EGU2020-9826
https://doi.org/10.5194/egusphere-egu2020-9826
EGU General Assembly 2020

Using magnetotelluric and seismic geophysical observations to infer viscosity for Glacial Isostatic Adjustment calculations

Florence Ramirez[1], Kate Selway[2], and Clinton Conrad[1]
[1]Centre for Earth Evolution and Dynamics, University of Oslo, Norway (florence.ramirez@geo.uio.no)
[2]Department of Earth and Planetary Sciences, Macquarie University, Australia

A physical property that is important for understanding the geodynamics of Earth's lithosphere and asthenosphere is the effective viscosity η_{eff} (the ratio of stress and strain rate). This is particularly important for accurate Glacial Isostatic Adjustment (GIA) calculations, which are increasingly crucial for estimating ice loss and sea level rise from the Greenland and Antarctic ice sheets. Mantle viscosity cannot be measured directly, but can be inferred from strain rate, for example as observed by ground uplift following deglaciation or a seismic event. Empirically, mantle strain rate is mainly controlled by stress, temperature, grain size, and composition (water content and partial melt). The influence of these controlling parameters can be inferred from geophysical observations such as seismic and magnetotelluric (MT) measurements, which are useful for imaging the subsurface of the Earth but do not directly constrain viscosity. These observations can be used to improve constraints on viscosity using a three-step conversion process: (1) constrain temperature from MT, seismic, and other data; (2) constrain compositional structure from MT and seismic data (water content of nominally anhydrous minerals from MT, partial melt content from MT and seismics); and finally, (3) convert the calculated thermal and compositional structures into a constrained viscosity structure. In each conversion process, we can assess and quantify the involved uncertainties. Furthermore, we determine the dominant deformation regime in order to accurately interpret the sensitivity of viscosity to its controlling parameters. For instance, water content strongly affects viscosity for the dislocation-accommodated grain-boundary sliding (dis-GBS) and dislocation creep regimes, while diffusion creep and dis-GBS are highly sensitive to grain size. Stress and grain size are important parameters for determining where these critical transitions may occur. Although neither MT nor seismic velocity observations place strong constraints on grain size, information about seismic attenuation or tectonic history can potentially provide information about grain–size. Overall, we find that seismic and MT observations together can significantly improve estimates of mantle viscosity, and in particular can place useful constraints on the amplitude of regional variations in mantle viscosity. Such constraints will be particularly useful for studies to estimate the impact of such variations on GIA processes.