Continental Relamination Drives Compositional and Physical-Property Changes in the Lower Crust

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A long-standing paradigm for the genesis and evolution of Earth's continental crust holds that the crust is andesitic and reached this composition in the 'subduction factory' by delamination or foundering of a dense, mafic or ultramafic component into the mantle from the base of initially basaltic arc crust. However, the range of suggested compositions for the lower crust and our incomplete understanding of subduction-zone processes render this paradigm non-unique. Recent discoveries from (ultra)high-pressure xenoliths and terranes, combined with re-evaluation of methods for inferring lower crustal compositions from seismic velocity data, show that "relamination" of buoyant, subducting continental crust may be an efficient means of altering the composition of the lower crust.

Ultrahigh-pressure terranes show that large areas (>60,000 km^2) of continental crust are subducted to depths >100 km where they undergo heating to temperatures of 600–1000°C for periods of up to 20 Myr. Xenoliths from the Pamir show that subduction erosion can drag continental rocks to depths >90 km and temperatures of ~1200°C. In both settings, devolatilization and melting transform cold, hydrous, low-density crust into hot, less hydrous residues. Felsic and intermediate rocks attain densities similar to the middle–lower continental crust; buoyancy may drive such rocks to rise through the mantle to pond at the Moho or higher crust levels. The calculated seismic wavespeeds of such material are indistinguishable from the bulk lower crust. Both ultrahigh-pressure continental subduction and subduction erosion operate at rates of 1–1.5 km^3/yr, such that over the lifetime of Earth either could have led to large-scale 'continental relamination', refining the composition and physical properties of the continental lower crust.