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A regional multi-scale 3-D geological model of the Eastern Sub-Athabasca Basement, Canada: Implications for vectoring towards unconformity-type uranium deposits

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The Proterozoic Athabasca Basin of northern Saskatchewan is one of the most important mining districts in Canada; hosting the world's highest grade uranium deposits and prospects. In the basin, many of the near-surface deposits have been discovered; hence new ore deposits at greater depths need to be discovered. To help make new discoveries, 3D geological modeling is being carried out.

Here, we present our multidisciplinary approach, whereby a 3D geological model of the eastern sub-Athabasca basement of northern Saskatchewan (i.e. the eastern and western Wollaston domains, the Wollaston-Mudjatik Transition Zone (WMTZ), and the Mudjatik Domain) was developed in the common earth environment. The project was directed towards building a robust 3D model(s) of the upper 3-5 km of the Earth's crust in three different scales: deposit-, district-, and regional-scale, using the GOCAD software platform (Paradigm). Our eastern sub-Athabasca basement model is constrained by both geological studies and geophysical techniques, such as topographic, outcrop, drill hole, petrophysical, and petrological data, along with geophysical potential field, electrical, and high-resolution regional seismic data, in order to better understand the regional- to district-scale tectonics and controls on the uranium mineral system(s) operating pre-, syn-, and post-Athabasca deposition. The resulting data were interpreted and visualized as 3D-surfaces and bodies in GOCAD. This model reveals a framework of key lithological contacts, major high-strain zones, and the setting of unconformity-type uranium deposits. As a result, this new knowledge is being used to identify key exploration vectoring criteria for unconformity-type, magmatic, and metamorphic/ metasomatic uranium deposits and to delineate new exploration targets in the basin. Hence, this regional-scale 3D GOCAD model can be utilized as a guide for exploration activities within the region (e.g. picking new drill targets).

As well, this 3D model reveals the complex crustal architecture of the sub-Athabasca basement underlying the Athabasca Basin and the complex structural-alteration features of its associated unconformity-type deposits (Figure 1). Eventually by adding a time component, our model will be used to construct a schematic 4D geological evolution model of the eastern Athabasca Basin.

In summary, the GOCAD common earth environment allows integration of multiple geological, geophysical, geochemical, and petrophysical data sets from surface to depth. As a result, we are able to manipulate and visualize the regional to district to mine scale architecture of the Wollaston fold-and-thrust belt (Figure 1) and its intersection with the Athabasca unconformity, especially with the aid of high-resolution seismic profiles. Most importantly, high-resolution seismic profiles and drilling constrain the 3rd dimension. In addition, the GOCAD model can be imported easily into other modeling applications (e.g. FLAC 3D, OST 3D) for gaining further knowledge about the mineral systems.

In conclusion, our research is bringing new insight(s) to the role of the Archean/Paleoproterozoic basement in the genesis of unconformity-type U deposits of the Athabasca Basin.

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