MobileMT: Detailed Conductivity Mapping from Surface to Depth Over 1 km

SUMMARY

Mobile MagnetoTellurics (MobileMT) is the latest innovation in airborne electromagnetics and the most advanced generation of airborne AFMAG technologies. The patent-pending MobileMT technology utilizes naturally occurring electromagnetic field in the frequency range of 25 – 20,000 Hz. Compared to other airborne AFMAG systems, the MobileMT provides a wider frequency range with a higher number of frequencies and eliminates data bias distortions. Unlike tipper type method with one Z component, MobileMT is free of bird motion distortions and does not require bird attitude corrections. A test block near Cochrane, Ontario, Canada was flown in May 2018. The MobileMT data in 21 frequency windows from 33 Hz to 13 kHz were processed. Maps of the MobileMT data demonstrate the high lateral and depth resolution from the surface to the depth over 1 km. Analysis of MobileMT data on the preliminary, pre-inversion stage is presented.

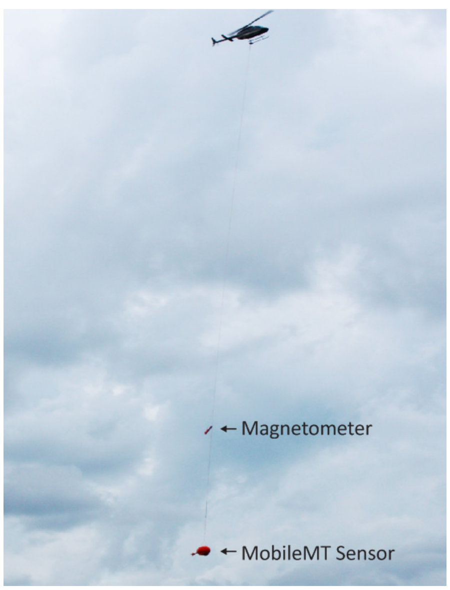

Figure 1: MobileMT bird towed by helicopter

MOBILEMT SYSTEM DESCRIPTION

The MobileMT system consists of an airborne system and a ground station. An airborne bird, towed by a helicopter, measures variations of the magnetic field with three orthogonal induction coils, while a ground station measures variation in electric field with four sets of electrodes. Each electrical component on the MobileMT base station is registered independently from two grounded lines (signal and reference) which are used to eliminate the data bias distortions. The total magnetic field is measured by Geometrics cesium magnetometer G-822A located in a separate bird attached to the tow cable 16 m above the MobileMT bird. The auxiliary equipment includes GPS navigation system, second GPS antenna located on the magnetic bird, radar altimeter and data acquisition system.

SURVEY DESCRIPTION

The test survey was conducted near Cochrane, Ontario, Canada in May 2018. The survey area lies in the Broken Evil volcanogenetic massive sulfide prospect in northern Ontario, Canada and belongs to the Eastern part of Superior Province of the Abitibi Greenstone Belt (Kaminski et al., 2016).

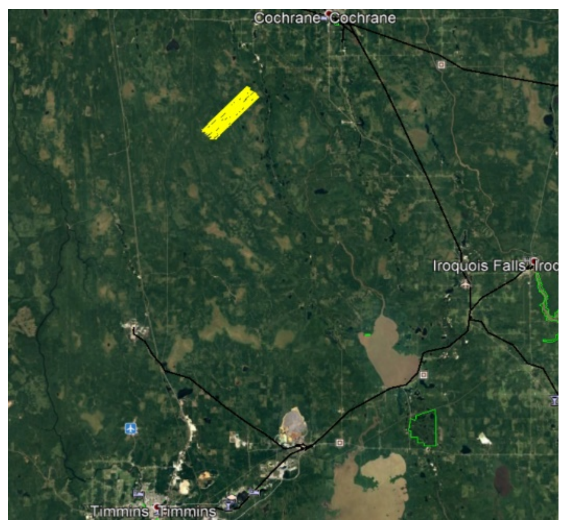

Figure 2: Survey area location

According to different electromagnetic surveys, the area is moderately conductive; depth of investigation with a popular time-domain airborne EM system is in the range 200-500 m from the surface (Kaminski et al., 2010, 2016). The goal of the MobileMT survey was to prove the technology's ability to investigate a geological environment from near surface to more than 1 km depth with high resolution continuously in depth and scattered over an area.

