

3D Inversion Modelling, Integration, and Analysis of Geophysical Data for the QUEST Project, BC, Canada

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Overview

To further the use, understanding and benefit of gravity, magnetic, and electromagnetic data collected in two airborne surveys over the QUEST project area, the Advanced Geophysical Interpretation Centre at Mira Geoscience is inverting these data to provide density contrast, magnetic susceptibility, and electrical conductivity models. The modelling comprises of 3D gravity and magnetic modelling and 1D electromagnetic modelling using a suite of inversion codes developed by the University of British Columbia. We present preliminary results from this study.

The models are being combined to form an integrated earth model from which a selection of derived products will be generated. These products include 3D surfaces defining intersecting regions of anomalous physical property values of significance to mineral exploration. The resulting models and model derivatives will be available for download in different formats. In addition to the digital model products mentioned above, visualization of the results will be possible using downloadable 3D PDF scenes of different parts of the QUEST project area. This will enable more widespread communication and understanding of the surveys and results.

The available products can be directly employed in regional exploration to target prospective ground based on different exploration criteria relating to different exploration strategies, and serve as an example of what can be achieved in more detailed studies.

Background

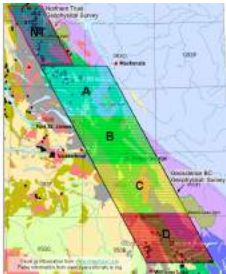


Figure 1. Regional geology with NTS map sheets showing coverage of the airborne geophysical data split into 5 segments: NT, A, B, C, and D.

Geoscience BC's QUEST Project, initiated in 2007, is a program of regional geochemical and geophysical surveys designed to attract the mineral exploration industry to an under-explored region of British Columbia between Williams Lake and Mackenzie (Figure 1). The QUEST Project is focused on the Quesnel Terrane, which has good potential for copper and gold porphyry deposits, but in this region is covered by a thick layer of sand and gravel left behind by glaciers (source: www.geosciencebc.com/s/Quest.asp).

3D inversion modelling of geophysical data provides located physical property distributions of the earth. This process enables direct spatial correlation between physical properties and geology, geochemistry, drill-hole databases, and known mineral resources or mineralized showings. At a regional scale, large geologic features can be defined, the thickness of overlying units better determined, and the relationship to mineralization can be investigated. The resulting physical property models are best viewed and analysed in a 3D environment where quantitative 3D GIS methods can be used to yield exploration targets.

Data

Gravity Data:

The gravity data set consists of airborne gravity data collected by Sander Geophysics in 2008 at a line spacing of 2000m (East-West lines), and regional gravity data compiled by the Geologic Survey of Canada in the Canadian Gravity Database (Figure 2). Bouguer data corrected at a density of 2.65 g/cm³ is used.

The data are combined and prepared for regional inversion modelling as a processing step that enables effective removal of regional signal prior to detailed modelling of each of the five survey segments denoted in Figure 1.

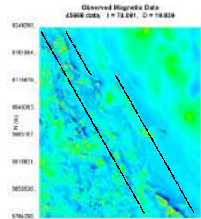


Figure 2: Bouguer gravity data prepared for regional inversion modelling. The Quest airborne survey outline is shown.

Magnetic Data:

The magnetic data set consists of helicopter-borne data collected by Geotech Ltd. in 2007 at a line spacing of 4000m (East-West lines) in conjunction with a VTEM survey, and magnetic data collected in 1961 with 800m line spacing (available from the Geophysical Data repository at Natural Resources Canada (Figure 3)).

As with the gravity data, the data are combined and prepared for regional inversion modelling prior to regional signal removal and detailed modelling of each of the five survey segments denoted in Figure 1.

Figure 3: Total Magnetic Intensity data prepared for regional inversion modelling. The Quest airborne survey outline is shown.

