Effects of Channels on Fold Geometry and Fracture Patterns in the Grande Cache Area, West-Central Alberta

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Introduction

The Grande Cache area in west-central Alberta contains numerous folds that change geometry or orientation along trend. This change tends to be associated with the presence of channels or a lateral transition to sandstone-dominated strata. An example of this changing geometry is seen in a secondary fold on the MacEvoy anticline that changes from a cylindrical to a box fold over a distance of 300 m. This change is accompanied by secondary structures and variations in the fracture patterns.

Background

The geometry of folds in the Grande Cache area in west-central Alberta is well exposed due to coal mining (Figure 1). These coal mines have cleared all the overlying stratigraphy off of the bedding plane below the coals allowing for the entire geometry of the fold to be seen in three dimensions, in addition to the overlying stratigraphy outcropping in three walls of an open pit (Figure 2). This unique exposure allows for the structure and changing fracture patterns to be seen at different locations around the fold and along the trend of the fold.

The fold of interest is located on the forelimb of the MacEvoy Anticline within the Grande Cache Member of the Gates Formation which is Late Cretaceous in age (Figure 3). The Grande Cache member contains numerous coal and shale layers that act as detachment horizons and deform in a ductile manner between more consolidated siltstone and sandstone layers. The sandstone layers contain numerous channels that act like buttresses during deformation with their location and orientation influencing the orientation and geometry along trend of the structures in this area. These changes in structural style result in the development of secondary structures and numerous fracture sets.

The geometry of the fold below the coal layer changes from a simple cylindrical fold to a box fold with secondary folding and faulting within a distance of about 300 m. At the transition between fold geometries a channel is found in the overlying stratigraphy and apparently caused the geometry to become more box like. The occurrence of this channel also affects the local fracture patterns especially on the forelimb of the box fold where a very dominant fracture set has developed with visible displacements in the same direction.

