Tonga-Kermadec

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

The onset of the present-day Tonga-Kermadec subduction zone occurred at around **50 Ma** with the subduction of the Pacific plate under the Australian plate (e.g., Crawford et al., 2003; Whattam et al., 2008; Meffre et al., 2012). However, the date of this SZI event is highly debated, with some models suggesting that subduction was active since ~100 Ma (Schellart et al., 2006) and others that it started at ~30 Ma (van de Lagemaat et al., 2018).O

Most models suggest that the Tonga-Kermadec subduction zone initiated due to the collision of the Papuan peninsula with the trench of the New Caledonia subduction zone (NE dipping subduction) at around 55 Ma (e.g., Whattam et al., 2008). This collision jammed subduction locally and caused a **polarity reversal** that started the Tonga-Kermadec subduction zone in the north, which progressively propagated southward (e.g., Crawford et al., 2003; Whattam et al., 2008; Meffre et al., 2012). It is also suggested that W-dipping subduction was previously active in the same region (85-65 Ma) and that collision reactivated the fossil subduction zone (Whattam et al., 2008). In this case, the event could be considered as 'episodic subduction', but it is here preferred to use 'polarity reversal' as it is the main driving mechanism.

Direct evidence (based on direct measurements)

Meffre et al. (2012) dated forearc basalts to 52-49 Ma. However, they interpret these basalts as the product of back-arc magmatism of the east-dipping Loyalty-Three Kings subduction zone and thus are not related to the Tonga-Kermadec SZI event. *Boninites* are still forming today in the Tonga-Kermadec subduction zone (e.g., Cooper et al., 2010) and are thus not necessarily related to SZI. The oldest arc ages are ~44 Ma, found in rhyolitic lavas in the south part of the Tonga ridge basement (McDougall, 1994). Similar ages are also observed in different arc rocks in 'Eua Island (Todd et al., 2012).

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

In the model of Müller et al. (2016), the Tonga-Kermadec SZI event occurs at 44 Ma. The initiation of the Tonga-Kermadec subduction zone coincides with the cessation of a sub-parallel subduction zone ('South Loyalty Basin subduction zone) that lies between 0 and ~800 km to the southwest of the Tonga subduction zone (and passes through the trace of the future Kermadec subduction zone at a high angle). The location of the Tonga-Kermadec subduction zone furthermore appears to approximately trace an older subduction zone along the northeast side of the Proto-Loyalty Arc plate, which was active until 56 Ma. The initiation of the Tonga-Kermadec subduction zone was associated with the formation of a new plate, the North Loyalty plate, and shortly before the initiation of the Tonga-Kermadec subduction zone at 44 Ma, there was a major change in the motion and heading of both the Pacific and Australian plates at 47 Ma.

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

The Tonga-Kermadec slab is represented by a fast seismic anomaly reaching to a depth of 1500-1600 km (van der Meer et al. 2018), but P- and S-wave tomography models are consistent only until 1400-1550 km in the vote map (7-6 out of 10, respectively). The anomaly is quite homogeneous along the entire Tonga-Kerdamec trench, although the slab penetrates more vertically to the transition zone to the South (van der Meer et al., 2018).

