MobileMT: 3-dimensional structural mapping and shear zone identification (the Holdsworth Gold Project, Wawa, Ontario, Canada)

This case study illustrates the effectiveness of the MobileMT airborne electromagnetic technology in detailed 3-dimensional resistivity mapping from the surface to depths in excess of 1 km. The broadband MobileMT system has collected data over the Holdsworth Gold Project in the Archean Superior Province in July 2018. The collected data demonstrates the abilities of the system to perform deep structural mapping and reveals specific shear zone alteration patterns.

Geological setting and gold mineralization style

The survey block, in regional geological scale, is situated in the Wawa Subprovince of the Archean Superior Province (Figure1). Archean, shear zone-hosted within metamorphic tonalitic/trondhjemitic terrane, gold-quartz vein mineralization is economically significant in Northern Ontario. The property position is in the area known as the Michipicoten greenstone belt which includes Island Gold, Renabie, Edwards, Surgula deposits, and numerous historical gold mines. Orogenic gold mineralization is noticeably structurally controlled in the region and confined to variably-oriented shear zones (Callan, 1991). Carbonate alteration and potassium metasomatism associated with shear zones and gold veins are present here (Sage, 1994).

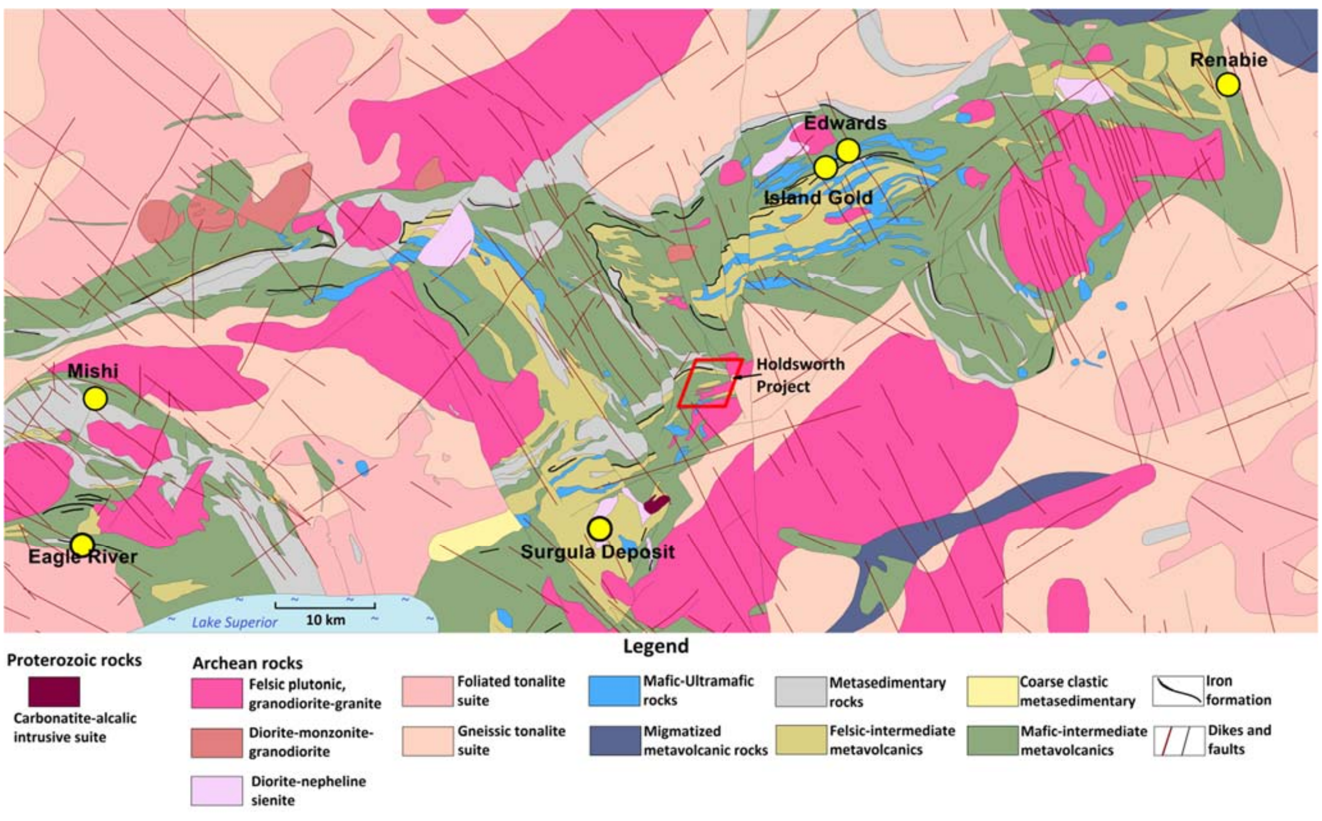


Figure 1 - Regional location of the survey block on the geological map for the Michipicoten greenstone belt (OGS geological map) with adjacent mines and deposits

