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Re-evaluating Scandinavia's Apatite Fission Track data set

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Scandinavia is host to one of the world's more complete Apatite Fission Track (AFT) datasets. Compilation of the eastern Fennoscandian AFT sample ages (Hendriks and Redfield 2005) has shown these correlate inversely with uranium concentrations. This can be explained by the underestimation of annealing in the apatite crystal structure in conventional AFT annealing models, that do not include Radiation Enhanced Annealing (REA; e.g. Ewing and Wang 2002).

This problem is exacerbated by the ubiquitous presence of Cl: where samples low in Cl exhibit REA as the dominant annealing mechanism, in samples with more intra-grain variation in Cl content (or other elements such as Fe, Mn, Mg, etc.) the correlation of age with ^{238}U concentration (and REA) may be effectively masked. These discoveries have clear implications for denudation estimates derived from AFT data, from Fennoscandia as well as the rest of the world.

Since REA is dependent on the concentration of α-emitting actinides in apatite, conventional AFT analysis, which constrains only ^{238}U concentrations, cannot be used when REA is considered as an annealing mechanism in AFT datasets. An alternative approach being developed at Apatite-2-Zircon Inc., involving LA-ICP-MS measurements, provides high precision determations of ^{238}U, ^{232}Th and ^{147}Sm concentrations which allows calculation of the total αgose experienced by the apatites analyzed.

Although dominant probably only in stable cratonic settings, REA would be expected to affect fission track stability also in younger, more active settings. For example, it is well known that in Durango apatite spontaneous mean track lengths are significantly shorter than tracks induced in the same apatite species by irradiation in a nuclear reactor. It has been suggested that this track length reduction may also be related to radiation effects. If REA is indeed more important than thermal annealing at temperatures below ∼60 ˚C (Chaumont et al. 2002), the shortening of tracks at temperatures below ∼60 ˚C will be underestimated by conventional annealing models. The observed track length data that are put into the model will be 'too short'; in order to compensate, the model will remain hotter longer. As the model time approaches the present, the model trajectory will be forced to the surface. The resulting inflection may be (and certainly has been) erroneously interpreted as a geological cooling event, and the total amount of denudation overestimated. The effect will be dose-dependant in that apatite with higher concentration of actinides will be more strongly affected within a given time span. Thus, all model-dependant conclusions should be re-evaluated.

In Fennoscandia, we consider all data greater than ∼300 Ma to be dominated by REA and thus rendered geologically meaningless (Hendriks and Redfield 2005). Fennoscandian data younger than ∼300 Ma likely retain sufficient geological meaning within the reported uncertainties. While REA renders modeling results untenable, the predictable nature of the AFT age vs. elevation relationship suggests the annealing process is still thermally dominant in western Fennoscandia. The large magnitude sea-level AFT juxtapositions observed at the western Scandinavian margin are indicative of net down-to-the-west structural offset: whilst the 'youngest' ages found on Edøy in the main Møre Trøndelag Fault Complex may be nearly to completely dominated by REA, those of the innermost Sundal region retain a much greater percentage of their thermal history.

J. Chaumont, S. Soulet, J.C. Krupa and J. Carpena, Competition between disorder creation and annealing in fluoroapatite nuclear waste forms, J. Nucl. Mater. 301 (2002) 122 - 128.

Ewing, R.C. & Wang, L. 2002: Phosphates as nuclear waste forms, in: Kohn, M.J., Rakovan, J. and Hughes, J.M. (eds.). *Phosphates, Reviews in Mineralogy and Geochemistry 48*, Mineralogical Society of America, 673 – 699.

Hendriks, B.W.H. & Redfield, T.F. 2005: Apatite fission track and (U-Th)/He data from Fennoscandia: An example of underestimation of fission track annealing in apatite. *Earth and Planetary Science Letters 236*, 443 – 458.