Tectonic setting of the lower Fernie Formation: insights from subsidence analysis

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Introduction

In this study, the Fernie Formation in west-central Alberta is informally divided into upper and lower Fernie. The lower Fernie contains the Nordegg, Gordondale, Red Deer, Poker Chip and Rock Creek Members. These are separated from the Upper Fernie shales by many unconformities, simplified here as a single regional unconformity (Figure 1).

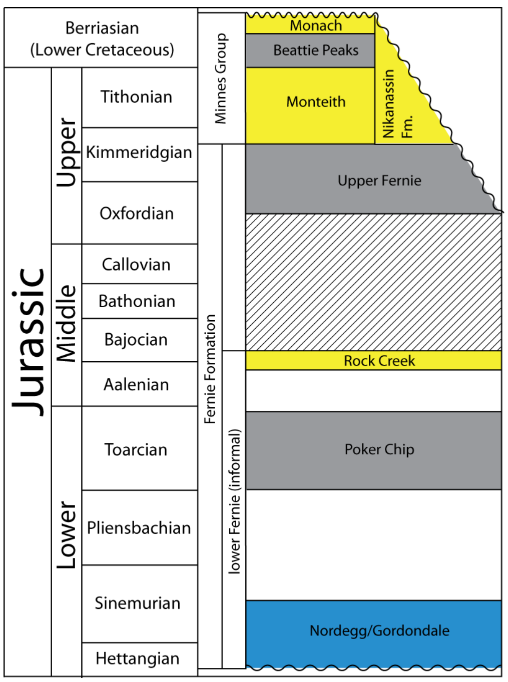

Figure 1: Simplified stratigraphic column of the Fernie Formation. In this study, the Fernie Formation is divided into the Upper Fernie (shales) and the lower Fernie (Rock Creek, Poker Chip Shale, and Nordegg). The unconformities separating the Upper Fernie from the lower Fernie are here represented as a single, regional unconformity.

The Nordegg and Gordondale Members of the Fernie Formation were deposited during the early stages of tectonic loading in the Cordillera to the west. These members, along with the Poker Chip and Rock Creek Members, were studied to look for evidence of this tectonic activity in the sedimentary record. The results give new insights into current understandings of the lower Fernie Formation.

Theory and Method

Tectonic subsidence measures the tectonically controlled vertical movement of a basin. Calculating the amount of tectonic subsidence the basin has undergone involves accounting for sediment compaction, paleobathymetry, sea-level changes and post-depositional sediment compaction.

In basin analysis, tectonic subsidence plotted on a depth vs. age chart is used to classify the type of basin the sediments were deposited in. The tectonic subsidence curve of a foreland basin is blocky and concave down with a low initial rate of subsidence followed by a rapid increase in subsidence (Figure 2; Angevine et al., 1990; Xie and Heller, 2009).

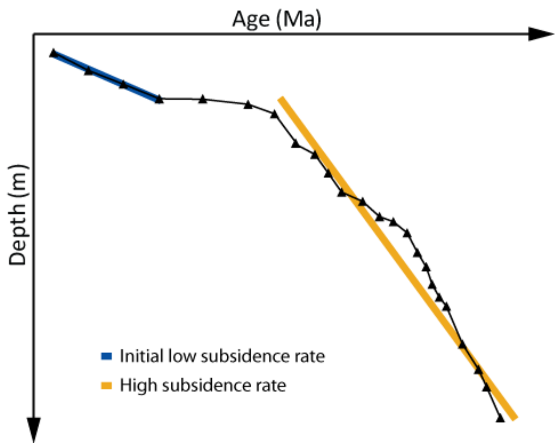

Figure 2: Idealized subsidence curve for a foreland basin showing the blocky, concave down profile with low initial subsidence (blue) followed by a rapid increase in subsidence (yellow)

Tops within the Fernie Formation were identified on well logs and the tectonic subsidence calculations were carried out on over 300 subsurface wells in west-central Alberta (Figure 3) using automated Excel macros. Some of this methodology was presented at Recovery 2011.