In terms of genetics, gold, associated sulfides, and sometimes tellurides fill brittle sites developed during shear deformation which subsequently focuses hydrothermal activity (Callan, 1991). Gold deposition can occur from early to late brittle ductile deformation in the belt. The property's position is in contact with the Hawk Lake Granitic Complex, as a representative of Archean caldera structures (Sage, 1994). Clastic metasediments of sideritic iron formation, well exposed in the Michipicoten iron ranges, are associated with mafic to felsic volcanism (Callan, 1991). Holdsworth property has all direct and indirect geological attributes to host a large gold system, including a deformation corridor, evidence of an oxidized cap of a shear zone, iron formation analogous to one of favourable hosted-vein environment, and multiple gold showings.

MobileMT scope of application

In practice electromagnetic (EM) methods, particularly airborne, are not always effective in directly targeting gold-bearing veins even if the veins are followed by sulfide assemblages. The latter, if they exist, are usually far from a dominant component of the gold-bearing veins (disseminations and stringers, <5%) and do not form conductive circuits to allow for a measurable inductive response. However, the resistivity is a very sensitive parameter to alteration and hydrothermal processes (Williams, 1997), lithological differentiations, and potentially, to structural deformation consequences. By measuring resistivities, EM methods can play a multipurpose role in the process of the gold-bearing systems exploration, but the applicability of particular methodologies and equipment depends on many technical specifications.

Several advantages, in comparison with other EM airborne systems and approaches, make MobileMT technology an effective instrument for gold exploration and specifically for exploration of the orogenic style of mineralization. The main advantages include:

- the technology, based on magneto-telluric principles, is not limited to recovering resistivity variations in a highly resistive geological environment, as opposed to the time-domain principle;
- total field measurements provide the ability to define contrasting boundaries in any direction, from horizontal to vertical;
- very wide frequency bandwidth, of four orders of magnitude, ensures a depth of investigations from the surface to below 1 km. The wide depth of investigation covered from top to bottom in high-resolution is a crucial advantage for 3-dimensional mapping of shear zones – deep-level equivalents to faults.

Based on its advantages, MobileMT was chosen for detailed 3-dimensional resistivity mapping over the gold prospecting area.

The MobileMT data includes magnetic field data and apparent conductivity determined on 18 windows collected in the frequency range of 54-18,456 Hz.

MobileMT Survey Results

One of the main problems which has been solved with the detailed 3-dimensional resistivity mapping of the property is structural lineations mapping. Lineaments have been extracted from the MobileMT-observed magnetic and electromagnetic data for detecting structural attributes reflected in the geophysical data. Examples of EM data on high and low frequencies are in Figure 2. High frequency MobileMT data reflects near-surface structural features and low frequency reflects deep structures. Figure 3 shows jointed lineament layers of apparent conductivity measured by the MobileMT system for all 18 frequency windows obtained, displayed in 3-dimensional view.

