Cosmogenic ^{3}He in Apatite, Titanite, and Zircon

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Cosmogenic dating using ^{3}He is fast and inexpensive compared with cosmogenic radionuclides, but is restricted to mineral phases with low initial ^{3}He and which retain helium under earth surface conditions. Here we explore the potential of cosmogenic ^{3}He dating of the common accessory phases apatite, titanite and zircon. Cosmogenic ^{3}He was measured in ~5 mg aliquots of these three minerals and cosmogenic ^{21}Ne in quartz at 13 depth intervals in a 2.7 m long drill core in a Miocene ignimbrite from the Altiplano of Bolivia. ^{3}He and ^{21}Ne concentration profiles decay exponentially with depth, with $\Lambda = 180 \pm 11$ g/cm^2. Based on the ^{3}He/^{21}Ne ratios and the known ^{21}Ne production rate we find apparent cosmogenic ^{3}He production rates in apatite, titanite, and zircon of 105, 91, and 82 atoms/g/yr respectively (at SLHL). The uncertainty on these estimates is ~20% (2σ). These production rates are only apparent because the long stopping distance of spallation ^{3}He and ^{3}H will cause net implantation of these isotopes, an effect that increases with decreasing size of dated grains.

The major limitation on the use of this method is likely to be the presence of nucleogenic ^{3}He from ^{6}Li(n,α)^{3}H$\rightarrow$^{3}He in grains with (U-Th)/He ages older than perhaps 30 Ma. Although the Li content of these minerals is likely quite low, a more important consideration is that the nucleogenic ^{3}H is emitted with ~2.7 MeV of energy, and hence there may be net implantation of ^{3}He from surrounding Li-rich phases (e.g., hbl, mica). This source likely dominates over in-situ nucleogenic production. Work is in progress to assess the level of ^{3}He commonly found in unexposed samples, and to evaluate the efficacy of abrasion for removing this implanted component.