Geophysical Research Abstracts
Vol. 18, EGU2016-15274, 2016
EGU General Assembly 2016

Common-lead problems related to allanite Th-U-Pb dating: Are muliple growth zones the problem or the solution?

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Allanite Th-U/Pb dating has proved to be a powerful tool to unravel the timing of magmatic and metamorphic processes. Different techniques (ID-TIMS, LA-ICP-MS, SHRIMP/SIMS) and optimized algorithms for the calculation of ages have been concocted over the last 25 years. Major differences concern the correction of age data for the initial common lead incorporated in allanite, which is required to interpret single analyses in terms of geologically meaningful ages. Much like garnet, allanite commonly shows growth zoning. Analytical progress improving the spatial resolution is thus most welcome for dating allanite, as it allows spots in single growth zones to be measured, rather than an average of several growth zones in single grains or worse, over several grains (early ID-TIMS).
Regarding the conversion of isotopic data to geological meaningful ages, spot age dating of allanite has developped from two opposite ambitions: (i) Single spot approach: Each analytical spot yields an age, which can be averaged over the same growth zone in order to obtain a more precise age; (ii) Isochron approach: Only groups of single spots analyzed together can reveal a correct age. The main differences between these approaches are the basic assumptions used for the interpretation of the ages. The single spot approach assumes that the the ratios of initial common lead incorporated in allanite is known, whereas for the isochron approach assumes that a single growth zone can be identified and hence only analyses from the same one are employed.
We present an approach that combines the two ambitions to date metamorphic allanite: Th-U/Pb-data from LA-ICP-MS spot analysis, EPMA data and results of different imaging techniques are reported. The composition of initial lead incorporated in allanite is estimated from the Tera-Wasserburg and the Th-isochron diagram. Estimates of this initial lead composition in allanite show that the common lead fractions in allanite are variable.
Case examples are presented. They show that the combination of standardized chemical maps with the chemical composition of spot analysis bears valuable information on allanite growth mechanism and helps identify the reasons for variable common lead fractions. The improved understanding of allanite growth mechanism allows defining a clear strategy for the calculation of ages based on accurately measured isotope ratios. In addition, the composition of initial lead in allanite can be used to constrain the allanite forming reactions and derive reaction or growth rates based on age dating of successive growth zones.
For metamorphic allanite at least, our findings imply that common lead cannot be understood based solely on global lead evolution models or even on a single value for an entire rock sample. Local reactions can lead to local changes in common lead, and these need to be understood for age dating.