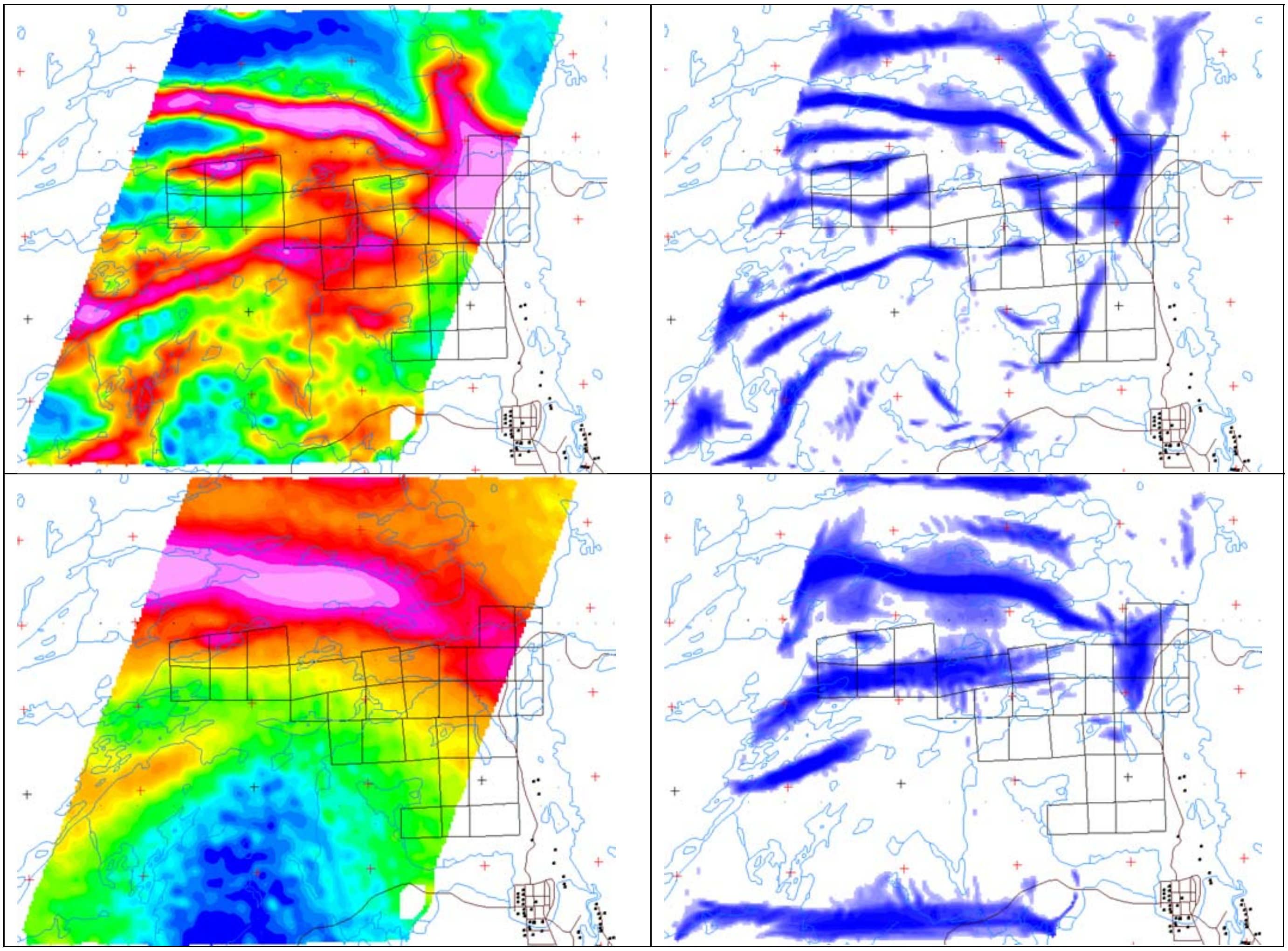


Figure 2 - Two MobileMT measurement frequencies – 16,127 Hz (top) and 80 Hz (bottom). Apparent Conductivity (left) – higher conductivity with warmer colours; high and low Apparent Conductivity lineaments (right).

