Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.16859

Developing Reference Materials for High-Resolution Apatite Petrochronology

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Apatite U-Pb petrochronology is increasingly used to constrain the timescales of magmatic, tectonic, and hydrothermal processes, yet significant challenges remain in reconstructing high-resolution geological/thermal histories from apatite. Because apatite incorporates significant amounts of non-radiogenic (common) Pb during crystallization, corrections are required to obtain geologically meaningful U-Pb dates. There are multiple ways to correct for common-Pb, including: 1) unanchored regressions through multiple U-Pb data points to form a 2D or 3D isochron; 2) assuming a common-Pb composition from models of the evolution of bulk silicate Earth (BSE) Pb reservoirs; and 3) analyzing Pb in co-genetic, low U/Pb phases. The 3D isochron approach ($^{238}U/^{206}Pb$-$^{207}Pb/^{206}Pb$-$^{204}Pb/^{206}Pb$) arguably produces the most robust U-Pb dates, but this method is seldom employed by *in situ* studies due to limited ^{204}Pb data from reference apatites. To this end, we focus on developing reference materials with relatively high common-Pb to enable ^{204}Pb corrections from *in situ* apatite U-Pb analyses. We examine prospective reference apatites from rocks used for reference zircons (Fish Canyon, Mount Dromedary, Temora2, and Duluth) using isotope dilution thermal ionization mass spectrometry (ID-TIMS) and laser ablation split stream inductively coupled plasma mass spectrometry (LASS). We find that assuming BSE models for common-Pb compositions is not always valid for apatite and may yield inaccurate dates. Further, the Pb compositions of low U/Pb minerals (e.g., feldspar) seldom match the common-Pb compositions defined by apatite isochrons, suggesting these phases were not in isotopic equilibrium during crystallization or open-system behavior of U and/or Pb. The apatite dates do not always overlap with existing zircon U-Pb TIMS dates, consistent with either later resetting, growth, or slow cooling. This study highlights the need for *in situ* common-Pb corrections in generating accurate thermal histories, and the development of apatite reference materials with well-characterized common-Pb compositions is a crucial step towards that goal.