Cradle dates of ^{3}H - ^{3}He dating

I. TOLSTIKHIN

Geological Institute, Kola Scientific Center RAS, Apatity, 184209, Russia (igor.tolstikhin@gmail.com)

The proposal to use ^{3}H – ^{3}He systematics for ground water dating was inspired by discovery of anomalously high ^{3}He abundance in He emanated by hot springs of the Kuril volcanic arc [1]. Because of the high [^{3}H] concentrations in meteoric waters in mid-sixties (up to ~ 10,000 TU), ^{3}He accumulation in an air-isolated water parcell could result in a substantial ^{3}He(^{3}H) signal. Even though decay of bomb-produced ^{3}H was considered in [1] as an objectionable explanation for the high ^{3}He contribution in volcanic He, ^{3}H – ^{3}He$_{TRI}$ duo appeared to be quite a promising (in some respects unique) hydrological tracer [2].

The first ^{3}H – ^{3}He dating of terrestrial waters was performed for the North Atlantic: according to the excellent contribution [3], a ^{3}He maximum at depth 500 m along with enhanced [^{3}H] yielded ^{3}H – ^{3}He apparent age 2.6 ± 0.6 yrs, in agreement with an earlier estimate from [^{3}H] along [4]. Even much deeper ^{3}He excess at ~2 km was also considered as a core of down welling cold waters from the Labrador sea, the ^{3}H – ^{3}He apparent age of this core being 12 yrs and the mean velocity of a water stream ~0.01 m sec^{-1}.

Later on data obtained for the Great Lakes [5] illuminated facilities of the method. The spring and fall overturns of lake waters provided a constant [^{3}H] within a lake and its efficient degassing and thus set the ^{3}H – ^{3}He clock at zero. Hence, excess ^{3}He versus depth profiles portrayed ^{3}H – ^{3}He ages, from a few days for the epilimnion to a few months for the hypolimnion waters. ^{3}H - ^{3}He age of these waters in Huron (110 days) was similar to time between the spring overturn and sampling, supporting a closed system approximation for the hypolimnion and the ^{3}H – ^{3}He age derived.

Almost 20 yrs after [2] the first ^{3}H – ^{3}He results were obtained for ground waters [6,7], these are discussed as examples of early approaches to the dating. Some data for shallow aquifers in Russia are also presented [8].

[1] Mamyrin *et al*. (1969) *Dokl. Akad. Nauk* **184**, 122-126. [2] Tolstikhin & Kamensky (1969) *Geokhimiya* **8**, 1027-1029. [3] Jenkins *et al*. (1972) *EPSL* **16**, 122-126. [4] Begemann & Libby (1957) *GCA* **12**, 277-296. [5] Torgersen *et al*. (1977) *Limnol. Oceanograph*. **22**, 181-193. [6] Schlosser *et al*. (1988) *EPSL* **88**, 353-362. [7] Poreda *et al*. (1988) *J. Hydrol.* **103**, 1-9. [8] Kamensky *et al*. (1991) *GCA* **55**, 2895-2899.

Mantle and crustal helium in ancient mafic rocks: Components, sites and mobilities

I. TOLSTIKHIN[1], I. KAMENSKY[1], S. TARAKANOV[2], J. KRAMERS[3], M.PEKALA[3], V. SKIBA[1] AND M. GANNIBAL[1]

[1]Geological Institute, KSC, Russian Academy of Sciences, Apatity, Russia (igor.tolstikhin@gmail.com)
[2]The Laboratory of Glass Properties, St. Petersburg, Russia
[3]Institute of Geology, University of Bern, Bern, Switzerland

To specify sites of noble gas isotopes, shed light on their origin and estimate their residence times we investigated 2.5 Gyr old mafic rocks from the Moncha Pluton (Kola peninsula, Baltic shield) using different extraction methods: crushing, fusion, step-wise, isothermal and incremental heating. A contribution of in-situ produced He$_{RAD}$ was estimated from U and Th concentrations.

The He release pattern obtained by relatively fast (~ 1.5 hour) incremental heating of olivine consists of three distinct release peaks for He: a low-temperature (600°C) *l*-peak, a middle (800 to 1100°C) *m*-peak and a high-temperature (~1400°C) *h*-peak; however, He extraction from the powder yields mainly the middle *m*-peak: the *l*- and *h*-peaks gases are derived from gas-liquid inclusions opened in the course of crushing. Slow heating (14 hours) also results in a broad He release peak in contrast to two well-separated *l*- and *h*-peaks of ^{40}Ar*. This implies He migration from *l*- and *h*- inclusions into the matrix *m* during long heating, in contrast to less mobile Ar. A simple model envisaging the three different sites for noble gases was able to reproduce both fast- and slow-heating release patterns for ^{40}Ar* and He. The diffusion parameters (for He in the olivine), $D_0 = 2.4 \times 10^{-2}$ cm^2 s^{-1} and $Ea = 133$ kJ mol^{-1}, are similar to published values [1, 2]. The He solubility found for olivine, H_{He} ~0.01, greatly exceeds estimates reported in [3]; however the products $D_{He}(T) \times H_{He}$ (that governs He migration in materials consisting of matrix and inclusions) are similar. Extrapolation to the ambient temperature (0°C) gives long and similar He residence times in *l*- and *h*- vesicles, exceeding 10^{10} yrs, and even longer time scales ~ 10^{16} yrs are obtained for the matrix. Therefore, at low temperatures our samples may be considered as excellent samplers of trapped volatile species, including He.

[1] Blard *et al*. (2008) *GCA* **72**, 3788–3803. [2] Shuster *et al*. (2003) *EPSL* **217**, 19-32. [3] Trull & Kurz (1993) **57**, 1313-1324.