GeoConvention 2015
GEOSCIENCE
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Telus Convention Centre • 4-8 May 2015 • Calgary, AB Canada

The Nature of the Kananaskis Thrust at Quaite Valley, Exshaw, Alberta

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Summary

The northern limit of the Kananaskis Thrust system terminates near Exshaw Alberta. Structural features within Quaite Valley are intricately related to the deformational processes involved in the development of the thrust. This study investigates the deformation variations observed as displacement along the thrust decreases along strike towards the tip point.

Structural and stratigraphic data collected in the field were used to construct a geological map and balanced cross-sections to reveal the geometry of the Kananaskis Thrust within the subsurface. Displacement and shortening along the fault increase to the south along strike, and decreases to the north where it tips out. A fault propagation fold formed in the strata above the thrust at the northern tip. In the southern portion of the study area, the record of any folding that may have been present at earlier stages of fault development has been eradicated as a result of erosion.

Previous work, mainly done using low resolution topography maps and aerial photographs, failed to recognize folding in the study area. The original map projects the northern termination tip of the Kananaskis Thrust to be north of the Bow Valley. This study suggests that the surface trace of the thrust terminates on the northern slope of Biffy Peak, providing an important amendment to the geologic map of the area with implications on the development of the Front Ranges in Kananaskis.

Improvement of technology fosters more precise and efficient mapping in the Front Ranges, warranting new exploration. With the availability of accurate base maps, and reliable GPS equipment, field mapping can be conducted quickly and precisely. The finer detail of structural data found in this area is an example of the potential that could be found elsewhere. Now that this technology is available, other areas in the Front Ranges might warrant a relook, unlocking hidden subtleties that will further our understanding of the development of the Rocky Mountains.

Method

The Quaite Valley study area (Figure 1), near Exshaw, Alberta, encompasses the region surrounding the northern end of the Kananaskis Thrust, which extends to the south for approximately 30 km (McMechan, 1995). Outcrop exposure in the study area is limited. Often, only boulder-sized outcrops are visible and bedding is not always apparent. Plane attitudes, when discernible, were measured using a Brunton compass.

Field mapping was carried out over eight days in September, 2013. Outcrop locations were recorded with a 2013 Garmin GPSMap 62st and plotted on a digital elevation model (DEM) acquired from

ALTALIS. The GPS instrument was WAAS (Wide Area Augmentation Service) enabled to provide horizontal precision of 3-5 m.

The measured stratigraphic section is on the northeastern slope of Biffy Peak. This portion of the mountain has the most continuous section of outcrop exposed in the study area, and minimal deformation in the Southesk and Cairn formations at this location makes it ideal for the determination of stratigraphic thicknesses of the formations most involved in the fold. Contacts on the geological map are positioned to ensure all observed lithologies fall within their proposed unit boundaries.

Balanced cross-sections AB and CD (Figure 1) are orientated perpendicular to the local structures, in order to characterize the major folds in the study area. Displacement farther south along the Kananaskis Thrust was measured in cross-section CD, and the difference in displacement between these two locations was used to estimate the northern extent of the fault by assuming that displacement decreases linearly along strike.

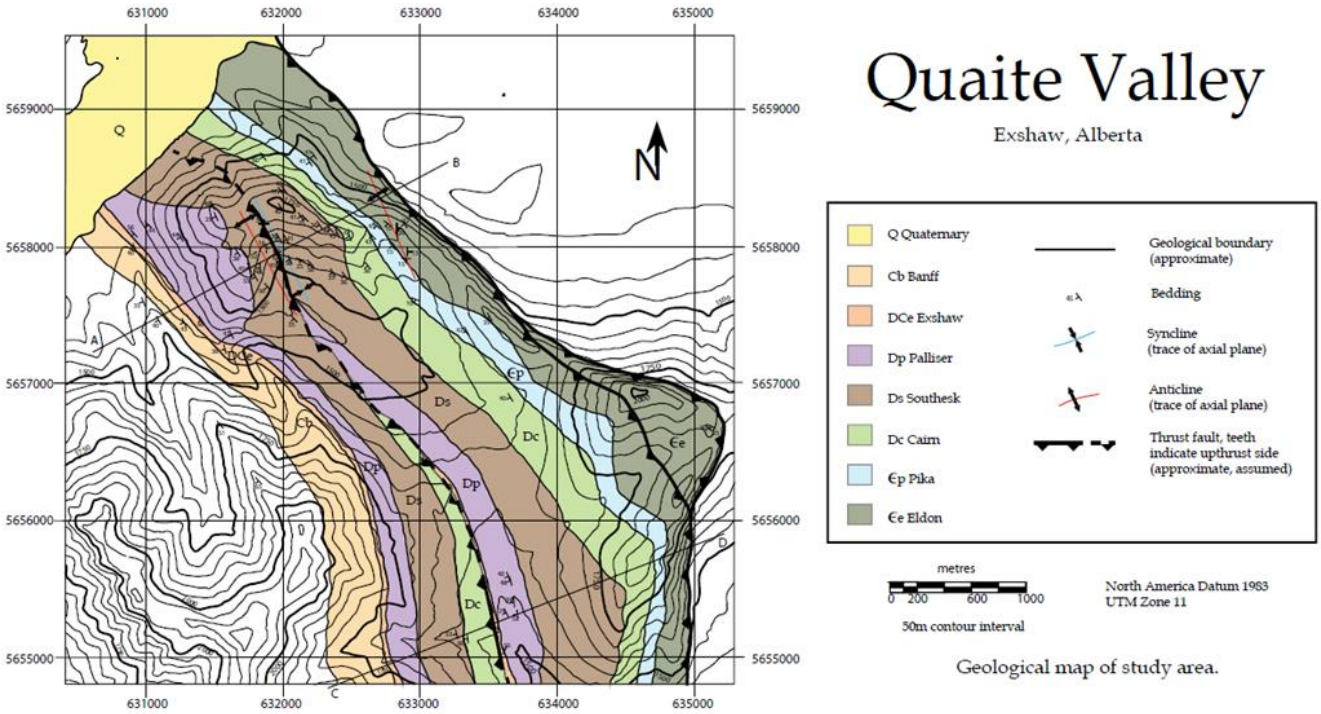

Figure 1: Geological map of Quaite Valley, showing the surface trace of the Kananaskis Thrust and location of two cross-sections.

