ASSESSMENT OF FALCON AIRBORNE GRAVITY GRADIOMETER DATA FROM THE ATHABASCA BASIN, SASKATCHEWAN CANADA

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SUMMARY

The Falcon airborne gravity gradiometer system was flown over two areas in the Athabasca Basin, Saskatchewan to aid in the discovery of unconformity style uranium deposits. The Falcon outcomes along with other geoscience data, including airborne EM and magnetic data were evaluated. The assessment of these data suggests that the Falcon survey is showing responses believed to be derived from both the overlying Athabasca sandstone and likely, the Archean basement both which could be related to ore-forming mineral processes.

Key words: Falcon AGG, Athabasca Basin, unconformity uranium deposit

INTRODUCTION

The Falcon airborne gravity gradiometer system was developed by BHP Minerals (now BHP Billiton) to aid in the discovery of mineral deposits (vanLeeuwen 2000). The technology was used by BHP on an exclusive basis October 1999 to the end of 2007 when the technology was sold to Fugro Airborne Surveys (Street 2009). For a brief period in 2005-2006, BHP offered Falcon surveys to the uranium industry on a simple fee-for-service basis. A series of such surveys were undertaken in the Athabasca Basin, SK and the results of a recent assessment of two of these surveys are discussed here. The locations of these surveys in relationship to the Athabasca Basin are shown in Figure 1.

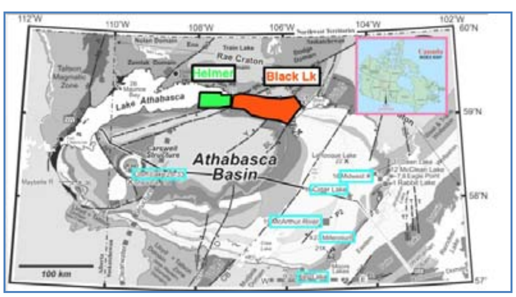

Figure 1: Location of Helmer and Black Lake Falcon surveys.

GEOLOGY

The Athabasca Basin is a Paleo to Meso-proterozoic quartz arenite basin in the northern part of the provinces of Saskatchewan and Alberta. Exploration for uranium began in the mid-1960's with companies looking for sandstone and/or paleochannel-type uranium deposits. Early discoveries at Rabbit Lake (1968) and Cluff Lake (1970), by airborne and ground radiometric prospecting and systematic drilling, lead eventually to the establishment of a significant resource in the Basin and recognition of the unconformity deposit type.

The discoveries at Key Lake and Cigar Lake led to a growing emphasis on graphitic fault conductors in the upper basement near the unconformity with the overlying sandstone as a key factor in the formation of these deposits. This has in turn led to a large increase in the use of ground and airborne EM techniques to explore for these conductors at depth.

Most of the economic uranium deposits in the Athabasca Basin occur below, across, and immediately above the unconformity (Figure 2). The deposits were formed by extensive hydrothermal systems occurring at the unconformity's structural boundary between the older and younger units. Major deep-seated structures are also interpreted to have played an important role in the hydrothermal process, likely acting as conduits for the hot mineralized fluids that eventually pooled and crystallized in the structural traps provided by the unconformity.

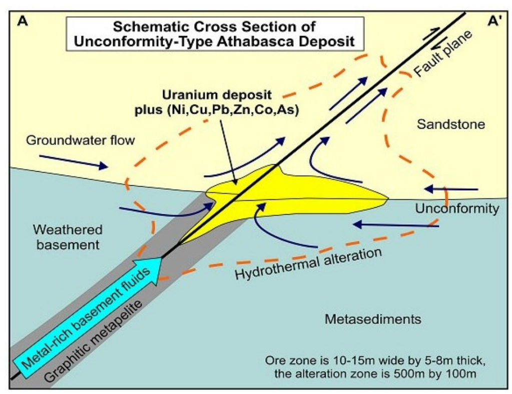

Figure 2: Typical geology and alteration zones associated with unconformity uranium deposits.

