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Mud Sedimentation in a Distal Offshore Setting: Upper Cretaceous (Santonian) Puskwaskau Formation, North-Central Alberta

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Summary

Some of the words used to describe marine mudstones in the past include “grey”, “shaly”, and “homogeneous”. Marine mudstones were commonly interpreted to have been deposited through vertical settling of silt and clay in deep, quiet environments. However, this view is quickly changing, because observations in modern environments and the ancient rock record shows that at least some mudstones were deposited by dynamic, energetic processes. Recent research on the Upper Cretaceous (Santonian) Puskwaskau Formation provides evidence of the depositional processes that were responsible for the structure and fabric of these marine mudstones. Preliminary results from high-resolution allostratigraphic correlations reveal how mud-rich successions are organized into genetic packages in a distal foredeep to forebulge setting.

Introduction

The Santonian-early Campanian Puswaskau Formation is a mudstone-dominated succession that spans a large portion of the Western Canada Foreland Basin (WCFB). Rocks of the Puskwaskau Formation are organized into 14 regionally-mappable allomembers, labeled A-N in ascending order (Hu 1997; Hu and Plint 2009). Hu and Plint (2009) grouped the 14 allomembers into three larger stratigraphic packages, with each package interpreted to have been deposited in a distinct flexural depocenter. These flexural depocenters were interpreted to be the product of distinct episodes of deformation in the fold-and-thrust belt. The present study examines the Puskwaskau Formation in a more distal location than studied by Hu (1997), and provides new information on the style of stratification, the controls on the ratio of accommodation to supply, and the sedimentology of mud-rich successions in the WCFB.

Theory and/or Method

A subsurface grid was constructed in north-central Alberta using wireline log data from over 1000 wells. Preliminary results from detailed correlations delineate subtle unconformities and lap-out patterns of mud-rich sequences in a distal foredeep and forebulge setting.

An outcrop locality in north-west Alberta was visited and 19 mudstone samples were retrieved by ‘box core’ sampling. This sampling method involved hammering a steel box into a cleaned and smoothed outcrop surface. The samples are carefully excavated and taped to maintain sample integrity during transportation. Samples were air dried and then impregnated with an epoxy resin which transformed the soft, fragile mudrock into a hardened block of mud. The mud block was cut into perpendicular slices from which 38 oriented large thin sections were made. Petrographic examination shows that these mudstones are quite heterogeneous at a sub-millimetre to millimetre scale and are organized into thin beds of varying silt and clay content. Scanning electron microscopy has reveled information about the packing arrangements of clay mineral particles, pore fabrics and organic matter distribution (Figure 1).

Example

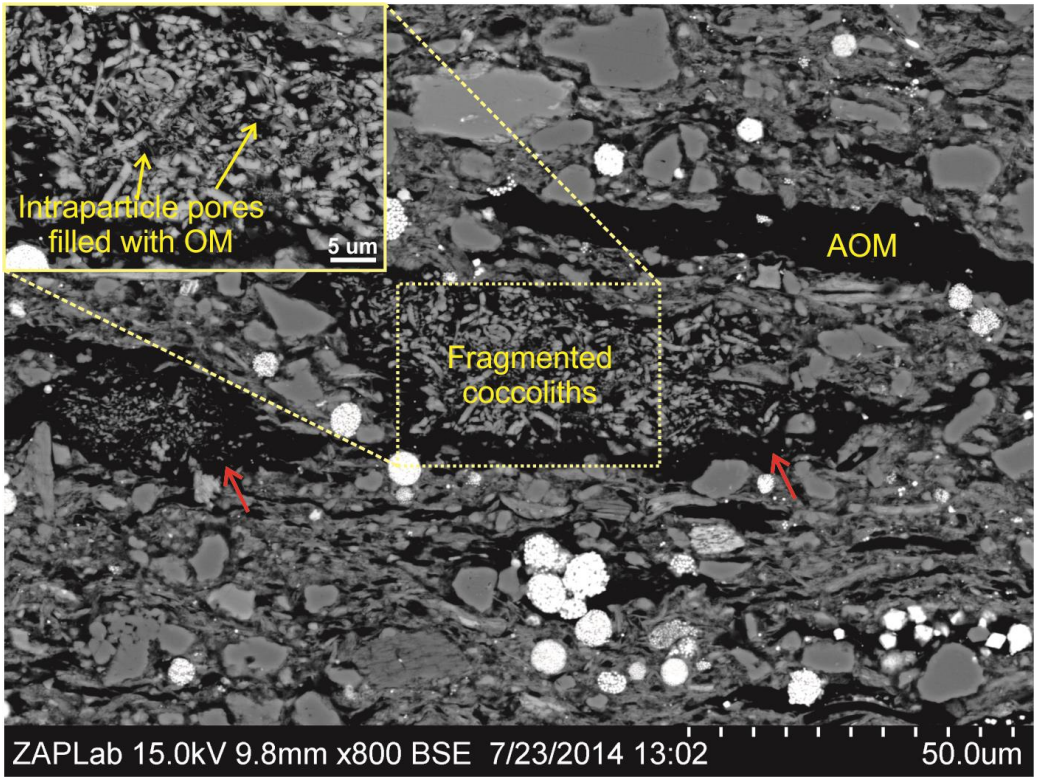

Figure 1: Backscatter scanning electron photomicrograph of a vertical section of mudstone of the Puskwaskau Formation, north-central Alberta. Amorphous organic matter (AOM) and framboidal and euhedral pyrite is ubiquitous in this sample. Fecal pellets (red arrows) contain fragmented coccoliths and display considerable porosity. Intraparticle pores contain abundant organic matter (OM).

Conclusions

Detailed allostratigraphic mapping of genetic depositional units provides information on the stratigraphic architecture and controls on the ratio of accommodation to supply in the more distal offshore portion of the Puskwaskau Formation. Thin section observations of offshore marine mudstones reveal a wealth of information about the microfacies at the mm-scale and the microfabrics at the micron-scale. Mudstones in the study area are quite heterogeneous and are not the product of “quiescent, suspension settling”. This heterogeneity is evident in the form of sharp-based graded beds of silt and clay, cut-and-fill structures and low-angle cross-lamination. Advective storm-driven flows probably dispersed sediment both as bedload and fluid mud to sites where accommodation was available. Near the top of the studied outcrop succession (correlatable to allomember ‘G’), organic matter becomes abundant. The basal few meters of allomember G is the most radioactive part of the succession and may constitute an interval of maximum flooding.

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