Combining Fry Analysis with 3D Modelling and Geophysical Inversion: a Data Integration Study of the Southeastern Margin of the Athabasca Basin, Northern Saskatchewan, Canada

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Introduction & Research Problem

This work proposes the integration of several methodologies of structural analysis, implemented to target for unconformity-type U deposits. Understanding the feedback-type relationship between the history of deformation of the southeastern part of the Athabasca basin and its unconformity's palaeotopography, is among the key factors that could contribute to the discovery of new U deposits, in this leading world-class mineral district. Here we propose a refined interpretation of the southeastern part of the Athabasca basin architecture and its interplay with the Archean to Neoproterozoic basement of the Hearne province. A mineral prospectivity model is in phase of development. Described key elements are used to firstly understand which structures are key mineralizing corridors and secondly through the unconformity reconstruction we aim to constrain, with an integrated numerical approach, likely depths of emplacement for mineral deposits of the sought style.

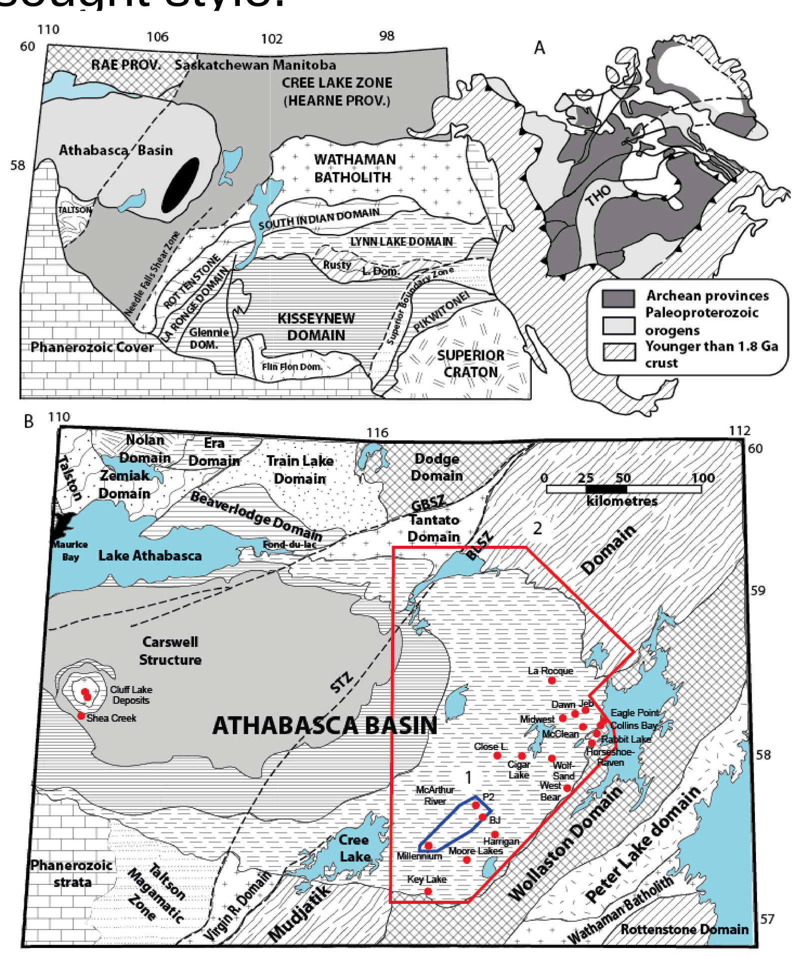

Fig. 1. Maps illustrating the geodynamic context and key structures intersecting the Athabasca basin. Modified form Tran et al. (2008). Red and Blue insets represent study areas.

