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Quantifying denudation rates with apatite (U-Th)/He thermochronology - do we need an alpha correction?

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Apatite (U-Th)/He (AHe) thermochronology is increasingly applied for quantifying denudation rates and for describing near-surface processes. During the last years, however, a number of studies revealed considerable inconsistencies between the results of apatite fission track (AFT) and AHe thermochronology, which are either ascribed to insufficient knowledge of fission track annealing or alternatively to insufficient knowledge of helium diffusion and retentivity in apatite. The problem of inconsistent AFT and AHe ages seems to be most pronounced for slowly cooled terranes. Here, we test the integration of AFT and AHe thermochronology for two different settings: (1) slowly cooled rocks from the Azov Massif (Ukraine), which is part of the East European Craton. From this area, independent geological evidence indicates a period of significant heating and erosion during the late Permian to early Triassic. Accordingly, AFT and AHe ages are expected to be early Triassic or younger; (2) rapidly cooled volcanoclastic rocks from the Bermuda Rise. Because of the volcanic origin of these rocks, deposition ages provide additional and independent constrains for the "real ages" of the samples. Apatites from both areas were re-dated for AHe thermochronology after mechanical abrasion of the outer $\sim$30 μm of the grain. In the case of the Asov Massif, both raw AHe ages (i.e., not corrected for ejection of alpha particles at the grain margins) and AHe ages of abraded grains consistently cluster around 226 Ma, in agreement with the geological history and the corresponding AFT ages of

$\sim$240 Ma. If AHe ages are corrected for alpha ejection, however, they yield an average age of 278 Ma and are thus inconsistent with the AFT ages and the independently constrained geological evolution of that area. In the case of the Bermuda Rise, AFT ages agree with deposition ages, whereas alpha corrected AHe ages are consistently older. Raw ages and AHe ages from abraded grains, on the other hand, are consistent with AFT and deposition ages. In both examples described here, alpha correction of AHe ages is obviously responsible for the discrepancy between AHe and AFT ages. For the Azov Massiv, we explain the overcorrections by the influence of diffusion, whereas for the Bermuda Rise, the overcorrected AHe ages can be attributed to the effect of "bad neighbourhood", i.e., the implantation of helium from surrounding grains (pyroxene, volcanic glass; U-content up to 75 ppm) into apatite (average U-content = 1.6 ppm). Our examples show that a careful evaluation of the geological framework is necessary before applying the alpha correction for apatite (U-Th)/He thermochronology.