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Modelling magnetotelluric profiles in three-dimensional environments doing joint inversion of different electromagnetic tensor relationships: New opportunities for resource exploration

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As a consequence of measuring regional current flows, magnetotelluric data in a three-dimensional environment can be strongly affected by geological structures located far away from the sites where the data is acquired. This can complicate the characterization of the electrical resistivity distribution of the subsurface below the survey area. In this study we analysed the role of three different types of electromagnetic data: the MT impedance tensor responses (Z), the geomagnetic transfer functions (GTF) and the inter-station horizontal magnetic transfer-functions (HMT). We discovered that joint inversion of the three types of data greatly increases the quality of the modelling of magnetotelluric profiles in three-dimensional environments. The improvements in characterizing the electrical resistivity distribution of the subsurface offer new opportunities for resource exploration, particularly for onshore hydrocarbon exploration, using electromagnetic methods, due to the increase in the sensitivity of the models to highly electrically resistive anomalies (e.g. where hydrocarbons are present) and better characterization of the extent of low resistivity layers (e.g. sealing formations).

We evaluated the sensitivity of each type of data to different electrical resistivity anomalies, showing that the degree to which each site and each period is affected by the same anomaly depends on the type of data used. Subsequently, we evaluated the effectivity of each type of datain recovering the geoelectrical structures of the subsurface in a three-dimensional environment. Results show that joint inversion of the MT impedance tensor responses (Z) with the geomagnetic transfer functions (GTF) and the inter-station horizontal magnetic transfer functions (HMT) remarkably increases the quality of the model when recovering the electrical resistivity distribution of the subsurface. Joint inversion of the three types of data provides four major improvements: (1) more accurate location of resistivity anomalies below the measurement sites and avoidance of anomalies further from the sites, making the results from the inversion of MT profiles in three dimensional environments more reliable; (2) the capacity for the characterization of high resistivity anomalies that cannot be recovered by using the impedance tensor (Z) data alone; (3) improvement in recovering the base of low resistivity anomalies, thus increasing the sensitivity of the electrical resistivity models below low resistivity anomalies; (4) more accurate constraint of the continuity of low resistivity anomalies, helpful when attempting to determine the presence of discontinuities in a sealing formation.