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Seismic anisotropy measured at the scale of a continent: Australia

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The seismology group at the Research School of Earth Sciences, ANU, made extensive deployments of seismological broadband recorders at the scale of the Australian continent over the last 12 years. This has given an unprecedented coverage of a continent, which, together with a convenient location with respect to worldwide seismicity, has allowed the implementation of many kind of studies to investigate the lithospheric structure of the continent.

Since the temporary deployments were mainly designed for receiver functions and surface wave tomographic studies, the average time span of recording did not exceed 6 months, which is rather limited for shear wave splitting analyses. The data set however provides a full continental scale survey, data being recorded at 190 sites spread out all over the continent. The complexity of the Australian crust related to its long and complex tectonic history raises the question of possible mechanical coupling between the crust and the upper mantle, and shear wave splitting analysis appeared to be the most appropriate tool to investigate the structure of the upper mantle for this purpose.

Shear wave splitting measurements result in two parameters: Ø, the orientation of the polarisation plane of the fast S-wave and dt the delay between the arrival time of the fast and slow S-waves. Ø is a proxy for the orientation of the [100] axis of olivine, the most abundant mineral in the upper mantle, whose lattice preferred orientation results from anisotropy frozen in the lithosphere or asthenospheric mantle flow, and dt is proportional to the intrinsic anisotropy, the thickness of the anisotropic layer and the vertical coherence of the mantle fabric.

Previous studies of seismic anisotropy beneath the Australian continent dealt with 1) permanent IRIS and GEOSCOPE stations and revealed isotropy or 2) the first three stages of the SKIPPY experiment, covering the northern and eastern parts of the continent and highlighting relatively small levels of splitting and a complex pattern. All the available data recorded within the framework of the many successive deployments have been processed and our new and far more extensive results indicate considerable complexity within the pattern of seismic anisotropy from shear wave splitting beneath Australia

No direct correlation between Ø and the absolute plate motion as defined by various models is found. The lithosphere-asthenosphere boundary beneath Australia appears to be pretty complex and deviation of the asthenospheric mantle flow around the lithospheric roots cannot be ruled out. At a regional scale, some evidences of fast split S-waves being polarized in planes oriented parallel to local structural trends (along the Halls Creek orogen bordering the eastern edge of the Kimberley basin or along the New England and Lachlan fold belts in the southeastern part of the continent for instance) may account for anisotropy frozen in the lithosphere during post-tectonic thermal relaxation. It seems therefore difficult to interpret the complex pattern of anisotropy from shear wave splitting beneath Australia in terms of either mantle-flow related or frozen anisotropy within the lithosphere: a contribution from both the lithospheric and sublithospheric mantle is likely.