Izu-Bonin-Mariana

Interpretation (based on geologic data, plate reconstructions, seismic tomography, geodynamic modelling)

The onset of the presently active Izu-Bonin-Mariana (IBM) subduction zone likely occurred at around **52 Ma** with the subduction of the Pacific plate under the Proto-Philippine Sea plate, which was mostly formed of arc terranes at the time of subduction initiation (e.g., Ishizuka et al., 2018). The age of this SZI event is mostly based on the age of the oldest *Early basalts* (e.g., Reagan et al., 2019), which are considered to be the first magmatic product of SZI and to erupt very soon after the onset of subduction.

The most common view is that subduction initiated along a **pre-existing fracture zone** after a plate reorganisation due to the subduction of the Izanagi-Pacific ridge beneath Asia at around 60-55 Ma (O'Connor et al., 2013; Lallemand, 2016) or the collision of the Olutorsky arc (Domeier et al., 2017). Regardless of the cause, these stress changes might have caused compression across a transform fault (or a pre-existing fracture zone) and locally initiated subduction (Hall et al., 2003). Additionally, ocean-island basalt (OIB) magmatism in the West Philippine basin indicates the presence of a mantle **mantle plume** (the Oki-Daito plume) that started its activity almost at the same time as the IBM SZI (Ishizuka et al., 2013).

Direct evidence (based on direct measurements)

The oldest age of *Early basalts* is around 51 Ma (Reagan et al., 2019). *Early basalts* are found along the entire length of the trench, suggesting that subduction started roughly at the same time everywhere along the IBM trench (e.g., Ishizuka et al., 2011). *Boninites* erupted soon after the *Early basalts* between around 51-44 Ma (Reagan et al., 2019). Afterwards, more typical tholeiitic arc lavas started to erupt at around 44 Ma (Ishizuka et al., 2011).

Reconstruction (based on reference model by Müller et al., 2016, AREPS)

In the model of Müller et al. (2016), the Izu-Bonin SZI event occurs at 52 Ma. The nucleation of the subduction zone occurs parallel to and generally within ~200 km of a pre-existing subduction zone ('Philippine Subduction') along which the Pacific plate subducted beneath the North Philippine Basin. The polarity of the Izu-Bonin subduction zone is the same as this pre-existing subduction zone. No major plate motions occur at ~52 Ma itself, but the motion of the North Philippine Basin plate changes significantly at 54 Ma (i.e., 2 Myr before the Izu-Bonin SZI event).

Seismic tomography (based on Vote Maps of 10 seismic tomography models and the Atlas of the Underworld)

The Izu-Bonin and the Mariana slab appear to be separated today (van der Meer et al., 2018). From a 3-D view of the anomalies on a vote map, it is clear that the two slabs are connected in the upper mantle, but while the Mariana slab goes straight down to the lower mantle, reaching around 1250 km depth, the Izu-Bonin slab has a shallower dip and it flattens out around the transition zone (reaching a maximum depth of 850 km).

