New Hebrides - New Britain

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

The New Hebrides - New Britain (NHNB) SZI event evolved into the present-day subduction system that includes the New Hebrides, San Cristobal, and New Britain trenches. The Australian plate currently subducts below a former portion of itself, lying to the north-east, that today makes up the North Fiji Basin (e.g. Schellart et al., 2006). These trenches are all currently connected to each other and initiated at similar times, which is why their onset is here attributed to one single event.

It has been suggested that the onset of the NHNB subduction zone, which is related to subduction of the Australian plate below the Pacific plate, originated by a **reversal in subduction polarity** at around **10 Ma**. While some studies favour a time period for the SZI event between 10 and 6 Ma (Chase, 1971; Auzende et al., 1988), others suggest an onset age of between 14-11 Ma (Greene et al., 1994; Schellart et al., 2006). This polarity reversal likely occurred as a result of the collision of the Ontong Java plateau with the Vitiaz trench (e.g. Greene et al., 1994; Holm et al. 2013). The Ontong Java plateau lies on the Pacific plate that was subducting below the Australian plate during the collision, prior to the polarity reversal.

Direct evidence (based on direct measurements)

The arc associated with this SZI event builds on the pre-existing arc of the south-dipping subduction of the Pacific plate (before the polarity reversal). Therefore, the oldest ages found in the New Hebrides arc (~25 Ma) are linked to the previous subduction zone (Greene et al., 1994). At around 14-11 Ma the arc activity ceased. New arc volcanism starts again at around 6 Ma, this time related to the New Hebrides subduction (Monjoret et al., 1991; Greene et al., 1994). Similarly, along the New Britain trench, the subduction of the Pacific plate below the Australian plate built an arc (43-26 Ma). Afterwards, a gap in volcanic activity is observed between 20-12 Ma. Finally, arc volcanism associated with the new subduction zone (i.e., after the polarity reversal) started again at around 10-5 Ma (Holm et al., 2013).

Timing of SZI is based on the opening of the North Fiji basin interpreted as a backarc basin behind the New Hebrides subduction. Paleomagnetic data in different locations of the New Hebrides arc display a 28-52° clockwise rotation of the eastern limb of the arc since the Late Miocene in response to the opening of the North Fiji basin (Falvey, 1978; Musgrave and Firth, 1999). Magnetic seafloor anomalies identified in the North Fiji basin constrain the initial phase of basin opening to around 12-8 Ma (Auzende et al. 1988; Pelletier et al. 1993).

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

In the model of Müller et al. (2016), the New Hebrides - New Britain SZI event occurs at 12 Ma. This subduction zone initiated on the south side of an island arc that had a pre-existing subduction zone along its northern margin ('Pacific Melanesia subduction zone' in the model). The subduction zone on the north margin of the island arc, which had a south-dipping polarity (i.e., opposite to that of the New Hebrides - New Britain subduction zone), shutdown at the same time that the New Hebrides - New Britain SZ started (12 Ma). Thus, in this model, the New Hebrides - New Britain SZI can be seen as a subduction polarity inversion. The distance separating these subduction zones was ~200-350 km. In conjunction with this SZI event, the motion of the Solomon Sea plate changed at 12 Ma, but no major plate reorganisations occurred at or immediately before 12 Ma; the motion of the Australian and Pacific plates, for example, remained unchanged during this time.

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

The New Hebrides and the New Britain slabs are both imaged and cataloged in the Atlas of the Underworld (van der Meer et al., 2018). Both anomalies reach the upper-lower mantle boundary. However, the New Britain slab (575 km deep) seems to be shallower than the New Hebrides slab (675 km deep). Compared to a vote map, we find a consistent fast anomaly until around 800 km depth.

