

Ryszard KRYZA<sup>1</sup>

## MONAZITE AS A GEOCHRONOMETER: USEFUL, INEXPENSIVE – BUT NOT SIMPLE

### INTRODUCTION

During the last two decades, a rapid development of micro-sample geochronology (“microgeochronology”) has taken place, enabling the dating of single mineral grains and their micro-domains. Recently, among a range of instrumental techniques (SIMS, SHRIMP, LA-ICPMS, TIMS, Micro-PIXE, EMMA etc.), Electron Microprobe (EMP) dating, in particular, is becoming popular. As a chemical dating method, it does not require analysis of isotopes, only of the bulk contents of “parent” and “daughter” elements. The concept is not new but the method has been undergoing a renaissance since the 1990’s, when EMP began to be routinely applied for precise analysis of Th, U and Pb in monazite (Mnz) (e.g. Suzuki and Adachi 1994, Montel et al. 1996). In Poland, monazite has been chemically dated by M. Michalik, M. Kusiak and M. Paszkowski (Cracow: refs. in Lekki et al. 2003) and by J. Janeczek and colleagues (Sosnowiec). This paper outlines the technique in the context of ongoing KBN-supported studies in Karelia, Ukraine and SW Poland.

### CHEMICAL DATING OF MONAZITE: THEORETICAL BACKGROUND

Monazite is a LREE phosphate, rich in Th (often 3 to 25 wt. %) and U (c. 100 ppm to 5 wt. %). Virtually, all Pb in Mnz is, normally, radiogenic in origin. It quickly attains levels high enough for precise measuring by EMP.

The obtained age is geologically meaningful provided that (a) the amount of non-radiogenic lead in the mineral is negligible, and (b) the U, Th and Pb concentrations are governed by radioactive decay and not by, say, elemental diffusion or hydrothermal alteration. The first condition is normally fulfilled, and the second is possible to assess by careful analysis (Montel et al. 1996).

### PRACTICAL ASPECTS

Monazite is a common accessory mineral in many granitoids and high-grade metapelites. Small grains (5-20  $\mu\text{m}$ ) are fairly common in mafic rocks, and authigenic Mnz nodules are also found in sedimentary rocks (Evans and Zalasiewicz 1996). The mineral can be found in conventional polished thin sections, although optical identification is difficult. The simplest way to identify it and to characterize its textural

---

<sup>1</sup> *University of Wrocław, Institute of Geological Sciences, ul. Cybulskiego 30, 50-205 Wrocław;  
e-mail: rkryza@ing.uni.wroc.pl*

position and internal structure (e.g. zonation) is to use BSE imaging (Fig. 1) and EDS spectra. Potential Pb-contaminants must be avoided during sample preparation.

The quality of EMP dating strongly depends on analytical procedures. The instrument requires careful standardization against optimal standards. Scherrer et al. (2000) suggest using synthesized REE-phosphates, and prefer, for Th-U-Pb dating,  $\text{ThP}_2\text{O}_7$ , a synthesized Th phosphate, over  $\text{ThO}_2$  (which is often spongy), and  $\text{UO}_2$  over elemental U; for Pb, crocoite or synthesized glass is best.

