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Seismic anisotropy indicators in Pan-African orogenic belt: Shear wave splitting and receiver function analysis

Yusuke Usui[1]; Tomofumi Inoue[2]; Akira Yamada[1]; Masaki Kanao[3]

[1] GRC, Ehime Univ.; [2] Biology and Earth Sci., Ehime Univ; [3] NIPR

http://www.sci.ehime-u.ac.jp/˜usui/

It has been known that crust and upper mantle is anisotropic and the degree is up to 10%. The studies of seismic anisotropy have been performed in all over the world. Since we could directly discuss the Earth dynamics to analyze the seismic anisotropy, it has been powerful tool to know stress and strain fields of Earth's deep interior. In this study, we investigate the crust and upper mantle anisotropy beneath Lutzow-Holm Bay Region (LHB), East Antarctica and Sri Lanka. LHB is considered to be part of the Pan-African orogenic belts and has been connected with South India and Sri Lanka before breakup of Gondwana in the mid-Mesozoic. The results of crust and upper mantle anisotropy enable us to discuss the evolution of the Antarctic Plate, together with the effects of assembly and break-up process of Gondwana.

We investigate the upper mantle anisotropy using broad-band seismic data from 1996 to 2008 recorded at eleven seismic stations in LHB, East Antarctica and Sri Lanka. We select moment magnitude (Mw) greater than 5.6 and the events located within epicentral distances of 85˜130 degree. The source parameters are provided by Harvard Centroid Moment Tensor catalog. The core-phases (SKS, SKKS and pSKS) are used for upper mantle anisotropy. We calculate the splitting parameter (f, dt) using Silver and Chan (1991). f is fast direction of split shear wave and dt is the delay time of two split waves. The splitting parameters are determined by minimizing the energy of the transverse component by net grid search technique with intervals of 1 deg. and 0.1s, respectively. Additionally, we assume more complex models as a two-layer model with four independent parameters. The apparent splitting parameters are fitted by the four parameters (f1, dt1, f2, dt2), with index 1 corresponding to the lower layer and index 2 to the upper layer. For crust anisotropy, we use P-to-S converted waves. From 3-component broadband records of teleseismic P waves we compute radial and transverse component receiver functions using the method of Ammon (1991). We applied the water-level (c=0.001) and Gaussian Filter (a=1.0) and grouped the data into 20 deg. back azimuth bins.

Investigations of seismic anisotropy may contribute to ideas about influence of recent or fossil mantle flows and/or the tectonic evolution of the study regions. For the upper mantle, fast polarizations directions of the lower layer are generally parallel to the directions of Absolute Plate Motion (APM) based on the HS3-NUVEL1 both LHB and Sri Lanka. We consider that it is reasonable that the structures of lower layers anisotropy might have been produced asthenospheric mantle flow. The upper layers don't coincide with the APM direction (the difference is about 70-90).

The directions correspond well to polarization of NE-SW convergence direction between East and West Gondwana in Pan-African age. Furthermore, the spreading direction of the Gondwana break-up was NW-SE and the strike of the rift is generally parallel to continental margin. The fast polarization directions of upper layer are roughly parallel to the continental margin in LHB. Therefore, it is plausible that break-up processes affected the formation of anisotropy in the upper layer. The preexisting lithospheric structure may also influence the formation of the anisotropy during Gondwana break-up. We conclude that the upper layer anisotropy is caused by plate convergence during Pan-African time involving Gondwana assembly, subsequently modified by rifting and continental break-up.

The fast polarization directions of crust are NW-SE. These directions correspond with the results of previous works (Kubo and Kanao, 1997). Since the strike of metamorphic band is NW-SE from the study of regional metamorphism among Pan-African orogeny and magnetic anomalies, the crust anisotropy is caused by the lithospheric deformation during the formation of LHB in the Pan-African age.