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Ultra-deep Subduction of Continental Crust: Evidence from Natural Rocks and Experimental Investigations

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Much of what we know about the deep subduction of continental crust is gained from study of the mineralogy of ultrahigh-pressure metamorphic (UHPM) rocks incorporated within continent-continent collision belts. UHPM rocks of metasedimentary origin were only recently recognized due to discovery of coesite, diamond, titanite inferred to have contained six-fold coordinated Si before exsolution of coesite, and TiO₂ with alpha-PbO₂ structure. Modern seismic tomography provides remarkable images that suggest lithospheric plates are subducted to the core-mantle boundary and may remain there stagnated during long geological times; the presence of continental material within such plates cannot be excluded. The mineral phase transformations possible within deeply subducted continental crust have been the subject of intensive laboratory experimentation during the last decade. Though many new UHP minerals were synthesized at P~ 6 to >20 GPa (e.g., wadeite, topaz-OH, phase Egg, K- and Na-hollandite) in the KNASH, KASH and ASH chemical systems, none except topaz-OH has yet been identified in UHPM rocks. The microstructural evidence of former majoritic garnet decompression is proven only for garnet peridotite, whereas no evidence of such structures has been reported yet from diamondiferous felsic rocks. It is not clear if this is because the UHPM minerals of felsic rocks are easily lost during retrograde metamorphism, or if this is because garnets crystallized in the felsic systems do not contain a large majoritic component at high pressures. There is no clear indication of what portion of subducted continental crust is returned back to Earth's surface, and what fraction may have become more dense than mantle rocks and sunk down to the mantle transition zone and even deeper. Is there any connection between mantle plumes and deeply subducted continental rocks? The UHPM discipline would also benefit from new experiments designed to reproduce decompression structures of UHP minerals and evaluation of melting in rocks of diverse crustal lithologies during very deep subduction to enable numerical modeling to predict what other phases or decompression products may yet be found in UHPM rocks.