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# Seismic Thermography

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What is next in seismic tomography? In this presentation, we make a case that a key future direction is the inversion of seismic data directly for temperature within the Earth. We term this emerging branch of seismic imaging Seismic Thermography. Variations in temperature are of great interest because they indicate the thickness and, consequently, mechanical strength of the lithosphere and density variations and convection patterns in the sub-lithospheric mantle. Seismic tomography maps seismic-velocity variations in the mantle, which depend on temperature. Temperatures and the lithospheric structure and thickness are, thus, often inferred from tomography. Tomographic models, however, are non-unique solutions of inverse problems, regularized to ensure model smoothness or small model norm, not plausible temperature distributions. For example, lithospheric geotherms computed from seismic-velocity models typically display unrealistic oscillations, with improbable temperature decreases with depth within shallow mantle lithosphere.

It is more accurate to invert seismic data directly for temperature and avoid the errors due to the intermediate-model non-uniqueness. Because seismic-velocity sensitivity to composition is weaker than to temperature, we can use computational petrology and thermodynamic databases to invert seismic data primarily for temperature, with reasonable assumptions on composition and other relevant properties and with additional inversion parameters such as anisotropy.

Here, we apply thus defined Seismic Thermography to the thermal imaging of the lithosphere, asthenosphere and the lithospheric thickness using surface waves. Conductive geotherms and standard compositions fit the data from Precambrian continents and from Britain and Ireland, which we use as examples. Exotic compositions and temperature profiles can also be mapped, when required by the data, using specially defined components of the parameterisation. The accuracy of the models depends critically on the accuracy of the extraction of structural information from the seismic data. Random errors have little effect but correlated errors of even a small portion of 1% can affect the models strongly.

Seismic Thermography builds on the techniques of seismic tomography and relies on computational petrology but it is emerging as a field with its own scope of goals, technical challenges and methods. It is producing increasingly accurate models of the Earth and important inferences on its dynamics and evolution.