Conclusions

A fault propagation fold is the main structural style associated with the Kananaskis Thrust. Cylindrical folding near the northern termination tip is observed at the surface, but the majority of folded strata have eroded away, especially further south where displacement (about 1 km) is more pronounced (compared to the northern cross-section where 200 m displacement seen in the Pika Formation, and zero displacement in the Exshaw Formation). This structural style is common in initial stages of thrust fault development. The northern projection of the surface trace of the Kananaskis Thrust is approximately 1125 m north of cross-section AB (Figure 1).

Cross-section AB in the north section of the study area displays a fault propagation fold structural style (Figure 2). The Kananaskis Thrust is a listric fault that branches from the McConnell Thrust decollement. Displacement decreases from 300 m displacement at the bottom contact of the Eldon Formation, to 0 m at the fault tip within the Palliser Formation. The curvature of the fold is constructed using structural data measured from the Southesk Formation. Fractures within the hinge zone likely developed to accommodate the local extension.

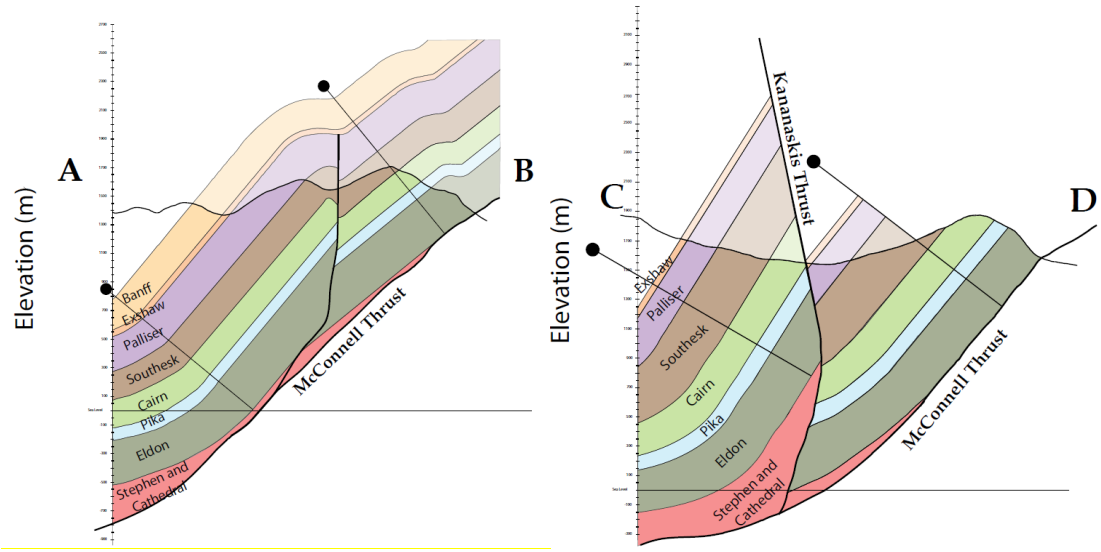

Figure 2: Cross-sections of the Kananaskis Thrust at the northern end of the study area (AB) and the southern end of the study area (CD). Pins indicate the western boundary of the balanced cross-sections. Cross-section AB displays approximately 200 m displacement in the Pika Formation, roughly 10% shortening. Cross-section CD displays approximately 1100 m displacement and 45% shortening. No Vertical displacement.

Cross-section CD in the south displays a typical thrust fault that is characteristic of the Front Ranges (Figure 2). Planar units are displaced by a listric fault attached to a lower decollement, in this case, the McConnell Thrust. Displacement at this location of the Kananaskis Thrust is about 900-1100 m. Small scale deformation may have contributed to internal thickening of the units in this area. The Fairholme Group is about 200 m thicker in the southern part of the study area compared to the north.

Displacement along the thrust increases from essentially no displacement in the north to about 1 km displacement in the south. The pins in each cross-section were placed so the restored sections are the same length to allow for easy comparison. About 10% shortening caused by folding and faulting in section AB increases to 42% shortening in section CD. Thrust systems in the Front Ranges often display a variant of a bell curve displacement profile, with maximum displacement at the center of the fault tapering to zero at either end (Fossen, 2010). For this study we assume that the displacement profile between cross-sections AB and CD is linear, and predict that displacement within the Southesk Formation ceases about 300 m north of section AB (Figure 1).

Numerous small scale deformation features may merit further study: (i) There may be useful outcrops in unexplored creek beds in the study area. (ii) Detailed exploration on the northern slope of Biffy peak may help pin-point where displacement along the thrust goes to zero, and validate a linear displacement profile. (iii) Mapping the southern part of the Kananaskis Thrust may reveal if similar processes occur at the southern termination tip. (iv) A detailed fracture analysis may bring further insight to the deformation associated with the thrust since fracturing is pervasive throughout the area.

References

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