The survey helicopter, a Bell 206 Long Ranger, was operated by Expedition Helicopters. A test block of 8 km x 2 km, comprising of 12 lines, 8 km long each, was flown. The mean MobileMT bird terrain clearance was approximately 126 m.

TEST SURVEY RESULTS

Typical signal spectrums are presented in Figures 3 and 4. MobileMT data profiles over one line are shown in Figure 5.

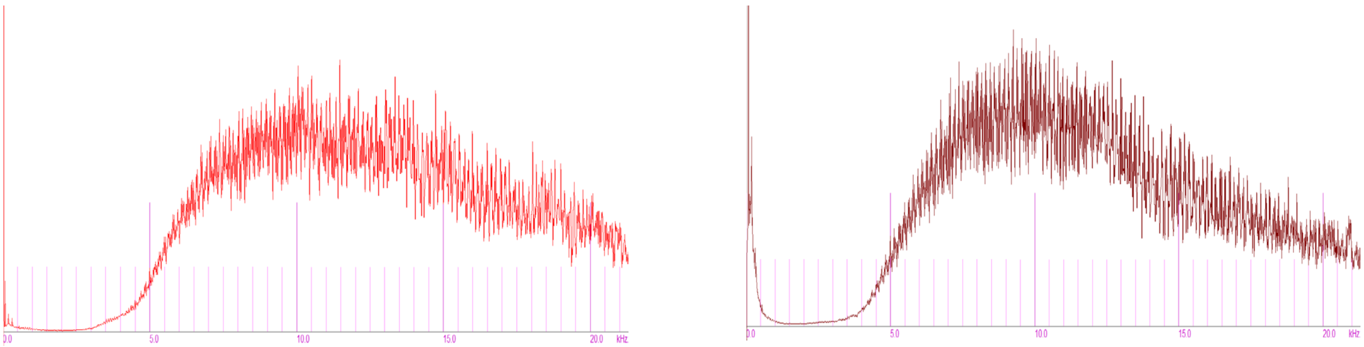

Figure 3: Airborne magnetic X-coil spectrum up to 22,000 Hz range (left) with the corresponding electric X-line 1 spectrum (right)

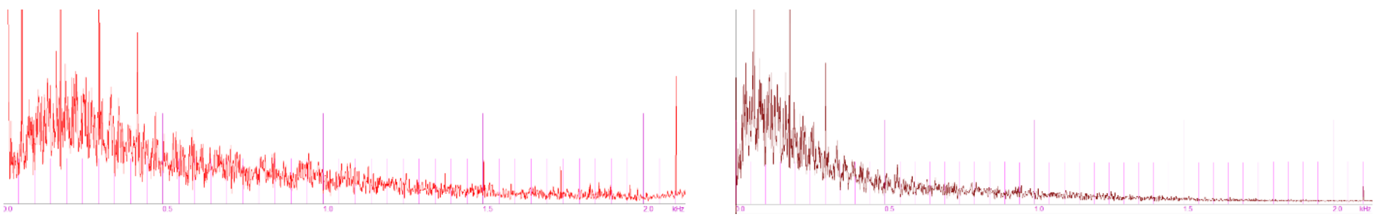

Figure 4: Airborne magnetic X-coil spectrum up to 2.2 kHz range (left) with the corresponding electric X-line 1 spectrum (right)

