PROBLEMS OF MONAZITE DATING BY EMPA

NAGY, G.
Research Centre for Earth Sciences, Laboratory for Geochemical Research, Hungarian Academy of Sciences, Budaörsi út 45, H-1112 Budapest, Hungary.
E-mail: gnagy@sparc.core.hu

Theory

Monazite is suitable for age determination due to the following properties: 1) It can incorporate Th and U (up to >10%). 2) It is stable even at high P-T conditions. 3) Due to the low diffusion rate the emerging Pb does not escape.

The radiogenic lead emeging during t time is:

$$Pb_{rad}(t) = Th \cdot k_1 \cdot (\exp\{\lambda_{Th} \cdot t\} - 1) + U \cdot [k_2 \cdot (\exp\{\lambda_{238U} \cdot t\} - 1) + k_3 \cdot (\exp\{\lambda_{235U} \cdot t\} - 1)]$$

If t<400Ma it can be approximated linearly:

$$Pb_{rad}(t) \approx 4.46 \cdot Th^* \cdot 10^{-5} \cdot t[Ma] \quad \text{where} \quad Th^* = Th + 3.2 \cdot U$$

By electron microprobe analysis (EMPA) the local Th, U and Pb contents can be determined so that even small and inhomogeneous monazite grains can be dated.

Analytical problems and conditions

The amount of radiogenic Pb is usually small, near to the detection limit. (If Th* = 10%, t = 200Ma, Pb ≈ 0.09%; the background intensity is equivalent with 0.2% Pb content.) Pb M_α line was used for analysis, which is relatively free of overlaps, however due to numerous high-order and satellite lines it was difficult to find the proper spectrometer positions for background determination.

The analyses were performed at 20 kV, 80 nA, with focussed electron beam; counting times 100 s on peaks, 50 s on both background positions. M_α lines measured on PET crystals were used for all three elements. Differential discriminator was applied to decrease Pb background. Lead was measured twice in each point and has been corrected for Y L_γ overlap. On standards and applied ZAF correction factors see NAGY *et al.* (2002). The standard deviation for individual Pb analyses obtained from 200 duplicates: σ_{Pb} = 0.014wt-%, the statistical limit is ≈ 0.012%.

Evaluation

1) *Isochron method according to* SUZUKI *et al.* (1991) starting from the fact that in the Th*–Pb plane the isochrons are straight lines. A line is fitted to the data points by least squares method, the ages are calculated from the slope and the uncertainties from the confidence intervals. This method can be used only if the Th* values fall in a wide range.

2) *Method of* MONTEL *et al.* (1996). Accepted that non-radiogenic Pb in monazite is negligible, each Th-U-Pb data set is evaluated individually and weighted average is formed. They described also a statistical method by which multiple events can be discriminated.

3) More recent *method of* COCHERIE & ALBAREDE (2001) approaches the data by a straight line in the plane of Th/Pb – U/Pb quotients. The ages are calculated from axis intercepts. This method can be applied only for relatively U-rich monazites.

Results

In metamorphic rocks of Sopron Hills (Eastern Alps) two monazite generations were found, giving ages of ca. 300 Ma and ca. 75 Ma (NAGY *et al.*, 2002). The method has been applied to Hungarian and Iberian granitoids and Veporic migmatites, too.

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