Electromagnetic Data:

Time-domain, helicopter-borne electromagnetic data were collected by Geotech Ltd. using the VTEM system. Lines of data were collected at a spacing of 4000m, with station spacing of a few meters. The data were averaged over a few stations in order to provide a reasonable number of data for modelling. The data are modelled on a line-by-line basis for quality control (Figure 6) Each individual station has 39 channels of data, and the components used for the inversion modelling are principally the z-component data, and the x-component data when of satisfactory quality.

Modelling

Regional inversion modelling of the gravity and magnetic data has been completed as a first stage prior to more detailed local modelling on individual segments of the Quest survey. The model is discretized into many cells each with a horizontal dimension of 200m and a 250m vertical dimension. The models extend to a depth of 10,000m throughout the survey area in order to capture large-scale geologic features.

Inversion modelling is being performed using GRAV3D, MAG3D, and EM1DTM, a collection of modelling codes developed by the University of British Columbia Geophysical Inversion Facility.

Subsequent, more detailed inversion modelling for each of the 5 survey segments is being performed using cell sizes of 500m x 500m x 250m (x, y, z respectively), and once completed will be combined to provide a detailed model of the entire Quest area.

Electromagnetic modelling is being performed using 1D inversion modelling in order to define the thickness of overlying sediments and basalts, and to detect underlying conductive features (Figure 6).

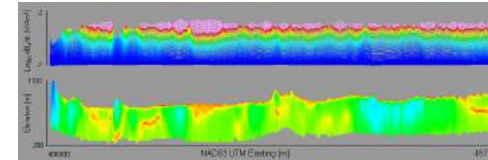


Figure 6: VTEM data and concatenated 1D inversion conductivity models for a single survey line (L1470). Conductivity values range from 0.001 S/m (blue) to 0.1 S/m (red). A vertical exaggeration of 10 has been applied.

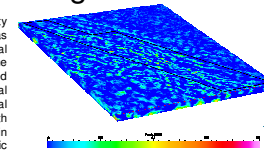


Figure 4: Three-dimensional regional density contrast model showing high density-contrast regions as warm colours, and the Quest survey outline.

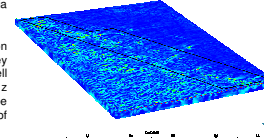


Figure 5: Three-dimensional regional magnetic susceptibility model showing high susceptibility regions as warm colours. The Quest survey outline is also shown for reference.

Integration and Analysis

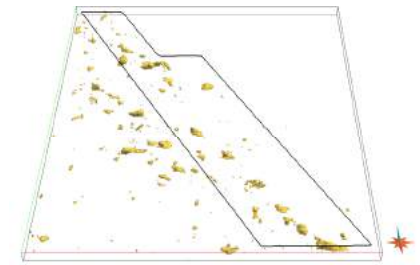


Figure 7: Three-dimensional perspective view of regions of high density-contrast (> 0.05g/cm³) and magnetic susceptibility (> 0.1 S.I) in the Quest area.

The physical property models are brought into the Gocad 3D GIS environment where they are analyzed and quantitatively interrogated. Plan-, depth-, and cross-sections, and iso-surfaces are generated for integration with other exploration data.

Regions of anomalously high or low physical properties can be identified, and intersections of these regions from the different modeling results can be computed in 3D using basic 3D GIS functionality. Figure 7 shows an example of located 3D bodies of anomalously high density contrast and magnetic susceptibility in the Quest area. Through the understanding of physical properties, these regions can be related to geology and be assigned an exploration significance; and subsequently used in regional targeting using appropriate exploration criteria.

On a more detailed scale, the conductivity models are integrated with the density and magnetic susceptibility models, and geology, in order to provide a more complete view of the geologic context, and provide valuable information about the thickness of overburden.

Communication

The results will be communicated to Geoscience BC for public distribution in four ways:

1. Digital models and interpretational products in Gocad, and other formats.
2. Three-dimensional PDF display scenes of segments of the survey area that can be viewed in the freely available Adobe Reader software.
3. Report summarizing the results.
4. Posters and presentations.

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