P-wave tomography of the source zone of the 2015 Bonin deep earthquake

*Moeto Fujisawa[1], Dapeng Zhao[2], Genti Toyokuni[2]

1.JAPEX, 2.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University

On 30 May 2015, a distinct deep earthquake occurred to the west of the Ogasawara (Bonin) Islands with a focal depth of 682 km and a magnitude of 8.1 determined the Japan Meteorological Agency (JMA). Such a great deep event is very rare, and it is the deepest large earthquake occurring in Japan during the observational history of the JMA. The 2015 Bonin deep earthquake is an isolated event which is over 100 km deeper than the Wadati-Benioff zone seismicity recorded so far. It is very important to clarify the generating mechanism of this deep event, which will shed new light on the slab structure and subduction dynamics in the Izu-Bonin region.
Seismic tomography is a very powerful tool for investigating the 3-D structure of the Earth’s interior. Usually a dense local seismic network is required to obtain detailed tomographic images of an area. However, there are only a few seismic stations in the Bonin region where the 2015 deep event occurred. Thus, it is hard to image its source zone using the conventional methods of local earthquake tomography or teleseismic tomography. In this work, we have adopted a modified version of the global tomography method (Zhao, 2004, 2009). To express the 3-D seismic velocity structure, a denser 3-D grid with a grid interval of ~50 km is arranged at depths of 0-1000 km beneath the target area including the 2015 Bonin deep event, whereas a coarse grid with a grid interval of ~220 km is arranged in the whole crust and mantle of the Earth. We used over five millions P-wave arrival times of P, pP, PP, PcP and Pdiff waves from 39,323 earthquakes recorded by 9141 seismic stations in the world, which are selected from the ISC-EHB catalogue as well as the Annual Bulletin of Chinese Earthquakes. Thus our target Bonin area is well sampled by the up-going and down-going rays of both the direct P waves and later phases.
Our tomographic results show clearly that the 2015 Bonin deep event took place within the high-velocity subducting Pacific slab which is penetrating down to the lower mantle. In the Izu-Bonin region, the subducting Pacific slab is split roughly at 28 degree north latitude, i.e., slightly north of the hypocenter of the 2015 deep event. In the north, the slab becomes stagnant in the mantle transition zone, whereas in the south, the slab is directly penetrating down to the lower mantle. We have relocated the 2015 Bonin deep event using our 3-D velocity model. The relocated focal depth is 667.3 km with an uncertainty of 0.5 km. Previous study has revealed that the 670 km discontinuity is locally depressed down to more than 690 km depth in the Bonin area. Thus, the 2015 Bonin deep earthquake is certainly located above the upper-lower mantle boundary.
In summary, our results suggest that the generation of the 2015 Bonin deep event was affected by several factors, including the fast deep subduction of the Pacific slab, changes in the stress regime and phase transformation in the slab near the 670 km discontinuity, as well as complex interactions between the subducting slab and the ambient mantle.
References
Zhao, D. (2004) Global tomographic images of mantle plumes and subducting slabs: insight into deep Earth dynamics. *Phys. Earth Planet. Inter*. 146, 3-34.
Zhao, D. (2009) Multiscale seismic tomography and mantle dynamics. *Gondwana Res.* 15, 297-323.

Keywords: 2015 Bonin deep earthquake, seismic tomography, Pacific slab