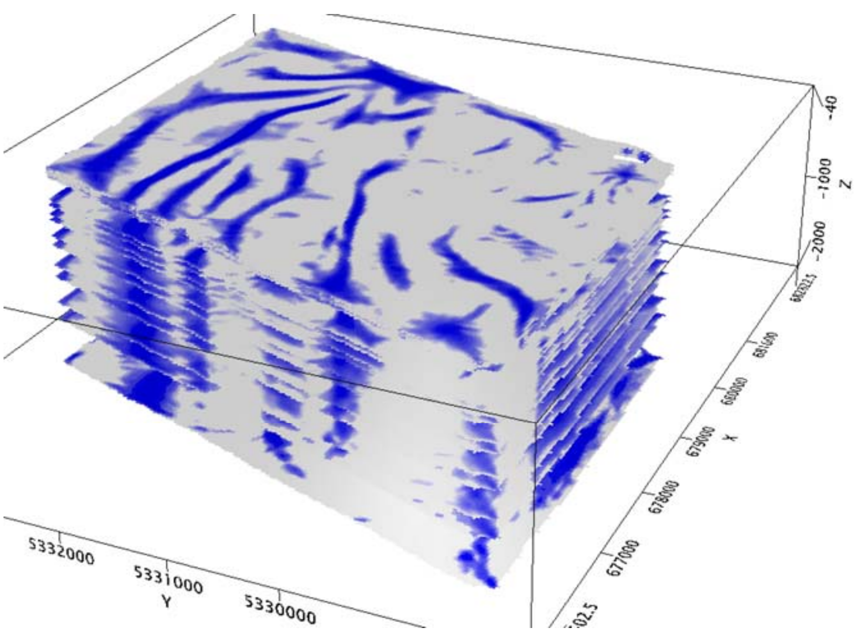


Figure 3 – 3D view of Lineaments of Apparent Conductivity for all 18 windows collected in the frequency range 54-18,456 Hz. Z – depth in meters in accordance with skin-depth of frequencies.

The main geophysical signatures (conductive and resistive zones, magnetic lineaments) are presented on the geological map of the surveyed block (Figure 4). MacDonald Mines Exploration (2018) identified a 500 m deformation corridor (shear zone) which hosts the linear pyrite zones, Soocana Vein System (1) and BMK gold discovery (2) showed on the map (Figure 4). The deformation zone is clearly reflected in a distortion of a conductive zone and its curved, “elastic” pattern. There are linear orthogonal CVG magnetic trends, directed to NW and NE, intersecting this pattern.

The shear zone pattern reflection in apparent conductivity distribution is changed with depth and disappears at frequencies less than 635 Hz (deeper~600 m skin depth) (Figure 5).

Figure 6 shows the apparent resistivity section along a survey line crossing western part of the block from south to north.

