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Evidence of South American Lithosphere Mantle beneath the Chile Mid-Ocean Ridge

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Numerous geochemical studies on mid-ocean ridge basalts have established the presence of both compositional and lithological heterogeneities in the upper mantle. These studies have successfully constrained the composition and age of the chemical heterogeneities within the Earth's upper mantle. However, the origin of those heterogeneities remains highly debated. The Chile Mid-Ocean Ridge in the southeast Pacific Ocean is one of the few places on Earth, which is colliding and subducting under the South America plate for the last ~14 million years promoting the formation of a slab window. This unique geological framework provides an unprecedented opportunity to understand the interaction between the Andean sub-arc mantle and Chile Ridge mantle. Comprehensive geochemical data (major, trace, volatile element contents and Sr, Nd, Hf and Pb isotope ratios) on Chile Ridge submarine glasses collected over the 1000 km ridge length demonstrate significant mantle compositional variability, some carrying an unusual "arc-like" trace element signature (Nb/U as low as 5.4, Ce/Pb as low as 12.5). Four main mantle components have been recognized for the Chile Ridge glasses: the typical Pacific MORB mantle, an enriched mantle (e.g., EM-1), a Subduction Modified mantle, and an anciently depleted mantle with unusually high Hf isotope ratios. Surprisingly, despite the large compositional variability, all glasses - including those with a subduction signature - have volatile-refractory element ratios (H_2O/Ce = 78-327) within the range of the Pacific normal MORB. We propose that the Patagonia sub-continental lithospheric mantle, variably metasomatized since the Early Paleozoic, is eroded and incorporated into an asthenosphere with a south Atlantic MORB mantle composition that is flowing westward through the slab window from South America to the Chile Ridge. This scenario contrasts with a well-accepted geodynamic model that predicts the opposite direction of mantle flow.