Slab melting as a transition zone carbon filter

ANDREW R. THOMSON[1]*, MICHAEL J. WALTER[2], SIMON C. KOHN[2] AND RICHARD A. BROOKER[2]

[1]Department of Earth Sciences, University College London, WC1E 6BT (*correspondance: a.r.thomson@ucl.ac.uk).

[2]School of Earth Sciences, University of Bristol, BS8 1RJ.

The exchange of volatile elements between crustal and mantle reservoirs dominates the surface volatile inventories on geological timescales, controlling atmospheric composition and maintaining a habitable planet [1]. Whilst volcanic outgassing controls the addition of volatiles to the atmosphere, subduction is responsible for the replenishment of mantle reservoirs. Many sub-lithospheric diamonds contain inclusions that possess a strong affinity with recycled oceanic crust [2], which is evidence for the survival of carbon in subducting assemblages to deep upper mantle depths.

Previous experimental studies have investigated the melting behaviour of recycled basalt, but these studies have considered a limited and somewhat displaced compositional spectrum when compared with natural mid-ocean ridge basalt (MORB) rocks. Furthermore, all previous studies have used bulk compositions with very high CO_2 contents and only one extends to transition zone pressures. Therefore, to understand better the behaviour of deeply subducted crust we have determined the high pressure melting phase relations of a synthetic MORB composition containing 2.5 wt.% CO_2 [3].

Our results show there is a deep depression of ~200 °C along the solidus of carbonated MORB between 300 and 700 km depth. This is explained by the shift towards more Na-rich clinopyroxene compositions and saturation of an Na-carbonate mineral (approximately $Na_{0.33}Ca_{0.67}CO_3$) in the subsolidus phase assemblage with increasing pressure. Melting is expected to occur in the majority of slabs as subduction geotherms intersect the solidus depression. Near solidus melts are alkaline carbonatites that are highly mobile and reactive with overlying peridotite [4]. Our simulation of this reaction generates a mineral assemblage that reproduces many characteristics of diamond-hosted inclusion suites.

We predict that the solidus depression forms a barrier to the carbon transport into the deepest mantle that may have operated throughout Earth's history. Natural diamonds appear to provide direct evidence of the carbon filter, a process of fundamental importance in the Earth's deep carbon cycle.

[1] Zahnle et al. (2007) *Space Sci. Rev.*, 129, 35–78. [2] Thomson et al. (2014) *Contrib. Mineral. Petrol.*, 168, 1081. [3] Thomson et al. (2016) *Nature*, 529, 76-79. [4] Hammouda & Laporte (2000) *Geology* 28, 283–285.