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Caveats on tomographic images

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Geological models of the mantle and its geodynamic evolution rely essentially on joint interpretations of published seismic tomography images and petrological/geochemical data. This approach tends to neglect the fundamental limitations of, and uncertainties in, seismic tomography and geochemistry. Counter-intuitively, teleseismic tomography cannot image the three-dimensional structure of the mantle. Tomography cannot determine with certainty the strengths of calculated anomalies, since the results depend on subjective choices of inversion parameters. However, anomaly strengths are still commonly translated directly into critical geological properties such as temperature, density, and convective motion with little justification. Tomography does not return thermal or geological information, but seismological parameters, and assumptions are required to translate these seismic results into other physical properties. Resolution- and error-assessment methods cannot encapsulate the true errors, and are insensitive to critical experimental limitations that invalidate parts of most derived structures. Much of Earth's mantle is unsampled by crossing seismic waves. One must know what regions are well sampled in order to understand which parts of published images are reliable and which are not. Other tomographic limitations and uncertainties involve theory, correcting for the crust, and choice of what background model to subtract to reveal anomalies. Methods do exist for retrieving absolute wave speeds, and not just differences from a starting model, and the former should be preferred. Finally, the selection of cross-sections for publication is subjective, and can give a misleading impression of the three-dimensional structure retrieved. It is common to overestimate the power of geochemistry to identify magma sources. Geochemistry is limited by our poor knowledge of the thermal structure of the mantle and the size and the distribution of geochemical and mineralogical heterogeneities, and a range of conclusions is usually permitted by the data. We will present a relatively non-technical summary of the most important of these problems in a form accessible to non-seismologists. Appreciation of these issues is essential if final geodynamical models are to be robust, and required by the scientific observations in contrast to merely being selected candidate interpretations.