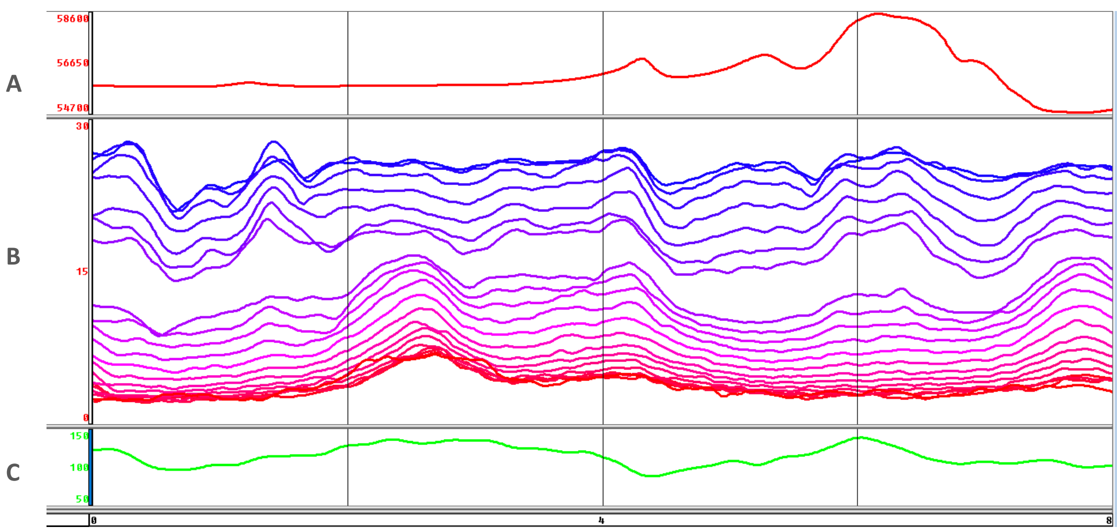

Figure 5: MobileMT data profiles: Part B - apparent conductivity, mS/m, frequencies (from bottom to top): 33 Hz, 42 Hz, 54 Hz, 70 Hz, 91 Hz, 118 Hz, 152 Hz, 197 Hz, 256 Hz, 332 Hz, 432 Hz, 561 Hz, 730 Hz, 948 Hz, 2703 Hz, 3515 Hz, 4569 Hz, 5939 Hz, 7721 Hz, 10037 Hz and 13047 Hz; Part A – total field magnetic, nT, Part C – MobileMT bird terrain clearance, m

The output data of MobileMT system are derived in the units of apparent conductivity (mS/m). A set of sounding curves is presented in Figure 6. As it can be seen in Figure 6 and in the apparent conductivity section in Figure 7, the geoelectrical background on the survey area has a prominent tendency from more conductive on the top (high frequencies, near surface formations) to less conductive to depth (low frequencies, deep formations). For mineral exploration purposes it is important to derive structural signatures and discrete anomalies from the background of the host environment. All details in the electromagnetic field (or apparent conductivity in the MobileMT case) is easy to visualize applying unique color distribution for each frequency (or depth) separately as shown in Figures 8-10.

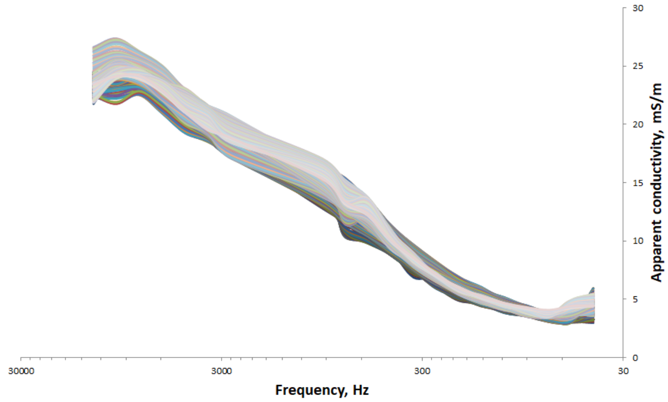

Figure 6: MobileMT apparent conductivity sounding curves series along a survey line.

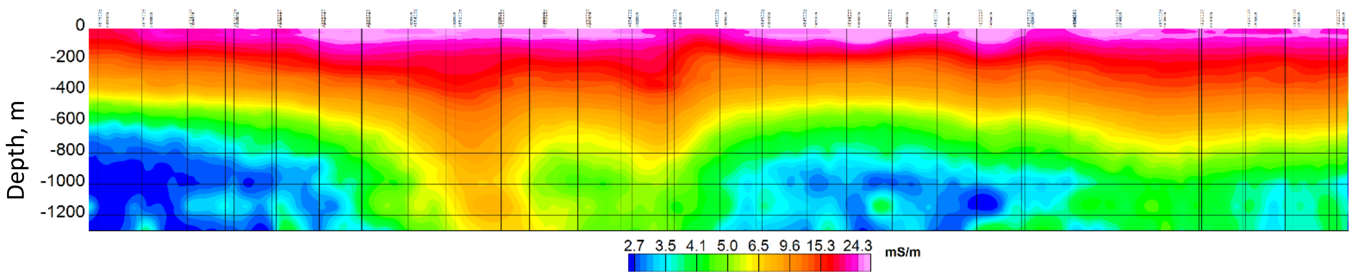

Figure 7: MobileMT apparent conductivity section along the line 7520. Depth is estimated based on frequency and a conductivity reference.

