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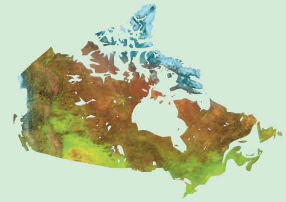

Preliminary 3D geophysical modelling of the Aberdeen sub-basin, northeast Thelon Basin region, Nunavut

V. Tschirhart, W.A. Morris, H. Ugalde, and C.W. Jefferson

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Abstract: The Paleoproterozoic Thelon Basin, transecting the border of Northwest Territories and Nunavut, and situated in the interior of the western Churchill Province between the Slave Province and the Snowbird tectonic zone, is both tectonically and stratigraphically similar to the Athabasca Basin, known world-wide for its unconformity-associated uranium deposits. This paper reports a compilation and interpretation of the existing geophysical and geological data for the Aberdeen sub-basin located in the northeastern part of the Thelon Basin. Limited seismic profiling, along with sparse borehole data, permits only broad-scale regional models of the sub-basin. An improved interpretation of the unconformity surface between the Thelon Formation and underlying basement is derived from 2D forward modelling of the regional scale gravity and aeromagnetic data. The resulting depth-to-basement model invokes a more magnetic and dense basement which is unconformably overlain by nonmagnetic and less dense siliciclastic strata of the Thelon Formation. Limited geological constraints on the models were provided by borehole logs, seismic shot points, and physical property attributes from the Kiggavik deposit and Athabasca Basin. Integration of the results of the model cross-sections in 3D suggests that the Aberdeen sub-basin is deeper than previously thought. Aeromagnetic data demonstrate high potential for being useful for predictive mapping of buried basement lithological units. The gravity and aeromagnetic models set the stage for acquiring new basic petrophysical and borehole constraints to map basement rock units beneath the Thelon Basin.

Résumé : Situé à cheval sur la limite des Territoires du Nord-Ouest et du Nunavut et reposant à l'intérieur de la Province de Churchill occidentale, entre la Province des Esclaves et la zone tectonique de Snowbird, le bassin de Thelon du Paléoprotérozoïque est similaire à la fois sur le plan tectonique et sur le plan stratigraphique au bassin d'Athabasca, reconnu mondialement pour ses gisements d'uranium associés à des discordances. Le présent rapport offre une compilation et une interprétation des données géophysiques et géologiques existantes pour le sous-bassin d'Aberdeen, situé dans la partie nord-est du bassin de Thelon. Un nombre limité de profils sismiques, de même qu'une faible densité de données de forage, ne permettent d'élaborer que des modèles régionaux à grande échelle du sous-bassin. Une meilleure interprétation de la surface de discordance entre la Formation de Thelon et le socle sous-jacent est dérivée de la modélisation directe 2D des données gravimétriques et aéromagnétiques à l'échelle régionale. Le modèle de la profondeur jusqu'au socle qui en résulte met en jeu un socle plus magnétique et plus dense, surmonté en discordance par les strates silicoclastiques non magnétiques et moins denses de la Formation de Thelon. Une quantité limitée de données contraignantes de nature géologique ont été fournies pour les modèles par des diagraphies en sondage, des points de tir sismique et les attributs des propriétés physiques du gisement de Kiggavik ainsi que du bassin d'Athabasca. L'intégration des résultats des coupes transversales du modèle 3D donnent à penser que le sous-bassin d'Aberdeen est plus profond que ce qu'on avait supposé. Les données aéromagnétiques sont très prometteuses pour la cartographie prévisionnelle des unités lithologiques enfouies du socle. Les modèles gravimétriques et aéromagnétiques établissent le contexte pour l'acquisition de nouvelles données contraignantes fondées sur les caractéristiques pétrophysiques de base et les sondages, afin de cartographier les unités lithologiques du socle, sous le bassin de Thelon.

INTRODUCTION

Concern over the changing climate has brought with it an increased demand for low-emission, clean-energy resources, such as nuclear power. Nuclear power is increasingly viewed as a way of enhancing electrical power generation with significantly reduced emissions. Canada was the world's largest uranium producer for many years, accounting for about 22% of world output, but in 2009 was overtaken by Kazakhstan. (World Nuclear Association, 2011; Jefferson et al., 2007a). Exploration is still active in a number of Canadian districts with known or potentially economic uranium deposits (Intierra Mapping, 2009), despite the recent economic downturn, proving that there is a broad market belief that the world requires nuclear power as part of a diversified and climate-friendly approach to national energy security plans around the world (International Atomic Energy Agency, 2007; Mamay, 2008). One of the goals of this project is to improve the knowledge framework within which industry can locate and develop economic nuclear-fuel deposits to sustain Canada's long-held position as a reliable supplier.

This paper focuses on the Paleoproterozoic Thelon Basin that straddles the Nunavut-Northwest Territories border in the interior of the western Churchill structural province (Fig. 1). Preliminary exploration and research in the 1970s and 1980s located uranium prospects in the Thelon that were both tectonically and stratigraphically similar to world-class deposits of the Athabasca Basin, but the magnitudes and spatial extents of these resources were incompletely documented (Miller and LeCheminant, 1985; Fuchs and Hilger, 1989; Gandhi, 1989; Hasegawa, et al., 1990). The second millennium's nuclear energy revival brought with it renewed exploration. A number of companies exploring the Thelon area acquired new ground and airborne geophysical data within their property limits. The work reported here represents the early part of a major northeast Thelon River compilation activity under the Geo-mapping for Energy and Minerals (GEM) Uranium Project that aims to provide insights into the Thelon Basin's potential uranium resources by mapping the tectonic and stratigraphic framework, and subsurface geology of the basin.

Even with the recent surge of investments, exploration within the Thelon Basin has been limited. Over half of the basin is a protected game sanctuary, restricting access to its centre. Access is currently permitted only in the northeast portion in Nunavut, here termed the Aberdeen sub-basin (Fig. 2), where exploration companies have acquired considerable new high-resolution geophysical data. Due to the high cost of surface mapping and exploration, the use of such data are essential to focus ground activities on the most promising areas and reduce risk. Aeromagnetic and gamma-ray data are currently being compiled under an agreement with eight of the exploration companies; however, their

