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Recycling of continental sediments into the deep mantle: Experimental constraints at 15-25 GPa

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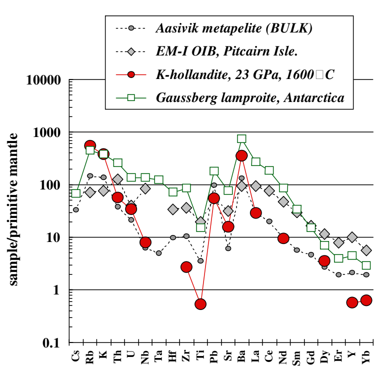
There is strong geochemical and geophysical evidence for deep recycling of continent-derived sedimentary lithologies, via subduction, through and in some cases beyond the mantle transition zone and into the lower mantle. In particular, EM-type ocean-island basalts (OIBs) associated with upwelling plumes rising from the deep mantle often carry a "continental" isotopic and geochemical signature, and lamproites from Gaussberg, Antarctica, have been interpreted as representing partial melts from the transition zone containing admixtures of subducted Archean sediments [1]. We have carried out a series of phase-equilibria experiments in the multi-anvil apparatus at 15-25 GPa on a natural metapelite from the Aasivik terrane in West Greenland. These experiments show that K-hollandite ($KalSi_3O_8$) is stable into the lower mantle at at temperatures below 1800-1900°C, and comprises approxinmately 30-40% of the high-pressure phase assemblage. Ion microprobe analyses of K-hollandite indicate that this phase is the principle repository for heat-producing and large-ion lithophile elements in deeply subducted sediments, carrying most of the K, U, Th and incompatible elements of the bulk starting material. The primitive-mantle normalized trace-element abundance pattern of K-hollandite mimics those of typical EM-I type OIB from French Polynesia and the Gaussberg lamproites, especially in terms of their relative Ti-Pb-Sr-Ba-La ratios (see Fig. below), implicating hollandite breakdown in the petrogenesis of these rocks.



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5.1.42

Petrology of the lowermost mantle

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Seismic observations of the thermal boundary layer abov the core-mantle boundary (CMB), including Ultra-Low Velocity Zones and D" discontinuities with velocity jumps of either sign, suggest that the bottom of the mantle may be compositionally distinct and, in places, partially molten[1]. Our new shock-wave data constrain the melting curve and liquid equation of state (EOS) of the key lower mantle component $MgSiO_3$ perovskite and suggest neutral or negative buoyancy of this melt at CMB pressure.

Extending this result to allow quantitative testing of candidate compositions for the D" layer requires a thermodynamically consistent model in which the EOS for liquids and solids govern density, sound velocity and the changes in phase stability with pressure. Shock-wave, diamond-anvil, multianvil, and ambient pressure data on lower-mantle phases and liquids in the MgO-FeO-CaO-SiO_2 system are used to formulate and calibrate a preliminary model. The model predicts seismic signatures and melting behavior for model D'' compositions: normal pyrolite, subducted slab material, core-mantle reaction products, and primitive (accretion core) material.

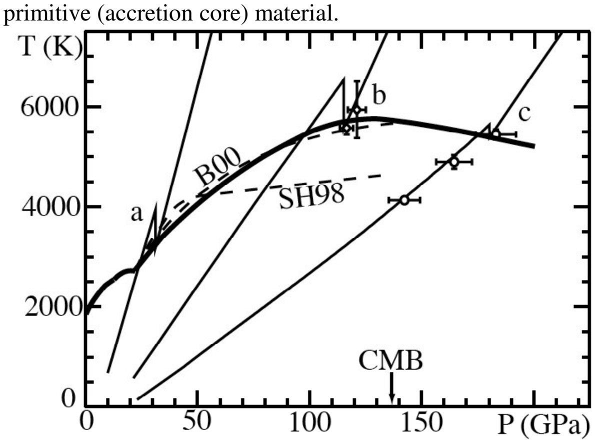

Figure 1. Melting curve of $MgSiO_3$ perovskite based on shock temperature (ST) data. B00[2] and SH98[3] are extrapolations of diamond anvil cell data. a, b, and c are Hugoniot ST of porous MgO+SiO_2, glass, and crystal $MgSiO_3$. From shock EOS data, volume change on melting is positive at a, about zero at b, and negative at c.

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