Complex phase transitions and seismogenic stresses in the Tonga subduction region

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The Tonga-Kermadec-Hikurangi subduction zone forms a compact and one of the most complex plate tectonics systems on planet Earth. The tectonism in the Southwest Pacific region started in the Late Cretaceous (i.e. approx. 100 Ma ago). The onset of subduction of the Pacific plate below the Australian plate along the Tonga-Kermadec-Hikurangi subduction zone still remains enigmatic and a subject of scientific debate. According to previous research a wide range of 30-85 Ma [e.g. van de Lagemaat et al., 2018] was suggested for the subduction initiation in this region. Nowadays, the Pacific plate is subducting under the Australian plate at the Tonga-Kermadec-Hikurangi subduction boundary moving west-northwestward at a velocity of approximatelly $5 - 11$ cm/yr [Schellart and Spakman, 2012].

Focal mechanisms of deep earthquakes in the transition zone usually show down-dip compressional stresses which are typical for slabs at these depths due to the resistance to penetration into the lower mantle. The Tonga slab seems to be special in this regard. Fukao et al. [2014] observed a set of unusually deep earthquakes at $\sim$ 680 km depths to exhibit focal mechanisms with vertical tension and horizontal compression. Such rotation of compressional stress axes toward the horizontal is most probably connected with the forces exerted by the phase transitions and viscous resistance of the lower mantle. They could be caused by various effects: bending of the slab in the transition zone, viscous coupling between the slab and the lower mantle when the bent portion of the slab is driven sideways, interplay between the positive petrological buoyancy and negative thermal buoyancy of the slab above and under the 660 km phase transition. The phase transitions in this exceptionally old and cold slab are probably affected by recently reported complicated phase transformation of ringwoodite to bridgmanite through akimotoite. In this study we employ numerical modelling to test the above mentioned mechanisms and their effect on possible stress rotation.

References

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