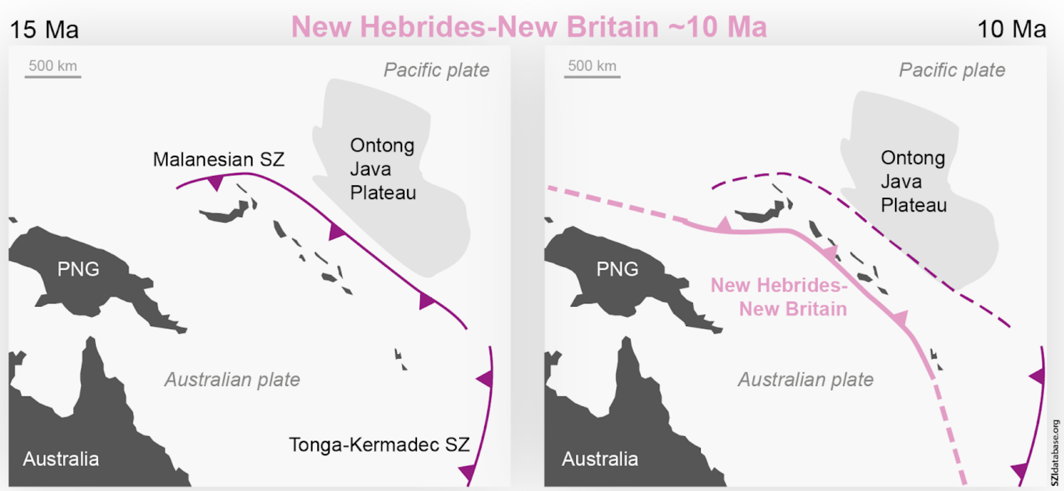

Figure. Schematic tectonic reconstruction of the New Hebrides-New Britain SZI event (modified from Schellart et al., 2006 and Holm et al., 2016). The collision of the Ontong Java plateau with the trench of the Malanesian subduction zone is suggested to have caused a flip in subduction polarity, initiating the New Hebrides-New Britain subduction zone. Shown are the new subduction zone (pink line) and other active (solid purple lines) and inactive (dashed purple lines) subduction zones.