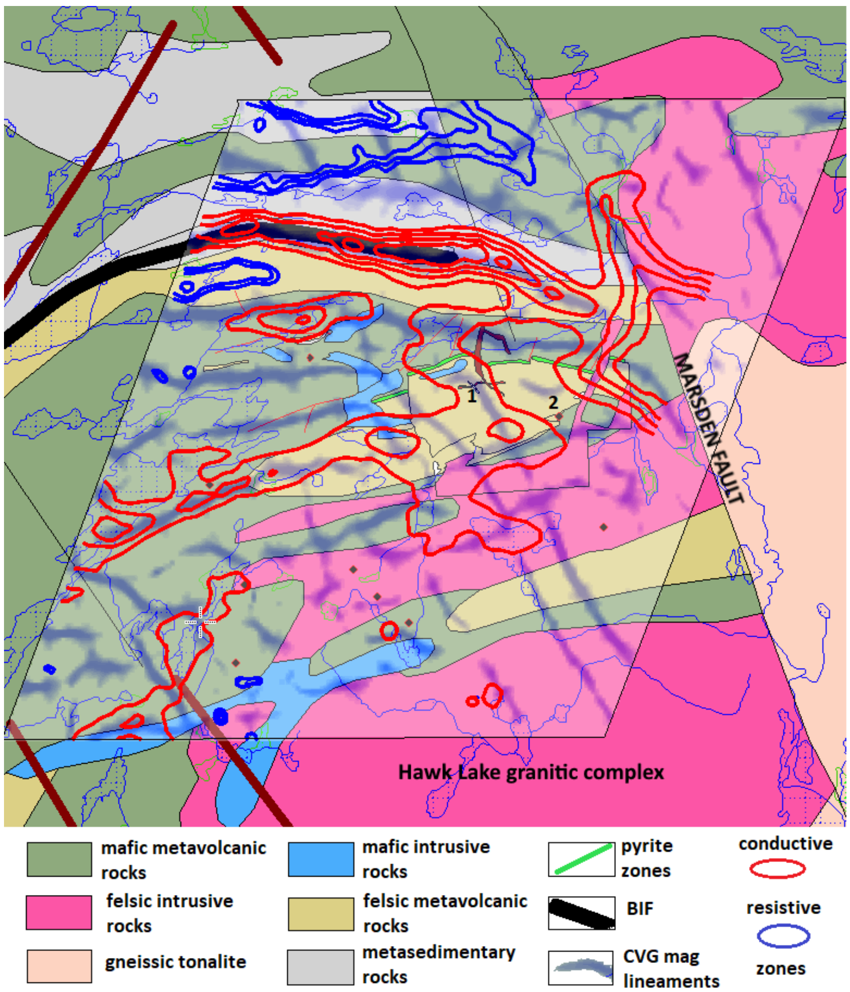
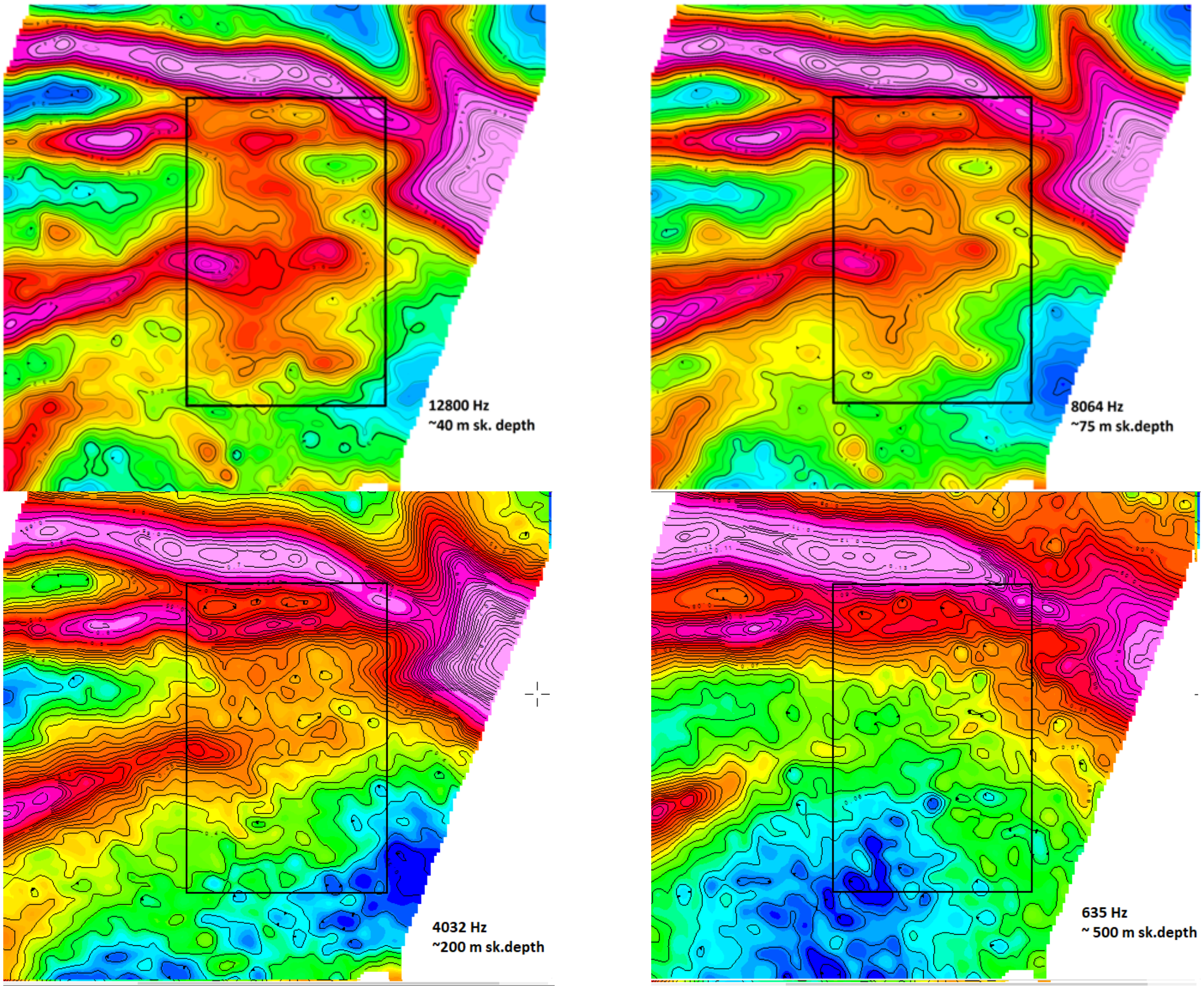


Figure 4 Geophysical signatures on the geological map. Conductive and resistive zones from a high frequency.



