Fault-controlled deposition of the Cardium Formation in southern Alberta, revealed by high-resolution allostratigraphy and trend surface analysis

Joel A. Shank, Dept. Earth Scinces, University of Western Ontario, London, Ontario.
jshank2@uwo.ca
and
A. Guy Plint, Dept. Earth Sciences, University of Western Ontario, London, Ontario. gplint@uwo.ca

GeoConvention 2012:Vision

Summary

High-resolution, regional-scale allostratigraphic correlation of the Turonian-Coniacian Cardium Formation in southern Alberta has revealed abrupt changes in the thickness of certain allomembers that follow linear trends. The position and orientation of the thickening trends align with normal faults previously recognized in published seismic interpretations, and also revealed by a trend surface analysis of the Second White Specks. Structural cross-sections show vertical displacement of allostratigraphic surfaces, and in some wells, parts of the stratigraphy have been cut out by post-depositional normal faulting. This work confirms the previously unproven hypothesis that linear features in the Cardium Formation are controlled by faults and basement structures.

Introduction

The Cardium Formation was deposited in a shallow marine, storm-dominated setting, and was strongly influenced by relative sea-level changes. Numerous long, narrow accumulations of sandstone and conglomerate have been delineated in subsurface and interpreted as lowstand shorelines (Pattison and Walker, 1992). Linear erosional notches and stratal bevelling has been attributed to transgressive ravinement (Wadsworth and Walker, 1991). Some authors have speculated that the position of these shoreline features was controlled by subtle topography of the basin floor, caused by syndepositional arching or faulting (e.g. Hart and Plint, 1993), although a direct spatial correlation to underlying structures has not previously been demonstrated. Published seismic interpretations have recognized deep-seated normal faults east of the triangle zone in southern Alberta (Lemieux, 1999), although the geographic extent of these faults has not been investigated. New, very high-resolution allostratigraphic correlations of the Cardium in southern Alberta, integrated with studies of basement structures and faults, makes it possible to test the possibility of direct fault control on Upper Cretaceous stratigraphy and depositional patterns.

Methods

This study is based on allostratigraphic correlation of the Cardium Formation in southern Alberta, using over 1100, 25 outcrops, and 11 cores. The study is regional in scope, covering over 95,000 km^2, but is also of high stratigraphic resolution (allostratigraphic units range from 5-20 m thick). This method allows very subtle thickness changes to be recognized, from which may be inferred subtle spatial differences in subsidence, uplift, and erosion.

The study has also employed a trend surface analysis (TSA) of a data-set of over 150,000 industry picks of the Second White Specks (directly underlying the Cardium Formation). The analysis uses aspects of the methods described by Davis (2002) and Mei (2009) to recognize deviations from regional structural trends of the Second White Specks.

Results

Isopach mapping shows that certain Cardium allomembers display abrupt thickness changes that follow linear trends. The TSA of the Second White Specks shows linear discontinuities in residual elevation trends that align with the minimum horizontal *in-situ* stress of the basin. These discontinuities in trend surfaces correspond spatially with the location of faults recognized by Lemieux (1999). Structural cross-sections show vertical displacement of Cardium allomember-bounding surfaces across these faults. In addition, wells in which the Cardium section has been thinned by normal faulting are located in the vicinity of faults revealed through TSA. The trends observed in the TSA are therefore interpreted as the spatial expression of the normal faults recognized by Lemieux (1999). The position of these faults corresponds closely with abrupt thickness changes revealed by isopach maps of certain allomembers of the Cardium Formation.

Conclusions

Isopach mapping of allomembers within the Cardium Formation reveals abrupt thickness changes, the position and orientation of which corresponds to normal faults east of the triangle zone. It is probable that the linear trends of previously-mapped lowstand shorelines (Pattison and Walker, 1992) and erosional bevels (Wadsworth and Walker, 1991) are also structurally controlled. The subtle thickness changes that reveal these linear trends can only be identified by very high-resolution allostratigraphic analysis, thus emphasizing the importance of detailed stratigraphy in basin analysis.

Acknowledgements

Shank acknowledges partial support of fieldwork through the AAPG Grant-in-Aid program; Plint acknowledges Discovery Grant support from the Natural Sciences and Engineering Research Council of Canada. This research stems from the Ph.D. thesis of J.A.S.

References

Davis, J.C, 2002, Statistical and Data Analysis in Geology. 3rd Edition. John Wiley & Sons, New York, U.S.A. 656 pp.

Lemieux, S, 1999, Seismic reflection expression and tectonic significance of Late Cretaceous extensional faulting of the Western Canada Sedimentary Basin in southern Alberta: Bulletin of Canadian Petroleum Geology, **47**, 375-390.

Mei, S., 2009, Geologist-controlled trends versus computer-controlled trends: introducing a high-resolution approach to subsurface structural mapping using well-log data, trend surface analysis, and geospatial analysis: Canadian Journal of Earth Science, **46**, 309-329.

Pattison, S.A.J. and Walker, R.G., 1992, Deposition and interpretation of long, narrow sandbodies underlain by a basinwide erosion surface: Cardium Formation, Cretaceous Western Interior Seaway, Alberta, Canada: Journal of Sedimentary Petrology, **62,** 292-309.

Wadsworth, J.A. and Walker, R.G., 1991, Morphology and origin of erosion surfaces in the Cardium Formation (Upper Cretaceous, Western Interior Seaway, Alberta) and their implications for rapid sea level fluctuations: Canadian Journal of Earth Science, **28,** 1507-1520.