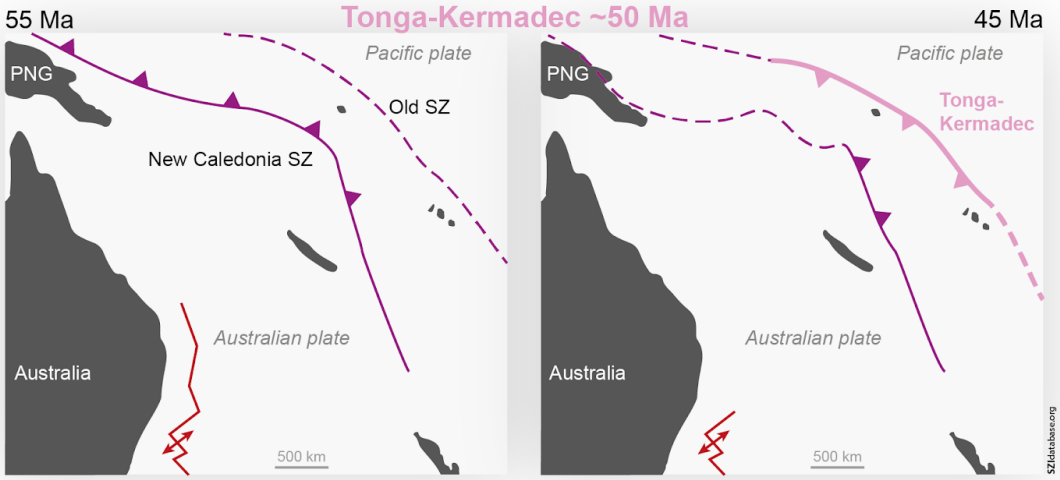

Figure. Schematic tectonic reconstruction of the Tonga-Kermadec SZI event (modified from Whattam et al., 2008). The collision of the Papua New Guinea continental block with the Loyalty-Three Kings trench is suggested to have caused a flip in subduction polarity, initiating the new Tonga-Kermadec subduction zone, possibly exploiting a weakness due to the presence of an old subduction zone. Shown are the new subduction zone (pink line), other active (solid purple lines) and inactive (dashed purple lines) subduction zones, and spreading ridges (solid red lines).

