Geophysical Research Abstracts
Vol. 15, EGU2013-5825, 2013
EGU General Assembly 2013

A novel inversion strategy for dealing with single crystal fragment ages in thermochronometry

Romain Beucher (1), Roderick Brown (1), Steven Roper (2), Fin Stuart (3), and Cristina Persano (1)

(1) University of Glasgow, School of Geographical and Earth Sciences, Glasgow, United Kingdom (romain.beucher@glasgow.ac.uk), (2) School of Mathematics and Statistics, University of Glasgow, Glasgow, UK., (3) Scottish Universities Environmental Research Center, East Kilbride, UK

In many thermochronometry systems the diffusion domain size is the physical grain itself, and so analyzing a range of grain sizes will help to constrain the T-t modeling of the measured apparent ages. However, if the grains are broken during mineral separation significant age dispersion arises simply due to the variable concentration of the daughter product within the grain due to thermal diffusion. Here we demonstrate the practical application of a new approach to harnessing useful information about the thermal history recorded by this source of dispersion. Over the last decade the (U-Th)/He technique has proven to be a useful tool for quantifying thermal histories. However, over-dispersion of the (U-Th)/He apparent ages measured for single grains from the same sample is a common observation, and understanding what causes this dispersion is critical to interpreting ages properly. While acceptable reproducibility is usually considered to be within 10% including a standard analytical error of about 3%, we often deal with dispersion greater than 20% or more. Natural dispersion of the apparent helium ages is expected as a function of grain size and radiation damage accumulation effects, with the maximum effect for cooling histories with protracted residence time in the Helium partial retention zone. Some additional dispersion may also be attributed to inappropriate alpha ejection corrections, heterogeneous distribution of parent isotopes and to invisible U-rich inclusions or helium implantation. In a companion abstract we show that a substantial range of excess dispersion also arises naturally from the fact that analyzed individual crystals are often fragments of larger crystals, and most importantly that this dispersion contains useful information about the shape of the diffusion profile within grains and hence the thermal history of the sample.

We describe a new numerical approach that explicitly treats each broken grain as a fragment of an initially larger grain. This is achieved by solving for the diffusion and ingrowth of Helium in a finite cylinder. We show that it is practically possible to exploit this source of dispersion of (U-Th)/He fragment ages to retrieve information about the time-temperature history. The new code (HELFRAG) solves the forward model for a given thermal history and a given set of fragments. Currently only fragments with one termination are taken into account. A large number of forward models (typically 5000-10000) are run and a suitable optimization scheme used to minimize a misfit function thus finding the “best” thermal-history explaining the age dataset. The main unknowns, apart from the T-t history of course, are the original lengths (Lo) of the crystals being analyzed. We show that while in theory it is possible to fit both the unknown thermal history and the unknown Lo values simultaneously, in most cases this can be easily simplified by using a common, long Lo. We present a set of experiments using synthetic fragment ages randomly generated for increasingly complex thermal histories and show that information can be extracted from datasets showing very large dispersion. The advantage of our approach is that it explicitly exploits the true grain size information as well has handling the fragmentation effect, and it can easily be adapted to accommodate the T-t information arising from differences in effective eU and consequent accumulation of radiation damage.