Unusually deep Bonin earthquake (M7.9) of May 30, 2015 near the junction of the northern and southern Bonin slabs

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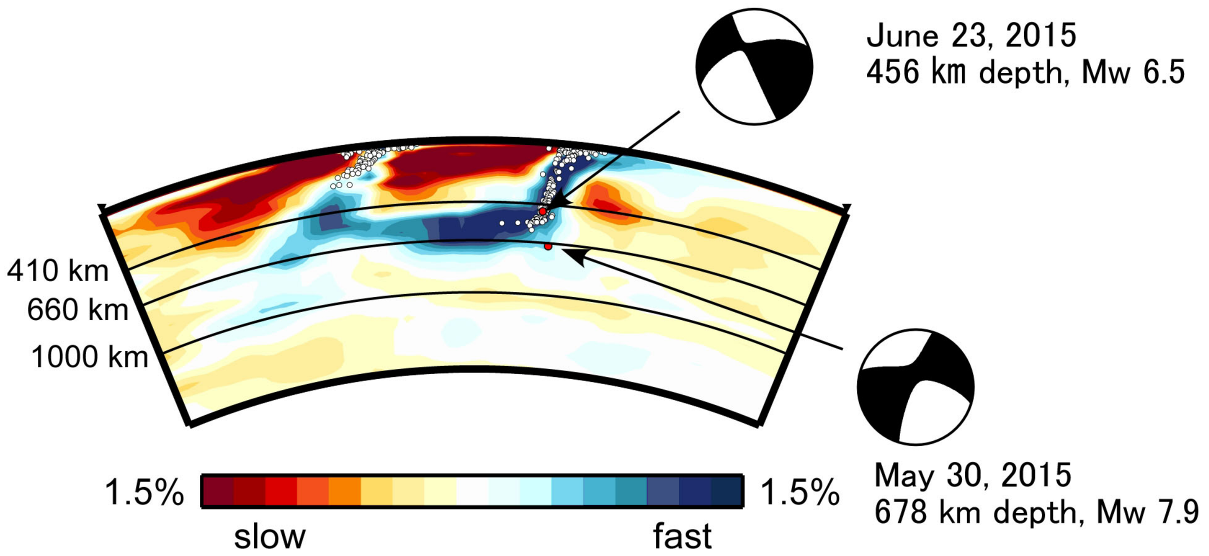
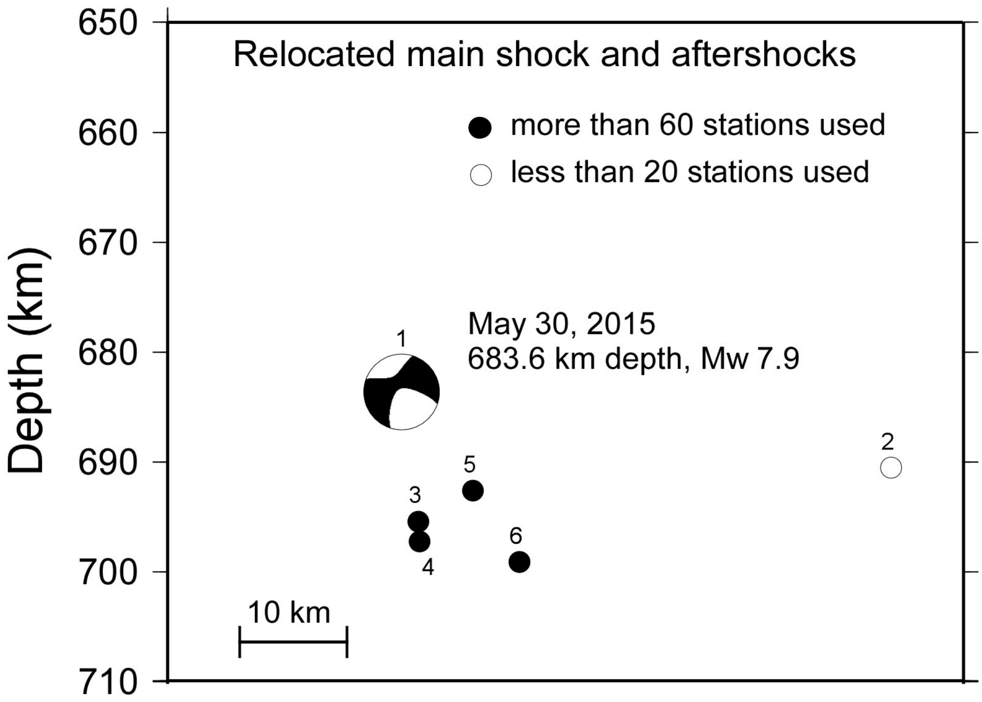
A great shock occurred at an unusual depth of 679.9 km (centroid depth of GCMT) far away from the well-defined Wadati-Benioff zone of the Izu-Bonin arc. To the north of this region the slab is stagnant above the 660-km discontinuity and to the south it penetrates the discontinuity. In this transitional region, the steeply dipping part of the slab bends sharply to horizontal and the great shock happened at the lowest corner of the bent portion. The CMT solution indicates pure normal faulting with the gently-dipping tensional axis and the steeply-dipping compressional axis, both approximately trench-normal. We suggest that this mechanism (Fig.1) reflects the stress environment of the lowest corner of the bent portion of the slab, where the slab is stressed near vertically by the negative buoyancy of the overlying slab and the positive buoyancy due to the phase boundary depression and near horizontally by the sharp bend of the slab upon its encounter to the discontinuity.

Among the reported 5 aftershocks, the first three occurred within 2 hours after the main shock and the remaining two, including the largest event with Mb 4.9 event (2 June 2015), occurred 3 to 5 days after the main shock. We relocated the main shock and aftershocks simultaneously using the absolute P-wave traveltime residuals and the differential travel time residuals between different events at the same stations to constrain the relative locations. The travel time residauls were calculated with respect to the three-dimensional P-wave velocity model GAP_P4 (Obayashi et al., 2013). The depth of the main shock is relocated at 683.6 km. The relocated aftershocks do not lie on ether of the nodal planes of the main shock but in deeper directions roughly along the axis of the principal compressive stress of the main shock (Fig.1). This situation may be compared to such a situation as observed further to the south where the downgoing slab buckles towards the Pacific side before its penetration into the lower mantle. We suggest that the slab portion in the relevant region begins to penetrate the 660, leaving the horizontally bent portion as a seismically inactive stagnant slab.

Because the occurrence of Wadati-Benioff zone earthquakes is fairly stationary in time and space, the resultant stresses give a measure of how stresses in the slab are perturbed by such earthquake occurrence. We calculated the cumulative stress perturbation due to 26 Wadati-Benioff zone earthquakes using their CMT solutions. The cumulative stress perturbation changes rapidly along a trench-normal profile at a depth of 680 km so that only the heel portion of the bent slab is stressed to enhance the occurrence of deep shocks of the type of the 2015 great shock. The occurrences of Wadati-Benioff zone earthquakes and the isolated 2015 great earthquake are mutually cooperative in terms of the resultant stress fields.

Keywords: Bonin Deep Earthquake, Tomography, Subducting slab, Focal mechanism, Aftershock distribution


June 23, 2015
456 km depth, Mw 6.5
410 km
660 km
1000 km
May 30, 2015
678 km depth, Mw 7.9
1.5%
1.5%
slow
fast


Relocated main shock and aftershocks
more than 60 stations used
less than 20 stations used
May 30, 2015
683.6 km depth, Mw 7.9
1
2
3
4
5
6
10 km
Depth (km)
650
660
670
680
690
700
710