In the past decade, there has been a growing awareness of the diversity of alteration and mineralization styles. Research has shown that alteration can extend well above a deposit (left hand image Figure 3). As well, the mineralization can extend up into the sandstone or down into the bedrock (Figure 3) in addition to the traditional location at the actual unconformity. This research has resulted in the use of other geophysical techniques to try detect the alteration signature and enhance the detection of 'non-standard' deposit styles.

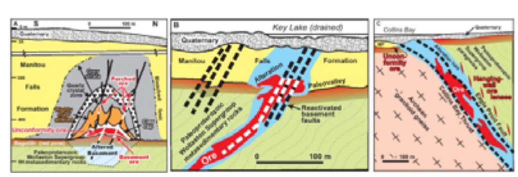

Figure 3: Variety of mineralization and alteration styles.

BACKGROUND GEOSCIENCE DATA

Airborne EM and magnetic surveys were conducted over both study areas and results from these have been used by the property holders to guide additional exploration work, including ground geophysics and drilling. A zone of uranium mineralization is located just NE of the Helmer study area (controlled by CanAlaska Uranium), but this is considered a somewhat atypical style of occurrence for the Basin. On the Black Lake property (controlled by UEX Corporation), there is a defined zone of 'classic' unconformity uranium mineralization lying along a conductive structure associated with the Platt Creek Fault zone.

FALCON SURVEYS

Both the Helmer and Black Lake surveys were flown in late 2005. A total of 2 259 lkm with a 400 m spacing were acquired in the Helmer surveys and 7 850 lkm was acquired on the Black Lake property with a 250 m line spacing. In addition to the airborne gravity gradiometer (AGG) data, magnetics, LIDAR and radiometric data sets were also acquired. The LIDAR data was used in the reduction of the gravity data. The radiometric data has not been assessed in this study. The main elements and sequence of processing of the gravity data performed by the contractor were as follows:

1. Instrument noise corrections and Post Mission Compensations (PMC, corrections for extraneous accelerations) are applied.
2. Self Gradient corrections are calculated and applied to reduce the non-static gradient response from the aircraft and platform.
3. A digital elevation model (DEM) is created from the laser scanner data and the DGPS data.
4. Terrain corrections are calculated and applied.
5. $\mathbf{G_{NE}}$ and $\mathbf{G_{UV}}$ are transformed into **Gdd** and **Gd**.

POST-MISSION DATA PROCESSING

The EM results for both study areas was inverted using a 1D code and then converted into a 3D voxel model using the 3D gridding function in encom pa. The magnetic and gravity data were inverted using the 3D inversion codes developed at the University of British Colombia. Using an unconformity model derived from available drilling, a constrained inversion model was generated for the magnetic results. By applying a constraint, the susceptibility was in effect forced into the basement rocks and out of the overlying sandstone.

OUTCOMES

The two survey areas, while adjacent to one another, were processed and assessed separately; hence the outcomes presented here will deal with the results separately as well.

Helmer: The uniformity model and drilling is shown in Figure 4. The thickness of sandstone varies from <100 m across the northern part of the study area to over 600 m along the southern boundary. There were four lines of seismic refraction covering the central part of the area but the interpreted unconformity depths did not agree that well with the drilling and so the seismic was not used to define the final unconformity model.

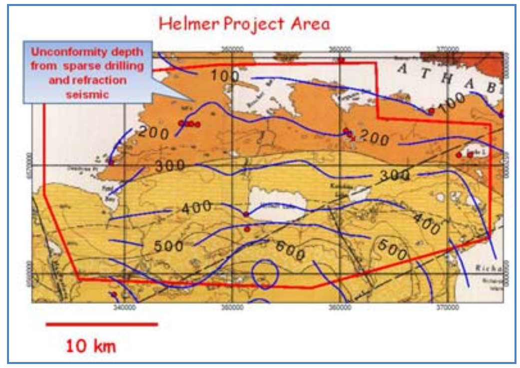

Figure 4: Helmer area showing depth to uniformity and drilling.

