Global and regional waveform tomography with massive datasets: new insights into the structure and evolution of the continents

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Waveform inversion was introduced in global seismic imaging in the early days of seismic tomography, in the beginning of the 1980s. Thanks to the continual improvements in the data sampling and methodology since then, waveform tomography has been getting more and more effective in extracting structural information from seismic records and producing detailed 3D models of the Earth’s crust and upper mantle. Today, tomography’s original problems relating to the large-scale Earth structure have been solved: the structure at the scale of thousands of kilometres is remarkably consistent across recent global models. Resolution of the imaging is now at hundreds of kilometres, the scale of tectonic units and major tectonic and magmatic processes. This has opened a new chapter for waveform tomography. It now fuels discoveries on the structure of individual cratons, evolution of cratons in general, origins of intraplate volcanism, plume-lithosphere interactions and other processes.

In continents, high-resolution tomography can now map the deep boundaries of different tectonic blocks with useful accuracy. A global comparison with geological data shows that, as a rule, Archean crust is underlain by thick (180-250 km), cratonic mantle lithosphere. This mantle lithosphere is likely to be of the Archean age as well, as often evidenced by mantle xenoliths. Where Archean crust is unexposed (covered by sediments), its presence can be inferred from the presence of the cratonic mantle lithosphere, imaged by tomography. A growing number of previously unknown cratons in different continents are now being discovered by waveform tomography. The lateral extent of other cratons, hypothesized previously, can now be established.

The lithosphere of most known cratons has been remarkably stable since its Archean formation, thanks to its compositional buoyancy and mechanical strength. In some instances, however, cratonic lithosphere is known to have been eroded. This is inferred from the existence of the thick lithosphere in the past, as evidenced by diamondiferous kimberlites, and its absence at present, as evidenced by seismic imaging. Waveform tomography of continents now reveals more and more occurrences of this process and offers new insights into its mechanisms.

References