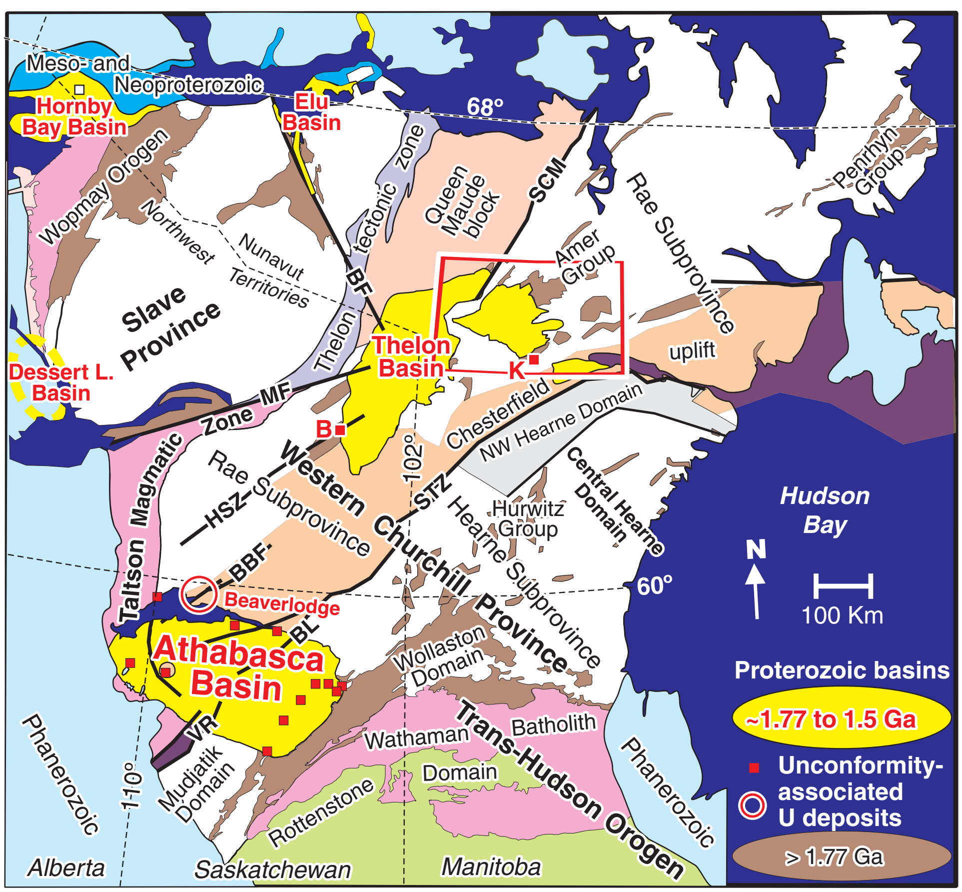

Figure 1. Location of the Thelon Basin in the interior of the western Churchill Province, straddling the border between Nunavut and the Northwest Territories. The area of Figure 2 (Aberdeen sub-basin) is outlined in red. B = Boomerang Lake, BBF = Black Bay fault, BF = Bathurst Fault, BL = Black Lake shear zone, HSZ = Howard Lake shear zone, K = Kiggavik uranium deposit, MF = MacDonald Fault, SCM = Slave-Chantrey mylonite zone, STZ = Snowbird tectonic zone, VR = Virgin River shear zone (*after* Jefferson et al., 2007b).

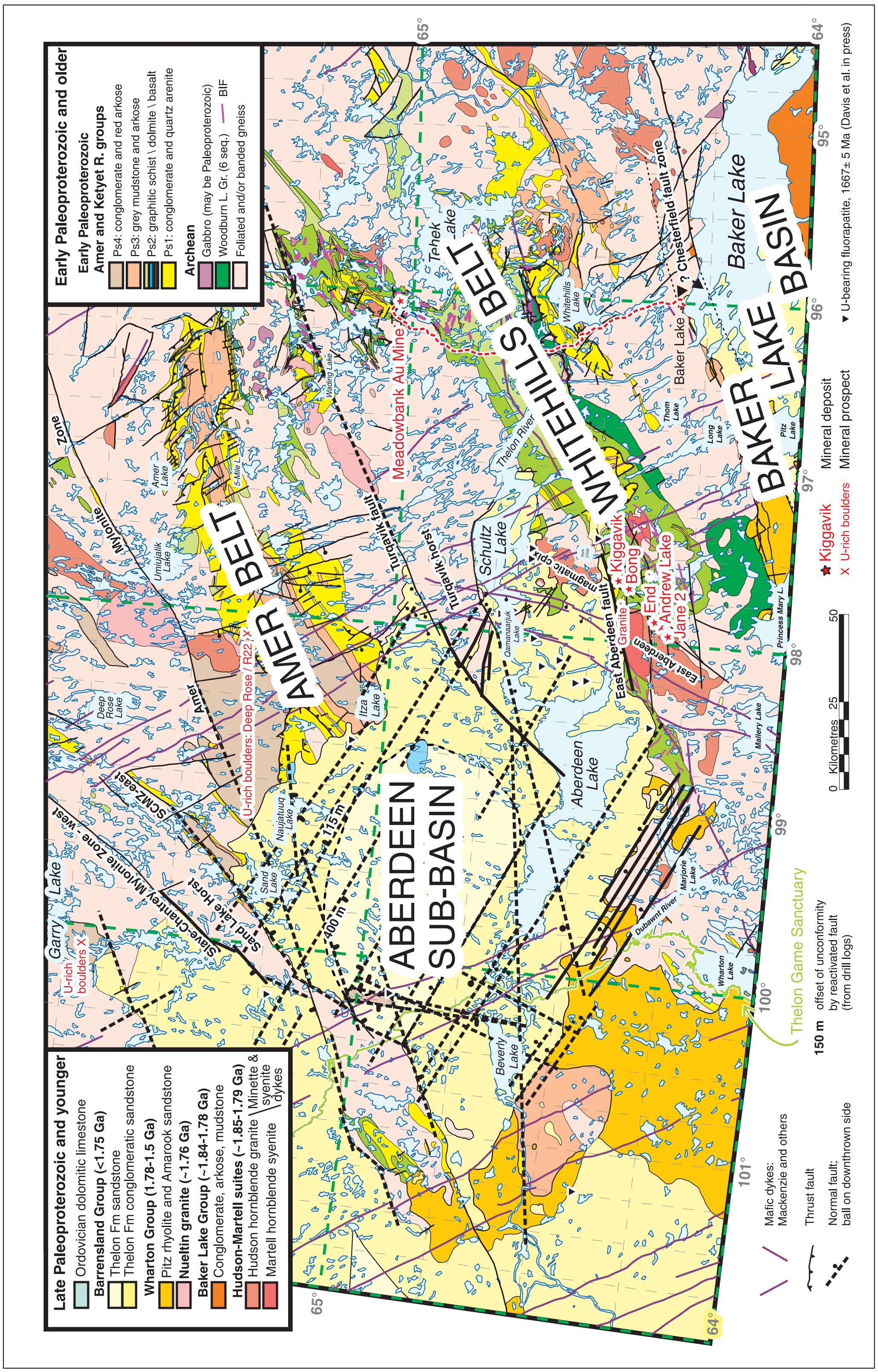

Figure 2. Geological map of the Aberdeen sub-basin region, *after* Skulski (unpub. map, 2010), Tella (1994) and Davis et al.(2011).

data are confidential until March 2011 and a framework is required to organize the new high-resolution material. This paper demonstrates modelling that can be derived from publically available low-resolution data for the region, such as the first-ever 3D model of the unconformity surface between basement and the overlying Thelon Formation, a vital framework for evaluating uranium potential and planning exploration for buried deposits.