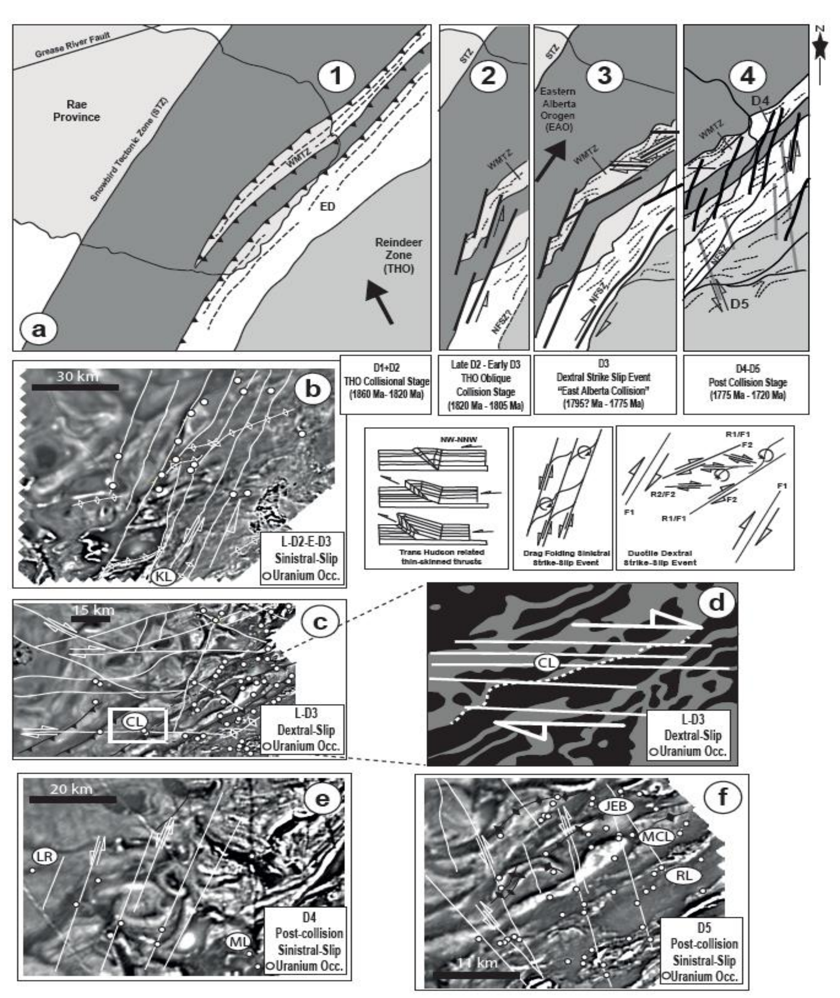

Fig. 2. Diagrams illustrating 4 phases of evolution of the southeastern margin of the Athabasca basin, which highlights key controls on mineralization, modified from Annesley et al. (2005).

Methodology

The study is multidisciplinary in nature and proposes the use of Fry analysis in a more quantitative way in mineral prospectivity mapping, with the objective of extracting knowledge from the clustering organization of mineral occurrence data, but also transfer such knowledge of spacing and orientation to the whole study region. The result offers a predictive model in itself. Numerical favorability scores are then applicable to 3D interpretations for structures that are within a certain buffer distance of the Fry corridors and share similar orientation. In conjunction with this study the understanding of the 3D morphology of the unconformity an its numerical representation can be fused with this information to increase or decrease favorability scores in the 3D mineral prospectivity model. Figs (1-5) illustrates the various phases of this study and the datasets considered in this preliminary component. The unconformity surface reconstruction considers also an element of geophysical inversion conducted using the VPmg software.

