Cosmogenic ^{3}He production rate: comparison of He and Be data from Himalayan samples.

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In the framework of a more general study of erosion rates in the Himalayas, we developed the measurement and use of cosmogenic ^{3}He (^{3}He$_c$) in garnets from glacial polished surfaces and moraines in the Narayani basin, Central Nepal. As a reference we also measured ^{10}Be in coexisting quartz from the same samples. We derived cosmogenic ^{3}He concentrations from helium measured in garnet, correcting for inherited nucleogenic ^{3}He. The importance of this nucleogenic component is related to the Li concentration in garnet (about 30 ppm) and is confirmed by the ^{3}He content of non-exposed garnets sampled in a nearby mine. After corrections, the cosmogenic concentrations of ^{3}He and ^{10}Be display good linear correlation, which supports the validity of applied corrections for inherited component.

However, beside the nice correlation of cosmonucleides concentrations, the exposures ages derived from ^{3}He$_c$ are 2.7 times higher than those derived from ^{10}Be$_c$ (from < 500 yr to ~5000 yr) using the classical production rates and scaling factors. All the data being verified for possible analytical bias, this proportional factor suggests that the production rate of ^{3}He$_c$ in these garnets is about 2.7 times higher than that of ^{10}Be$_c$. Two hypothesis can be proposed to explain the ^{3}He$_c$ and ^{10}Be$_c$ difference: 1) A compositional dependence of the ^{3}He$_c$ production rate related to garnet features. Indeed, for other phases such as olivine Licciardi et al. (GSA Bull. 2001) had shown a correspondence between 3He$_c$ exposure ages and ^{10}Be$_c$ exposure ages in quartz. 2) An underestimated production rate of ^{3}He$_c$ at high altitude, as all samples have elevations between 4000 m and 4500 m.

To address the first hypothesis we measured ^{3}He concentration in coexisting garnet and olivine of a kimberlite from the Lesotho Plateau, South Africa (2500 m). In this exposed rock, garnets and olivines contain the same concentration of ^{3}He. Other additional measurements indicate that the ^{3}He contained in olivines and garnets is dominated (more than 2/3) by cosmogenic ^{3}He. All these observations are in favour of a common ^{3}He$_c$ production rate for olivine and garnet. These and future results from lower elevation samples will be used in assessing a possibly different altitudinal dependence of the ^{3}He production rate than that traditionally assumed by classical scaling.

Depletion Factor as a Paleodepth Indicator

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Laboratory and field studies showed that the fractionation factor (α) between atmospheric CO_2 and total dissolved carbon (C_T) may turn from the “normal” equilibrium value of ca. 1.008 to a very low value of 0.979 to 0.986. The later occurs during CO_2 invasion into solutions highly depleted in C_T and results in brine having negative δ^{13}C. This phenomenon was termed as the “Baertschi Isotopic Effect” (BIE). Here we present experimental and field data that enable to predict the physicochemical conditions to the onset of BIE and formulate an expression for the minimum degree of depletion (Depletion Factor – DF) needed to turn the value of α below unity. It is suggested that the values of δ^{13}C of carbonates and organic matter from the sedimentary record of stromatolitic paleoenvironments are proxies for the depth of the ancient water body when substituted in the DF formula.

Field measurements of CO_2 invasion were conducted in two hypersaline water bodies along the northern Gulf of Aqaba, Red Sea; one, the evaporation pans of Israel Salt Company, a solar salt production plant; and the second, the Solar Lake. Both environments were highly depleted in C_T due to the intense metabolic activity of the benthic Microbial Mat Communities (MMC), the modern equivalents of stromatolites. Brine samples were taken in several places, each having different depth ranging from 5 to 50 cm. Laboratory experiments consisted of MMC taken from the Solar Lake, incubated in closed cells under different water levels and exposed to alternate light and dark conditions.

The data show that when $DF=0.09\ d^{-1}$ (depletion of 9% of the water column C_T inventory per day) the fractionation factor, α, is “normal” and larger than unity, while at $DF=0.3\ d^{-1}$ the value of α becomes much lower than unity (the onset of BIE) and C_T of the brines becomes negative. For a given environment, the water column C_T inventory is inversely correlated with water depth, hence, the shallower the water the higher the potential DF. Therefore, the δ^{13}C value of carbonates (as proxies for the isotopic composition of the brine) in stromatolitic environment can be used as depth indicator.