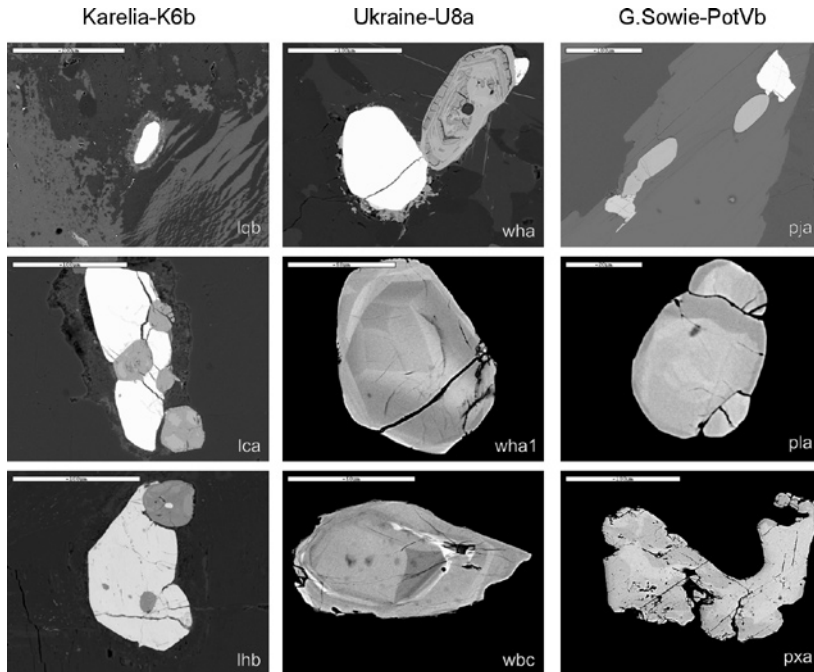


Fig. 1. BSE images of monazites in Precambrian granites from Karelia and Ukraine, and in Palaeozoic (Ordovician-Devonian?) anatexites from the Góry Sowie, Sudetes (SW Poland).

Though rarely published, background positions are crucial; optimally, they should be defined on each spectrometer using adequate standards. Peak overlaps, e.g. between  $\text{U}_{\text{Mb}}$  and  $\text{Th}_{\text{Mg}}$ , and between  $\text{Pb}_{\text{Mb}}$  and  $\text{U}_{\text{Mz}}$ , present serious problems. The measured U and, afterwards, the measured Pb, must be corrected using correction coefficients carefully determined for individual instrument and spectrometer settings. Finally, the quality of the results and analytical precision depend on the microprobe settings and counting statistics. The accelerating voltage commonly used is 15 or 20 kV, with a beam current between 20 and 250 nA. The counting times should be long enough to ensure good statistics: e.g. minimum 300 s for Pb, 150 s for U, and 100 s for Th (Scherrer et al. 2000).

Various strategies are possible to collect and treat data for monazite dating. The high spatial resolution of EMP enables separate analysis of grains of different textural

relations, and of different domains of zoned crystals. Data interpretation should account for sources of uncertainty to explain age distributions within individual rock samples: (a) the presence of different age populations, (b) analysis of overlapping age domains, (c) Pb disturbances due to diffusion and/or dissolution/accumulation processes, (d) analytical uncertainties. Dating samples by other means can help to constrain the influence of these factors.

## DRAWBACKS AND ADVANTAGES OF EMP DATING

Drawbacks:

(1) Mnz is relatively limited in occurrence, and the Mnz-forming reactions are poorly understood.

(2) The need for careful instrument standardization; peak interference; relatively poor detection limits and low precision (optimum results range within +/- 5 to +/- 15 Ma for ages ranging from 300 Ma to 3000 Ma). Dating rocks in rocks younger than c. 100 Ma is difficult.

Advantages:

(1) Good spatial resolution enabling analysis of small grains (c. 5  $\mu\text{m}$  in size) and zoned crystals, and so recognition of different age domains. Efficient assessment of element diffusion/disturbance processes.

(2) "In situ" non-destructive analysis in conventional thin sections enables relation of ages to mineral parageneses and structural histories (P-T-t-d paths).

(3) The method is easily accessible, cheap and fast.

The study was supported by KBN project 6P04D 051 21. Norman Charnley and Henryk Siagó are thanked for their help in SEM and EMP work.

## REFERENCES

- EVANS J, ZALASIEWICZ J. A., 1996: U-Pb, Pb-Pb and Sm-Nd dating of authigenic monazite: Implications for the diagenetic evolution of the Welsh Basin. *Earth and Planetary Science Letters*, 144, 421-433.
- LEKKI J., LEBED S., PASZKOWSKI M.L., KUSIAK M., VOGT J., HAJDUK R., POLAK W., POTEPA A., STACHURA Z., STYCZEN J., 2003: Age determination of monazites using the new experimental chamber of the Cracow proton microprobe. *Nuclear Instr. & Methods in Physics Research B* (in press).
- MONTEL J.-M., FORET S., VESCHAMBRE M., NICOLLET C., PROVOST A., 1996: Electron microprobe dating of monazite. *Chemical Geology*, 131, 37-53.
- SCHERRER N., ENGI, M., GNOS E., JACOB V., LIECHTI A., 2000: Monazite analysis: from sample preparation to microprobe age dating and REE quantification. *Schweiz. Mineral. Petrogr. Mitt.*, 80, 93-105.
- SUZUKI K., ADACHI M., 1994: Middle Precambrian detrital monazite and zircon from the Hida gneiss on Oki-Dogo Island, Japan: their origin and implications for the correlations of basement gneiss of southwest Japan and Korea. *Tectonophysics*, 235, 277-292.