A monazite-forming reaction, CHIME U-Pb ages and the choice of background for analyzing Pb

(3 figs)

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One of the hottest topics in modern geochronology is the use of in-situ techniques (e.g. CHIME; CHemical Th-U-total Pb Isochron MEthod) to obtain U-Pb ages. In-situ techniques circumnavigate the questionable geological significance of U-Pb mineral ages from conventional techniques such as U-Pb ID-TIMS analyses of mineral separates. As with most new analytical techniques, the exact range of applicability of the CHIME technique is uncertain. One major limitation for the CHIME technique is the detection limit of electron microprobes. This was used by William et al. (1999) to propose a lower limit of ~100 Ma for CHIME analyses. This study, proposes a monazite-forming reaction, emphasizes the importance of the CHIME techniques and explores this proposed lower limit.

Along the Rocky Mountain Trench of the Canadian Cordillera, back-scattered electron images and x-ray elemental maps support a monazite-producing reaction from detrital monazite, epidote and allanite (Fig. 1). Several outcrops have All-Ep-Mnz+/-Xno complexes. Smith and Barreiro (1990) also observed All-Ep-Ap-Mnz complexes in their study of the Central Maine Terrane (USA). In the Central Maine Terrane, monazite was located in the center of these complexes. Smith and Barreiro (1990) concluded that detrital monazite was being consumed to produce All-Ep-Ap. In the Canadian Cordillera, most monazite is located at the edges of these complexes (Fig. 1). X-ray elemental maps of Pb, U, Th, Ce and Y demonstrate that both these monazite and ones located in the center of the All-Ep-Mnz+/-Xno complexes have simple concentric zoning which supports new growth of monazite (not monazite consumption which would have produced more complicated zonation patters; Fig. 2). Unfortunately, these All-Ep-Mnz+/-Xno complexes were destroyed during the separation technique for ID-TIMS analyses. This emphasizes the vital importance of being able to analyse these minerals in-situ (Fig 3).

CHIME analyses, in the Canadian Cordillera, were initially used to separate samples with detrital (Cambrian and older) monazites and/or detrital monazite cores from samples with only new metamorphic monazites (Jurassic and younger). CHIME monazite U-Pb ages also demonstrated that new monazite grew at staurolite + kyanite grade (not staurolite grade as observed by Smith and Barreiro). In these cases, CHIME analyses served as an excellent first approximation of U-Pb monazite ages.

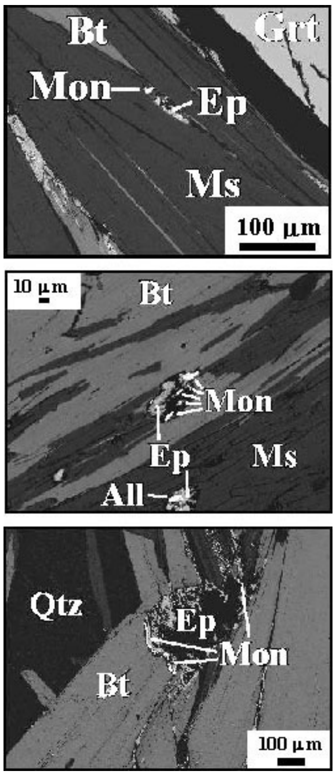

Fig. 1

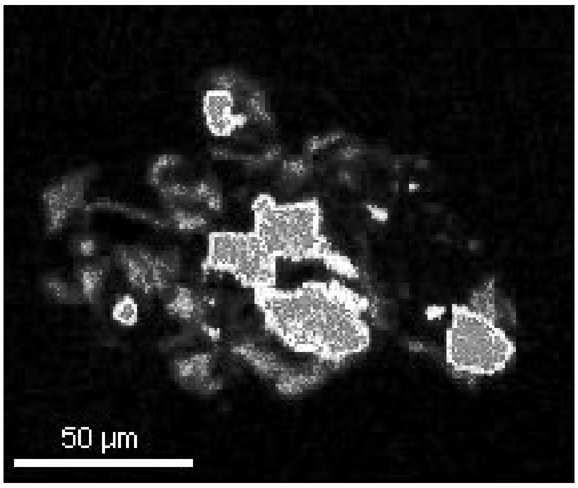

Fig. 2

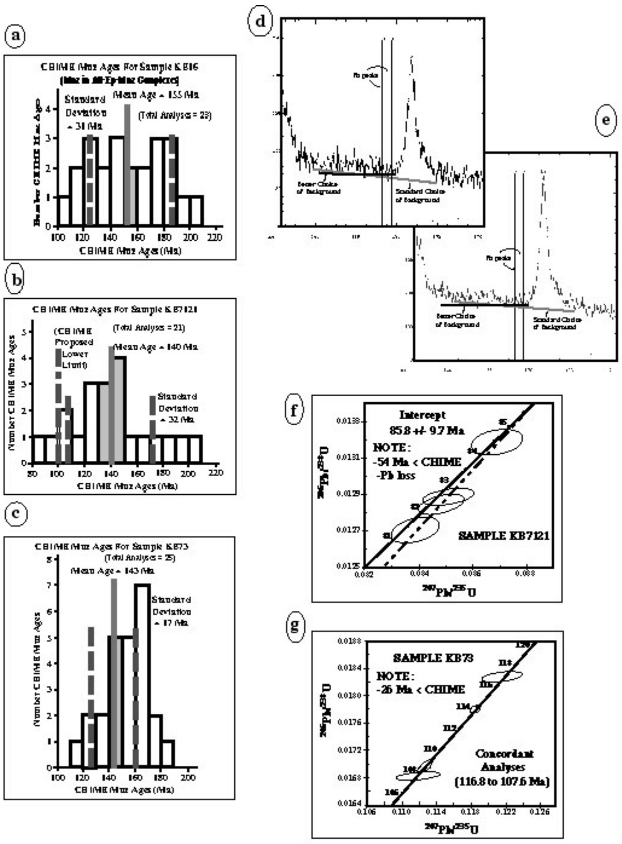

Fig. 3

However, a comparison of ID-TIMS and CHIME ages demonstrated that the more precise ID-TIMS ages were 26 to 54 Ma younger than the corresponding CHIME ages (Fig. 3). Analyzing young monazites is very challenging because the low Pb and U contents are very close to the detection limit of the electron microprobe. In fact, WDS scans (Fig. 3) across several of the monazites (with 3500 msec dwell time for Pb) show very little evidence for a Pb peak. These WDS scans also effectively demonstrate the importance of choosing the correct range for background analyses and that the appropriate background range is not necessarily the same for each monazite. If the background is not reduced to the right of the Pb peak, the background curve would dip to the right causing an over-estimation of Pb content (which would incorrectly skew the resultant CHIME age to an older age).

A second reason for this inconsistency between the CHIME and ID-TIMS ages is evident in the concordia plots for two of the monazite samples (Fig. 3). Some monazite samples suffered Pb-loss, which is not detectable by the CHIME technique. This would cause the resultant ID-TIMS ages to be younger than the corresponding CHIME ages.

This study emphasizes the importance of carefully choosing appropriate background ranges for Pb analyses with the CHIME technique. In young monazites slight changes in the use of background many have a profound effect on the resultant CHIME age (26 to 54 Ma in the Canadian Cordillera; Fig. 3). It is recommended that, when analyzing young monazites, a WDS scan be completed first, and that the background ranges be carefully chosen from these WDS scans. This technique could also improve CHIME analyses for older monazites such as those in the Central European Variscides.

References

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