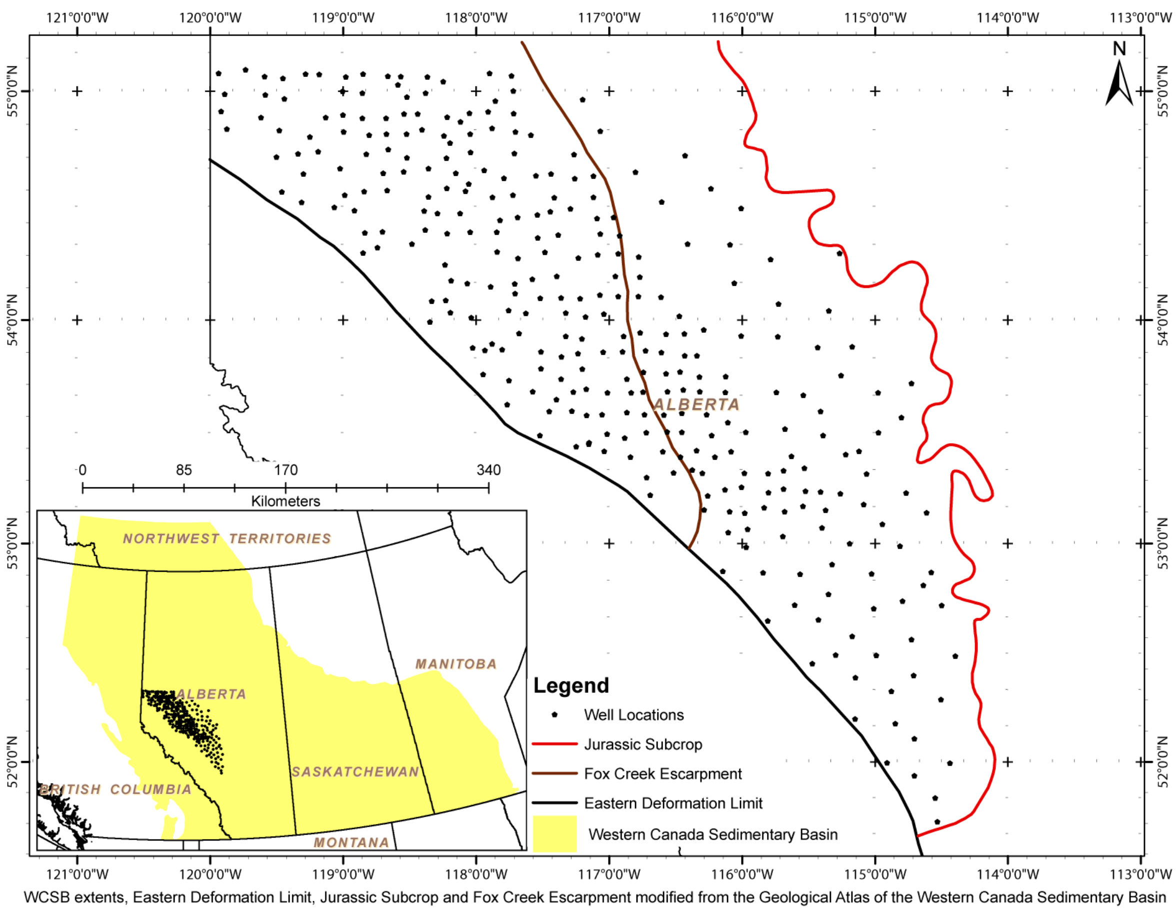

Figure 3: The study area in west-central Alberta, with the well locations for the 300+ wells studied

The volume of wells in this study requires an innovative approach for displaying the tectonic subsidence variations. Subsidence rates can only be used when good age constraints are available. Instead, a suite of maps were developed to investigate the relationship between the total amount of tectonic subsidence that occurred during deposition of a layer and the thickness of the layer (Figure 4). These maps are: isopach, tectonic subsidence, tectonic subsidence residual (the difference between tectonic subsidence and thickness), and tectonic subsidence ratio (ratio of tectonic subsidence to thickness).