There is no record in the literature of any geological models of the Thelon Basin based on comprehensive geophysical-data interpretation. The three cross-sections constructed by Jefferson (*in* Davis et al., 2011) are the first published attempt to represent the current basin structure. Their cross-sections are limited by the few boreholes that could be logged, many of which do not intersect the basement, and by the reconnaissance nature of the 35 seismic shot points acquired by Overton (1979). The depth-to-basement estimates provided by the seismic data and any other geophysical depth estimates are hampered by a lack of physical rock-property data for units of the Thelon Basin, so assumptions must be made based on geophysical data from analogous basins, in particular the Athabasca Basin (Mwenifumbo et al., 2004; Jefferson et al., 2007b; Thomas and McHardy, 2007; Thomas and Wood, 2007).

This paper aims to provide an estimate of the depth to basement from an analysis of regional-scale gravity and aeromagnetic 2D models for the Aberdeen sub-basin. The revised tectonic framework and depth-to-basement model for the Aberdeen sub-basin will provide a starting point to incorporate new high-resolution imagery, generate broad concepts for explorationists, and ultimately yield a detailed geoscience framework within which industry can plan uranium-prospecting strategies over the entire Thelon Basin.

To overcome the lack of petrophysical data for the Thelon Basin region, the densities of basement units chosen for the computations in this preliminary analysis are based on previous work data collected around the Kiggavik Main Zone located on the eastern edge of the Aberdeen sub-basin (Hasegawa et al., 1990). As the basement-hosted Kiggavik deposit has been exposed by removal of the previously overlying Thelon Formation, data for basin-filling sandstone rock properties, especially density, were derived from the Athabasca Group (Mwenifumbo et al., 2004). Primary constraints were placed on the depth of the Thelon Basin in these models by sparse seismic data of Overton (1979) and lithological logs of archived drill core (Davis et al., 2011).

GEOLOGICAL SETTING

The Thelon Basin is late Paleoproterozoic, intracratonic, and formed approximately contemporaneously with the Athabasca Basin (Davis et al., 2011). It covers almost 10 000 km^2. Resting on the Rae Craton of the western Churchill structural province, it is an erosional remnant of a complex, dominantly fluviatile, sedimentary basin with a 200 000 000 year history (Davis et al., 2011). Beneath this basin, 1.85 to 1.70 Ga Dubawnt Supergroup strata unconformably overlie the approximately 2.2 to 1.9 Ga Amer Group and 2.7 to 2.6 Ga Archean supracrustal rocks, anorthosite-gabbro, granitic and older Archean gneissic rocks (Rainbird et al., 2003). The assemblage of basement rocks was deformed episodically from 2.5 to 1.83 Ga before deposition of the Dubawnt Supergroup (Davis et al., 2011). The Dubawnt Supergroup comprises three unconformity-bound successions: Baker Lake, Wharton, and Barrensland groups. The Barrensland sequence filled the Thelon Basin and comprises quartzose to subfeldspathic sandstone and conglomerate of the Thelon Formation (Palmer et al., 2004). It unconformably overlaps the previous two successions of the Dubawnt Supergroup, as well as the Amer and Woodburn groups (Davis et al., 2011). The basal unconformity surface of the Thelon Formation is marked by a major paleoweathering event that is also found beneath the Hornby Bay, Elu, and Athabasca basins (Gall and Donaldson, 2006). The MacKenzie diabase dykes, which cut through much of the Thelon Basin, were emplaced at 1.27 Ga (Heaman et al., 1992). The basement to the Thelon Basin is also characterized by multiple alkalic igneous events that punctuated the Paleoproterozoic tectonic and sedimentary evolution of the northeastern Thelon Region at 1.833 to 1.826 Ga and 1.765 to1.750 Ga (Peterson, 1994; van Breemen et al., 2005; Peterson, 2006). The highly potassic mafic Kuungmi lavas are the second youngest unit of the Barrensland Group, dated at 1.56 ± 30 Ga (Chamberlain et al., 2010).

METHODS

The geophysical data contributing to this paper were downloaded from the Geological Survey of Canada (GSC) Geoscience Data Repository. Oasis montaj software from Geosoft® was used for all the gridding and data processing. The local projection system used in all databases and maps is WGS84 UTM 14N. The regional gravity database consists of stations measured in 1970 at a spacing of about 12 km. The database was corrected for elevation, terrain, and Bouguer effects. The residual Bouguer gravity was reduced with a slab density of 2.4 g/cm^3 to correct for the reduced attraction to the low-density Thelon Formation and overburden. The limited number of Bouguer-corrected gravity-station observations was gridded at 2 km using a minimum-curvature algorithm.

The regional magnetic data are an aeromagnetic survey flown in 1972 using a Spartan Proton magnetometer at 800 m spaced lines, at a nominal flight height of 300 m above the surface. Navigation and flight-path recovery were based on photo mosaics. Diurnal and tie-line corrections were performed on the data to minimize the effect of diurnal drift and noise associated with the signal. The levelled aeromagnetic data were interpolated onto a grid with 200 m node spacing using a minimum-curvature algorithm. Residual between-line corrugations were diminished by microlevelling in accordance with Minty's technique (Minty, 1991).

Overton's seismic-depth estimates were digitized and imported into Oasis montaj. Of the 35 seismic shot points taken across the Thelon Basin, only six record the depth to basement within the Aberdeen sub-basin. A map showing the location of the publically available boreholes was compiled from assessment reports such as Stanton (1980, 1981), publications such as Hiatt et al.(2003), and company Web sites. Locations of the boreholes were georeferenced and plotted alongside the seismic depths (Fig. 3). Only some of the boreholes actually transected the unconformity between the Thelon Formation and underlying basement rocks. The remaining boreholes therefore provide minimum depths of the basin. These basement-depth observation points are widely dispersed within the Aberdeen sub-basin so any attempt to produce a depth-to-basement model based on these estimates must, of necessity, be very crude. An additional absolute constraint on the zero edge of the sub-basin is provided by the topographic elevation of the mapped contact between the Thelon Formation and underlying basement. The individual depth estimates from the various data sets were combined in a single grid using a minimum-curvature algorithm with a 20 km node cell size (Fig. 3). The resulting basin-depth surface contains no sharp discontinuities that might be associated with fault displacements. Whereas previous geological mapping has outlined some localized fault offsets throughout the sub-basin, the low resolution of the gravity grid and the large grid-cell size used in the gridding made it impossible to image such detailed features in this preliminary model of the surface of the basal unconformity.