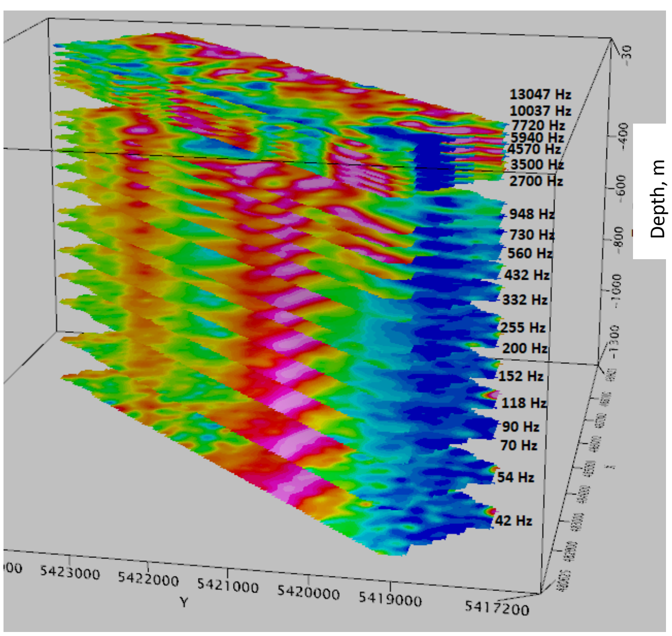

Figure 8: Apparent conductivity grids for 20 frequencies distributed with depth in 3D view

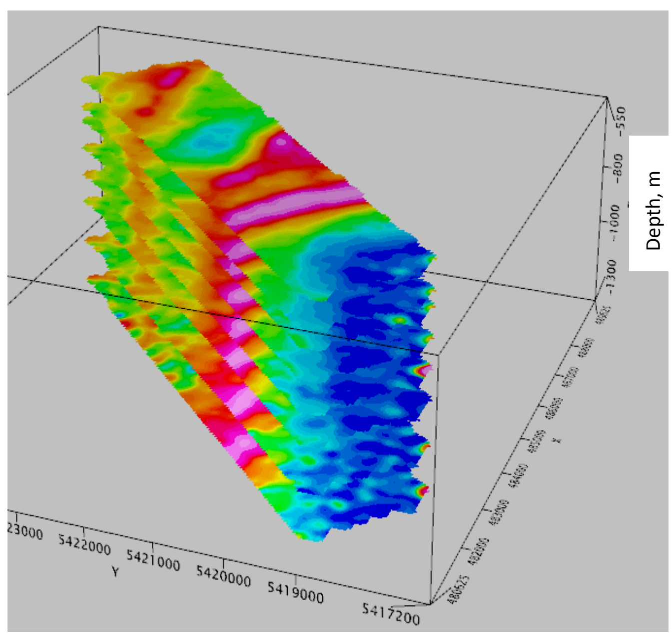

Figure 9: Apparent conductivity grids for 7 low frequencies distributed with depth in 3D view.