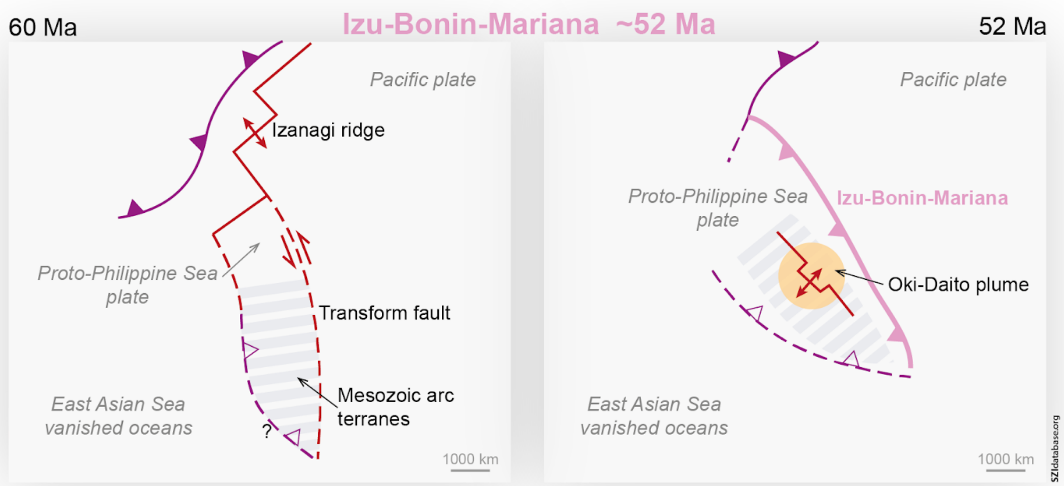

Figure. Schematic tectonic reconstruction of the Izu-Bonin-Mariana SZI event (modified from Lallemand, 2016). A plate reorganisation, possibly due to the arrival of the Izanagi ridge at the trench, is suggested to trigger SZI along a pre-existing transform fault in the south, initiating the Izu-Bonin-Mariana subduction zone. The orange circle shows the location of the Oki-Daito plume. Shown are the new subduction zone (pink line), other active (solid purple lines) and inactive (dashed purple lines) subduction zones, spreading ridges (solid red lines), and transform faults (red dashed lines).

