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LiDAR assisted mapping and deformation history of Crowsnest Pass, Alberta

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Summary

LiDAR (Light Detection And Ranging) shows subtle topographic features when displayed in simulated "hill shading" when utilising different azimuths and sun angles. LiDAR-derived maps used in the field help interpretation of inaccessible or hazardous areas increasing the accuracy of geological mapping. The resulting geological map of the Crowsnest Pass area, in the southern Alberta foothills shows fault-related folds. Layer thickness changes and strain in a fold are compared to those predicted by proposed kinematic models. The conclusions are relevant to thrust-fold relationships in the surface and subsurface.

Introduction

The Crowsnest Pass area, located in southern Alberta, is part of the foothills of the Cordillera Orogen. In 1903, a slope failure (the Frank Slide) led to increased research interest in the area. Detailed geological mapping revealed the location of map-scale structures in the Crowsnest Pass [Norris, 1993]. Most of the thrusts in the area expose Mesozoic clastic units at the surface, except for the Turtle Mountain Thrust which contains Paleozoic carbonate units in its hanging wall [MacKay, 1933].

LiDAR-derived maps taken into the field helped to interpret inaccessible or hazardous areas [Jaboyedoff et al., 2012]. The resulting geological map shows a number of folds that have close spatial relationships to faults. Some of these folds resemble standard fault-bend and fault-propagation folds. Many kinematic models have been proposed to describe these types of folds, each with different predicted distributions of strain and layer thickness.

Map-Scale Structures

Bare-earth-filtered digital elevation models (DEM) constructed from LiDAR data, and displayed in shaded relief images, show subtle topographic features. Using several "hill shade" maps, utilising different azimuths and sun angles, lineaments were manually traced. The lineaments, along with other features, were used on LiDAR-derived maps taken to the field. In inaccessible areas orientations were derived using lineaments seen in the LiDAR and topographic contours derived from the DEM. The lineaments, with field data, assist the interpretation of geologic structures (Fig. 1 and 2). Using this information, along with well data, cross-sections through the area can be established.

Strain Associated with Folds

Several methods of strain analysis, including Fry plots and calcite strain gauge methods, have been used on the backlimbs, hinges and forelimbs to help to determine fold kinematics. In addition, the accurate geological map and cross-sections reveal changes in thickness across folds. These methods are used to test the available kinematic models for folds in the area.

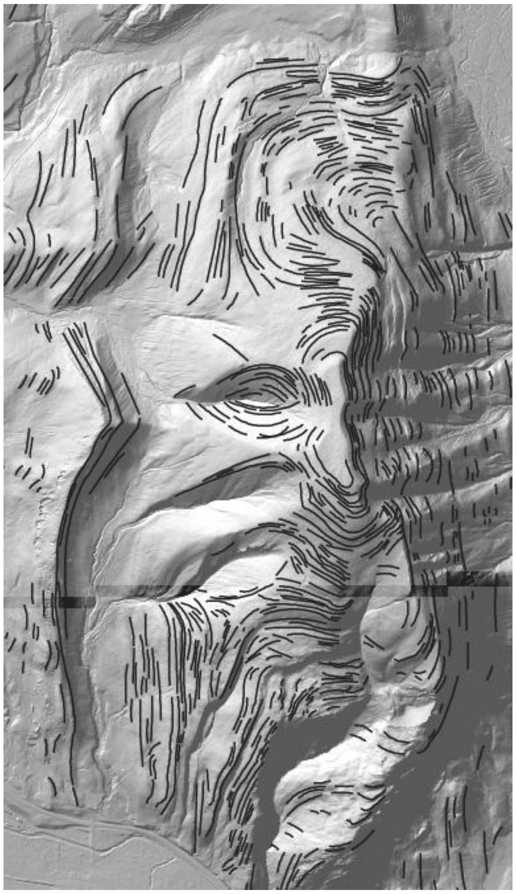

Figure 1: Traced lineaments over hill-shaded map. Scale 1:50,000.

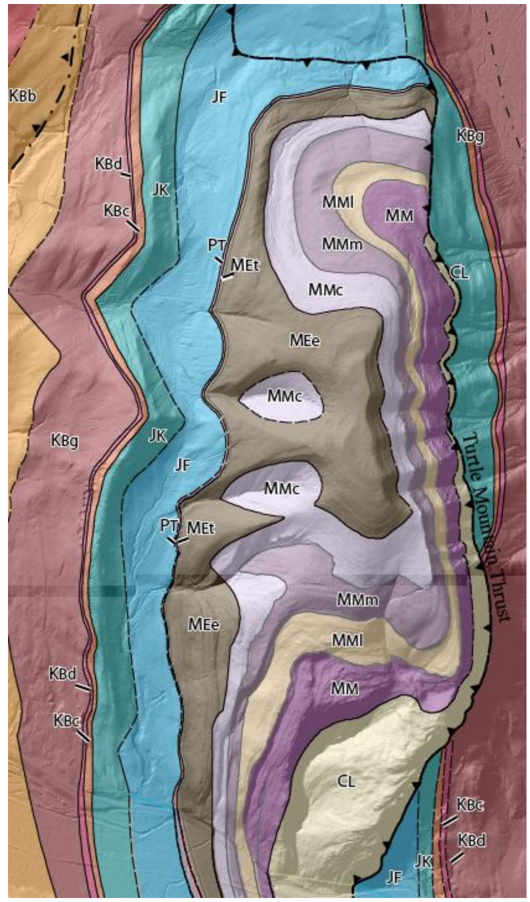

Figure 2: Hill-shade map with unit boundaries and thrust. Scale 1:50,000.

Conclusions

The results of this study show that traditional field mapping techniques can be effectively combined with remotely sensed data such as LiDAR, in extending and extrapolating units into unexplored or inaccessible areas. The use of LiDAR data increases the accuracy of geological mapping.

The geometry of folds and thrusts are much more effectively defined with the help of these data than in previous studies. Cross-sections through the area with strain analysis helps to compare the dominant fold in the area with kinematic models. These results will be of relevance to thrust-fold relationships in both the surface and the subsurface.

Acknowledgements

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References

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