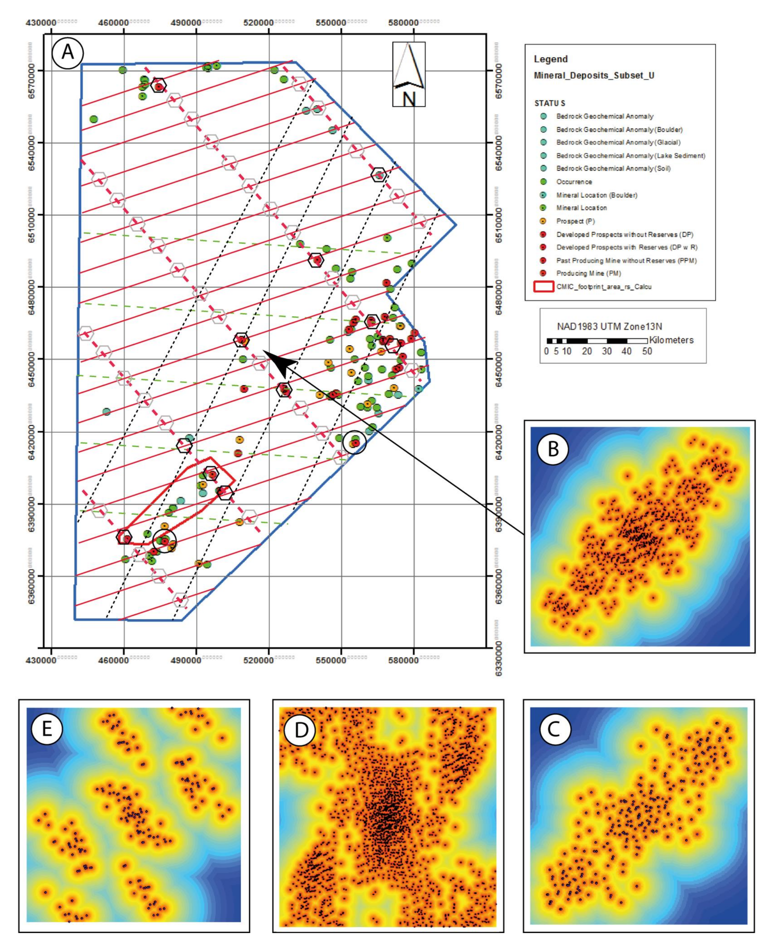

Fig. 3 Summary of Fry Analysis conducted on different subsets of mineral occurrence data (classified according to stage of development). Respectively: (A) Study of intersections of key corridors (spacing, orientation). (B-E) Fry plots for sub-sets for comparison.

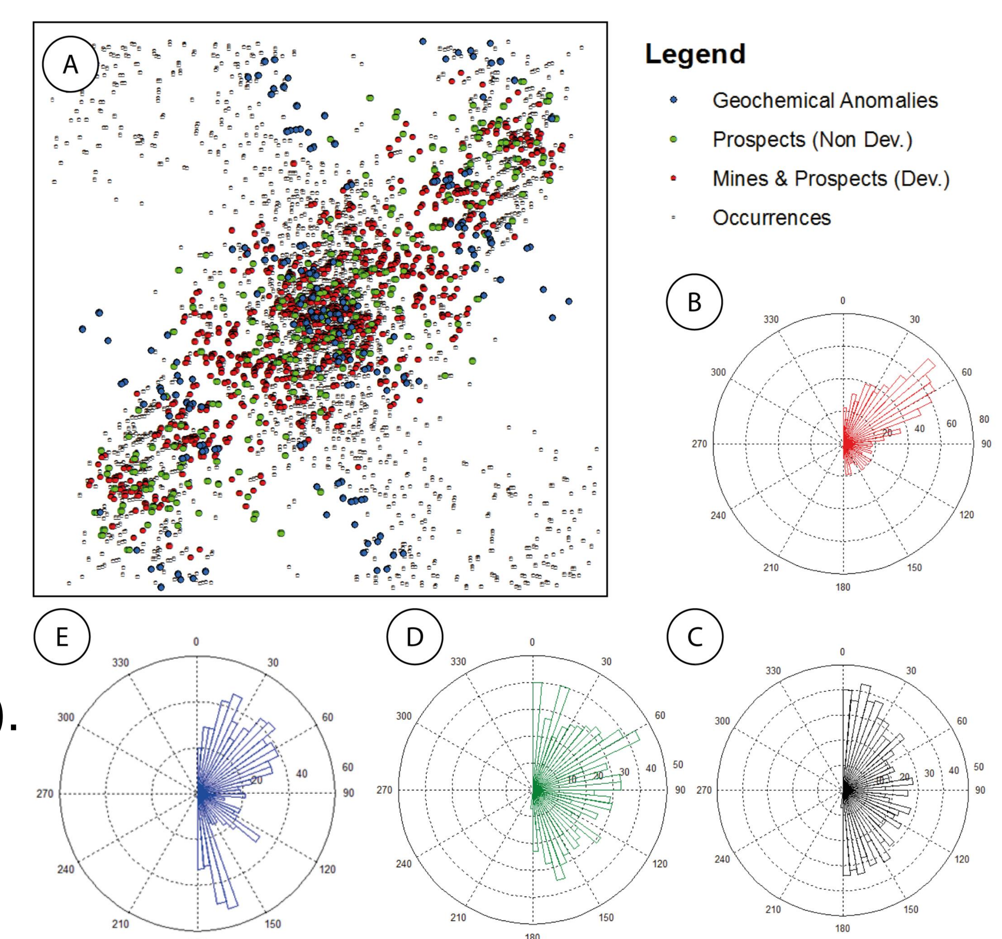

Fig. 4 Combination of Fry patterns colored according to sub-set. Respectively: (A) Summary Fry plot. (B-E) Study of first and second quadrant statistics on orientations of Fry pairs (Carranza 2009).

