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Seismic body wave travel time anisotropy tomography of the seismotectonic structure of the 2013 Ms7.0 Lushan earthquake, China

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On April 20, 2013, a strong earthquake of Ms 7.0 occurred in Lushan County, Sichuan Province, causing large casualties and property losses. It has drawn a lot of attention from seismologists and brought extensive researches. The velocity model and slip distribution of the aftershock zone shows low velocity, high Vp/Vs and nearly no slip in the shallow parts, which may reveal highly development of cracks. By doing shear wave splitting analysis and tomography, we found that the anisotropy in this area is complicated (not unique distribution of fast shear wave polarizations) and higher (anisotropy percentage) in upper crust than lower crust. In order to obtain high-resolution image of 3D anisotropic structure, here we developed a local-scale joint P and S wave travel time azimuthal anisotropy tomography method and applied it to the aftershock zone of Lushan earthquake.

Body wave travel time anisotropy tomography can simultaneously characterize the spatial distribution of isotropic velocity, anisotropic velocity magnitude and fast direction, but mostly uses P wave travel times only. Liu and Zhao (2016) have developed regional-scale joint P and S wave travel time azimuthal anisotropy tomography method following Eberhart-Phillips and Henderson (2004). In order to obtain fine anisotropic structure of Lushan aftershock zone, we have developed local-scale joint P and S wave travel time azimuthal anisotropy tomography method following Eberhart-Phillips and Henderson (2004) and Liu and Zhao (2016). We constructed a checkerboard model to perform synthetic test and the results show that both anisotropy magnitude and fast direction can be better resolved by using both P and S wave travel times than only P wave travel times.

We used almost 4200 aftershocks recorded over a continuous period between 24/4/2013 and 19/5/2013. The distribution of anisotropic magnitude shows that anisotropy is higher in upper crust and is highest near the faults within each layer. This strong anisotropy implies that there was some deformation in the diagenetic layer although there was little evidence of a clear surface rupture of the Lushan earthquake. The high anisotropy area is separated into two stripes, which are associated with two conjugated faults, respectively. We think that the conjugated faults extended to subsurface and the edge of high anisotropic stripes at shallow depth may reveal their shape in the subsurface. The orientation of the anisotropy is primarily parallel to the trend of the Longmenshan fault system (LMF) in high anisotropy area, which is nearly perpendicular to the maximum horizontal compressive stress direction. It is likely that there is a damage zone of fractured rock along the fault, which could be very effective in generating seismic anisotropy with a fast direction parallel to the plane of the fractures, especially if they are water rich.