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Subduction-Driven Recycling of Continental Margin Lithosphere

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Subduction recycling of oceanic lithosphere, a central theme of plate tectonics, is relatively well understood. Recycling continental lithosphere is more difficult to recognize, can take a number of different forms, and appears to require an external trigger for initiation. Delamination and localized convective downwelling are two processes invoked to explain the removal of lithospheric mantle under or adjacent to orogenic belts. We describe a related process that can lead to the loss of continental lithosphere adjacent to a subduction zone: Subducting oceanic plates can entrain and recycle lithospheric mantle from an adjacent continent and disrupt the continental lithosphere far inland from the subduction zone.

Body wave tomograms from dense broadband seismograph arrays in northeastern South America (SA) and the western Mediterranean show larger than expected volumes of positive velocity anomalies which we identify as the subducted Atlantic slab under northeastern SA, and the Alboran slab beneath the Gibraltar arc (GA). The positive anomalies lie under and are aligned with the continental margins at sublithospheric depths. The continental margins along which the subduction zones have traversed, i.e. the northeastern SA plate boundary and east of GA, have significantly thinner lithosphere than expected. The thinner than expected lithosphere extends inland as far as the edges of nearby cratons as determined from receiver function images and surface wave tomography. These observations suggest that subducting oceanic plates viscously entrain and remove continental mantle lithosphere from beneath adjacent continental margins, modulating the surface tectonics and pre-conditioning the margins for further deformation. The latter can include delamination of the entire lithospheric mantle and include the lower crust, as around GA, inferred by results from active and passive seismic experiments. Viscous removal of continental margin lithosphere creates LAB topography leading to convective downwellings under the continental interior: We image one under SA and we infer that one or more have occurred in the past under the western Mediterranean. Removal of continental margin lithosphere by subduction-driven recycling helps reconcile numerous, sometimes mutually exclusive, tectonic models proposed to explain the complex oceanic-continental tectonics of these two subduction zones.