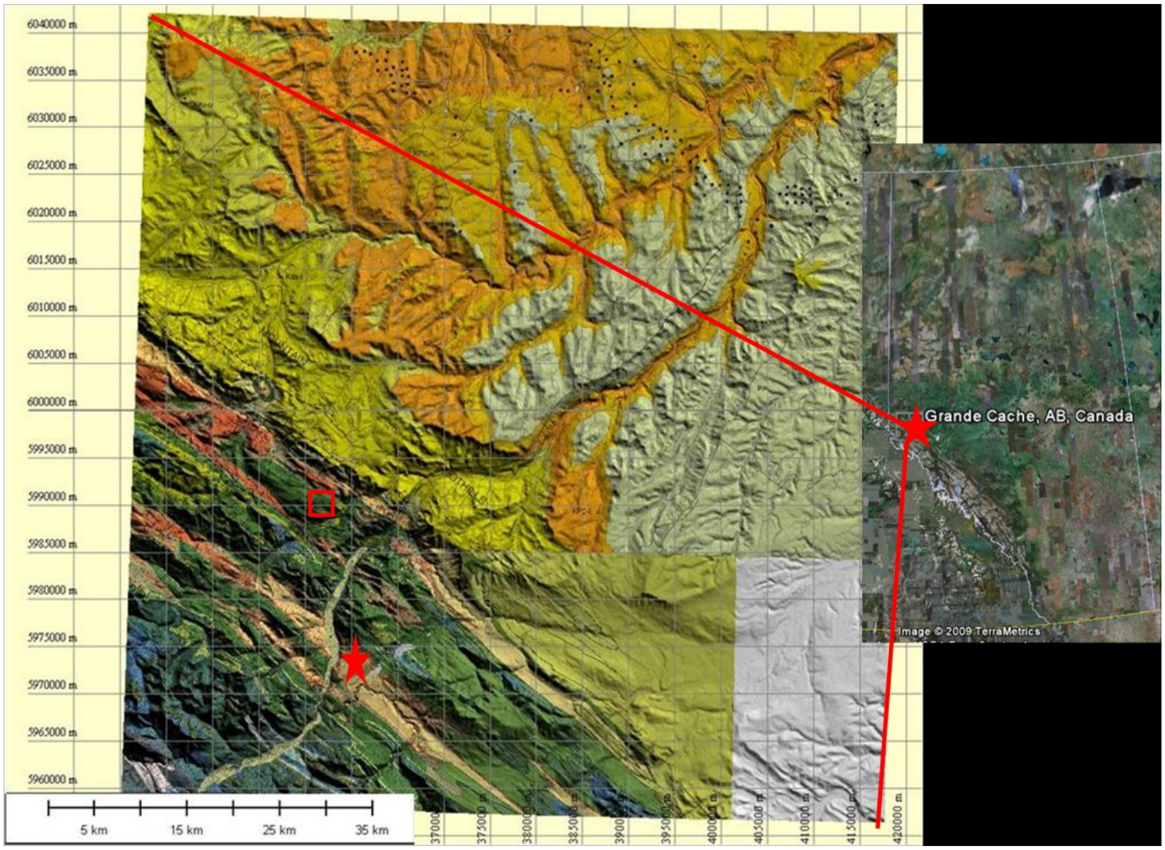

Figure 1: Maps showing the location of Grande Cache (Google Earth, 2009) and the geological map of the Grande Cache area with the red star and box representing the town of Grande Cache and the study area, respectively (modified DEM from Geobase, maps from McMechan (1996), Langenberg et al. (1987), McMechan and Dawson (1995), and Lang and Irish (1951).

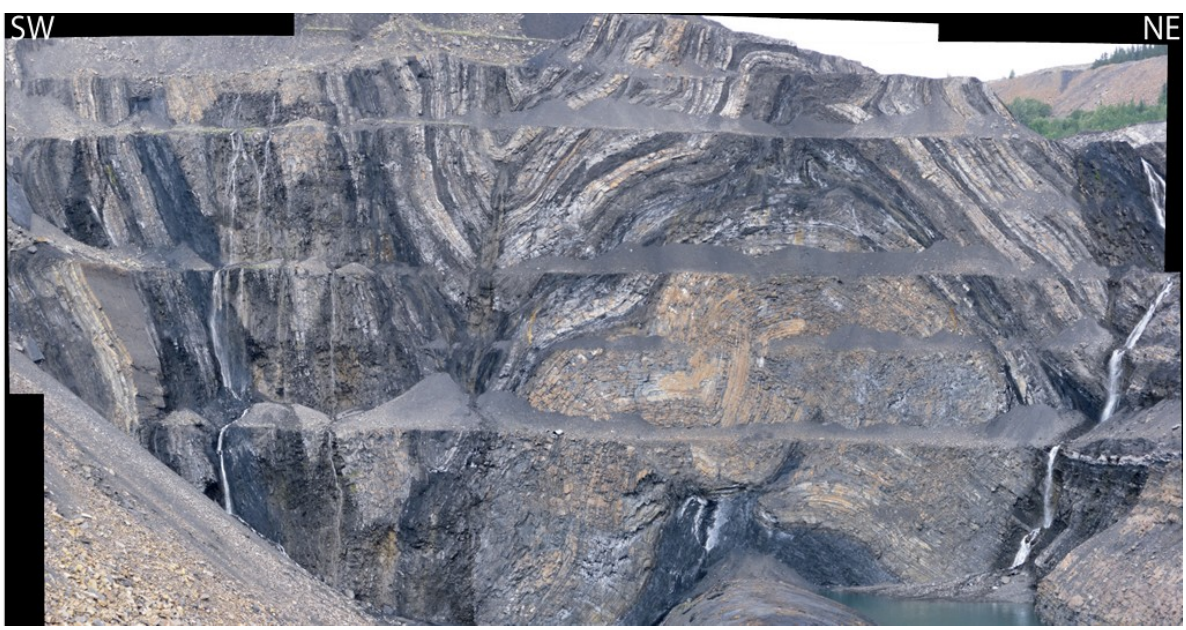

Figure 2: Photograph looking down the fold axis of a secondary fold on the forelimb of the MacEvoy Anticline.

