Geophysical Research Abstracts
Vol. 17, EGU2015-9006-1, 2015
EGU General Assembly 2015

Lithospheric structure of North America imaged using waveform inversion of global and USArray data

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The North American continent has had a long, eventful tectonic history. The assembly of the stable cratonic core has undergone numerous collisions and accretion at its boundaries, major rifting episodes within it, as well as the loss of ancient lithosphere beneath parts of it, all of which are type examples of key elements of cratonic dynamics and evolution. Seismic tomography offers rich evidence on the structure and evolution of the cratonic lithosphere. With the deployment of the USArray during the last decade, much of the North American continent has been densely sampled with broadband seismic data. The resolution of regional-scale imaging, however, remains uneven, with important questions regarding deep structure, lateral extent and evolution difficult to answer. Here we present a new high-resolution model of the upper mantle beneath North America constrained by waveform fits of over 700,000 vertical-component broadband seismograms. Automated multimode waveform inversion was used to extract structural information from surface and S waveforms, yielding resolving power from the crust down to the transition zone, and improved resolution for a variety of features in North America.

The internal structure of the Craton is resolved in detail, with clear delineation of the ancient cratonic lithosphere from the recently deforming continental margins. The northern boundaries of the cratonic lithosphere closely follow the coastlines, with North America's and Greenland's lithospheric roots clearly separated. Strong lateral velocity gradients at depth observed in western Canada indicate the transition from cratonic lithosphere to Cordillera closely follows the surface trace of the Deformation Front. On the eastern margin of the continent, where multiple episodes of continental rifting are superimposed, the craton boundary coincides with the western extent of the Appalachian orogenic front, with significantly lower lateral velocity gradients than in the west. Finally, high velocities between the Great Bear Arc and Beaufort Sea provide convincing evidence for the recently proposed 'MacKenzie Craton', unexposed at the surface.

Within the continental interior, the lithosphere surrounding the 1 Ga failed Mid-Continental Rift shows a reduction in wavespeeds compared to the surrounding craton, likely indicating thermo-chemical alteration of the sub-continental lithospheric mantle, in agreement with results from geochemical and petrological analyses of diamondiferous kimberlites and peridotites. We examine the spatial extent of the lithospheric mantle root and LAB variations across the continent, and compare them with respect to the spatial location of diamondiferous kimberlites. Finally, we discuss potential lithospheric control on the distribution crustal seismicity.