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Tensor CSAMT studies at the Buchans Mine in central Newfoundland

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ABSTRACT

A novel application of the tensor controlled source audio-magnetotelluric (CSAMT) method was part of a multidisciplinary geophysical study of an existing mine site at Buchans, Newfoundland. The orthogonal components of the horizontal electromagnetic fields used for magnetotelluric and CSAMT interpretation of the earth's conductivity structure were found to be inappropriate at Buchans because of strong scattering in the electric fields. Instead, the length of the major axes of the electric and magnetic field polarization ellipses and the vertical magnetic field were used as data. The data from two bipole sources demonstrate that the bulk response of the earth in the vicinity of Buchans is predominantly one-dimensional (1-D). These data were inverted to layered earth models with a first-order correction for electric field distortions. The parameter space considered during the inversion was contracted substantially by incorporating the vertical magnetic field data and by using depths to interfaces as determined by reflection seismic data. The model resulting from the inversions is essentially a two-layered earth with an increase in resistivity between 1000–1400 m depth. The contrast in the electrical properties is interpreted to be coincident with the Powerline Fault, a floor thrust of a duplex structure with significant out-of-sequence movement. Hence, the thrusting may have caused the emplacement of older fractured, and locally mineralized rocks over younger more competent (resistive) ones.

INTRODUCTION

The Buchans Mine site is situated in the central volcanic belt of Newfoundland and was based on one of the world's highest grade massive sulphide deposits. With over 80 years of work in the area, a sophisticated geologic model has been developed based on information from surface and underground drilling, geology, geophysics, geochemistry, and mining. The recent observation that there are only four major formations in the Buchans Group (Thurlow and Swanson, 1987) has resulted in a dramatic simplification of the volcanic sequences but with a corresponding increase in the difficulty of understanding the fault geometry (see the geology map in Figure 1). Unraveling the complicated tectonic history of the area is critically important to mineral exploration since the Buchans ores are bounded by thrust faults and the ores are not easily located by geophysical methods. For example, despite the very high metal content, the ore deposits have highly variable electrical conductivity. This variability occurs because some ores were fragmented after formation with redisposition as transported breccia deposits. As direct detection of the ores is difficult, recent studies have focused on providing information about the structural geometry and stratigraphy of the volcanic formations.

Reflection seismic and electromagnetic (EM) surveys were conducted along traverses near the mine site to understand better the structural setting of the Buchans Group. Seismic reflection and EM methods are, to a large extent, complementary. Electromagnetic methods are sensitive to the bulk distribution of electrical conductivity which is determined by porosity, pore fluids, fracturing, and chemical composition. In contrast, seismic methods are sensitive to local variations in rock densities and elastic properties and thus are more likely to resolve features such as faults, layers, intrusions, and thin zones of anomalous porosity. Some combination of bulk property measurements (e.g., EM) and

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