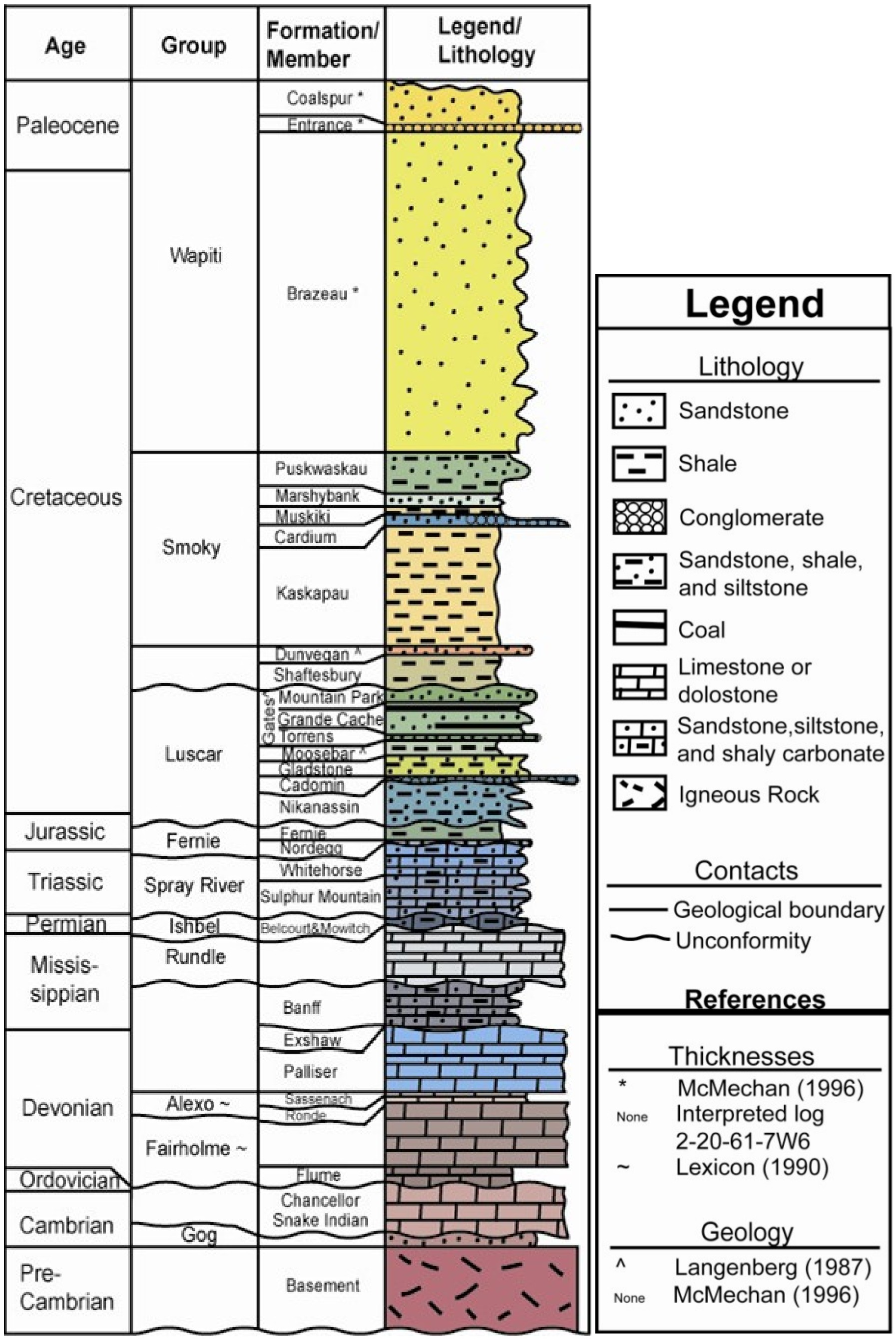

Figure 3: Stratigraphic column for the area surrounding Grande Cache.

The strata above the coal layer contain an anticline-syncline complex with a very different geometry than the cylindrical fold in the underlying stratigraphy (Figure 2). The anticline is part of a box fold with a fault propagation fold cutting a portion of the flat hinge of the box fold. Adjacent to this anticline is a tight chevron syncline with numerous detachment layers that extend into the stratigraphic layers surrounding the anticline. A thrust ramps from one of these detachment layers above the core of the box-fold. It is within the sandstone layer that defines the box fold that we find the channels affecting the underlying layers.

In addition to fracture measurements, two different fracture analysis methods were used to determine the changes in density of fractures around and along the trend of the anticline. The scanline fracture analysis method was used at each end of the fold and on the prominent fracture set on the forelimb of the box fold. Fracture densities in the area between the ends of the fold were documented using the circle-window method between areas covered by debris.

Conclusion

It is important to understand the controls on the geometry and orientations of structures that are clearly displayed in the Foothills to aid in interpretation and prediction of the structures in the adjacent areas where less information and direct observation are possible. In addition to understanding the larger sturctures this information will also help better predict fracture patterns along the structure.

Acknowledgements

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