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3D Inversion of ZTEM Data

Introduction

The Z-Axis Tipper Electromagnetic (ZTEM) method is an airborne natural source EM technique developed by Geotech Ltd. that is effective at mapping large-scale geologic structures. During a ZTEM suurvey, a helicopter is used to measure the vertical magnetic field over the surface of the earth. The measured data (typically between 30-720 Hz depending on signal strength) relate the measured vertical magnetic field recorded by the helicopter, to the horizontal magnetic field measured at a ground based reference station. The system exploits naturally occurring electromagnetic sources that have no geometric decay as they penetrate the earth. This gives the system superior exploration depth over most traditional controlled source EM methods. Depending on the conductivity of the earth and the electromagnetic skin depth, the system can image up to a few kilometres depth in some environments. In addition to the collected ZTEM data, the system also collects aeromagnetic data that can provide additional information for geologic interpretation.

3D Inversions and OcTree Meshes

In order to extract the maximum value from an exploration survey, the data must be inverted. Traditionally this has been done in 1D or 2D because of the difficultly with inverting data in 3D. Although computationally simple, working in 1D or 2D can lead to incorrect interpretations and inefficient use of resources since real geologic targets are complex and 3D in nature. At Computational Geosciences Inc. (CGI) we are pushing the boundaries of 3D inversions by exploiting new technological advances in mathematics and computer science. Our new inversion codes no longer use regular rectangular meshes and instead use semi-structured OcTree meshes which allow us to more accurately model geologic models using fewer cells (Figure 1). The net result is faster codes that deliver more accurate results.

The CGI OcTree Advantage

- **Higher Resolution Models**
- **Faster Inversion Times**
- **More Accurate Solutions**

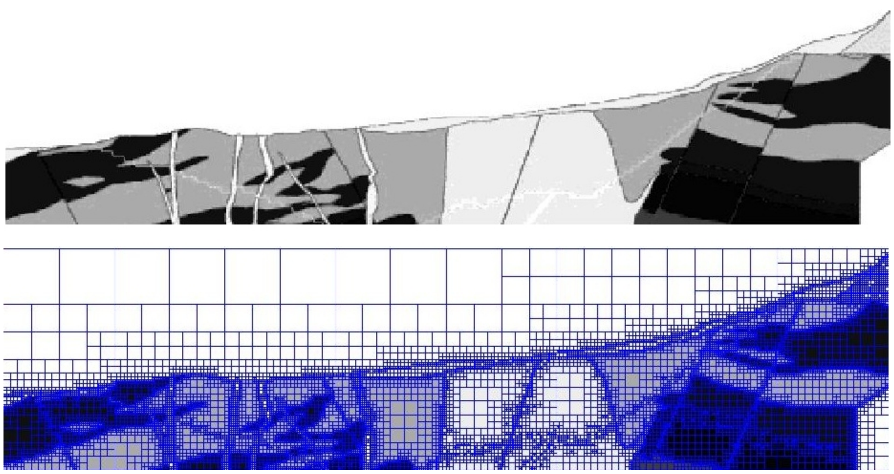

Figure 1: **Top:** Geologic cross section of the Chino porphyry mine in New Mexico (image taken from http://www.rocksandminerals.org). **Bottom:** Model discretized using an ocTree mesh. The geologic boundaries are disctrized more accurately using fewer cells than would be necessary with a regular mesh.

Large-scale Exploration

3D conductivity and magnetic susceptibility models derived by inverting ZTEM data and the accompanying aeromagnetic data can provide essential information about structures for regional exploration projects. In one example, presented in Figure 2, CGI inverted in 3D a ZTEM dataset of 25,000 line-km. The region contained extreme topographic relief and the survey geometry was non-rectangular. These features would make discritizing the earth very inefficient when done using regular rectangular meshes. Using our new OcTree code, we were able to invert the entire 25,000 line-km dataset at once. This would not have been possible using previous generation codes built around regular rectangular meshes.

