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The Fate of Subducted Continental Crust: an Experimental Perspective

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The occurrence of ultra-high pressure metamorphic (UHPM) index minerals within rocks from continental collision zones indicates that continental rocks may descend into the Earth's upper mantle and leave specific geochemical signatures during the continental collision.

The idea that volumetrically abundant lithologies of continental crust could be subducted into the transition zone has also been proposed from geochemical and seismic tomographic studies. It has long been suggested that continental crust is buoyant than that of the mantle rocks, and therefore might be gravitationally trapped during subduction. In order to understand the fate and exhumation of subducted continental crust, we conducted experimental studies up to 24GPa and 1800degree on natural UHPM gneisses in bulk compositions corresponding to average upper continental crust and terrigenous rocks, using piston-cylinder and multi-anvil apparatus. We found that the upper continental crust is no longer buoyant with respect to the surrounding mantle when it has been transported to a depth of 250 km (˜8-9 GPa), which defines the 'depth of no return' for the subducted upper continental crust. This in turn is consistent with the depth limit for most exposed UHPM rocks. Our experimental results suggest that the transformed subducted upper continental crust with a jadeite stishovitite lithology has the potential to sink into the transition zone. However, this density relationship is reversed at the base of the transition zone, leaving subducted upper continental crust being trapped at the bottom of the upper mantle, due to the presences of perovskite and magnesiowustite in the lower mantle.

Our results suggest that phengite/K-mica and epidote/lawsonite would be the dominant H2O carriers in the continental subduction zones at various depths above the transition zone. The thermal models of continental subduction zones would allow phengite and epidote/lawsonite to be transported to the mantle as deep as 300 km. The hydrous minerals were finally replaced by stishovite, garnet, and K-hollandite assemblage before reaching the transition zone, implying that water released from the continental crust cannot effectively transported into Earth's transition zone. The stabilities of phengite and epidote/lawsonite have significant implications for the recycling of large ion lithophile elements (LILEs) and other elements of continental signatures into the mantle. Some nominally anhydrous minerals (NAMs) such as stishovite, jadeite, and K-hollandite could also play an important role as the H2O carries in the transition zone.

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