Intercalibration of zircon (U-Th)/He and K-feldspar $^{40}Ar/^{39}Ar$ thermochronometry

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Deducing accurate thermal histories of rocks, especially over large temperature and time intervals, requires intercalibration of ages and cooling models from different thermochronometers. At low temperatures (e.g., ~300-50 °C), thermal histories are typically constrained by multi-diffusion domain modeling of K-feldspar $^{40}Ar/^{39}Ar$ age spectra, fission-track (FT) cooling ages and track-length models, and (U-Th)/He cooling ages of various phases. While temperature dependent diffusivity is the fundamental interpretational basis for all of these systems, each is based on different diffusing species and domain configurations, and is subject to potential influences besides temperature. Here we focus on comparisons between the low-temperature (<200 °C) portion of $^{40}Ar/^{39}Ar$ K-feldspar cooling models, and (U-Th)/He cooling ages, primarily for zircon. Previous work has only constrained the closure temperature (T_c) for He in zircon (~160-210 °C) within fairly broad bounds, and raised questions about the effect of radiation damage on effective T_c. Our new He diffusion experiments for zircon (E_a = 172 ± 0.4 kJ/mol (41.1 ± 0.1 kcal/mol); D_0 = 1.1 ± 0.3 cm^2/s) yield a closure temperature of 183 ± 4 °C (for dT/dt=10 °C /myr), and are consistent with diffusion domain and crystal size equivalence, as for titanite and apatite. However, we also confirmed higher He diffusivity in strongly radiation damaged zircon, raising the possibility that, at least in cases of highly radiation damaged zircons, (U-Th)/He closure may be a function of U-Th content and thermal history.

To compare these constraints with cooling ages and thermal histories of natural zircons from different geologic settings, we obtained detailed thermal histories from Pb, FT, Ar, and He systems for 4 samples (3 from New Zealand and 1 from Alaska) that cooled through ~200 °C between 9-85 Ma, at rates of ~10-75 °C/myr. Correlation factors (C_{fg}) for K-feldspar spectra (Lovera et al., 2002) in these samples vary from 0.88 to 0.94, suggesting good adherence of observed spectra to multi-diffusion domain hypotheses of the cooling models. Multiple replicates of laser-heated, single-grain zircon ages for most samples show 2-σ reproducibility of 5-10%, whose means are well within 1-σ of K-feldspar models (or their extensions) at 180 °C. Overall these data indicate good agreement for these chronometers and, assuming accurate K-feldspar models, restrict the zircon He T_c to 175 ± 25 °C for these samples, regardless of ages and U-Th contents that vary by factors of 10 and 3, respectively.

Lovera, O.M., Grove, M., Harrison, T.M., (2002), *Geochim. Cosmochim. Acta.*, 66, 1237.

The fate of wastewater indicator compounds during groundwater recharge

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Artificial recharge is increasingly used to augment groundwater water supplies. In Orange County, Southern California, water from the Colorado and Santa Ana Rivers (SAR) is feed to a deep recharge basin for groundwater recharge. Water samples from the recharge basin and two wells that draw water supplied by the basin were analyzed to evaluate trace organics behavior. In autumn of 1996 and again in spring of 1997, the basin was fed with water imported from the Colorado River (COR), which is high in sulfate (263 mg/L) compared to the river 100 mg/L. Residence times were obtained by identifying pulses of high-sulfate water in the wells. The average concentration after 20 d and 170 d travel are indicated in Table.

Table 1. Concentration after 0, 20 and 170 d travel

Time [d]	DOC mg/L	DO mg/L	EDTA µg/L	APECs µg/L
Basin	5.00	7.3	5.9	1.9
20	2.5	0.45	3.9	0.19
170	1.5	0.94	0.85	0.16

SAR DOC was removed during transport to the wells (approximately 50% 31% after 20 and 170 days of transport, respectively) and DOC removal consumed nearly all dissolved oxygen (DO). The fraction of DOC not removed was retarded with a retardation factor 1.3. EDTA and alkylphenol polyethoxy carboxylic acids (APECs) were removed to a greater extent than DOC but persisted at trace levels. Data from shallow (5 m) wells indicate that most of the DOC removal (40%) occurs within the first day after infiltration. EDTA passes through the 5 m infiltration zone with little attenuation. APEC removals decreased to 25% after basin cleaning but increased to 100% after approximately 3 weeks of basin operation. Data indicate trace organics can pass through the biologically active infiltration zone consistent with results from biological laboratory columns.

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