Modern and deglacial radiocarbon depth profiles from the Southern Ocean

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Mixing and upwelling in the Southern Ocean is thought to be an important driver of glacial-interglacial atmospheric CO_2 change, but paleoceanographic records from this region are sparse. Radiocarbon is a useful tool for reconstructing past circulation change because it is produced in the atmopshere, enters the ocean through air-sea gas exchange at the surface, and then decays away as it is isolated from the atmosphere. Here we present twenty-two new radiocarbon measurements of U-Th dated deep-sea corals from the Drake Passage and combine them with forty previously published deep-sea coral radiocarbon data from this region [1]. Measured $\delta^{234}U$ values from these corals are within error of modern seawater values, consistent with closed-system behavior of the uranium series isotopes. These new corals come from twelve new dredge sites ranging from 328 to 1710 m water depth, and grew between 9.9 and 27.2 thousand years ago. These additional corals provide an increased depth resolution which allows us to reconstruct radiocarbon depth profiles within the Drake Passage at important time intervals during the deglaciation, such as the Younger Dryas, Antarctic Cold Reversal, and Heinrich Stadial 1. We compare these depth profiles to modern radiocarbon profiles from seawater dissolved inorganic carbon. Millenial scale changes in the vertical structure of radiocarbon in the Drake Passage suggest variation in the mixing and exchange of carbon between different water masses and the atmosphere over the deglaciation.

[1] Burke, A. and Robinson, L. F. (2011) *Science Express* 10.1126/science.1208163.

"Bubble-less" degassing of MORB magmas

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Noble gas and major volatile systematics indicate that MOR magmas lose volatiles via open system distillation. However, given the low Stokes velocity of bubbles within basaltic magmas (~10 cm h^{-1} for a 300 µm vesicle), it is not possible to efficiently separate bubbles from their enclosing liquids and hence it is difficult to see how open system degassing can physically occur. However, if the magma – crust interface is sufficiently permeable, then volatile loss could be achieved via degassing directly into the crust, without necessarily passing through the vesicle phase. This "bubble-less" degassing could potentially be efficient because the partial pressure of volatiles in the enclosing crust should be very low in contrast to the partial pressure of volatiles within vesicles which is limited by their solubility at the pressure of the degassing magma.

In order that degassing directly into the crust can be efficient, three conditions need to be met: 1) the surface area of the magma-crust interface needs to be similar to or greater than the surface area of the sum of the vesicles; 2) the magma crust interface needs to be permeable; 3) the magma needs to be sufficiently convective to ensure that a significant fraction of the magma passes within the characteristic diffusion distance of the magma-crust interface.

We asses here condition #1. The surface area of bubbles in a magma depends on the bubble size distribution, the total vesicularity and magma pressure during degassing; typically specifc surface areas of magmas will be in the range 1 – 10 $mm^2\ g^{-1}$ for most MORBs (up to a maximum of ~50 $mm^2\ g^{-1}$ for the "popping rock"). Sill-like magmas have surface/volume ratios of between $1x10^{-2}$ and $1x10^{-5}$ (corresponding approximately to sills between 0.15 and 150 m) thick. Figure 1 shows that the total vesicle surface area of a magma is the same as or slightly higher than the surface area of the magma/crust interface. Given the uncertainties involved, it is possible that "bubble-less" degassing may be a potential mechanism through which magmas lose their volatiles. Further modelling will investigate conditions 2) and 3).

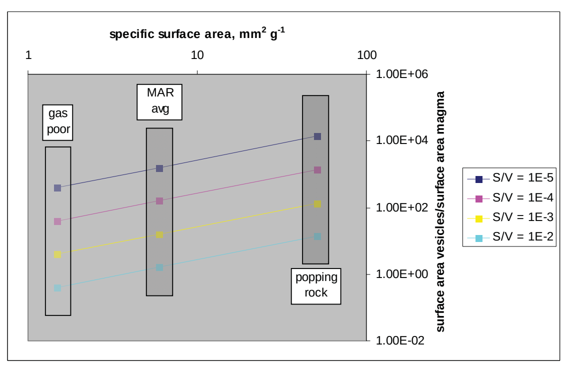

Figure 1: Variation of (vesicle surface area)/(magma-crust interface area) as a function of vesicle specific surface area ($mm^2\ g^{-1}$) for different magma geometries (different Surface/Volume ratios).