Magnetotelluric imaging of a shallow groundwater system in central Zagros, Iran

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SUMMARY

The results of an AMT exploration carried out in the Mond river basin, Bushehr province, southwest Iran are presented in this study. We aim to find the overall conductivity structure of the geological features controlling the aquifer in a basin where subsurface structure is little known. Dimensionality analysis of the data was performed by the phase tensor and the WAL invariants and distortion effects were removed employing the Groom-Baily decomposition method. Distortion corrected data were then modeled by a 2D smooth inversion approach and the results were further explored by applying sensitivity analysis to find the range of relevant models representing shallow aquifer system in the study area.
2D smooth inversion resolves a shallow conductive layer, extending throughout the model and a resistive basement detached by a moderately conductive zone. Another conductive anomaly exists at deep part beneath the NW of the profile.
A different class of resistivity model was derived using a distinct regularization approach which seeks the smoothest variation away from a starting model. The result shows the possible brine circulation between water-filled fractures constituting the conductor in the deep part of the model and the shallow alluvial aquifer layer.

Keywords: magnetotellurics, electrical conductivity, aquifer, Zagros

INTRODUCTION

Tectono-sedimentary basin evolution controls groundwater resources in alluvial aquifer systems. The Sena- Shonbe aquifer system, one of the 64 alluvial aquifers comprising the Mond river basin in southwest Iran, where only scarce information about subsurface is available. The Mond river is among the most important rivers originating in the high elevation areas of the Zagros region, generally flowing NE-SW for ~600 km to the Persian Gulf. The geology of the Mond river basin is complex and strongly affected by tectonic events in the Zagros Fold and Thrust Belt, a subdivision of the Zagros collision zone.

Here, we investigate an AMT data set obtained along a profile in Sena- Shonbe aquifer system. We applied different methods to unravel the dimensionality of the subsurface resistivity structure and a 2D inversion approach for further interpretation of the measured AMT data.

Dimensionality and Directionality Analysis

We applied the phase tensor (Caldwel et al., 2004) and Groom- Baily (McNise and Jones, 2001) decomposition approaches for dimensionality and directionality analysis of the measured data. At short periods, phase tensor ellipses are circles representing an electrically layered earth. At longer periods they represent a quasi 2-D geo-electric structure. the orientation of phase tensor ellipses at periods, where principal phase splits are garter than 3˚ are presented in figure 2. The results reveal a trend of about 30˚ for the regional strike direction.

2-D inverse modeling of MT data

Two-dimensional isotropic inversions of distortion corrected MT data were run using the WingLink software (Rodi and Mackie, 2001). Figure 3 shows the result of an inversion constrained to fit within 3.5% of apparent resistivity and 1˚ of phase data for both TM and TE modes. Model misfits are acceptable (RMS=1.48) with the general trends of the apparent resistivity and phase curves reproduced at all sites.

In the next step, we applied a-priori inversions to validate main features recovered in figure 3. all the conductive or resistive structures have been removed from the inversion. The outcomes were then used as starting models and allowed to evolve through the inversion procedure, where the closest model to the starting model was looked for. This strategy confines the starting district of the inversion and spotlights undetected or poorly constrained features (Schwalenberg et al., 2002). The experiment results (Figure 4) suggest that the main features in Figure 3 are data supported and their shapes do not change significantly through the sensitivity studies.

