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Influence of the lithospheric structure beneath the Philippine Sea Plate to the surrounding subductions from Anisotropic Rayleigh-wave phase velocity

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The Philippine Sea Plate (PSP), in western Pacific, is an oceanic plate surrounded by convergent boundaries. Its passed and present tectonic evolution has been discussed by several studies based on different observations, including magnetic and gravity surveys, and geochemical analyses. Most of these studies agreed that the PSP evolution started from an initial stage of back-arc spreading, related to the subduction of the Pacific Plate beneath the Eurasian Plate, accompanied by gravitational pull on the subducting slab, and extension in the overriding plate. However, different evolution models have been proposed for later stages.

In this study, we built an isotropic and azimuthally anisotropic Rayleigh-wave phase velocity model for the PSP. 7,914 earthquakes with magnitude greater than 5.0 (1998-2014) were used to measure Rayleigh-wave dispersion curves along 397 station-pairs over the Philippine Sea Plate. The measured dispersion curves are then inverted for isotropic and azimuthally anisotropic velocity maps at selected periods between 60 and 160s.

The resulting model displays a rather good agreement between the seismic velocities and the geologic structures: fast velocities are found beneath the oldest sea-floor of the West Philippine Basin, whereas the youngest formations (Shikoku and Parece Vela basins) exhibit slower velocities. Fast velocities are also observed in the eastern Philippine Sea Plate along the Izu-Bonin Trench and in the northern part of Mariana Trench, and are likely related to the subducting Pacific slab beneath the PSP.

Our model also draw a regionally coherent pattern of azimuthal seismic anisotropy beneath the studied region. This pattern is consistent with the hypothesis that the entire PSP experienced a single clockwise rotation, instead of independent rotations of the different basins.

The northern PSP exhibits NE-SW fast direction at periods from 60 to 100s, parallel to the geometry of the convergent boundary. At periods between 100 and 160s, the fast direction axis rotates clockwise by 60°, compared to the pattern observed at shorter periods, and agrees with the absolute plate motion in this region. This indicate thats beneath the Philippine Sea Plate, seismic anisotropy is radially distributed in two distinct layers, possibly as a result of different episodes of lithospheric deformation.

Consequently, the anisotropy in the southern Philippine Sea Plate is relatively minor. It is found herein to follow the direction of the absolute plate motion of the Philippine Sea and of the neighboring Caroline Plates that plays a role on the surrounding subductions.