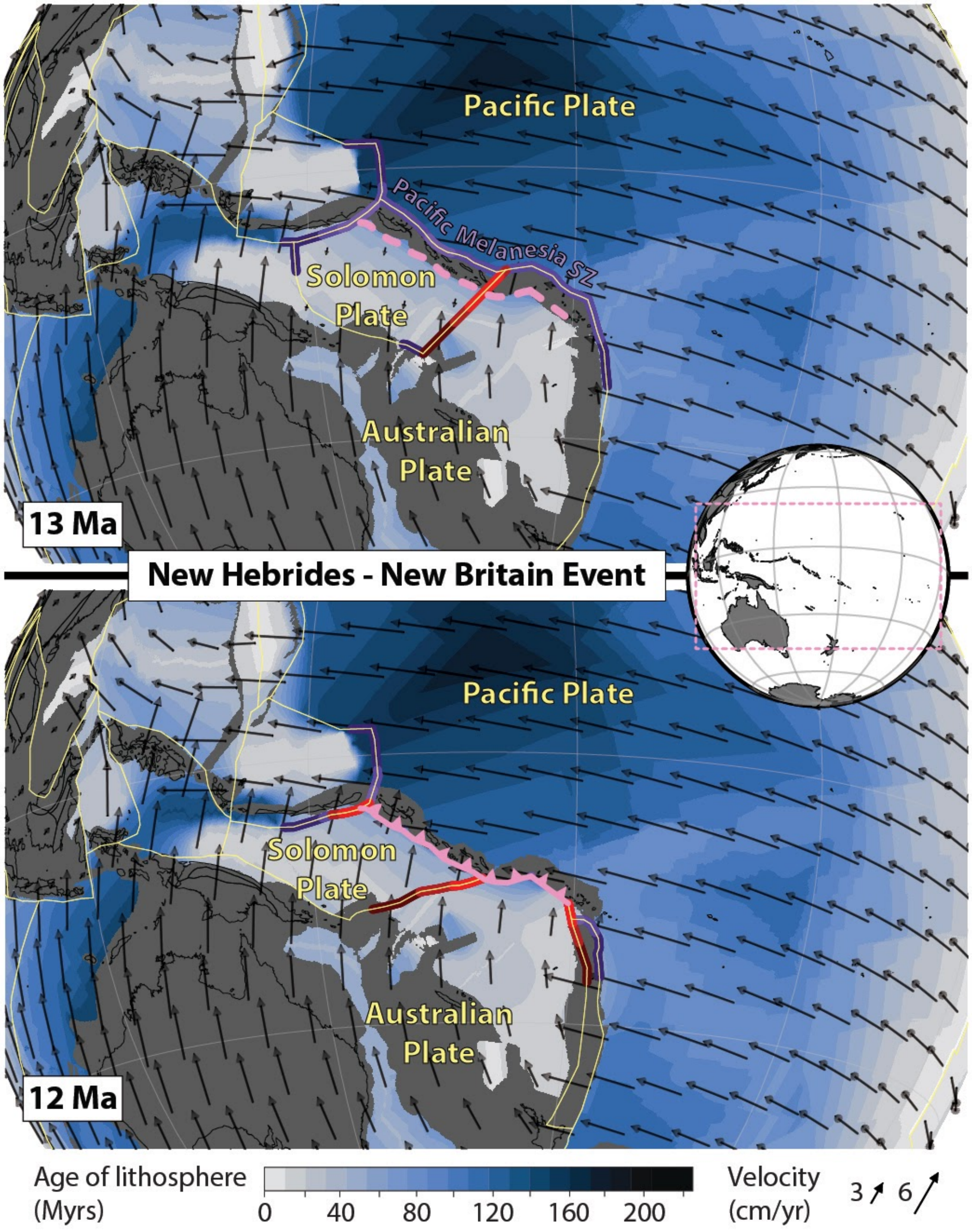

Figure. New Hebrides - New Britain SZI event as reconstructed in the model of Müller et al. (2016). Pink dashed (solid with teeth) line shows the New Hebrides - New Britain SZI trench 1 Myr before (at) SZI time in the model. Purple (red) lines show segments of neighbouring subduction zones (ridges and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

