Isochrones for in situ cosmogenic ^{3}He measurement

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The standard routine used to measure in situ cosmogenic ^{3}He ($^{3}He_{cos}$) in mafic phenocrysts (olivines and clinopyroxenes) is usually based on a 2 step analytical protocol: (i) preliminary in vacuo crushing followed by (ii) subsequent fusion of the phenocryts. This method is particularly suited for young (< 100 kyr) and U-Th poor lava flows because of its efficiency to unravel properly the magmatic ^{3}He contribution. However, the preliminary crushing step may trigger $^{3}He_{cos}$ release [1] and consequently lead to underestimate the actual cosmogenic concentration. Moreover, the $^{3}He_{cos}$ determination may be drastically complicated for rocks characterized by older ages and/or high U and Th content, which can lead to an unsolved system with three He components (cosmogenic, radiogenic, magmatic).

A *cosmogenic isochrone* can be defined as the regression line obtained plotting $(^{3}He/^{4}He)_{fusion}$ against $(1/^{4}He)_{fusion}$ for several aliquots that have the same cosmogenic ^{3}He concentration. The array of this plot can be directly used to address several undetermined problems, such as $(^{3}He/^{4}He)$ magmatic heterogeneities or variable radiogenic $^{4}He^{*}$ concentrations between aliquots. Some calculations simulating the respective influence of the independent key parameters (age of the rock, magmatic He content, U-Th content) were performed and confronted to new data sets. This comparison allowed to define several geochemical and geological configurations for which the use of *isochrones* (two He components) or *pseudo-isochrones* (three He components) may be considered as a pertinent technique to determine properly the cosmogenic ^{3}He concentrations.

In summary, whatever the additional corrections to apply, this approach basically avoids the crushing step and thereby potential $^{3}He_{cos}$ loss. It may also help to check the homogeneity of helium components (magmatic, radiogenic) in a population of few aliquots, which is a crucial point to validate the non-cosmogenic corrections. Moreover, skipping the crushing step may also provide a significant gain of time, especially for noble gases laboratories equipped with automated furnaces.

Reference

[1] Blard P.-H. et al. (2006), *EPSL*, in press.