The 2D forward gravity and magnetic inversion models were computed using Geosoft's GM-SYS 3D modelling software on profiles extracted from grids of the GSC regional-gravity and aeromagnetic data. Six east-west and two north-south profiles were constructed crosscutting the Aberdeen sub-basin (Fig. 4). The optimum locations for the cross-sections developed to constrain gravity models were compromises to optimize the locations of the gravity data stations (Fig. 3) and some of the key geological features in the area, for example crossing known faults, dykes and the edge of the Paleoproterozoic Thelon Basin at sufficiently high angles for modelling.

ASSUMPTIONS

To model the unconformity surface it was necessary to assign density values to the sandstone and basement units to account for their relative contributions to the observed Bouguer-gravity signal. The few published density measurements in the Thelon region were taken from the Kiggavik Main Zone, along the eastern edge of the basin. In their model

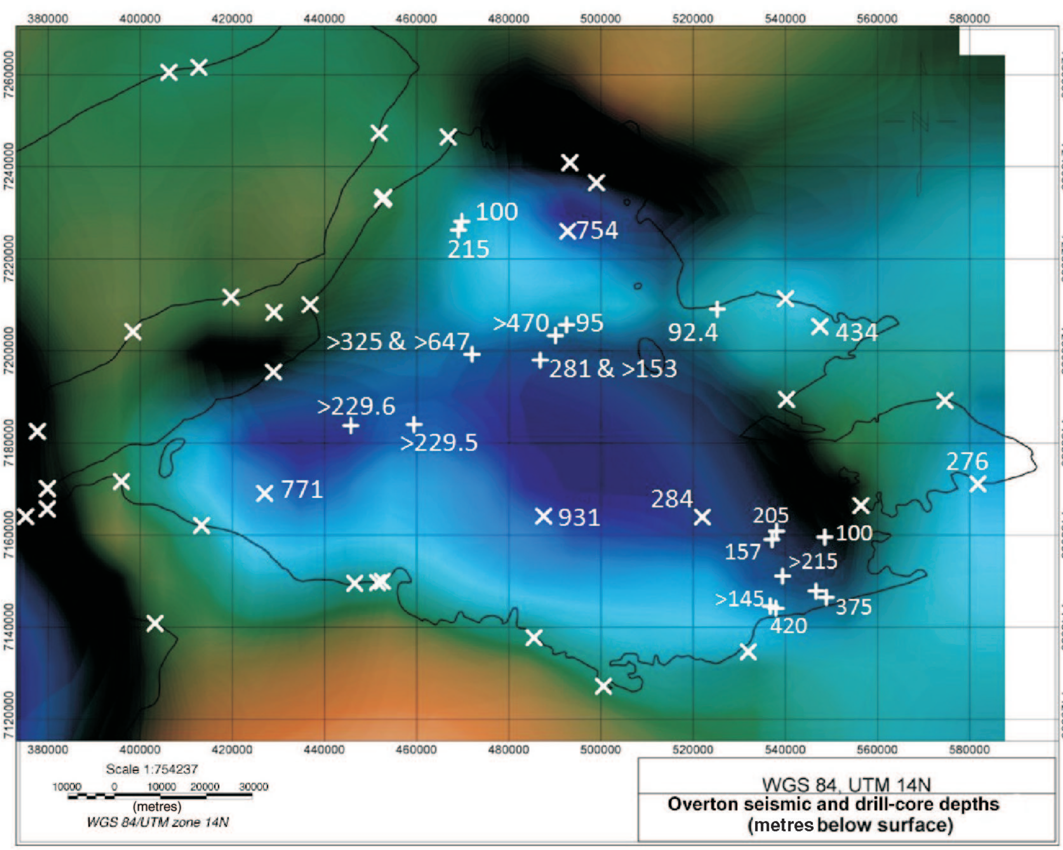

Figure 3. Gridded depth to basement showing location of Overton seismic shot points (x) and industry boreholes (+) showing depths to basement where applicable. The thin black line is the mapped boundary of the Aberdeen sub-basin which by definition outlines the zero thickness of the Thelon Formation.

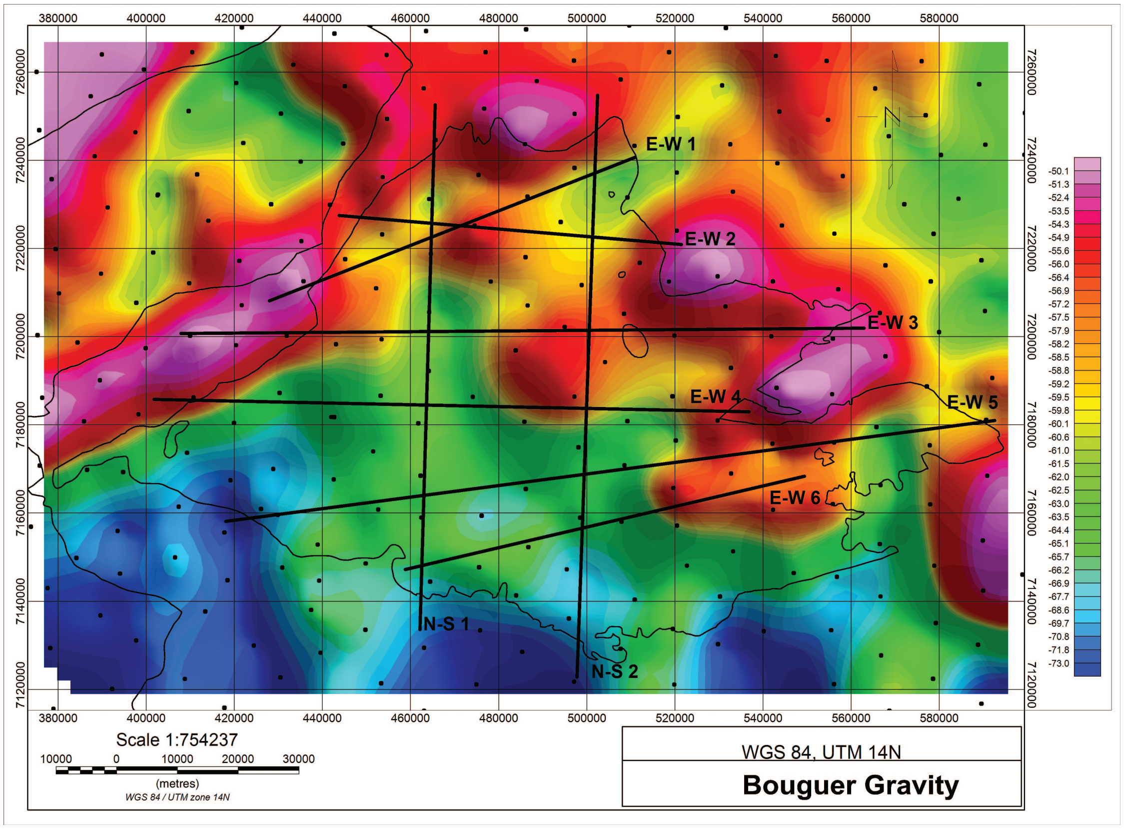

Figure 4. Locations of model profiles (thick black lines labelled E-W 1 through 6, N-S 1 and N-S 2) in the context of the Bouguer gravity map, with locations of gravity stations (•). The thin black line maps the exposed edge of the Aberdeen sub-basin that is filled by Thelon Formation.

