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Constrained inversion as a hypothesis testing tool, what can we learn about the lithosphere?

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Inversion of geophysical data constrained by a reference model is typically used to guide the inversion of low resolution data towards a geologically plausible solution. For example, a migrated seismic section can provide the location of lithological boundaries for potential field inversions. Here we consider the inversion of long-period magnetotelluric data constrained by models generated through surface wave inversion. In this case, we do not consider the surface wave model inherently better in any sense and want to guide the magnetotelluric inversion towards this model, but we want to test the hypothesis that both datasets can be explained by models with similar structure. If the hypothesis test is successful, i.e. we can fit the observations with a conductivity model with structural similarity to the seismic model, we have found an alternative explanation compared to the individual inversion and can use the differences to learn about the resolution of the magnetotelluric data and can improve our interpretation. Conversely, if the test refutes our hypothesis of coincident structure, we have found features in the models that are sensed fundamentally different by both methods which is potentially instructive on the nature of the anomalies.

We use a MT dataset acquired in central Botswana over the Okwa terrane and the adjacent Kaapvaal and Zimbabwe Cratons together with a tomographic model for the region to illustrate and test this approach. Here, various conductive structures have been identified that bridge the Moho. Furthermore, the thickness of the lithosphere inferred from the different methods differs. In both cases the question is in how far this is a result of the ill-posed nature of inversion and in how far these differences can be reconciled. Thus this dataset is an ideal test case for our hypothesis testing approach. Finally, we will demonstrate how we can use the results of the constrained inversion to extract conductivity-velocity relationships in the region and gain further insight into the composition and thermal structure of the lithosphere.