

New insights into the mechanism of deep-focus earthquakes

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Generally, deep-focus earthquakes were generated in subducting slabs and occurred along some specific regions such as Izu-Bonin zone and Tonga-Fiji zone. We have not identified their occurrence mechanisms, even though some plausible hypotheses, dehydration embrittlement, thermal and shear plastic instability, and transformational faulting, were proposed. In this study, we try to obtain new constraints that deepen the understanding of deep-focus earthquakes through waveform analysis of earthquakes in the Izu-Bonin subduction zone.

First, we picked up 460 quakes at a depth range of 300-400 km in 2003-2015 beneath Tokai area from the catalog data provided by Japan Meteorological Agency, and relocated them with double-difference earthquake relocation algorithm (hypoDD; Waldhauser and Ellsworth, 2000). Second, we computed their coherence values between all available pairs of earthquakes with cross-spectrum analysis. Then, we were successful to identify a few earthquake clusters that had a very high coherence value over 0.9 in a long time window of 40 s including P and S waves. Moreover, we relocated these earthquakes with hypoDD again by using precisely-determined differential travel-time data derived from waveform data. As a result, we could find that earthquakes in each cluster occurred on single fault plane with complementary rupture areas.

Additionally, we implemented moment tensor inversion (Gephart and Forsyth, 1984) and estimated the stress field around the region where we discovered a few clusters showing waveform similarities. Moreover, we computed the amount of stress drop of the similar earthquakes with spectrum analysis of seismic wave. Through these waveform analyses, we interpreted that the mechanism of these similar deep-focus earthquakes could be explained by combining two possible mechanisms; dehydration embrittlement that regulates the rupture initiation and thermal and shear plastic instability that controls the rupture propagation along a pre-existing fault.

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