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Origin of Long-Wavelength Magnetic Anomalies at Subduction Zones

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Most subduction zones have associated long-wavelength anomalies that can be seen in satellite models of the geomagnetic field. These signatures are not predicted by forward models in which magnetisation is confined to the continental crust and oceanic lithosphere that has not yet been subducted. To understand the origin of these anomalies, we model subduction zones defined by seismicity and seismic tomography using vertically integrated magnetisations (VIM) that cover a range of scenarios, from increasing to decreasing magnetisation away from the trench. These mimic end members of a magnetised dipping lithospheric slab, a magnetised mantle wedge, as well as intermediate cases, and are added to a global model of VIM based on continental and oceanic geology. We find that using a VIM distribution analogous to a dipping slab places the anomaly too close to the trench, while the other cases fit the data equally well, and use models where VIM is uniform across the slab region in the main part of the study. Anomalies at the Sunda, Aleutians, Cascadia, Central American and Kamchatka-Japan trenches are well modelled by uniform VIM of differing susceptibilities and lengths. We show the South American anomaly is weak because the magnetisation lies mainly in the null space that produces no external potential magnetic field; Izu-Bonin is similar but has a somewhat stronger anomaly because of its higher geomagnetic latitude. There is no anomaly associated with the Ryukyu system, an observation which our models fail to explain. The magnetic anomaly stretching down the Baja California peninsula to Cabo Corrientes in Mexico is not present in the prediction because there is no seismicity on which to base a slab geometry, but recent tomography suggests a fossil slab there and we propose that a the observed magnetic anomaly is related to historic subduction along the entire length of Baja.