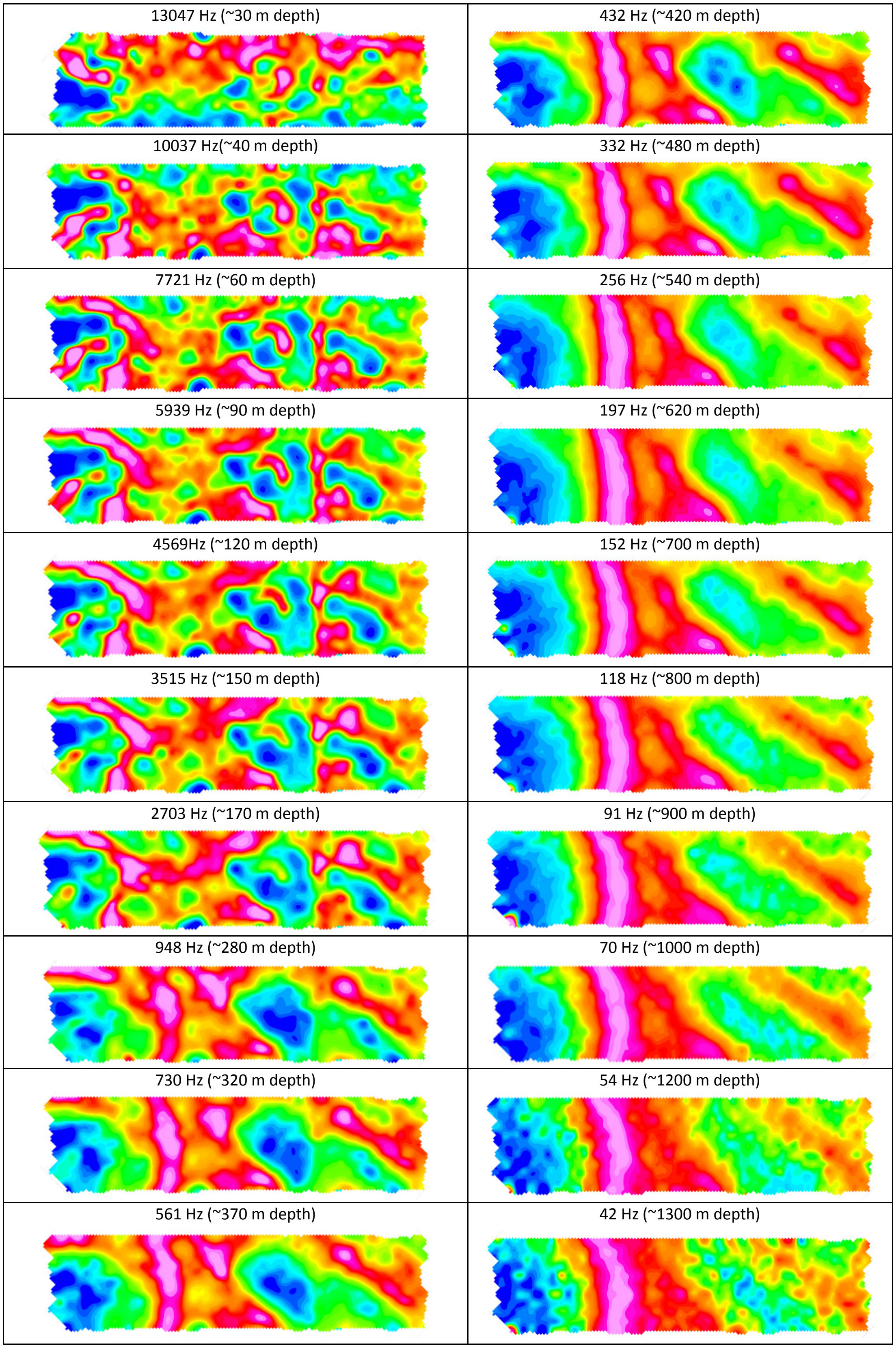

Figure 10: Apparent conductivity grids (plan view) for 20 frequencies with depth estimation.

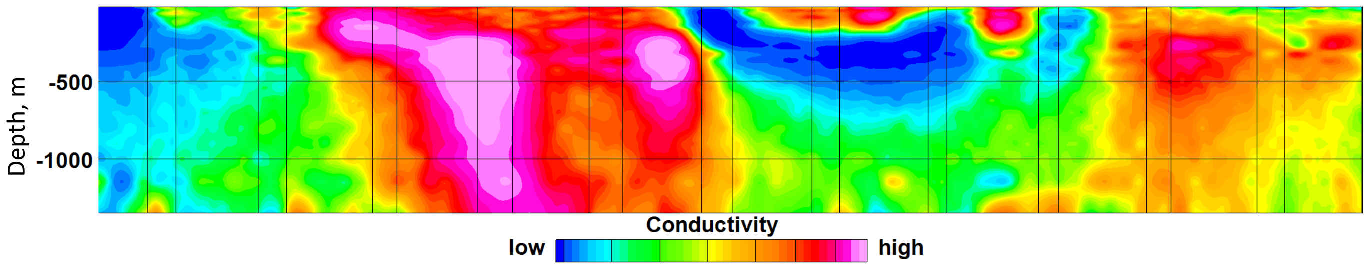

Figure 11: Reduced conductivity-depth section along the line 7520. See Figure 7 for comparison with original apparent conductivity distribution.