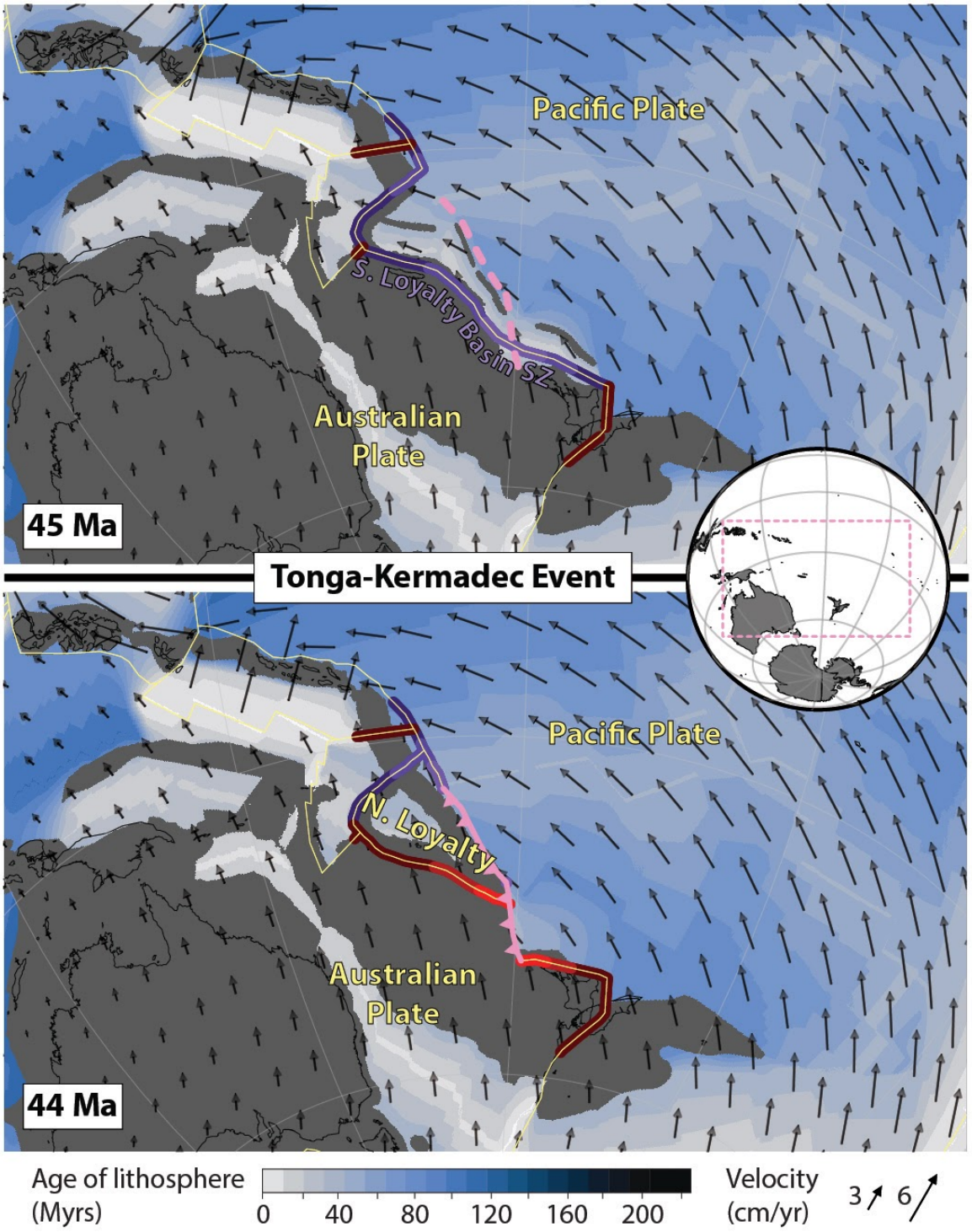

Figure. Tonga-Kermadec SZI event as reconstructed in the model of Müller et al. (2016). Pink dashed (solid with teeth) line shows the Tonga-Kermadec trench 1 Myr before (at) SZI time in the model. Purple (red) lines show segments of neighbouring subduction zones (ridges and transforms) that lie within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

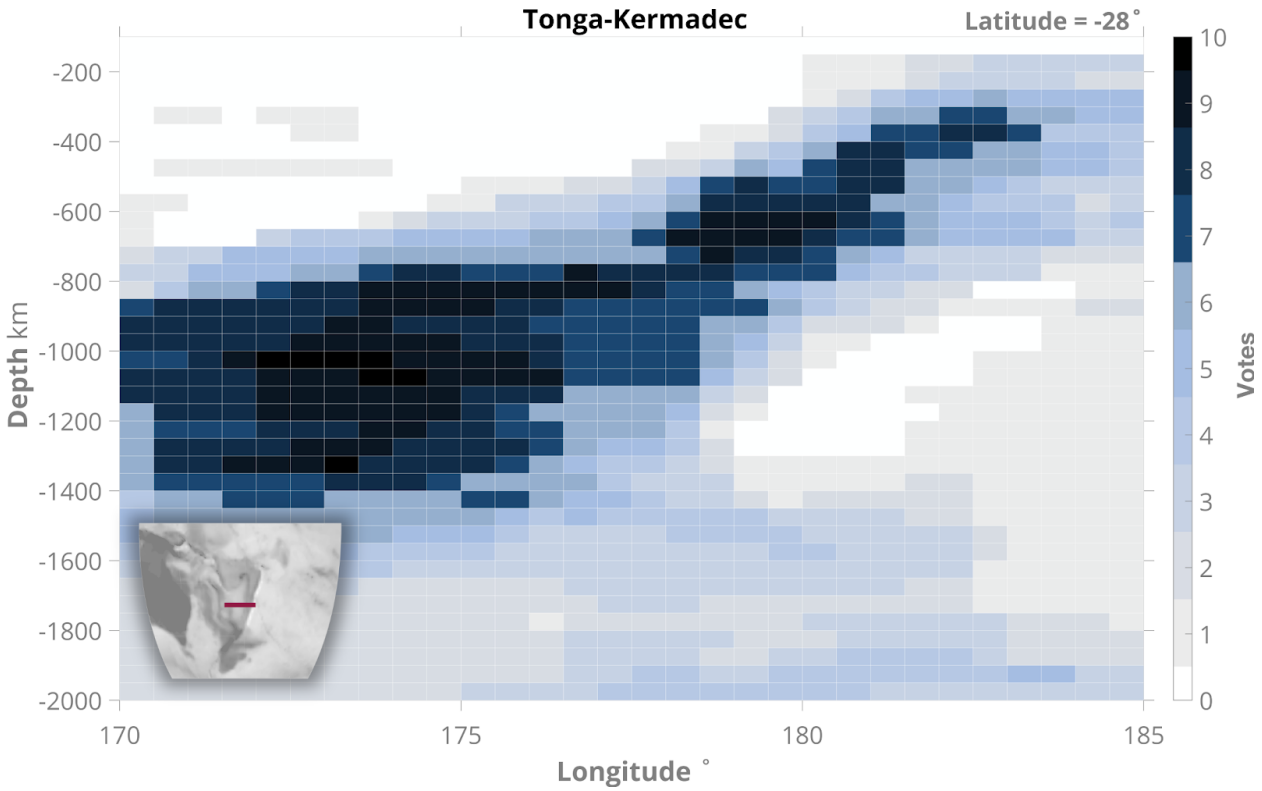

Figure. Seismic tomography VoteMap (Shephard et al., 2017) analysis of the Tonga-Kermadec SZI event.

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