of the Kiggavik deposit Matthews et al., (1997) assigned an average density value of 2.7 g/cm^3 to the Woodburn Group. To simplify the analysis here it is assumed that the 'basement' unconformably underlying the Thelon Formation throughout the entire sub-basin has the same homogeneous density of 2.7 g/cm^3. To further emphasize the preliminary nature of this model, we recognize that the basement under the Thelon is certainly not homogeneous and that this issue will have to be directly addressed in future iterations of this model. The Kiggavik Main Zone is located outside the basin, and, with no published density measurements for the Thelon Formation itself, data were borrowed from its sister Athabasca Basin. The typical density of the Athabasca Group sandstone units from Thomas and Wood (2007), 2.43 g/cm^3, was assigned to the Thelon Formation as a whole. With more data in future it may be possible to incorporate strong density variations in modelling the Thelon Formation like those documented by Mwenifumbo et al.(2004) for the Athabasca Group.

The Thelon Basin has been extensively glaciated in the past and, with the surrounding basement, is overlain by a variable thickness of glacial overburden. Hasegawa et al. (1990) assigned the overburden a density of 2.0 g/cm^3 in their model; however, this paper does not consider the overburden's density contribution. As it comprises such a small part of the stratigraphic sequence and the gravity data available are sparse, the overburden would at most represent a minimal contribution to the Bouguer signal at this resolution.

In order to refine the subsurface geology of the basement along transects, coincident profiles were extracted from the microlevelled aeromagnetic data. The final forward model computed for each profile is based on both the aeromagnetic and gravity data (*see* Fig. 10). The basement units were assigned susceptibilities ranging from 0.002 to 0.008 SI and the basin fill was denoted 0.0 SI, as samples of the sandstone tested in the laboratory are essentially non-magnetic. After optimization of each profile individually, the resulting profile model surfaces were exported into Encom Profile Analyst software to be incorporated into a 3D model of the sub-basin (*see* Fig. 7).

RESULTS AND DISCUSSION

Two examples of generated –east-west profiles are shown in Figure 5 (E-W 1) and Figure 6 (E-W 5). The depth-estimate profiles were created by closely matching the computed Bouguer signal with the observed Bouguer signal above the cross-sections (Fig. 7). The accuracy of these depth estimates is limited by two major factors. First, the available 12 km spacing gravity data were gridded using a 2 km grid cell. From signal processing concepts this means that it is not possible to detect any structures which have a wavelength of less than 24 km. It is not possible to incorporate any known low-amplitude, but high spatial-frequency, discontinuities such as faults into such data.

Second, as stated in the data-processing section, density measurements were arbitrarily assigned to the basin fill and the assumed crystalline basement, without actual control from borehole or petrophysical samples. The estimated physical-property values are based on the assumed equivalence of the Thelon Formation and Athabasca Group siliciclastic rocks. Giving one density to all units of the Thelon Formation assumes no lithological variation along the unconformity surface and no lateral sedimentary or diagenetic contrasts within the basin fill like those documented by Mwenifumbo et al.(2004) for the Athabasca Basin. Any deviations in density values between the lithological units of the two basins would be manifested as errors in the depth estimates. However, as gravity data respond to density contrasts rather than absolute density values, the models can still be correct provided that the relative density contrast between sedimentary rocks and basement is similar between the Athabasca and Thelon Basins, even if the absolute density values are different. Changes in the relative density values

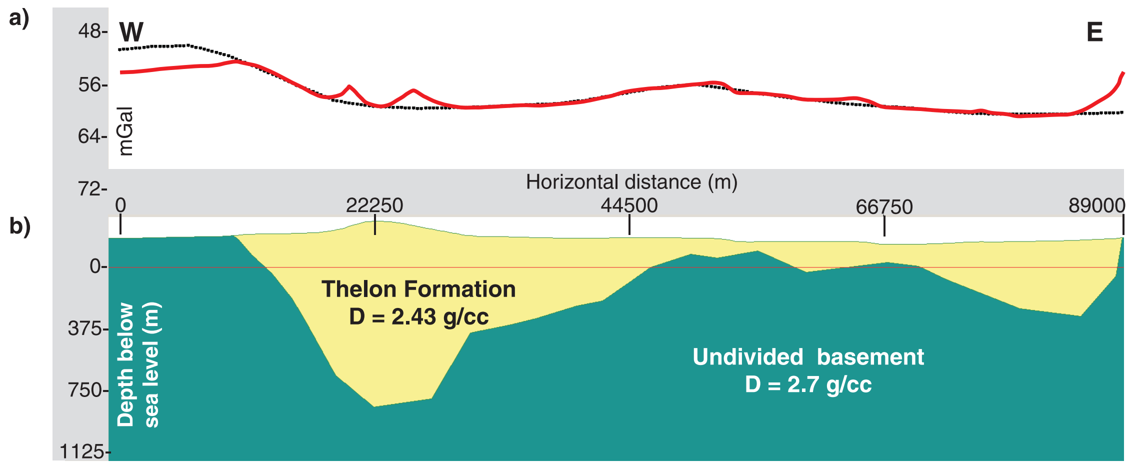

Figure 5. GM-SYS Bouguer profile for the E-W 1 transect located in Figure 4. **a)** Observed (black dots) and computed (red line) Bouguer gravity. **b)** Computed model for Thelon Formation sandstone (may include Wharton Group sandstone) overlying undivided basement.