The four voxel models (mag susceptibility, density derived from Gd, density derived from Gdd and conductivity) are shown in Figure 5. Two density models are shown; one derived from the Gd result and one for the Gdd.

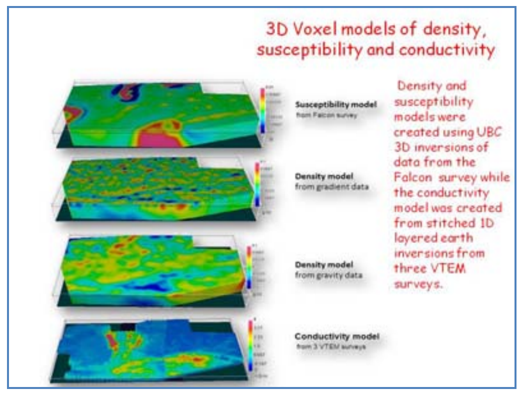

Figure 5: Voxel models created from Falcon and AEM surveys.

The processing of the magnetic data with and without constraint showed that for the constrained model the magnetic response in the basement was much sharper. This attribute is deemed a useful outcome separate from the AGG assessment as it provides the means to extract more structural information from magnetic surveys. This is highlighted in Figure 6. The Black Lake outcomes discussed later show a more significant enhancement using this processing.

Slices through the EM voxel model are shown in Figure 7. Due to levelling issues between surveys of different vintages, the early time portions could not be merged as well as the mid and deep sections of the model. There is considerable shallow conductivity apparent in the model. At the unconformity, an ENE trend in the conductivity is apparent in the south central part of the image; this is aligned with the strike of the Grease River Fault zone.

The depth slice shows the same zone associated with the Grease River Fault as well a strong zone of conductivity

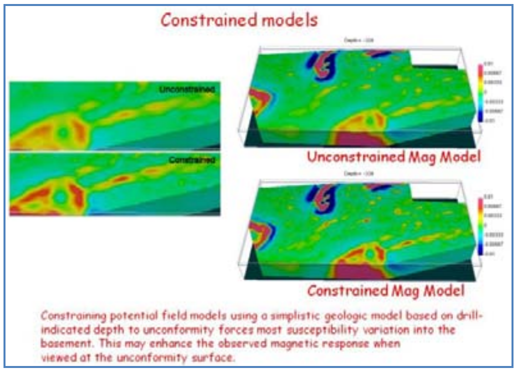

Figure 6: Unconstrained and constrained magnetic models.

that extends in a N-S direction. There is also a strong magnetic response associated with the N-S conductive zone. This type of response in bedrock could have base metal potential but this was not the focus of this assessment.

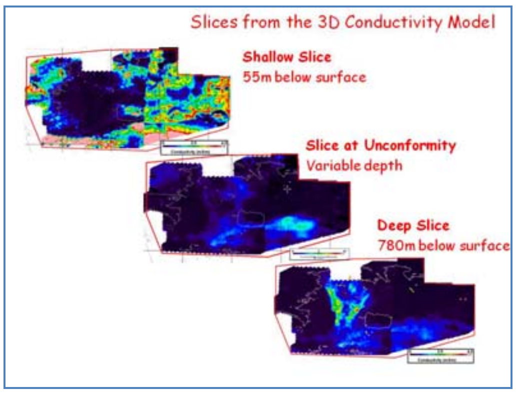

Figure 7: Slices through AEM conductivity model.

Figures 8 and 9 show the Gd and Gdd inversion models near the unconformity surface. Unlike the magnetic model, the AGG models were not constrained since significant variations in density could occur within the sandstone or basement (Thomas and Wood 2007).

A number of features have been identified with the Grease River Fault system showing up as a density low along parts of its strike extent.

These outcomes were then merged with the EM results and a synthesis is displayed on the DEM image in Figure 10.

While grid and voxel based approaches were a primary means to assess the survey results as a whole, modeling of discrete lines was also undertaken so as to better understand some of the localized features in greater detail. Figure 11 shows the 2.5D modeling of a line on the far eastern side of the survey block. Of interest are the two topographic ridges.

