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# Inferring the hydration of downgoing oceanic crust and lithospheric mantle from intermediate-depth earthquakes and outer rise faulting patterns

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It is commonly assumed that intermediate-depth seismicity is in some way linked to dehydration reactions inside subducting oceanic lithosphere. There is growing evidence that the hydration state of an oceanic plate is controlled by its structure and degree of faulting at the outer rise, but we do not yet have a quantitative understanding of this relationship.

Double seismic zones offer the possibility of investigating changes in oceanic-plate hydration not only along strike but also with depth beneath the slab surface. To quantify the impact of oceanic-plate structure and faulting on slab hydration and intermediate-depth seismicity, with a focus on the genesis of double seismic zones, we correlate high-resolution earthquake catalogs and seafloor maps of ship-based bathymetry for the northern Chilean and Japan Trench subduction zones. The correlations show only a weak influence of oceanic-plate structure and faulting on seismicity in the upper plane of the double seismic zone, which may imply that hydration is limited by slow reaction kinetics at low temperatures in the oceanic crust 5–7 km below the seafloor and by the finite amount of exposed wall rock in the outer-rise region. These factors seem to limit hydration even if abundant water is available.

Seismicity in the lower plane is, in contrast, substantially enhanced where deformation of the oceanic plate is high and distributed across intersecting faults. This likely leads to an increase in the volume of damaged wall rock around the faults, thereby promoting the circulation of water to mantle depths where serpentinization is faster due to elevated temperatures. Increased lower-plane seismicity around the projection of subducting oceanic features such as seamounts or fracture zones to depth may also be caused by enhanced faulting around these features. Our results provide a possible explanation for the globally observed presence of rather homogeneous upper-plane seismicity in double seismic zones as well as for the commonly patchy and inhomogeneous distribution of lower-plane seismicity.