On distribution of radiogenic argon in minerals

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In conventional K-Ar geochronology, bulk concentrations of K and Ar are required. Recently, interest has arisen for knowledge on distribution in mineral crystals of Ar concentration, which usually obtained by $^{40}Ar/^{39}Ar$ modification of the K-Ar method with a laser extraction technique. We suggest a procedure of obtaining the Ar distribution by means of a macroscopic experiment. In the case of conventional K-Ar system, K is postulated to be distributed homogeneously.

We consider an aggregate of mineral grains formed t years ago and subjected to metamorphic Ar losses t_1 years ago. At present, the bulk concentration of radiogenic Ar consists of two parts: one remaining just after t_1 (referred to as "inherited" Ar) and another one accumulated due to K-decay in the time interval $t - t_1$ (referred to as "normal" Ar). Due to solutions of Fick's diffusion equations the distribution of inherited Ar in the mineral is presented by a half-sinusoid, whereas the distribution of normal Ar by a rectangle. Fractions of the inherited and normal Ar in a grain with height h can be determined by a heating experiment at a constant temperature. Three portions of $^{40}Ar_{rad}$ (Ar_1, Ar_2, Ar_3), extracted at successive time intervals, allow to establish a set of algebraic equations and to calculate the ratio (α) of the inherited to normal Ar.

$$a_1=(1-\alpha)\Phi(Fo_1)+\alpha(1-\exp(-\pi^2 Fo_2)) \text{ and}$$

$$a_2=(1-\alpha)\Phi(PFo_1)+\alpha(1-\exp(-\pi^2 PFo_2)), \text{ where}$$

$$a_1=Ar_1/(Ar_1+Ar_2+Ar_3),\ a_2=(Ar_1+Ar_2)/(Ar_1+Ar_2+Ar_3),\ Fo_1=Dt_1/h^2,$$

$$Fo_2=D(t_1+t_2)/h^2,\ Fo_2=PFo_1,\ P=(t_1+t_2)/t_1, \text{ and}$$

$$\Phi(Fo_1)=4\sqrt{Fo_1/\pi}$$