The northernmost ridge is adequately explained as being the same density as the host mass (2.4 gm/cc) whereas the ridge to the south appears to require a higher density (2.7 gm/cc) to remove the effect of topography from the observed response. The geological interpretation would be that this ridge is very siliceous sandstone.

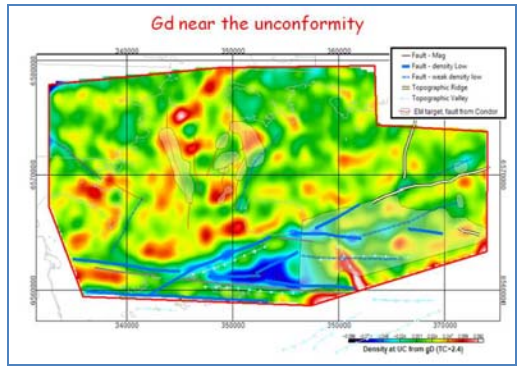

Figure 8: Gd near the unconformity surface.

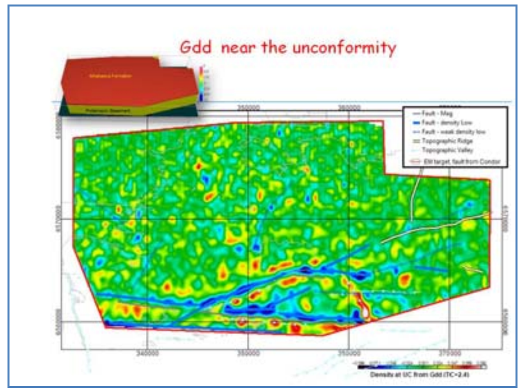

Figure 9: Gdd near the unconformity surface.

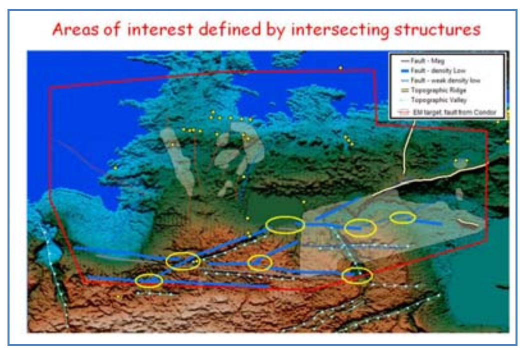

Figure 10: Areas of interest as defined from gravity and EM results displayed on DEM.

Black Lake: The Black Lake property had a known zone of mineralization located in the eastern part of the study area; this is indicated in Figure 12, an image of the EM time constant. Using a well-defined regional gravity feature, Figure 13 shows how well the Falcon data merges in with pre-existing data.

The 3D models for the magnetic, gravity and EM surveys are shown in Figure 14. Given the presence of mineralization along the Black Lake conductive structure, this area was studied in more detail. Figure 15 shows a comparison of the unconstrained and constrained magnetic model over the area of mineralization.

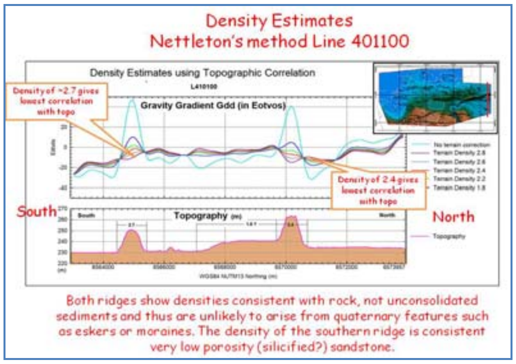

Figure 11: Modeling along survey line to obtain correct densities for terrain removal.

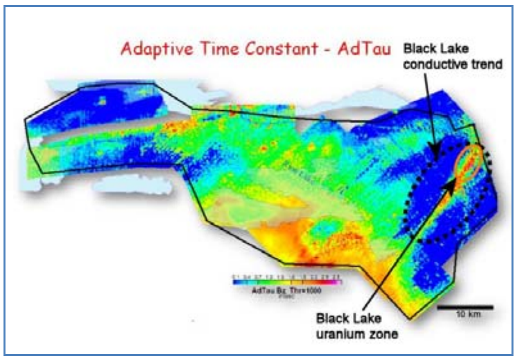

Figure 12: Image of EM time constant showing Black Lake conductive trend and uranium zone (at north end of conductive trend).