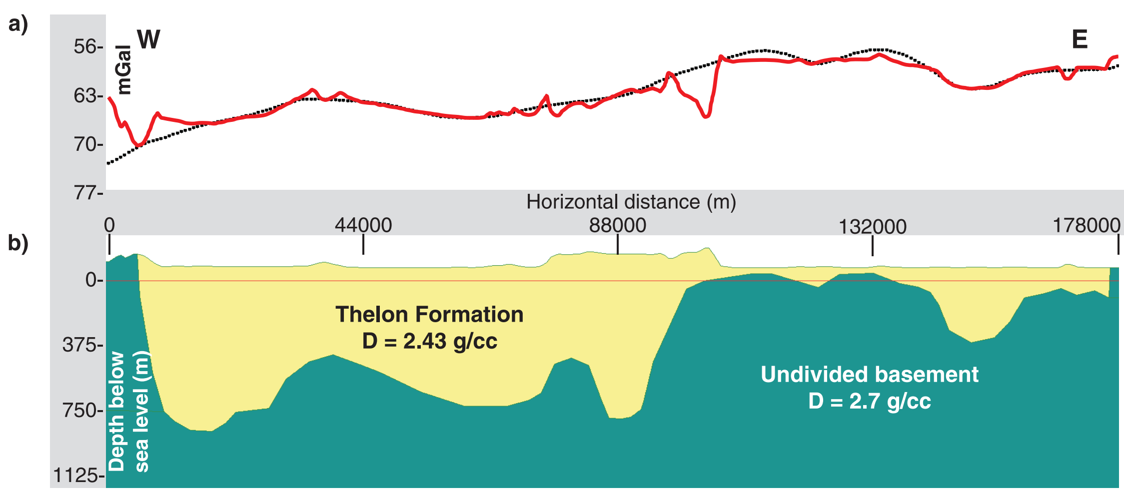

Figure 6. GM-SYS Bouguer profile for the E-W 5 transect located in Figure 4. **a)** Observed (black dots) and computed (red line) Bouguer gravity. **b)** Computed model for Thelon Formation sandstone (may include Wharton Group sandstone) overlying undivided basement.

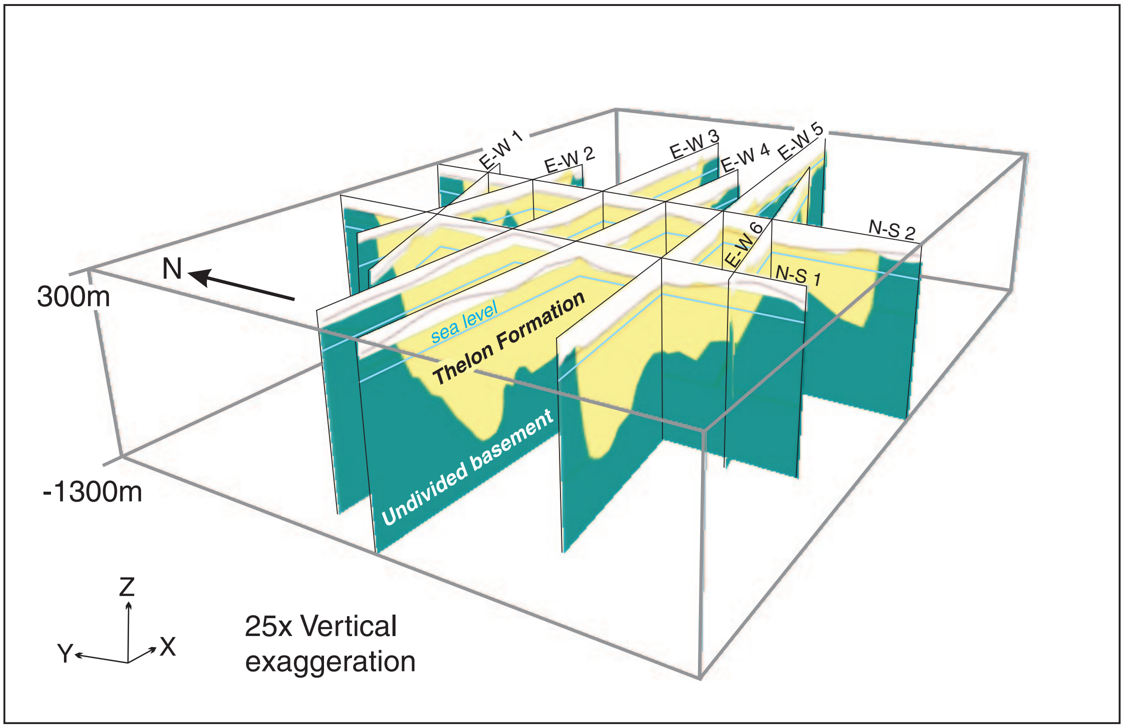

Figure 7. 3D model of 2D Bouguer profiles mapping depth to the unconformity at the base of Thelon (±Wharton) sandstone, locations on Figure 4. Details of lines E-W 1 and E-W 5 are shown in Figures 5 and 6, respectively.

between the two units utilized in the models will alter the depth estimations in some areas, but the regional trend of the basement-basin unconformity will not change.

In order to model the depth to basement in this study, the rock densities were considerably simplified. Ongoing analyses of outcrop and drill-core samples are generating quantitative data for the complete spectrum of rock types that constitute the Thelon Basin fill and the complex underlying basement. The next model iteration aims to distinguish the four major basement lithological types: crystalline granitoid gneiss, Hudson, Martell and Nueltin intrusive suites (van Breemen et al., 2005; Peterson, 2006), Archean supracrustal rocks of the Woodburn Belt (Hadlari et al., 2004), and Paleoproterozoic metasedimentary rocks of the Amer Belt (Tella, 1994). Further constraints can be placed on the model by incorporating newly acquired petrophysical data.

As only two density values were assigned, the final model is grossly simplified. The geological map shows as many as nine major units and multiple minor units immediately surrounding the basin (Fig. 2). Fortunately, the model depends on the density contrast between the individual units. If those units do not have sufficient density contrast to generate a gravity anomaly with the current station spacing of ~12 km, they will be transparent for the gravity data and this model remains valid.

Hasegawa et al.(1990) demonstrated the issue of overburden versus basement anomalous sources in their study of the Kiggavik deposit. This paper did not consider the effect of overburden (which in places may extend to a considerable depth) on the gravity models. Basement topography is another variable that can have a large impact on gravity models (Thomas and Wood, 2007). Similar-scale gravity anomalies can be attributed to lateral density changes within the basement, the sandstone (silicification or de-quartzification) or surface topography variations. Unfortunately, at this stage and without sufficient ground-truthing, there is no way to tell if the observed anomalies are due to basement topography or lithology changes. The profiles thus provide only a crude first-order regional model for the Aberdeen sub-basin.

