Slab temperature controls on the Tonga double seismic zone and slab mantle dehydration

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We present precise hypocenters of intermediate-depth earthquakes in the Tonga subduction zone obtained using data from local island-based, ocean bottom, and global seismographs. The results show a clear double seismic zone, with a downdip compressional upper plane and a downdip tensional lower plane with a separation of about 30 km. The double seismic zone in Tonga extends to about 300 km depth, deeper than in any other subduction system. This is due to the lower slab temperatures resulting from faster subduction, as indicated by a global trend towards deeper double seismic zones in colder slabs. Additionally, a line of high seismicity in the upper plane (“seismic belt”) is observed at 160–280 km depth, which shallows southwards as the convergence rate decreases. Thermal modeling shows that the earthquakes in this seismic belt occur at various pressures but a nearly constant temperature, which highlights the important role of temperature in triggering intermediate-depth earthquakes. This seismic belt may correspond to regions where the subducting mantle first reaches temperatures of ~500°C, implying that metamorphic dehydration of mantle minerals in the slab provides water to enhance faulting.

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