Geophysical Research Abstracts
Vol. 18, EGU2016-18360, 2016
EGU General Assembly 2016

Apatite U-Pb thermochronolgy applied to complex geological settings – insights from geo/thermochronology and geochemistry

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Application of high temperature (>350oC) thermochronology is limited to the U-Pb system of accessory minerals, such as apatite, under the assumption that radiogenic lead is lost to thermally activated volume diffusion into an infinite reservoir. Cochrane et al. (2015) have demonstrated a working example from the northern Andes of South America. Predictions from volume diffusion theory were compared with measured single grain U-Pb date correlated to shortest diffusion radius and in-situ profiles measured by LA-ICP-MS. Results from both techniques were found to be in agreement with predictions from thermally activated, volume diffusion. However, outliers from the ID-TIMS data suggested some complexity, as grains were found to be too young relative to their diffusion radius. Interaction of multiple processes can be responsible for the alteration of apatite U-Pb dates such as: (1) metamorphic (over)growth, (2) fluid aided alteration/recrystallization and (3) metamictization and fracturing of the grain. Further, predictions from volume diffusion rely on the input parameters: (a) diffusivity, (b) activation energy and (c) shortest diffusion radius. Diffusivity and activation energy are potentially influenced by the chemical composition and subsequent changes in crystal structure. Currently there is one value for diffusion parameter and activation energy established for (Durango) apatite (Cherniak et al., 1991). Correlation between diffusivity/activation energy and composition has not been established. We investigate if correlations exist between diffusivity/activation energy and composition by obtaining single grain apatite U-Pb date and chemical compostion and correlating these to their diffusion radius. We test the consistency of apatite closure temperature, by comparing the apatite U-Pb dates with lower temperature thermochronometers such as white mica and K-feldspar Ar/Ar and by petrographic observations. We test if chemical information can be a proxy to identify metamorphic (over)growth and fluid aided alteration/recrystallization. We seek to evaluate if apatite U-Pb thermochronology can be applied to a broad range of rock types and geological environments or if limitations must be drawn.