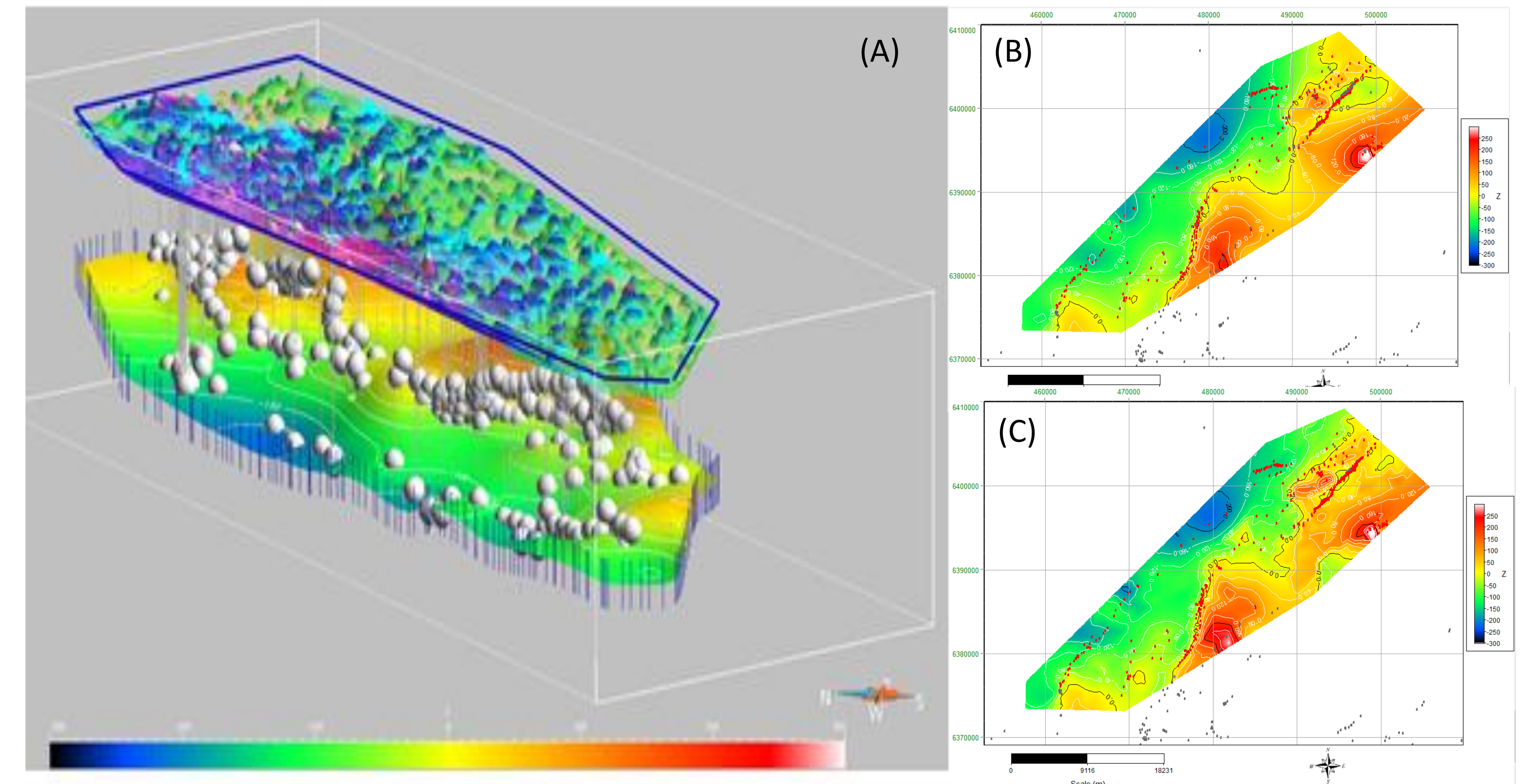

Fig. 5 3D representation of basement unconformity and topography SRTM data for blue sub-set in Fig.1 (McArthur-Millennium corridor). The unconformity position has been constrained using control points derived from SGS and CAMECO drill-holes. Respectively: (A) 3D visualization of data. (B-C) comparison of DSI interpolation based on CAMECO depth of basement (UC-markers).

Discussion, Results & References

Extracting knowledge from data is one of the key objectives of the CMIC-DI team. In this regard the Fry analysis conducted, documents important relationships between mineralization and basin architecture. In particular, ENE-NW intersections and their spacing appears to control the geospatial organization of the majority of the developed U mines and developed prospects. Less significant prospects and occurrences delineate instead N-S trends unrelated to major deposits, which are known to postdate at least the bulk of the U emplacement (interpreted as ca 1600-1300 Ma). Preliminary reconstructions of the unconformity surface confirm that mineral deposits are closely associated with abrupt slope changes.

References: Annesley, I.R., Madore, C. and Portella, P., 2005. Canadian Journal of Earth Sciences, 42(4): 573-597. Carranza, E.J.M., 2009. Ore Geology Reviews, 35(3–4): 383-400. Tran, H.T., Ansdell, K.M., Bethune, K.M., Ashton, K. and Hamilton, M.A., 2008. Precambrian Research, 167(1-2): 171-185.

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