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Implantation of radiogenic He into olivine and pyroxene phenocrysts: implications for cosmogenic ^{3}He production rate determinations

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The majority of the cosmogenic nuclide production rate determinations to date have been performed on post-Last Glacial Maximum (LGM) surfaces. Thus we have little information regarding how production rates may have varied in response to, for instance, fluctuations in geomagnetic field strength. Contrary to the expectation of many, studies performed as part of the CRONUS-EU natural calibration network have identified several basaltic flows from which multiple samples of flow tops from different sites yield exposure ages that are in excess of 100 kyr, and indistinguishable within analytical uncertainty. In the example closest to our hearts - the Airport ankaramite from Fogo, Cape Verdes – olivine and pyroxene pairs from 11 surfaces sampled over an elevation range of 60 meters yield an exposure age of 122.2 $\pm$ 4.5 ka. This implies that, given the right conditions, lava flow tops can exist largely unaffected by erosion and ash cover for many 10's kyr. The accurate determination of ^{40}Ar/^{39}Ar ages of these flows promises to allow determination of cosmogenic ^{3}He production rates beyond the LGM.

However, radiogenic He produced in the basalt matrix is implanted into the outer few 10's microns of phenocrysts. The effect increases with flow age and matrix U and Th concentration and with decreasing phenocryst diameter. Further, the effect depends strongly on the magmatic He concentration, and may preclude using small phenocrysts in old surfaces for cosmogenic He production rate calibrations. As a rule of thumb

implantation should not be ignored in basalts that are over 50 ka. Quantifying the contribution of implanted ^4He is possible. For the Airport ankaramite we calculate that up to 6 % (average 2.7 %, n = 11) of the measured ^4He is implanted in the pyroxenes and up to 3.5 % (average 1.7 %, n = 7) in the olivines. The effect is rather small due to the relatively large phenocryst size (0.8 to 1.2 mm). The uncertainty associated with any correction, due for instance to variation in phenocryst size, is more difficult to quantify. Removing the outer few 10's microns from all phenocrysts either by abrasion or acid etching may alleviate the problem. Using material from old exposed flows from Fogo and Fuerteventura we are undertaking experiments aimed at determining how best to etch olivine and pyroxene phenocrysts in order to remove implanted radiogenic He.