The origin of carbonate globules in silicate melts: Solids or liquids?

S.C. McMahon*, D.K. Bailey, M.J. Walter and L. Caricchi

Department of Earth Sciences, University of Bristol, BS8 1RJ (*correspondence: Sorcha.McMahon@bristol.ac.uk)

Carbonate globules found in mantle xenoliths, as inclusions in mantle minerals and in juvenile silicate melt lapilli are possible examples of primitive carbonatitic melts from the mantle [1]. Here we present findings from carbonate globules from Finca La Nava, a matrix-supported carbonatite tuff in the Calatrava Volcanic Province in central Spain; an alkaline mafic-ultramafic province comprising over 250 monogenetic cones and vents [1]. Carbonate globules are prolific within silicate melt lapilli. Silicate melts of at least two different compositions, melilitite and kamafugite, have been discovered within this one outcrop.

The origin of the carbonate globules within melt lapilli is debatable. Globule textures including curved menisci against silicate melt, budding, and coalescing of the globules, are compelling evidence for liquid immiscibility. However, recent experimental results suggest that similarly-shaped globules formed as solid calcite crystals in equilibrium with silicate melt [2]. Many, but not all, globule interiors in the Calatrava lapilli are apparently nearly phase-pure calcium carbonate with minor Mg, but Si, Al, and Na are virtually absent. Yet experiments show that carbonatitic melts equilibrated with mantle silicates or silicate melts can dissolve significant amounts of these elements, suggesting that the globules may have originated as solid calcite, as in the experiments. So did these carbonate globules originate as solids or liquids?

The 'pure' globules are in fact both compositionally and texturally heterogeneous on a micron scale. Initial findings made on the basis of sub-micron elemental mapping using a FEG-SEM demonstrate that considerable quantities of additional components of Si and Al, amongst other major elements, appear to have been exsolved and segregated to the globule rims during crystallisation. Such a mechanism may explain the observed 'pure' calcium carbonate composition of many globule interiors, and supports an immiscible liquid model for carbonatite tuff genesis in Calatrava.

[1] Bailey *et al*. (2005). *Mineral Mag* **69**, 907-915. [2] Brooker & Kjarsgaard (2010) *Journal of Petrology* doi: 10.1093/petrology/egq081

Timing and duration of Heinrich events in the North Atlantic

Jerry F. McManus

Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, USA
(*correspondence: jmcmanus@ldeo.columbia.edu)

The repeated iceberg discharges into the North Atlantic during the Pleistocene, known as Heinrich events, are widely believed to have influenced the global climate. Their millennial pacing, abrupt occurrence, and widespread impact make them important targets for understanding the rates of climate change. Efforts to date the sedimentary layers associated with these events have achieved some success, particularly for the few events within the range of ^{14}C methods. Similarly, the duration of the youngest events has been estimated by foraminifera ^{14}C and sedimentary $^{230}Th_{xs}$. Beyond these most recent events, the Heinrich layers of ice-rafted sediments have typically been dated by correlation to other sedimentary archives with independent chronologies, such as ice cores and speleothems. In this study, two different approaches to $^{230}Th_{xs}$ profiling have been utilized to explore directly the absolute timing and duration of each of the Heinrich events that occurred during the last large climate cycle of the Pleistocene. Both approaches incorporate new sedimentary data generated by ICP-MS at locations where initial results were produced by alpha counting. Heinrich event H11 is shown to occur within the penultimate deglaciation identified in foraminifera $\delta^{18}O$. Using Thxs profiling in a core from the Caribbean sea with an approximately constant accumulation rate, an age estimate of 133 ky is derived for the timing of H11, following Broecker and van Donk [1]. In core V28-82 from the subpolar North Atlantic, with a variable accumulation rate, the inventory of sedimentary ^{230}Th is shown to be in balance with the overlying seawater production of ^{230}Th, and Sackett's method [2] to quantifying the passage of time can be applied to estimate both the absolute age and duration of each of the Heinrich events. The results support previous estimates that the sedimentary layers associated with the events were deposited rapidly over the course of centuries, not millennia.

[1] Broecker, W. S. & van Donk, J. (1970) Insolation changes, ice volumes & the O18 record in deep-sea cores. *Reviews of Geophysics & Space Physics* **8**, 169–198. [2] Sackett, W. M. (1965) *Deposition rates by the protactinium method. In* "Symposium Volume." (D. R. Schink, & J. T. Corless, Eds.) pp. 29–40. URI.