2D Inversion of time-domain controlled source electromagnetic and differential electrical dipole data based on an update of MARE2DEM to the time-domain

Amir Haroon[1], Marion Jegen-Kulcsar[1], Shuangmin Duan[1], Zahra Faghih[1], Bradley Weymer[1], Sebastian Hölz[1], Bülent Tezkan[2]

[1]GEOMAR – Helmholtz Centre for Ocean Research Kiel, 24148, Germany
[2]Institute of Geophysics and Meteorology, University of Cologne, 50968, Germany

SUMMARY

Time-Domain Controlled Source Electromagnetic (TD-CSEM) methods are commonly applied to detect and delineate subsurface resistivity anomalies on land and in the marine environment. The most general form of the application utilises a horizontal electric dipole (HED) current excitation with an alternating waveform ranging from periods of several milliseconds to seconds. TD-CSEM experiments are commonly conducted along transects in a towed inline, or broadside configuration. Therefore, the data is generally sensitive to resistivity variations in the line between the source and the receiver, motivating the development of a 2D inversion for the data interpretation. A 2D inversion for frequency-domain controlled source electromagnetic data has recently become state of the art in academia through the availability of MARE2DEM (developed by Kerry Key, http://mare2dem.ucsd.edu/). This adaptive finite element algorithm allows the interpreter to easily implement the measurement geometry and his/her *a-prior* information into a 2D inversion scheme without much knowledge of the finite element method. Here, we present an update of MARE2DEM that accounts for time-domain data and, additionally, calculates signals for the novel Differential Electrical Dipole (DED) transmitter of the University of Cologne. This novel transmitter/receiver system consists of a double inline dipole current excitation using three electrodes where the central electrode has one polarity, and the two outer electrodes have the other polarity. In theory, the excited EM field is thereby focused underneath the transmitter making the method more sensitive towards lateral resistivity variations compared to the conventional HED systems. We use synthetic 2.5D forward and inverse modelling studies to validate the accuracy and applicability of the time-domain development and underline the necessity of using a 2D inversion algorithm for interpreting DED data. We apply the algorithm to two separate case studies targeting fresh groundwater reservoirs in shallow marine environments near the coast of Israel (DED) and New Zealand (HED).

Keywords: Time-Domain CSEM, 2D finite element inversion, Offshore Groundwater