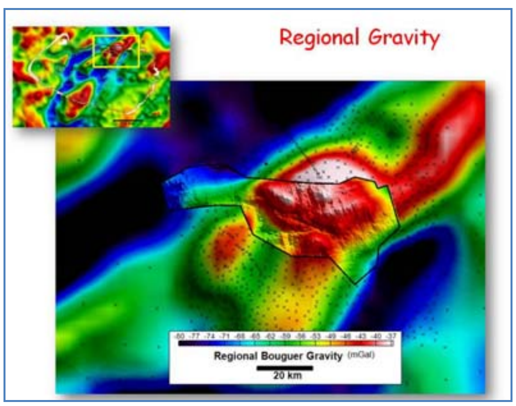

Figure 13: Falcon Gd merged with pre-existing regional gravity coverage.

The constrained model shows considerably greater resolution of the magnetic sources in the basement. This facilitates the recognition of what could be important second order structures which cross cut the mineralized horizon.

CONCLUSIONS

The present study shows that with innovative processing and the joint assessment of other data sets processed in a similar fashion, Falcon gravity gradiometer data can provide information useful for the development of targets which might be related to unconformity style uranium deposits. As with any new technique however, follow-up drilling is required to validate the value of these outcomes.

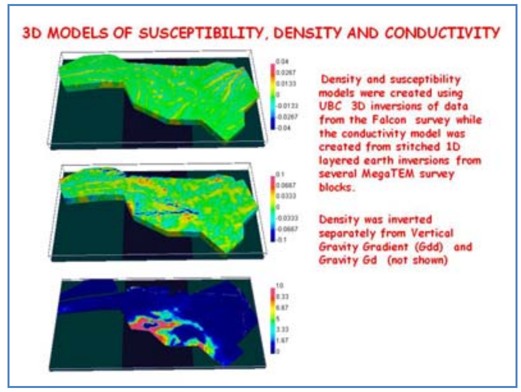

Figure 14: 3D models for susceptibility, density and conductivity.

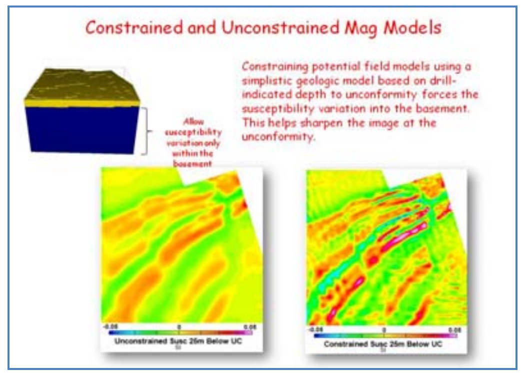

Figure 15: Unconstrained and constrained Mag3D models in vicinity of the Black Lake mineralized zone.

In Figure 16, the gravity and magnetic results are merged to highlight features of potential interest either along or nearby the Black Lake conductive zone.

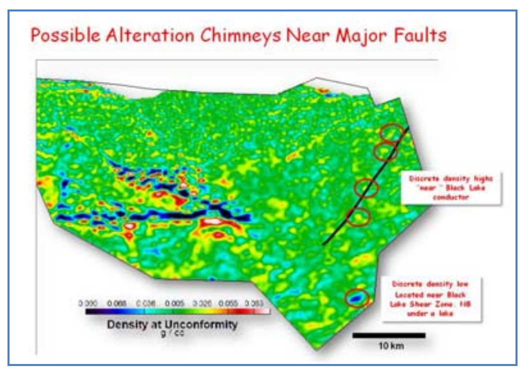

Figure 16: Merging of magnetic and gravity results to highlight features of interest along the Black Lake conductive trend.

ACKNOWLEDGMENTS

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