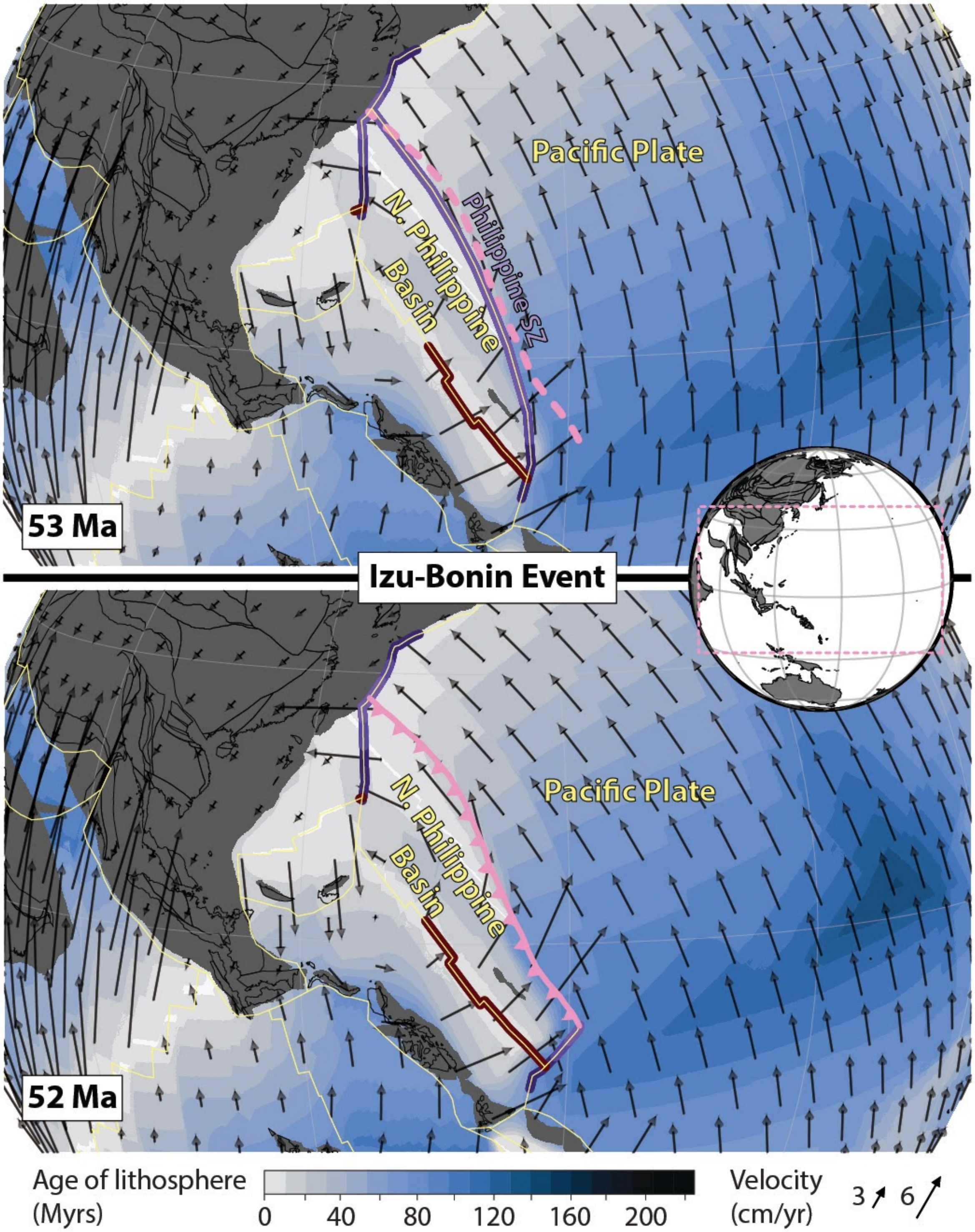

Figure. Izu-Bonin-Mariana SZI event as reconstructed in the model of Müller et al. (2016). Pink dashed (solid with teeth) line shows the Izu-Bonin-Mariana trench 1 Myr before (at) SZI time in the model. Purple (red) lines show segments of neighbouring subduction zones (ridges and transforms) that lie within some radius of the Izu-Bonin-Mariana trench (pink line); the brightness of the colours reflects 3 different distance thresholds of 250, 500 and 1000 km.

