The nature of water induced small degree melts in the deep mantle

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Slow S-wave velocities in the deep mantle have been used to argue for the presence of hydrous silicate melts. Small degree partial melts could potentially be formed due to a reduction in the H_2O storage capacity of mantle minerals due to pressure induced phase transitions or as a result of redox processes. Hydrous melt layers could accumulate at certain depths in the mantle due to neutral buoyancy. Water concentrations in the ambient mantle are at most likely to lead to only small degrees of melting. Such incipient melts would be in equilibrium with a peridotite assemblage containing minerals that would be practically identical in major elements as the unmelted assemblage. The compositions of such melts are important because their water contents constrain the relationship between melt fraction and the bulk water content. Furthermore, the water content and the iron content would mainly determine their buoyancy. To assess if neutrally buoyant small degree hydrous melt layers exist in the mantle and to determine how much water would need to be present to create them requires experimental determination of their compositions.

Determining the chemical composition of low degree melts and particularly their water contents is experimentally very challenging. At pressures higher than 2 GPa melts no longer quench to form glasses and can therefore not be analyzed to determine water contents. Small melt fractions are very hard to analyze due to their very small volume and due to modification through reaction with solid phases during quenching. One way to overcome these problems and produce an analyzable portion of incipient melt composition is by performing sandwich experiments. In this method an initial first guess melt composition is equilibrated with a sub-equal proportion of peridotite. The resulting melt is then re- equilibrated with peridotite in a series of iterative experiments until a composition is obtained that is in equilibrium with the entire peridotite assemblage.

We have used this procedure to determine the compositions of incipient melts at depths equivalent to around 200 and 400 km in the mantle at adiabatic temperatures. The sandwich technique has to be modified in a number of ways when used at very high pressures, mainly to ensure that water contents can be accurately determined through mass balance. The resulting melts have affinities with the major classes of kimberlite magmas and their compositions can be used to assess their buoyancy in the deep mantle.

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