Jefferson (*in* Davis et al., 2011) utilized geological-map and drill-log data to complement and extend the depth soundings by Overton (1979), showing that the Aberdeen sub-basin is much more complex than previously thought. Their data are further complemented by this preliminary analysis of gravity profiles. Based on depth estimates derived from the gravity models, the interior of the Aberdeen sub-basin attains depths as great as 1000 m. Until now, the greatest depth estimate was 856 m below sea level as imaged by Overton (1979). Overton's (1979) measurements were acquired from surveys constrained to frozen lakes in winter, which are sparse in the interior of the Aberdeen sub-basin, so that only six seismic shot points were obtained in this part of the Thelon Basin. Of the boreholes, ten intersect the basement in the interior Aberdeen, making the remaining borehole data only useful as minima. Figure 8 depicts the gridded depths for the basin compiled as described above in comparison with the depth estimates provided by the newly

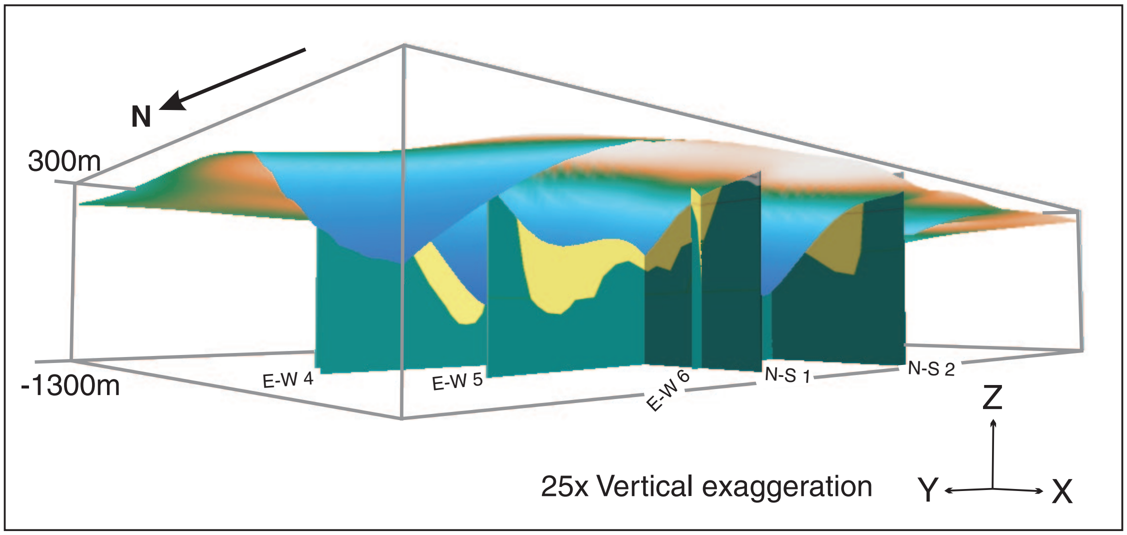

Figure 8. Gridded depth estimates from Figure 3 (top, after Overton, 1979) draped over 3D assembly of 2D Bouguer profiles from Figure 7 (bottom).

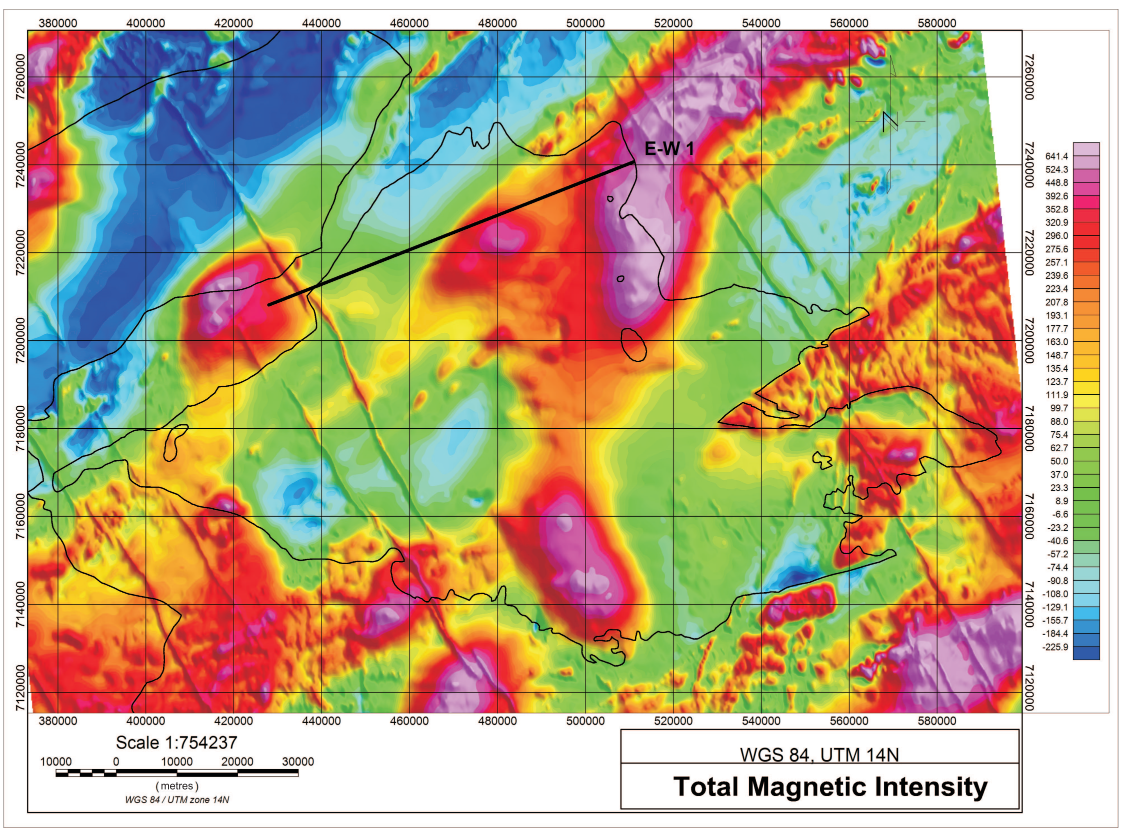

Figure 9. Public domain Total Magnetic Intensity for the Aberdeen sub-basin gridded to 200 m. Black line shows the location of the E-W 1 transect for the GM-SYS magnetic model of Figure 10.