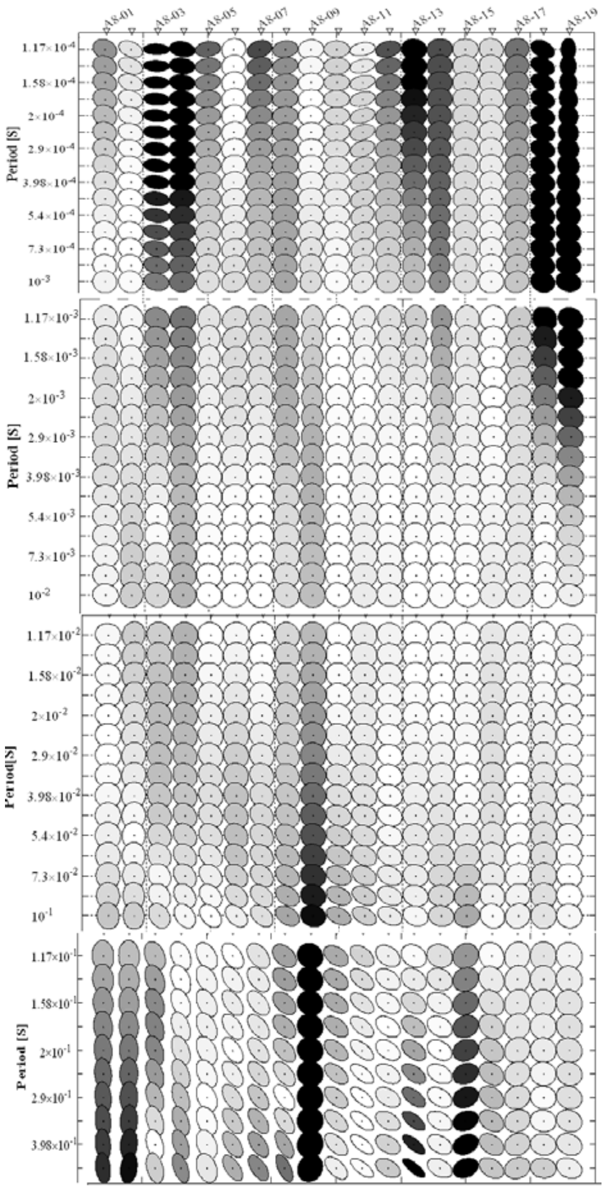

Figure 1. Pseudosection of phase tensors from the AMT survey, filled with the β skew angle.

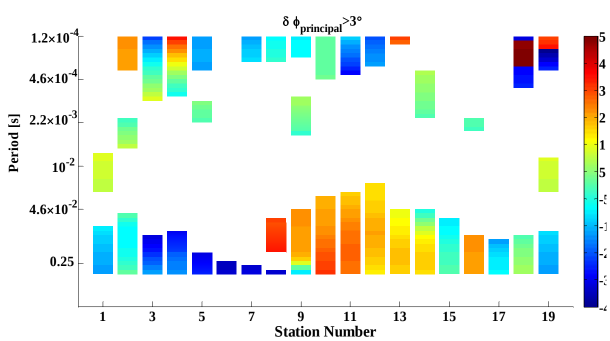

Figure 2. Pseudosection of phase tensor azimuths for the AMT survey. Azimuths are only shown for tensors with a split in the principal phases greater than 3˚.

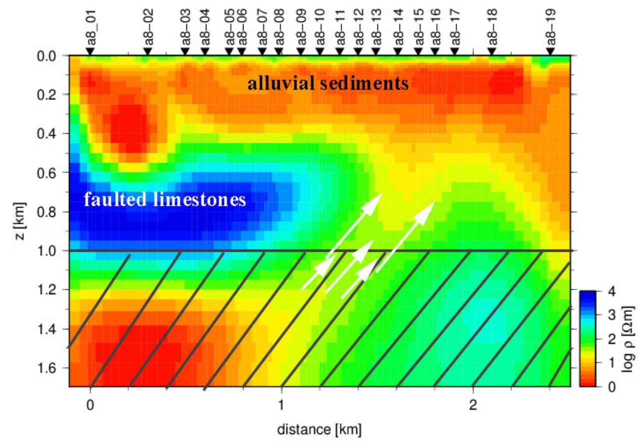

Figure 3. Final two-dimensional model produced from AMT data along profile A8 in central Zagros. The model used the TM and TE mode impedances as well as tipper data and reached an RMS value of 1.48.

Conclusions

In the course of this work, we outlined the results of dimensionality analysis and inversion results of an MT data set from central Zagros, Iran. The inversion model contains a thick conductive layer extending throughout the model, a deep conductor beneath the NW of the profile. Sensitivity tests support the existence of the narrow dipping conductive zone that connects the upper conductive layer and deeper conductor.

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References

Caldwell, T.G., Bibby, H.M. & Brown, C., 2004. The magnetotelluric phase tensor, Geophys. J. Int., 158, 457–469.

McNeice, G. W., & Jones, A.G. (2001). Multisite, multifrequency tensor decomposition of magnetotelluric data. *Geophysics*, 66, 158–173.

