Allostratigraphic analysis of the Muskiki and Marshybank Formations (Coniacian) in the Central Alberta Foothills and Plains: Possible evidence for an eustatic control on deposition

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Summary

The Muskiki and Marshybank formations, of Upper Cretaceous (Coniacian) age, form a major transgressive-regressive depositional cycle, about 100 m thick, that can be mapped throughout the Cretaceous foredeep of Western Canada. Detailed allostratigraphic results are lacking for central Alberta between townships 26 and 44; this study is designed to fill that knowledge gap. The investigation is based on detailed outcrop observation in the Foothills, linked to a regional allostratigraphic framework based on wireline logs. The studied rocks represent primarily shallow-marine environments and are abundantly fossiliferous. The rocks are organized into upward shoaling successions of mudstone and fine sandstone, typically 5-15 m thick. Successions are bounded by marine flooding surfaces that commonly bear pebble lags. Although the upward-shoaling successions resemble simple parasequences, the presence of winnowed pebble lags suggest a terminal period of shallowing and even subaerial emergence. The successions may therefore be interpreted as seaward expressions of depositional sequences. Repeated relative sea-level rise-fall cycles, on a timescale of a few hundred kyr, strongly suggest an eustatic control, plausibly attributable to glacio-eustasy in the Milankovitch band.

Introduction

The Muskiki and Marshybank formations of the Western Canada Cretaceous foredeep (Stott, 1963, 1967), comprise a major transgressive-regressive depositional cycle, about 100 m thick, that can be mapped from NE British Columbia at least as far south as northern Montana. The rocks range in age from late Early to Late Coniacian. An allostratigraphic framework for these rocks was developed for the northern Foothills between townships 76 and 44, and extended about 200 km eastward into the subsurface (Plint, 1990; Plint & Norris, 1991). Transgressive surfaces bounding 13 distinct, and relatively sandstone-rich allomembers (approximately equivalent to depositional sequences), were mapped throughout this northern study area. The four main shoreface sandstone units are sharp-based and imply deposition during relative sea-level fall. To the south, the same interval of rock gradually becomes dominated by mudstone. The Muskiki and Marshybank rocks between Twp 26 and Twp 1 in Alberta, and extending about 40 km south into Montana, were the subject of more recent allostratigraphic analysis (Grifi, 2012; Grifi et al. 2013).

Although the unconformable contact with the underlying Cardium Fm., and the upper contact with the Puskwaskau Fm. have been traced across the *terra incognita* between Twp 26 and 44 (Plint et al. 1986, Hu and Plint, 2009; Shank and Plint, 2012), the detailed internal stratigraphic organization of the Muskiki and Marshybank strata within this ~ 200 km portion of the basin has never been worked out.

Below we present a preliminary report of physical stratigraphic results from the 2012 field season in the Foothills, and some subsurface correlations. This new physical stratigraphy will provide a framework for complementary studies of biostratigraphy, carbon-isotope stratigraphy and geochronology. The sum of these efforts are intended to improve our ability to make long-distance, high-resolution correlations to the United Sates, Europe, and elsewhere.

Problem, and Method

The fundamental problem to be addressed concerns the reason for the persistent transgressive-regressive depositional cyclicity exhibited by Cretaceous shallow-marine clastic rocks. The unparalleled subsurface control available in Western Canada, coupled with excellent outcrop exposure in the Rocky Mountain Foothills, affords a unique opportunity to investigate not only the detailed sedimentology but also the three-dimensional stratal architecture of the basin-fill; the resulting geometrical and facies information provides the basis for tentative distinction of tectonic and eustatic driving mechanisms.

Outcrop sections in the Rocky Mountain Foothills were measured and sampled in detail, with particular attention paid to the recognition of genetic depositional successions, anomalous juxtaposition of facies, key flooding, erosional, bored/burrowed and lag-strewn surfaces. Spectral gamma ray logs were made for selected outcrop sections. Outcrop sections were correlated to the nearest wireline logs, thereby allowing the geophysical signatures to be calibrated with 'real' facies, and also allowing each bounding surface to be traced regionally, including between outcrop sections distributed along the basin margin.

Results

Our poster will present detailed stratigraphic logs of the Muskiki and Marshybank strata from Ram River, Lynx Creek, Chungo Creek, Blackstone River, Bighorn Dam, Bighorn River, Cardinal River and Thistle Creek. The basal unconformable contact of the Muskiki on the Cardium Formation is easily recognized in both outcrop and well logs. Similarly, the transition between more mudstone-dominated Muskiki strata and more sandstone-rich, sideritic and bioturbated Marshybank strata is readily recognized in well logs and in outcrop. The entire succession is characterized by stacked, upward-coarsening successions, typically 5-15 m thick. The proportions of sandstone and mudstone in each upward-shoaling succession are distinctive and allow matching against gamma-ray and resistivity log signals. In the north, the upper boundary of the Marshybank Formation is an easily-recognized, pebble-veneered erosion surface, whereas further south, in the present study area, the top is less distinctive, characterized by a succession of several, progressively weaker upward-coarsening successions of intensely bioturbated muddy siltstone. Several upward-coarsening successions are capped by veneers of extraformational chert pebbles, and/or intraformational sideritic or phosphatic intraclasts. In rare instances, sideritized surfaces are penetrated by borings of the *Glossifungites* ichnofacies. These lags and surfaces provide evidence for sea-floor erosion, probably attributable to a phase of relative sea-level fall at the end of each upward-shoaling succession. The presence of extra-basinal chert pebbles strongly suggests a previous period of subaerial exposure, leading to fluvial emplacement of gravel on the shelf. It is tempting to speculate that repeated relative sea-level falls, probably of no more than 10-20 m, may be attributable to glacio-eustasy (cf. Miller et al. 2005). Because depositional successions span only a few hundred kyr each, a Milankovitch control on climate cyclicity may be inferred.

Conclusions

Preliminary results suggest that upward-shoaling, shallow-marine successions in the Coniacian Muskiki and Marshybank formations are of regional distribution across the Cretaceous foredeep. Many transgressive-regressive successions preserve evidence, in the form of lags and bored surfaces, for a terminal period of shallowing and sometimes subaerial emergence. This suggests that apparently simple, upward-shoaling ‘parasequences’ are in fact depositional sequences, embodying evidence for both relative sea-level rise and fall.

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