Geophysical Research Abstracts
Vol. 20, EGU2018-12143, 2018
EGU General Assembly 2018

Three-dimensional inversion of the semi-airborne data collected over ancient antimony mine in eastern Germany

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We present first results of the extensive semi-airborne CSEM experiment undertaken in an area with ancient antimony mining in the Berga anticlinorium located in the Saxothuringian zone, Germany. A new semi-airborne system was developed and successfully tested within the DESMEX project (Deep Electromagnetic Sounding for Mineral EXploration). The semi-airborne technique assumes that part of the system is positioned on the ground and the remainder is airborne. This allows to use advantages of both ground (stronger magnetic field in the ground) and airborne (easier spatial coverage) techniques. In our setup, high-moment transmitter(s) and electric field receivers are set on the ground and magnetic field sensors, such as commercially available fluxgate and total field magnetometer as well as newly developed induction coils and Superconducting Quantum Interference Devices (SQUIDs) are installed in a helicopter towed bird. With high-moment grounded transmitters our system is able to achieve penetration depth of 1-1.5 km and allows spatial coverage of more than 20 square kilometers per flight.
Several test flights were performed to evaluate the system's performance and to determine the survey design. In the current study, we focus on the details of the main experiment, conducted in October 2017. Eight areas of 6x3 square kilometers were surveyed with two transmitter positions per area. The transmitters were horizontal electric dipoles of 1-2 km length installed parallel at a distance of 1-2.6 km apart from each other, depending on the ground conditions of each flight area. The time-varying electric currents of 15-27 A were injected at fundamental frequencies of 7.5 Hz and 10.4 Hz, using the generators operated by LIAG and University of Cologne (LOTEM transmitter), respectively.
All data were processed in frequency domain. The transfer functions between measured magnetic field vector components and the current are estimated only at fundamental source frequencies and their harmonics. The major difficulty is to overcome the problem of the motion noise and motion induced voltages, due to vibrations and the pendulum-like behavior of the bird. For this purpose, a processing technique was developed which corrects data for motion related noise. The 3D inversion models will be presented for selected transmitter positions and compared with the co-located 2D ERT inversion model and 1D helicopter borne EM models. A good agreement of the derived 3D resistivity structure of the region with geology and other available geophysical models (ERT, HEM) demonstrates feasibility of the developed semi-airborne approach. The system can be routinely used for geophysical surveying, e.g. mineral exploration.