Magnetotelluric imaging for mineral exploration

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Mineral exploration makes extensive use of electromagnetic (EM) geophysics to measure subsurface electrical resistivity. This rock property is important because its sensitivity to the presence of sulphide minerals, graphite, and the degree of hydrothermal alteration. Electrical resistivity models can also define the regional geology surrounding a deposit. Airborne EM exploration uses a variety of controlled source and has developed into an effective tool for measuring the resistivity from the near surface to depths of several hundred metres in resistive locations. Deeper exploration generally requires ground based EM methods with larger, more powerful transmitters. However these methods typically have high logistical costs.

Natural source EM methods provide an alternative method for deeper exploration. The magnetotelluric (MT) method uses natural EM signals, which removes the need to operate a transmitter. Since the EM signals used in MT are plane waves, the data analysis is simpler than with controlled sources using dipole transmitters. MT requires measurements of both the electric and magnetic fields and thus requires that the instrument is installed on the ground. The depth of investigation depends on the frequency of the signal used, so MT can provide a depth sounding by measuring a range of frequencies. MT has advanced in recent years with a combination of (a) improved instrumentation allowing the collection of larger and higher quality datasets and (b) development of fully 3D inversion programs that allow 3D models of the subsurface resistivity to be determined. An airborne natural-source variant called ZTEM was also commercialized 10 years ago.

These characteristics make MT a valuable complement to controlled source EM methods. In this presentation I will review a range of applications of MT in mineral exploration. These studies include exploration for porphyry copper, unconformity uranium and volcanogenic massive sulphide deposits. In each study the range of resistivity models derived from the MT data will be reviewed, with an emphasis on which features in each model are reliably resolved.

A number of recent mineral exploration studies have focused on the concept of mineral systems. In these studies, exploration focuses on the processes that led to the formation of the deposit at a range of spatial and temporal scales. This is in contrast to conventional approaches to mineral exploration in which geophysical studies were used to directly detect the deposit. MT exploration is especially valuable in these studies since it is able to image deep crustal structure that controlled emplacement through measurement of lower frequency data. Examples of MT data being used in this way will be reviewed.