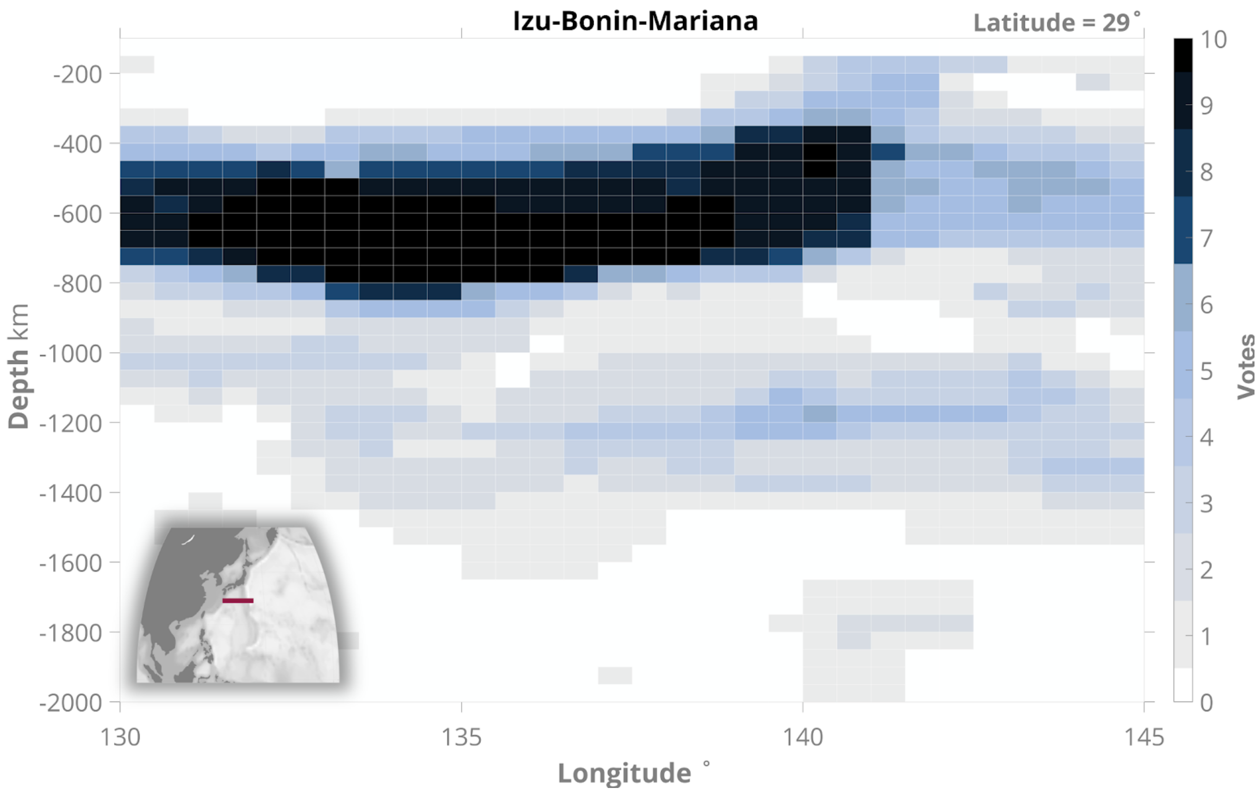

Figure. Seismic tomography VoteMap (Shephard et al., 2017) analysis of the Izu-Bonin-Mariana SZI event.

References

Domeier, M., Shephard, G. E., Jakob, J., Gaina, C., Doubrovine, P. V., & Torsvik, T. H. (2017). Intraoceanic subduction spanned the Pacific in the Late Cretaceous–Paleocene. *Science advances*, 3(11), eaao2303.

Ishizuka, O., Hickey-Vargas, R., Arculus, R. J., Yogodzinski, G. M., Savov, I. P., Kusano, Y., ... & Sudo, M. (2018). Age of Izu–Bonin–Mariana arc basement. *Earth and Planetary Science Letters*, *481*, 80-90.

Ishizuka, O., Taylor, R. N., Ohara, Y., & Yuasa, M. (2013). Upwelling, rifting, and age-progressive magmatism from the Oki-Daito mantle plume. Geology, 41(9), 1011-1014.

Ishizuka, O., Tani, K., Reagan, M. K., Kanayama, K., Umino, S., Harigane, Y., ... & Dunkley, D. J. (2011). The timescales of subduction initiation and subsequent evolution of an oceanic island arc. *Earth and Planetary Science Letters*, 306(3), 229-240.

Lallemand, S. (2016). Philippine Sea Plate inception, evolution, and consumption with special emphasis on the early stages of Izu-Bonin-Mariana subduction. *Progress in Earth and Planetary Science*, *3*(1), 15.

Hall, C. E., Gurnis, M., Sdrolias, M., Lavier, L. L., & Müller, R. D. (2003). Catastrophic initiation of subduction following forced convergence across fracture zones. *Earth and Planetary Science Letters*, 212(1-2), 15-30.

Müller, R. D., Seton, M., Zahirovic, S., Williams, S. E., Matthews, K. J., Wright, N. M., Shephard, G. E., Maloney, K. T., Barnett-Morre, N., Hosseinpour, M., Bower, D. J., Cannon, J. (2016). Ocean Basin Evolution and Global-Scale Plate Reorganization Events Since Pangea Breakup. *Annual Review of Earth and Planetary Sciences*, 44, 107-138.

O'Connor, J. M., Steinberger, B., Regelous, M., Koppers, A. A., Wijbrans, J. R., Haase, K. M., ... & Garbe-Schönberg, D. (2013). Constraints on past plate and mantle motion from new ages for the Hawaiian-Emperor Seamount Chain. *Geochemistry, Geophysics, Geosystems*, 14(10), 4564-4584.

Reagan, M. K., Heaton, D. E., Schmitz, M. D., Pearce, J. A., Shervais, J. W., & Koppers, A. A. (2019). Forearc ages reveal extensive short-lived and rapid seafloor spreading following subduction initiation. *Earth and Planetary Science Letters*, *506*, 520-529.

Shephard, G.E., Matthews, K.J., Hosseini, K., Domeier, M. (2017). On the consistency of seismically imaged lower mantle slabs. *Scientific Reports* 7.

van der Meer, D. G., van Hinsbergen, D. J., & Spakman, W. (2018). Atlas of the underworld: Slab remnants in the mantle, their sinking history, and a new outlook on lower mantle viscosity. *Tectonophysics*, 723, 309-448.