Rodi, W., and R. L. Mackie (2001), Nonlinear conjugate gradients algorithm for 2-D magnetotelluric inversions, Geophysics, 66, 174–187.

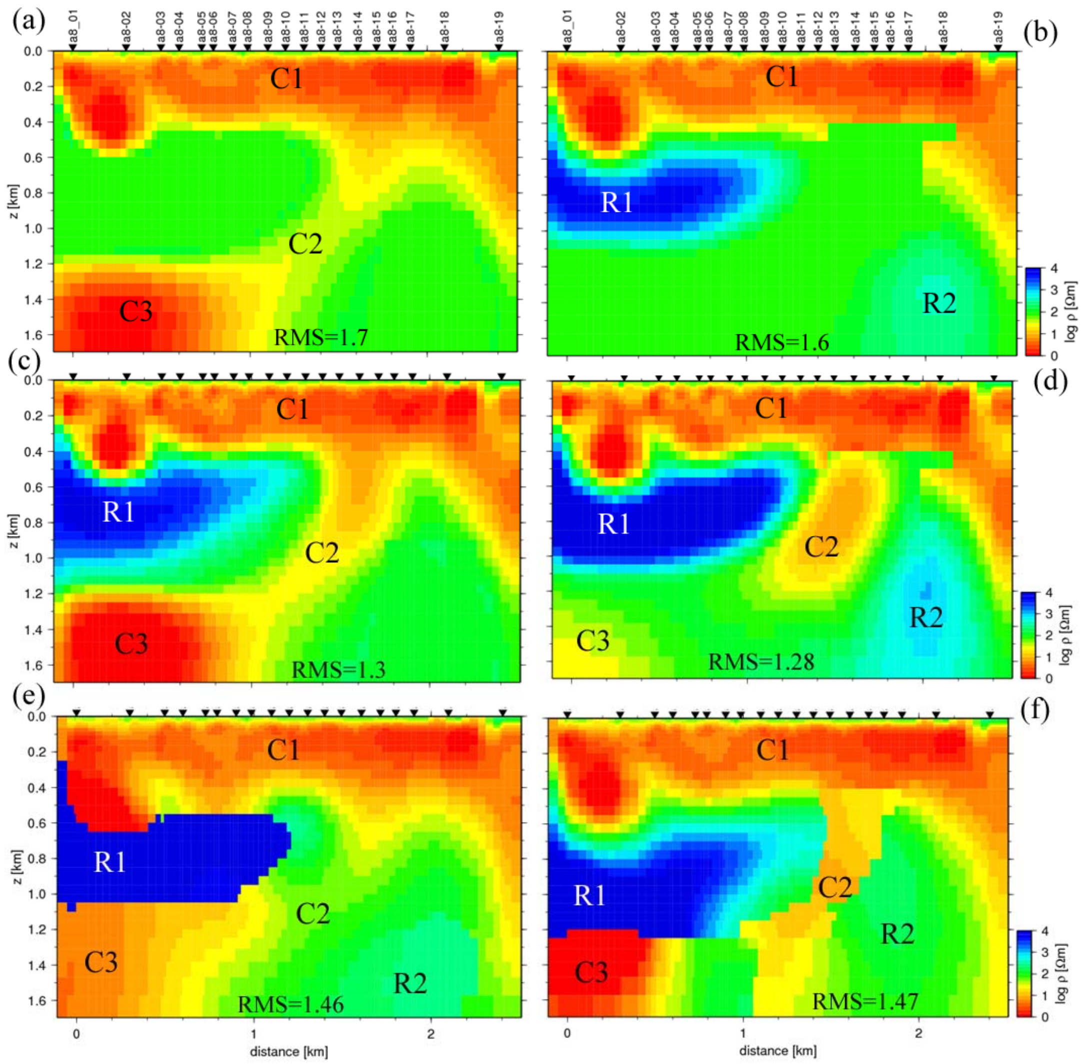

Figure 4. Inversion results where the closest to starting model was sought. (a, b) show the starting models, where the resistors (R1, R2) or the conductors (C2, C3) have been removed, respectively. (c, d) inversion results of (a, b). (e, f) inversion results where tear zones are introduced throughout the regions containing the resistors (R1, R2) and the conductors (C2, C3).