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Emerging Magnetotelluric technology and processes for exploration: delivering insights and discoveries from regional to local scales

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Summary

Geophysical exploration for mineral deposits has typically searched directly for ore bodies by looking for a region with anomalous properties such as density, resistivity, magnetic susceptibility or chargeability. Many ore bodies are formed by processes that occur in convergent plate boundaries such as subduction zones. Studying these processes can give insights into the formation and distribution of deposits. The mineral systems approach expands the exploration scope by looking for the entire system that formed the ore body, including regions where fluids originated, flow pathways and structures that caused mineral deposition. The value of this approach is being investigated by a number of recent initiatives in both governmental and university research. These studies use 3-D exploration methods that image crustal and upper mantle depths.

One of the most promising technologies for these deep investigations has been magnetotellurics (MT). This method, developed in the 1950's, but greatly improved upon in only the last 20 years, uses natural electromagnetic signals to measure the electrical resistivity of the Earth. The use of MT in exploration saw limited use through the 1990's but saw an increase of use and application in the 2000's. Since 2000 its use in deposit scale exploration has increased, and more recently has seen an uptick in more widescale applications across the mining industry. following a number of high-profile MT exploration successes. In Australia a large regional transect discovered a set of low resistivity fingers originating more than 40 km beneath the world class IOCG deposit at Olympic Dam (Heinson et al., 2006).

Magnetotellurics is one of the most promising electromagnetic technologies for deep investigations. This method measures natural magnetic and electric fields at the surface of the earth across a wide range of frequencies. The depth of investigation depends on the signal frequency, allowing the same instrument to measure resistivity from a few hundred meters to hundreds of kilometers. From MT measurements at several points, a 3-D model of the subsurface resistivity can be obtained. The time-varying electromagnetic fields are generated by a variety of natural phenomena such as solar storms and lightning strikes. Broadband MT measures these fields over a very broad frequency spectrum, typically 10000–0.001 Hz, giving information from surface to mid and lower crustal depths.

By bridging geophysics and geoscience through interdisciplinary collaboration, MT exemplifies how technological advancements can enhance mineral exploration's efficiency and sustainability. Its integration with the mineral systems approach promotes a shift in the natural resources sector, prioritizing comprehensive subsurface understanding and fostering innovative solutions for a sustainable future.

As the mining industry faces growing pressure to meet critical mineral demand while minimizing environmental impact, adopting advanced methodologies like MT becomes essential. By integrating MT with the mineral systems approach, the industry can better predict the location of mineralization events and highlighting deep structural features that may be indicative of mineral emplacement. This has helped optimize exploration strategies and contributes to the efficient and sustainable discovery of critical resources. This approach not only enhances exploration outcomes but also underscores the pivotal role of geophysical innovation in shaping the future of natural resource development.

This paper will highlight how MT can be used on a range of spatial scales that extend from regional (10-100 km) to local (10-0.1 km) mineral exploration as well as geothermal exploration. Examples presented will include (1) regional scale government funded initiatives from Australia, Ontario (Figure 1) and the Yukon, (2) local scale surveys in Ontario and British Columbia, and (3) mine site studies for planning and exploration. An example where the geophysical study contributed directly to the discovery of a new porphyry system below the mine will be highlighted.

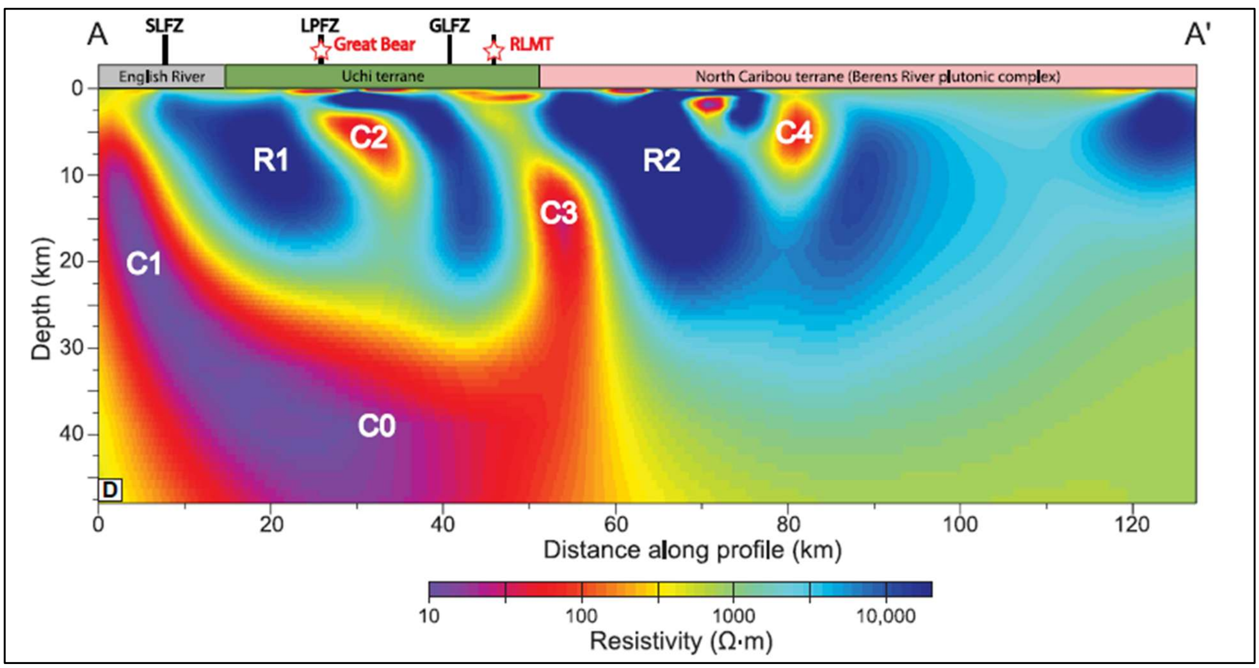

Figure 1 – Crustal conductivity footprint of the orogenic gold district in the Red Lake greenstone belt, western Superior craton, Canada showing resitivity information to depths of greater than 40 kilometers (Adetunji et al., 2023).

References

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