The limited extent of Pb diffusion in monazite

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Monazite, a light rare earth element of phosphate that is generally Th-enriched, is generally concordant and thus suitable for obtaining a U-Th-total Pb *in situ* age (1 μm spatial resolution) with an electron microprobe. Using the Pb = f(Th*) diagram (Th* = Th + U converted in Th) an isochron age is obtained, giving an age in agreement with conventional U-Pb data, and with a precision close to 20 Ma. This method therefore appears to be an inexpensive alternative for dating concordant monazite (Suzuki and Adachi, 1991; Montel *et al.*, 1996). Moreover, most of the common Pb included in the whole monazite, and thus involved in conventional U-Pb measurements after grain dissolution, can be avoided since silicate inclusions and the Fe-coated rim of the grain are not included in the age isochron calculation.

In the case of highly discordant monazite, the conventional U-Pb method sometimes gives results that are difficult to interpret and the discordance is often interpreted as a result of radiogenic Pb loss due to a process of Pb diffusion. Even if the data fit well in the Concordia diagram, several processes can lead to discordance: for example, more than two events may have been undergone by the monazite within the analytical error if at least two events are rather close (e.g. 100 Ma in Archaean times); or again, continuous radiogenic Pb loss can lead to a misunderstanding of the lower intercept insofar as representative points do not fit on a straight line for such a model. Examples from Archaean monazites having undergone several metamorphic events from the Archaean to the Proterozoic will be shown.

A study of monazites in three rock types from the Archaean of the Ivory Coast (migmatitic gneiss, anatectic mobilizate, kinzigitic metasediment) showed that three events are recorded by this mineral. Some of the monazites recorded mainly the oldest event (2.80 Ga) or the youngest event (2.03 Ga) and thus appeared as concordant or subconcordant monazite in the U-Pb Concordia plot. Other monazites recorded two or three events giving discordant data points. At micrometer scale, intermediate ages between 2.7–2.8 Ga and 2.03 Ga are not com+mon and homogeneous domains enable isochron ages to be calculated. Moreover, the proportion of ages younger than 2.03 Ga in the detailed grain study is negligible, showing clearly that there is no diffusion profile. The selection of homogeneous domains and the use of the isochron plot (Pb *vs* Th*) demonstrate that two Archaean events were recorded, one at 2.80 Ga and a younger age at 2.72 Ga (Cocherie *et al.*, 1998).

High-grade metamorphic events at anatexis temperatures (*c.* 700°C) do not necessarily imply complete resetting of the U-Th-Pb system. The observed discordance for complex monazites in the U-Pb Concordia plot are more likely to be caused by mixing phenomena. *In situ* recrystallization involving the replacement of pre-existing material seems to induce the observed age zoning in monazite, and may be in close relationship with fluid circulation. Such a process can reset the inner part of a grain, resulting in the core being apparently younger than the surrounding part of the grain.

The recording of all major elements for matrix correction for each individual point during U-Th and Pb acquisition, provided an opportunity to study possible relationships between composition and domains of homogeneous age in complex monazite grains. No evidence of such a relationship was revealed in the Ivory Coast samples.

Complex monazites appear more complicated at micrometer scale than expected from the U-Pb conventional age determination. Nevertheless, the microprobe ages are not spread randomly and they show no diffusion profile at grain scale. Small areas of 10–30 μm^2 form reset homogeneous domains in the vicinity of other unreset parts of the grain. The extent of Pb diffusion thus appears very limited in monazite.

References

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