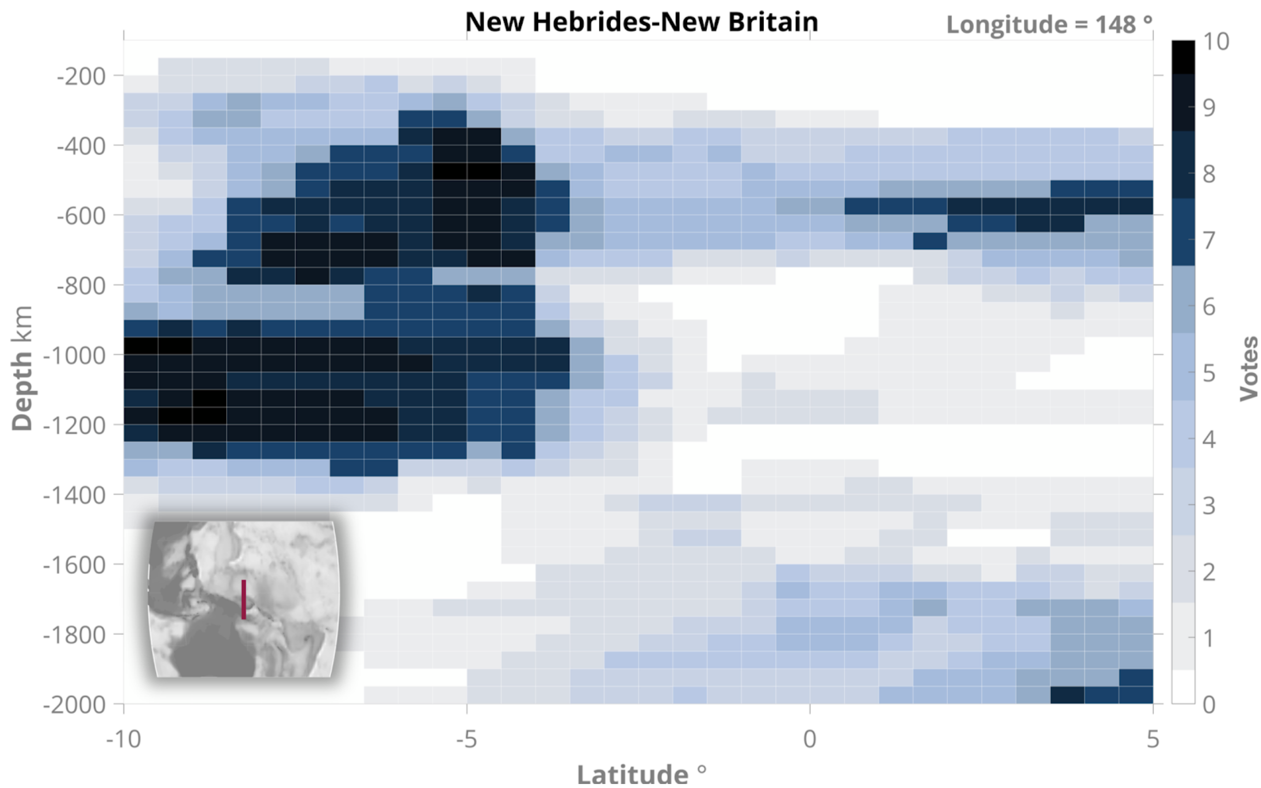

Figure. Seismic tomography VoteMap (Shephard et al., 2017) analysis of the New Hebrides-New Britain SZI event.

References

Auzende, J. M., Lafoy, Y., & Marsset, B. (1988). Recent geodynamic evolution of the north Fiji basin (southwest Pacific). *Geology*, *16*(10), 925-929.

Chase, C. G. (1971). Tectonic history of the Fiji Plateau. *Geological Society of America Bulletin*, *82*(11), 3087-3110.

Falvey, D. A. (1978). Analysis of palaeomagnetic data from the New Hebrides. Exploration Geophysics, 9(3), 117-123.

Greene, H. G., Collot, J. Y., Fisher, M. A., & Crawford, A. J. (1994). Neogene tectonic evolution of the New Hebrides island arc: A review incorporating ODP drilling results. In *Proceedings of the Ocean Drilling Program, Scientific Results* (Vol. 134, pp. 19-46). College Station, TX: Ocean Drilling Program.

Holm, R. J., Rosenbaum, G., & Richards, S. W. (2016). Post 8 Ma reconstruction of Papua New Guinea and Solomon Islands: Microplate tectonics in a convergent plate boundary setting. *Earth-Science Reviews*, 156, 66-81.

Holm, R. J., Spandler, C., & Richards, S. W. (2013). Melanesian arc far-field response to collision of the Ontong Java Plateau: geochronology and petrogenesis of the Simuku Igneous Complex, New Britain, Papua New Guinea. *Tectonophysics*, *603*, 189-212.

Monjaret, M. C., Bellon, H., & Maillet, P. (1991). Magmatism of the troughs behind the New Hebrides island arc (RV Jean Charcot SEAPSO 2 cruise): K-Ar geochronology and petrology. *Journal of Volcanology and Geothermal Research*, *46*(3-4), 265-280.

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.

Musgrave, R. J., & Firth, J. V. (1999). Magnitude and timing of New Hebrides Arc rotation: paleomagnetic evidence from Nendo, Solomon Islands. Journal of Geophysical Research: Solid Earth, 104(B2), 2841-2853.

Pelletier, B., Lafoy, Y., & Missegue, F. (1993). Morphostructure and magnetic fabric of the northwestern North Fiji Basin. Geophysical Research Letters, 20(12), 1151-1154.

Schellart, W. P., Lister, G. S., & Toy, V. G. (2006). A Late Cretaceous and Cenozoic reconstruction of the Southwest Pacific region: tectonics controlled by subduction and slab rollback processes. *Earth-Science Reviews*, *76*(3-4), 191-233.

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.