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Actinide-helium Thermochronology: Progress and Promise

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Low-temperature thermochronology provides critical data for quantitative evaluation of landscape evolution, uplift of mountain belts and subsidence histories of sedimentary basins. Recent progress in the development of the (U-Th)/^{4}He apatite thermochronometer promises to extend the available temperature range to as low as 40-50 ºC (as compared to ~120 ºC for apatite fission track (AFT)) and may bridge the gap between fission track methods and surface exposure dating. Development of the U-Th/^{4}He thermochronology and extension to other mineral phases (Reiners and Farley 1999) will provide an unprecedented tool for the exploration of near-surface processes.

This poster will present details of a new (U+Th)/He analytical system which has been established at the Scottish Universities Environmental Research Center (SUERC) over the last twelve months. Mineral separates are heated in an ultra-high vacuum furnace, in a Ta crucible from 300 to 1200(±5) ºC. The furnace temperature has been calibrated using an optical pyrometer and monitored during routine operation by a K-type thermocouple. For He extractions from apatite, samples are wrapped in copper foil packets and heated to 950 ºC for 20 minutes to quantitatively release He without melting the apatite (and avoiding U and Th loss). A second stage of heating at 950 ºC is used to screen for He trapped in retentive U+Th rich mineral inclusions such as zircon (House et al. 1999).

Released gases are purified by exposure to two Zr-Ti-Al getters (1 at 800 ºC and 1 room temperature) followed by an activated charcoal traps held at liquid nitrogen temperature. Purified helium is then admitted to a quadrupole mass spectrometer (Hiden HAL/3F) and helium abundances are measured on a Faraday cup. Data is acquired using MASSOFT control software, operated in peak jumping mode with a DDE link to Microsoft Excel 6.0. Hydrogen partial pressure is maintained at stable low levels during He analysis with a third getter at room temperature and liquid nitrogen cooled charcoal trap in the mass spectrometer volume.

Sample ^{4}He is spiked with a calibrated aliquot of ^{3}He to determine absolute sample ^{4}He abundances. System sensitivity ($2x10^{-6}$ A/cc He) is calibrated on a daily basis using a manometrically determined, pure ^{4}He standard. The gas standard delivers 1.836±0.097 (x10-7) cc ^{4}He (STP) per 0.105 cc aliquot. Standard ^{4}He abundances are measured within each run to ±0.1% (1σ) and between runs to ±0.5% (1σ). The spike to standard ratio variation (within each run) is ±0.05 1σ.

Uranium and thorium abundances are determined by isotope dilution using a VG PlasmaQuad 2 ICP-MS equipped with a micro-flow nebulizer for increased sensitivity. Apatite samples removed from the furnace, following He extraction, are dissolved in HNO_3 and spiked with ^{230}Th and ^{235}U. Uranium and Th are purified using column chromatography (Luo et al. 1995) to reduce matrix effects and enhance ICP-MS sensitivity. Measured U and Th abundances are accurate to ±2.5% (1σ).

Apatite separates are extracted by standard magnetic and density methods taking care to avoid heating samples to above room temperature. Each hand-picked apatite separate is rigorously screened for high U+Th mineral inclusions using both plane and cross polarized illumination. Size and shape analyses for recoil loss corrections are performed by two independent observers for each sample. In the future we aim to digitally photograph each sample to provide a permanent visual record prior to analysis.

Several research topics are currently being investigated. Combined fission track and U-Th/He analysis on apatite from granites along the escarpment and coastal lowlands of SE Australia in order to distinguish between models of passivee margin formation. Thermal history of the Upper Silesian Coal Basin in Poland. Apatite and zircon fission track and U-Th/He dating will provide a test of cooling models for the basin. Characterization of a He partial retention zone in the central core of the Pyrenean orogen. Preliminary results from these projects will be presented at conference time.

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House et al., *Earth Planet. Sci. Lett.*, **170**, 463-474, (1999).
Luo et al., *Int. J. Mass Spec. Ion Proc.*, **171**, 105-117, (1997).