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Could a deep earthquake cluster under Northeast China be associated with transformational faulting in an old Pacific slab?

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Deep‐focus earthquakes and their association with metastable olivine wedges (MOWs) remain enigmatic. Here, we perform a seismic-geodynamic analysis of the Pacific slab, which is stagnant at the 660 km deep bottom of the mantle transition zone. We investigate deep earthquakes with moment magnitudes (Mw) ranging from 5.3 to 6.9 from 2009 to 2017. They exhibit only minor (mostly implosive) isotropic components, yet they display strongly varying CLVD components. For the largest studied earthquake (Mw 6.9, 2010-02-18), we demonstrate significant stress-drop heterogeneity on a subhorizontal fault and a spatial change in radiation efficiency. We interpret the earthquakes with an evolutionary numerical subduction model with realistic mineralogy and rheology, including non‐uniform plate aging and subduction disruption due to the Izanagi–Pacific ridge sinking in the early Cenozoic. This process resulted in a present-day slab with a bent tip that agrees with tomography. The slab maintains low temperatures (900-1000 K), allowing the presence of a metastable olivine and thus potentially forming MOW with a correspondingly bent geometry. The accompanying internal deformation controls the deep seismicity in the slab tip with apparent changes in seismic radiation efficiency and rupture speed across the modeled temperature gradients. From a broader perspective, the MOW contortion may contribute to deformational anisotropy in the shallow lower mantle. Our results underscore the importance of joint interpretations of the evolutionary subduction models and seismic source inversions.

Reference:

Liu, J., Zahradník, J., Plicka, V., Gallovič, F., Bina, C. R., Čížková, H. (2025). Deep-Focus Earthquakes Under Northeast China—An Imprint of the Complex Tectonic History of Pacific Plate Subduction, J. Geophys. Res. Solid Earth 130, e2024JB030215. https://doi.org/10.1029/2024JB030215.