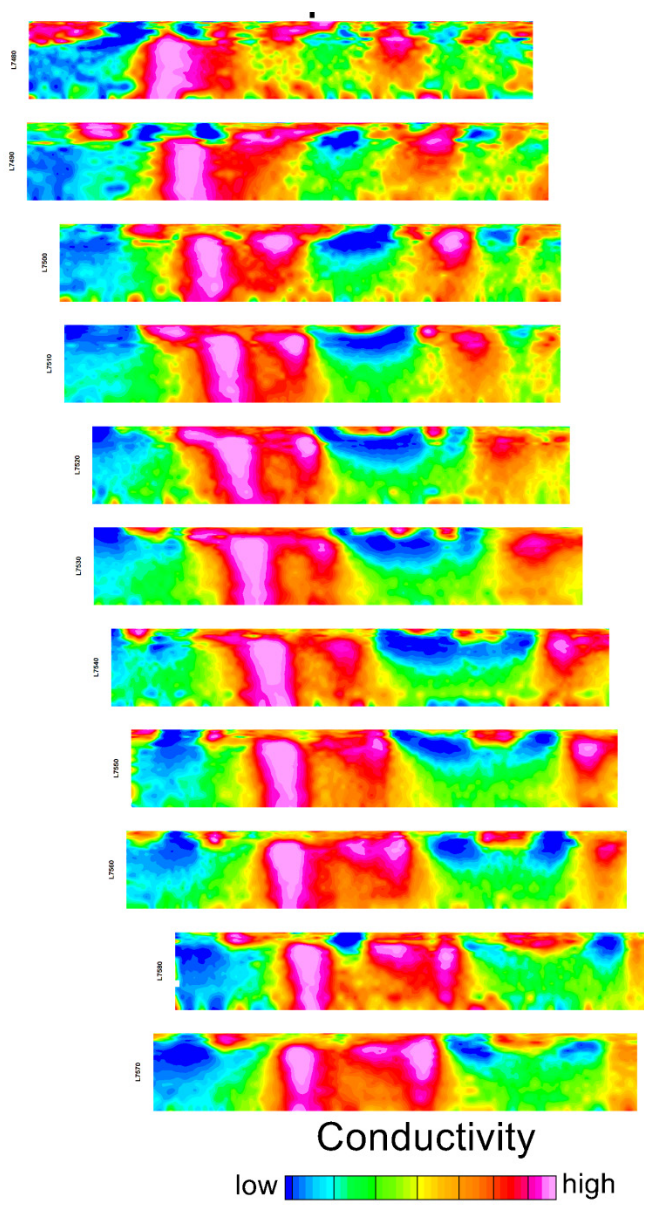

Figure 12: Reduced conductivity-depth sections along 11 surveyed lines with depth range 0-1300 m

Polynomial reduction was applied to the data to strip out the background trend and for detail visualization of conductivity-depth sections as shown in Figures 11 and 12. In this case, units are conventional and qualitative.

CONCLUSION

The test block survey results demonstrate that the MobileMT system maps in detail the conductivities from the surface to the depth over 1 km. Any exploration program, from regional to prospect scale, will benefit from MobileMT's broad frequency range, high resolution, low system noise, and combined electric/magnetic field measurement. MobileMT applications in mineral and hydrocarbon exploration are numerous and include:

- Direct detection of conductive metal ores without the conductance and depth limitations inherent to time-domain systems
- 3D full-scale deep structural mapping for wide range of structurally controlled minerals: gold, PGM, polymetals, diamonds (kimberlites)
- Detection and mapping precious metals ore bearing systems and porphyry-type ore deposits
- Cost-effective, rapid and detailed 3D full-scale complement to seismic techniques with high resolution from near surface to depth.
- Applicable for sedimentary geology due to measurements of total field

REFERENCES

Kaminski V., Di Massa D., Vezzoli A. (2016) Joint inversions of two VTEM surveys using quasi-3D TDEM and 3D magnetic inversion algorithms. Exploration Geophysics, 47(4) 260-268.

Kaminski, V. F., P. Kuzmin, and J. M. Legault (2010), The AirMt passive airborne EM system, presented at 3rd CMOS-CGU Congress.