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A tale of two modern flat slabs along the South America Convergent Margin

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The Peruvian and Pampean modern flat slab segments along the South American margin provide insights into the process of flat-slab subduction. Recent seismic imaging, using a wide range of techniques, has given us unprecedented views of both of these modern flat slabs' geometries and processes. Both of these flat slab segments have near-horizontal subducting segments that correspond to subducting oceanic ridges with overthickened oceanic crust, gaps in the modern volcanic arc, and inland crustal deformation. However, the two flat slabs flatten at different depths and displays different rates of seismicity, suggestive of variable degrees of hydration. Our seismic imaging shows that the subducting Nazca Ridge segment at the southern end of the large Peruvian flat slab has an oceanic Moho that is horizontal at a depth of ~70 km. Considering the overthickened oceanic crust of the Nazca Ridge, the top of the slab is likely at a depth of ~50-55 km and in direct contact with the continental crust. The subducting Nazca Ridge has displaced the South American lithospheric mantle and likely part of the lower continental crust beneath the high Andes suggesting the flat slab segment is strongly coupled to the over-riding plate. Seismic tomography shows the near-horizontal slab extends ~500 km inland before re-subducting at a near vertical angle into the mantle before flattening out in the lower mantle below the transition zone. However, the velocity contrast associated with the oceanic Moho weakens at ~350 km from the trench consist with eclogitization of the oceanic crust. This requires that the inboard continuation of the flat slab be supported by a mechanism other than low density oceanic crustal material. The continuation of the flat slab after eclogitization coincides with a large low-velocity anomaly imaged immediately below the flat slab that we identified in tomography studies. We hypothesize that this feature may provide at least some support for the flat slab. The subducting flat slab has relatively low rates of seismicity especially compared to the Pampean flat slab region.

In the case of the Pampean flat slab where the Juan Fernandez Ridge is subducting, we observe a high rate of seismicity in both the slab and the over-riding continental crust. Within the region, we image the horizontal oceanic Moho at ~100-110 km depth before it re-subducts into the mantle at a ~30-40° dip. As the subduction angle steepen, the oceanic Moho disappears, possibly because the oceanic crust has transformed to eclogite. The flat slab is at the base of the continental mantle lithosphere with no evidence of any asthenospheric wedge until the slab re-subducts. The high rate of seismicity is consistent with oceanic crust dehydration although the fate of any released fluids is uncertain. Seismic imaging indicates that both flat slabs have tears, although they are at different depths with different geometries and magnitudes. The tears associated with the Peruvian flat slab are generally shallow and north and adjacent to the Nazca Ridge and suggest that the subducting slab is in the early stages of breaking up. In the case of the Pampean flat slab, the largest tear is at a depth of 200-300 km down dip of the flat portion of the slab.