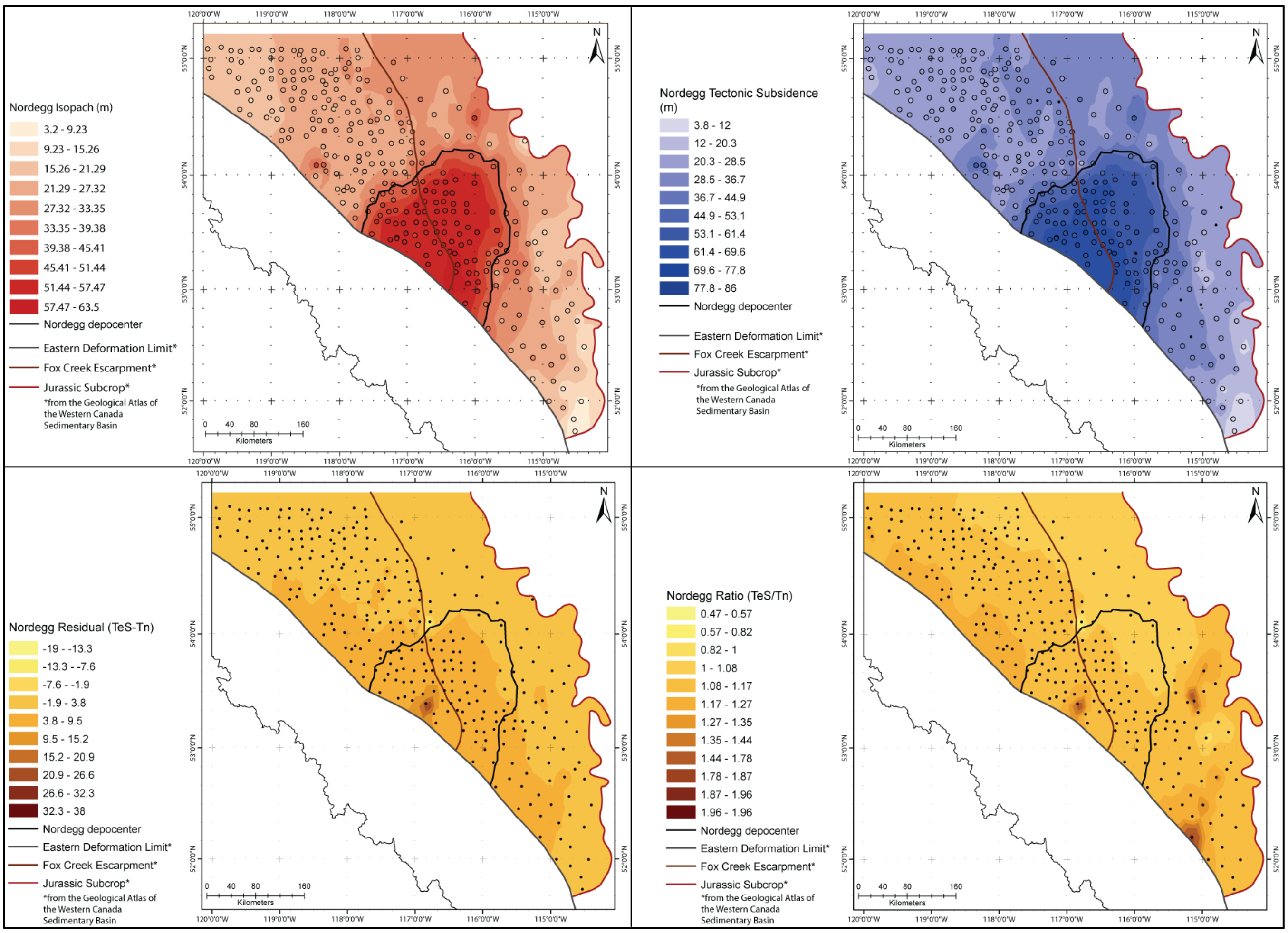

Figure 4: Suite of maps for the Nordegg Member, as defined in this study (Nordegg and Gordondale Members combined). Clockwise from top left, the maps are the isopach, tectonic subsidence, tectonic subsidence residual, and tectonic subsidence ratio.

Discussion

The subsidence curves for all wells in the study showed low subsidence rates during deposition of the oldest members of the Fernie Formation: the Nordegg and Gordondale Members. The low subsidence rate is attributed to the backbulge depozone of the foreland basin system described by DeCelles and Giles (1996). This interpretation was presented at GeoCanada 2010.

This data suggests that the Fox Creek Escarpment, an erosional scarp thought to have uplifted prior to deposition of the lowermost Cretaceous units (McLean, 1977; O'Connell, 1994), began uplifting during deposition of the Fernie Formation. Furthermore, boundaries within the data, for example the boundary between the Nordegg and Gordondale Members, appear to be related to underlying basement features.

Acknowledgements

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