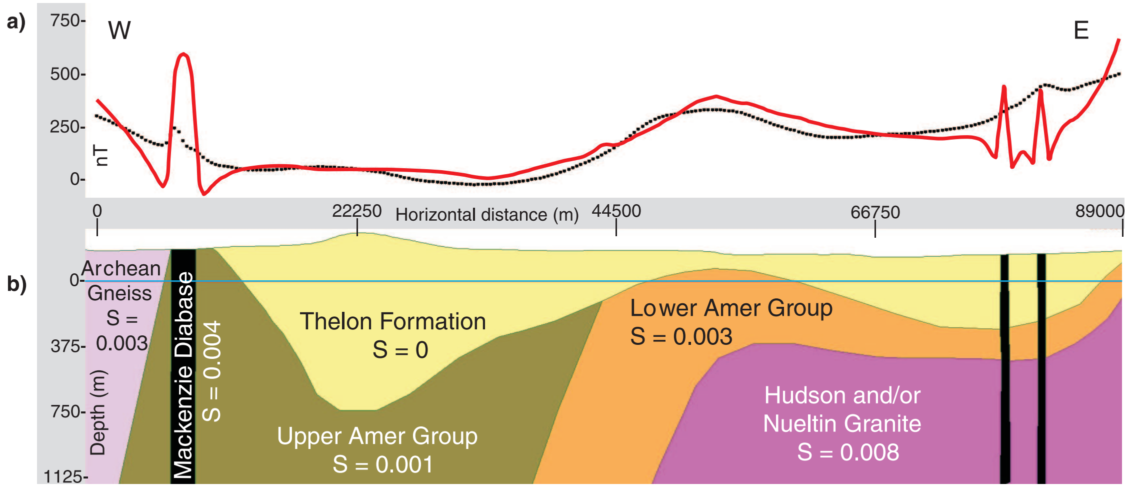

Figure 10. Extracted total magnetic intensity profile for section E-W 1. **a)** heavy black dotted line is the observed magnetic anomaly; red line is the magnetic anomaly computed from the model below. **b)** Preliminary geologist-generated model that is projected from nearby magnetic and outcrop data into this cross-section, consistent with the gravity model. The different model susceptibility values for simplified predicted major rock units are based on data from outcrop samples of these rock units elsewhere in the study region. The context for these rock units is summarized in the 'Geological Setting' section.

interpreted Bouguer cross-sections. The interpreted depths from Overton and boreholes are rarely as great as those derived from the Bouguer profiles, and provide less detail.

With the present seismic data it is not possible to distinguish the Wharton sandstone from the Thelon sandstone, and even upper parts of the Amer Group may be geophysically indistinguishable from the younger strata. In areas where the basin is bounded by the Wharton Group, it proved difficult to set the models to the correct contacts, as insufficient rock-property data are available at this time to distinguish them. Siliceous quartzose sandstone of the Wharton Group was intersected in drillhole DPR-8 located in the north-central part of the sub-basin. The Wharton Group outcrops in the southeast and northeast corners, and along the southern margin of the sub-basin. It is therefore probably more extensive beneath these parts of the sub-basin. Therefore, the basal unconformity contact modelled here likely reflects at least combined Wharton Group + Thelon Formation versus basement, giving much larger depth-to-basement estimates. Despite the relative crudeness of the gravity model, it still provides a more extensive, holistic, and dramatic depiction of the depth to basement of the Thelon Basin than existing published cross-sections. Newly acquired detailed gravity data and a cluster of eight logged boreholes in the eastern part of the sub-basin will support more detailed calibration in the future.

Aeromagnetic profiles were incorporated into the gravity models to determine if it is possible to differentiate geological units along the basin floor by incorporating magnetic-susceptibility estimates into the lithological units. A prominent northwest-convex magnetic high under the E-W 1 label in Figure 9 is associated with outcropping plutons mapped by Tella (1994) in that area. By inference the other large anomalies in the study area are also interpreted as similar Hudson and/or Nueltin plutons associated with major crustal structures. Figure 10 shows the EW-1 cross section integrating interpreted geology with the corresponding observed and computed magnetic signals along the profile. There is evidence for different units along the unconformity surface being manifested as changes in magnetic susceptibilities. These likely represent plutons of the Hudson (± Martell syenite) and/or Nueltin suites, outcrops of which are associated with some of the large magnetic highs shown in Figure 9. The northern part of the pluton modelled beneath the northeast end of transect EW-1 outcrops along the Amer shear zone in the north-central part of the study area, about 50 km northeast of the basin edge. Detailed geological and petrophysical mapping of the exposed plutons should help to resolve such questions in the subsurface by developing more robust geophysical models for them.

Although additional correlations appear to be feasible along the magnetic profile, insufficient information is available at this time to constrain the detailed signals to any definite geological units aside from mafic dykes and iron-formations. The Mackenzie dykes are expressed as linear northwesterly trending en échelon aeromagnetic highs (Fig. 9). Within the magnetic profile, they are expressed as small, thin spikes. Magnetic-susceptibility measurements are being obtained from outcrop and core samples in order to better constrain the characteristics of the basement units for further refining the profiles

CONCLUSIONS

Integrating Overton's seismic data with regional-scale magnetic and borehole data was the basis for modelling the subsurface geological framework of the Aberdeen sub-basin, giving new insights into general depths to basement in its interior. It is deeper than had previously been thought, with the sandstone-basement unconformity surface located as much as 1000 m below sea level. Despite the relative effectiveness of constructing the cross-sections using regional gravity data, these cross-sections remain crude. They are limited by the 12 km distances between observations and the lack of actual density measurements on the observed rock units in the area.

Initial analysis of the airborne magnetic data shows significant promise to enable mapping of the basement lithological units in detail below the sandstone, once detailed rock-property and geological-training data are incorporated from around the edges. A variety of dyke swarms and possible iron-formations can already be identified, especially the straight northwest-trending Mackenzie diabase dykes and the curvilinear McRae Lake diabase dykes, both with high magnetic contrasts. Jefferson *in* Davis et al.(2011) has postulated that the detailed morphology of the Thelon Basin was in part controlled by faults which were active both during and after sedimentation. Given the regional-scale resolution of the gravity and magnetic data, no attempt was made to incorporate such faults in the basin-floor grid model presented in this study. Once higher resolution data become available it will then be possible to construct a basal surface which incorporates fault discontinuities.

The Thelon Basin as a whole remains a frontier exploration region which will benefit from additional studies. New rock-property measurements will provide a stable foundation on which to improve the new profiles through ground-truthing. Incorporation of logs and rock properties from archived drill core would further constrain the models to known depths, unit thicknesses, and lithological correlations between drill cores.

Most importantly, however, the region would benefit from a high-resolution gravity survey. To detect subtle features along the basal unconformity, one needs a tightly spaced survey to detect the spikes in the data representing faults and vertical offsets. For a feature to be detected, the grid-cell size must be a minimum of half the width of the feature. At a 12 km spacing, the gravity stations are not close enough together to detect the associated geological source to any anomaly with a wavelength of less than 24 km, rather the spacing of gravity stations reveals a gradual transition. This makes the constructed cross-sections ideal tools for detecting broad basement features and gradual depth changes. Smaller fault zones and clay alteration zones important for uranium prospecting will go unnoticed except by very high-resolution ground or airborne gravity studies (Miller and LeCheminant, 1985). With time and continued geophysical research it will be possible to compile and enhance the geophysical and geological information surrounding the area basin. The models generated in this paper provide a fertile starting point for such continued improvements in knowledge and exploration ideas.

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