

Comparative 3D inversion of magnetotelluric phase tensors and impedances reveals electrically anisotropic base of Gawler Craton, South Australia

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SUMMARY

Isotropic three-dimensional (3-D) inversion has become a standard tool in the interpretation of magnetotelluric (MT) data. 3-D anisotropic inversion codes are under development, yet the number of unknowns increases by a factor of 6 rendering the problem extremely ill-posed. Presence of anisotropy is usually inferred from (i) spurious sequences of conductive and resistive bodies or (ii) comparison with two-dimensional anisotropic modelling approaches.

Here, we investigate the 3-D structure of the Gawler Craton down to ~250 km depth using 282 sites of the AusLAMP array located in the southern half of South Australia. Inversions of the MT impedance as phase tensors and real and imaginary parts result in diverging structures at depths > 70 km. We demonstrate that a unifying model which explains all data types similarly well is suggestive of an anisotropic resistivity structure at the base of the Gawler Craton lithosphere at depths of 120-210 km. Depth location and orientation of the anisotropy agrees well with results from analysis of seismic receiver functions. We suggest that electric anisotropy in the Gawler Craton is a result of lattice-preferred orientation of olivine crystals and metasomatic processes with macroscopic preferential orientation.

Our results illustrate that inversion of phase tensor data is superior for the direct imaging of anisotropic resistivity contrasts in otherwise isotropic resistivity models; inversion models obtained with impedances may miss such structures. 'Comparable' overall RMS misfits are often meaningless when comparing inversion results for various data types since sensitivities differ between data types. Reliable inversion results consistent with the entire data set can only be recovered if data fits are assessed systematically for all data representations. We also discuss the influence of error settings for phase tensors on the inversion.

Our study also revealed that, if persistent across large areas, (i) parallel orientation of phase tensor major axes, (ii) constantly high phase tensor maximum phases or (iii) diverging directions of phase tensor major axes and induction arrows are suggestive of anisotropic structures and corresponding hypotheses should be evaluated.

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