead be related to the transgression of the Bearpaw Sea and represent erosional surfaces, not the gradual transition from channels, to point bars, to overbank deposits on the floodplain (Thomas et al., 1987). The mudstones were investigated to determine how many facies are represented, and to determine the key characteristics that can be used to distinguish between them, so that the geometries of the different facies, and the relationships between them, can be mapped in the field.

Methods

Hand samples collected in the summer of 2012 from three measured sections in Dinosaur Provincial Park were analyzed and sorted according to the following characteristics: colour, estimated percentage of plant organics, type of organics (wood, conifer needles, roots), size of organics, and any sedimentary and pedogenic structures present (e.g., laminations, peds). Total organic content was tested based on the loss on ignition technique of Schumacher (2002) for determination of total organic content in soils. Select hand samples, 68 in total, were crushed using a mortar and pestle, and 10.00 g of each sample were weighed into a crucible and placed into a muffle furnace (Thermo Scientific Thermoylne Furnace Premium large muffle/atmosphere controlled ashing) at 350^{o}C for eight hours. The samples were allowed to cool overnight in the furnace and then weighed in the crucible to obtain the total weight lost, and was converted into a percentage.

Conclusions

Mudstones within the Dinosaur Park Formation have distinctive and visually recognizable differences in: colour, percentage of organics, type of organics present, size of organics, and any structures present. Differing energy levels within the depositional environments would cause these variations, and account for grain size differences. The low-gradient coastal plain would have been stretched out over many kilometers, allowing the wide variation in energy levels as the floodwaters were rising and falling both seasonally, and over several years (Eberth, 1996).

Mudstones within Dinosaur Park Formation make up 6 distinct facies:

1. Dark grey marine mudstones
2. Organic-rich (5-10 % organics) brown mudstones
3. Lethbridge Coal Zone – Plant organic-rich (10-20 % organics) black and dark brown mudstones
4. Muddy heterolithics
5. Massive blocky clays
6. Structureless mudstones

Additionally, white to whitish green-coloured bentonites are present.

To continue to test the hypothesis that facies other than overbank deposits are represented in the Dinosaur Park Formation mudstones, and that incised mud-filled channels are represented below the Lethbridge Coal Zone, research on these samples will continue. Methods will expand to include: grain-size distribution; bulk chemical analysis through X-Ray Fluorescence; and microfossil analysis. Together, this data can then be used to better distinguish between the mudstone facies and be used to map the mudstones in the field, to determine how they related to flooding events of the transgressing Bearpaw Sea.

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