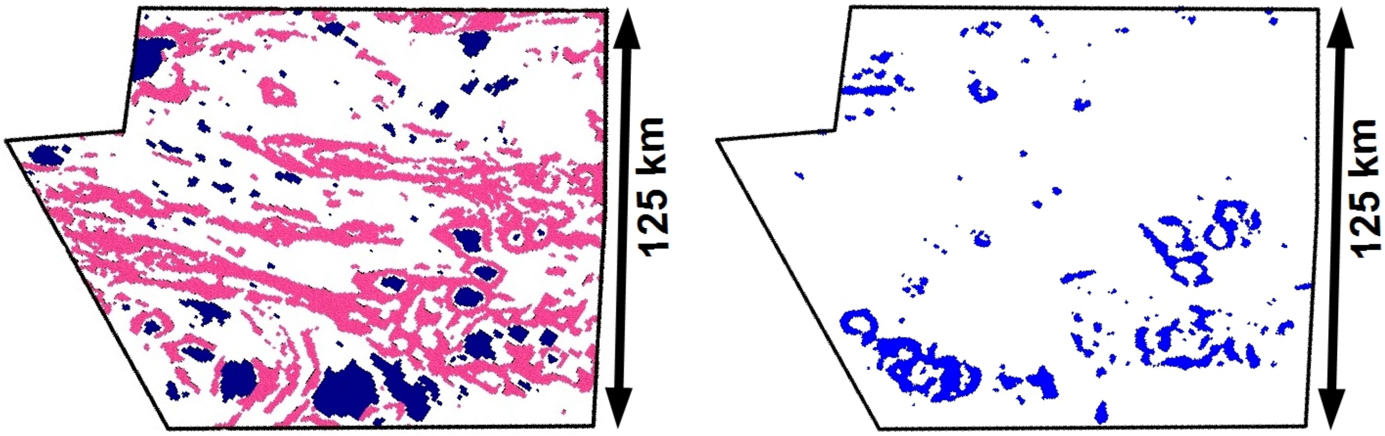

Figure 2: **Left:** A croped subsection of a 3D conductivity result obtained by inverting a 25,000 line-km large-scale ZTEM survey. Resistive and conductive cutoffs have been applied to show only the more conductive structures (pink) and more resistive features (blue). The inversion results delineate several interesting structures. **Right:** 3D magnetic susceptibility model obtained by inverting the accompanying aeromagnetic data from the ZTEM system. The magnetic susceptibility inversion provides complimentary information to the conductivity inversion, showing that many of the conductive ring structures are also magnetically susceptible.

Mt Milligan Porphyry Deposit

In October 2008, a ZTEM survey was flown over the Mt. Milligan porphyry deposit for Geoscience BC. The Mt. Milligan deposit owned by Thompson Creek Metals Company Inc., is a Cu-Au porphyry deposit located within the Quesnel Terrane in British Columbia. From the Terrane Metals Corp. 2009 43-101 report, Mt. Milligan is a tabular, near-surface, alkalic copper-gold porphyry deposit that measures some 2,500 metres (m) north-south, 1,500 m east-west and is 400 m thick. The Main Zone is spatially associated with the MBX monzonite stock and Rainbow Dyke. The mineralization and associated alteration are primarily hosted in volcanic rocks. Mineralization consists of pyrite, chalcopyrite and magnetite with bornite localized along intrusive-volcanic contacts. Copper-gold mineralization is primarily associated with potassic alteration which decreases in intensity outwards from the monzonite stocks. Pyrite content increases significantly outward from the stocks where it occurs in association with propylitic alteration, which forms a halo around the potassic-altered rocks. The Mt. Milligan copper-gold porphyry deposits contain Proven and Probable reserves of (Terrane Metals Corp, 43-101, 2009) 482 million tonnes (Mt) averaging 0.20% Cu and 0.39 grams per tonne (g/t) Au totalling 2.1 billion pounds copper and 6.0 million ounces gold. The 2008 test survey consisted of 25 ZTEM lines over an approximate area of 6 km x 8km for a total of 211 line-km of data. Five ZTEM frequencies (30, 45, 90, 180 and 360 Hz) were collected and inverted. Inverting using our new ocTree based code, we were able to finely discretize the earth and extract maximum resolution from the dataset.

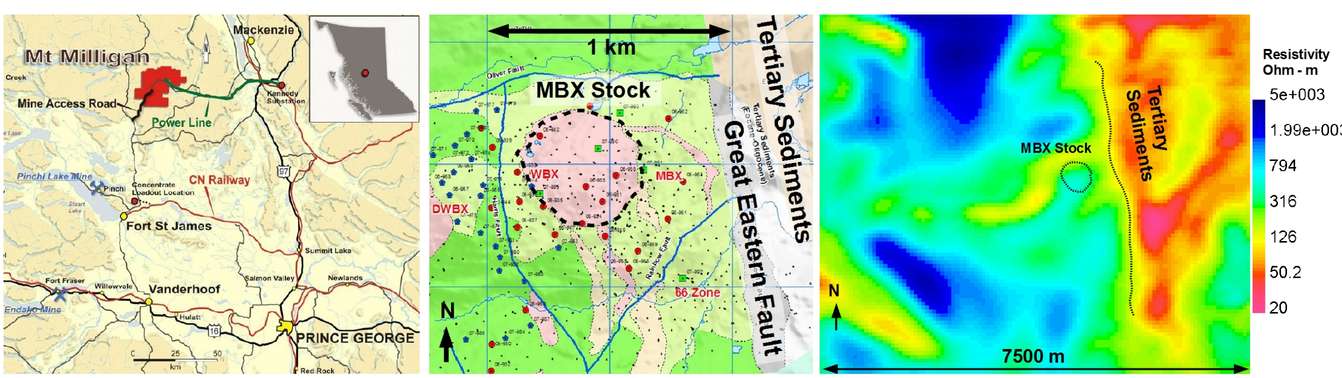

Figure 3: **Left:** Mt. Milligan location in British Columbia. **Center:** Main Zone general geology taken from the 2009 Terrane Metals Corp. 43-101 report. **Right:** Inverted ZTEM conductivity structure at a depth of 966 m. The inversion result clearly images the Great Eastern Fault and the associated conductive sediments as well as the resistive monzonite stalk and associated higher conductivity alteration.

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