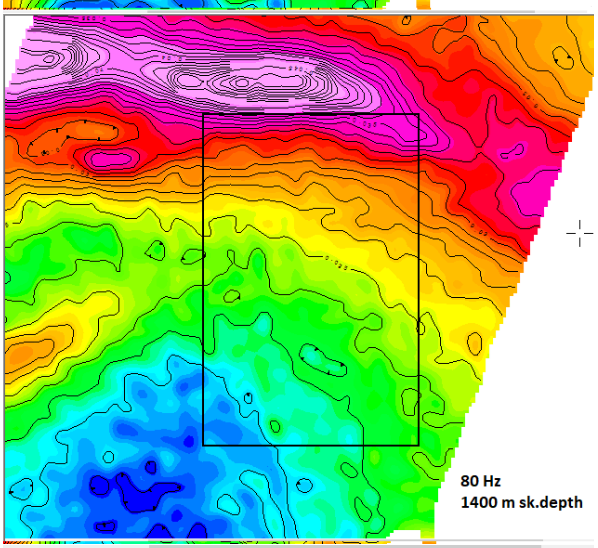


Figure 5 Apparent resistivity color grid (higher resistivity with warmer colour) on some selected MobileMT frequencies over the Holdsworth shear zone

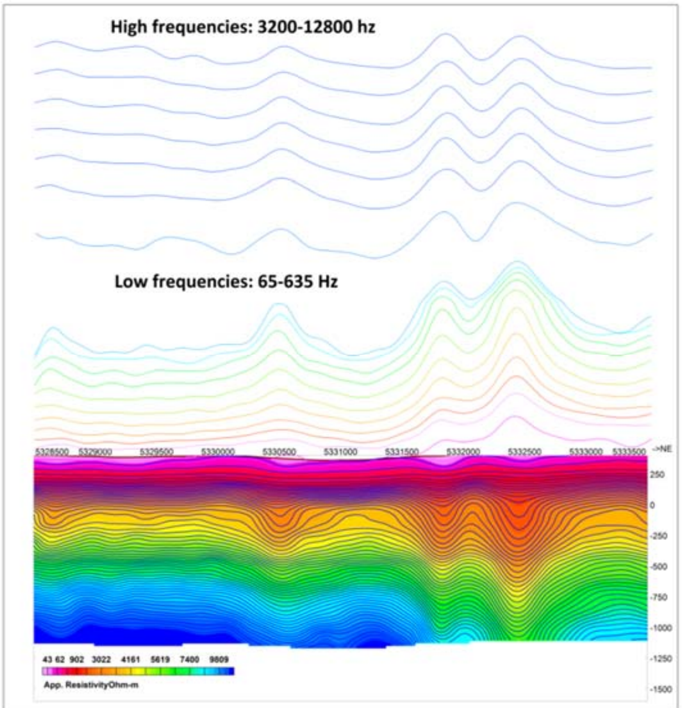


Figure 6. Apparent resistivity section (bottom) with EM data profiles (top). Line 1100. Represented 65, 79, 100, 126, 159, 200, 252, 318, 400, 504, 635, 3200, 4032, 5080, 6400, 8064, 10159, 12800 Hz apparent conductivity profiles.

Conclusion

The MobileMT high-resolution electromagnetic and magnetic data reveals structural trends and specific shear zone alteration patterns on the Holdsworth gold prospecting site. Highly informative across the full range of depth, the MobileMT natural field data records structural information and is effective for identifying fault zones including disturbing and deforming gold-bearing processes on both regional and local scales of investigations.

Acknowledgments

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References

1. Callan, N.J. (1991), Syn-Deformational Shear Zone-Hosted Au-Quartz Vein Mineralization in TTG Host Rocks, North Ontario. Ontario Geological Survey. Open File Report 5759.
2. Dube, B., and Gosselin P. (2007), Greenstone-hosted quartz-carbonate vein deposits. In “Mineral Deposits of Canada”. Geological Association of Canada, Mineral Deposits Division, Special Publication No.5, p.49-73
3. Lin, S., Williams P.F. (1992), The geometrical relationship between the stretching lineation and the movement direction of shear zones. Journal of Structural Geology, V.14, Issue 4, p.p 491-497.
4. Sage R.P. (1994) Geology of the Michipicoten Greenstone belt. Ontario Geological Survey. Open File Report 5888.
5. Williams, P.K. (1997), Towards a Multidisciplinary Integrated Exploration Process for Gold Discovery. In “Proceeding of Exploration 97: 4th Decennial International Conference on Mineral Exploration. P.1015-1028.
6. MacDonald Mines Exploration (March, 2018), Wawa-Holdsworth project (press-release).