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Heterogeneity within the subducting Pacific slab beneath the Izu–Bonin–Mariana arc: Evidence from tomography using 3D ray tracing inversion techniques

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Abstract

Distinct zones of seismic heterogeneity along the Izu–Bonin–Mariana arc have been investigated using complimenting regional bulk sound, shear wave speed, and *P*-wave tomographic images. The distribution of seismic anomalies and the inferred geometry of the subducting Pacific plate have been modelled in unprecedented detail using joint tomography and new *P*-wave model using a 3D inversion algorithm. The use of 3D ray tracing techniques and smaller cell parameterizations have greatly enhanced the resolution of gradients, therefore, the models show much more detail about the structure and physical properties of the subduction zone. The well-defined features from the multiple wave speed images are used to elucidate the distinct morphology change between slab beneath the Izu–Bonin (horizontal slab) and Mariana (vertical) arcs and the distribution of physical properties in the mantle and the subducting oceanic lithosphere. Changes in physical properties within the slab tear at the southern end of the Izu–Bonin arc, identified as a "gap or thinning" in the tomographic images, could be the result of the distortion of the Pacific plate as its shape transforms between near horizontal to near vertical, a decrease in the rigidity and strength of the lithosphere, the subduction of the Marcus–Necker Ridge, change in subduction velocity, or a combination of all these factors. Strong, slow anomalies exist both, in the mantle wedge, above and below the slab beneath the Izu–Bonin arc but are not present beneath the Mariana arc. At the junction between the Izu–Bonin and Mariana arcs it appears that the there are two separate pieces of the Pacific plate: the torn slab north of 26° N and a buckled near vertically dipping slab south of the tear. The transition between the two distinct slab morphologies coincides with the location of the Ogasawara Plateau and the trench.

Keywords: subducting slabs; tomography; Izu–Bonin–Mariana; 3D imaging

1. Introduction

Seismic tomography has developed into one of the most effective and significant sources of information

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in modern geophysical research. One of the objectives of seismic tomography has been to understand tectonic processes and the interior of the earth but it can also provide details on the physical properties of the mantle [1–3]. For example, the physical properties of subducting slabs have been revealed through the comparison of bulk sound speed and shear wave speed anomalies from joint *P* and *S* data inversions [2]. Such joint inversions provide sharp definition of subduction zone features through an inversion exploiting the selection of *P* and *S* wave arrival times that have similar ray paths and can be used to uncover seismic heterogeneity on regional and global scales.

While many features of subduction zones in the Western Pacific were first identified in the 1990s [1,3–7], new detailed images of the variation of bulk sound and shear wave speeds and a new *P*-wave inversion can reveal the heterogeneous structure and, moreover, physical and chemical properties. An area of specific interest in this study lies at the "junction" of the Izu–Bonin and Mariana arcs (between 20° and 34° latitude) in Fig. 1. A distinct change in morphology and seismic property beneath Izu–Bonin was identified by Miller et al. [8] and was suggested to be related to the distortion of the Pacific plate as its shape transforms from near horizontal to vertical, coupled with the

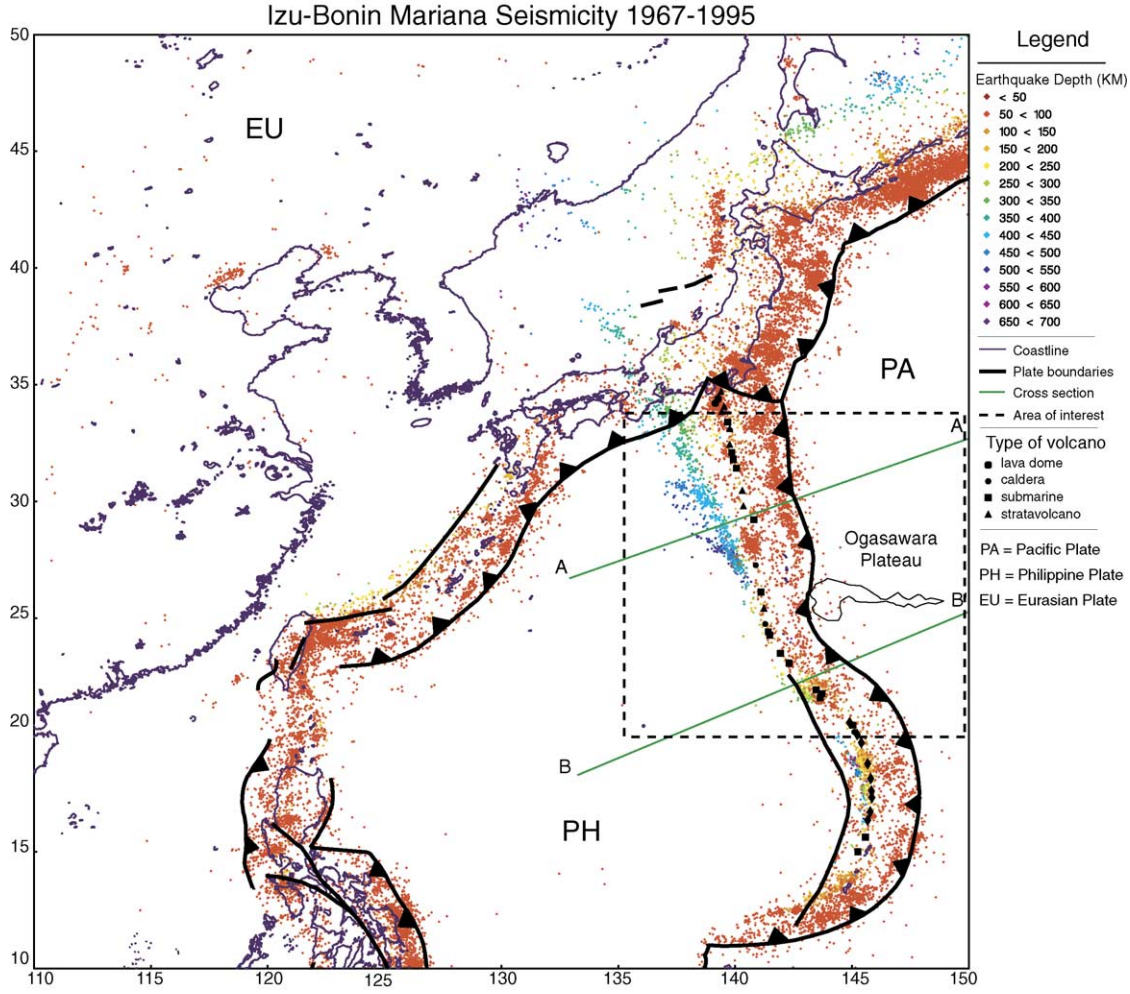

Fig. 1. Map of the Izu–Bonin–Mariana region with the major features of the area, hypocenters of events with magnitudes of 5.0 and greater from the NEIC catalogue, and location of the cross sections used in Fig. 4.