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Advancements in epidote U–Pb geochronology by LA-ICP-MS

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Epidote U–(Th–)Pb geochronology can be applied in many environments, as the occurrence of epidote is common in Ca-Al±Fe-rich lithologies. Magmatic Th-/REE-rich epidote (allanite) can date pluton emplacement. Epidote-clinozoisite is common in hydrothermal and skarn environments, and in regional greenschist-facies metamorphism, where it can constrain the timing of fluid circulation, mineralization, and retrograde metamorphism. However, epidote formation also extends to higher metamorphic grades, and detrital epidote is employed in provenance studies. Moreover, epidote trace element and isotopic (e.g., Pb, Sr, Nd, O, H) systematics can trace fluid sources and petrological processes. Hence, epidote is a powerful tool for investigating crustal processes, and it has provided unprecedented information on pre- and syn-orogenic fluid circulation in several localities [1,2,3], with far-reaching petrological and structural implications.

However, epidote U–(Th–)Pb geochronology is notoriously challenging. Similar to apatite, initial Pb contents can overwhelm those of radiogenic Pb, whose ingrowth forms the basis of U–(Th–)Pb dating. While the contribution of initial Pb can be corrected for in magmatic epidote by analyzing U-poor cogenetic phases or by employing terrestrial Pb evolution models, this is not the case for epidote in other settings, where it typically has higher initial Pb/radiogenic Pb ratios and initial Pb isotopic ratios not conforming to Pb evolution models. Therefore, geochronology of non-magmatic epidote requires different approaches.

We compare previously published and new protocols by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) that have enabled accurate U–Pb geochronology of epidote with unknown initial Pb isotopic compositions. We discuss the technical and geochemical challenges related to these types of measurements, and how they can be proactively tackled to ensure the optimal success of epidote geochronology. We compare LA-ICP-MS raster vs. static analysis modes, and the use of allanite as a closely matrix-matched reference material in both modes. Finally, we evaluate major and trace element characteristics contributing to making epidote dateable, presenting a strategy to screen epidote samples without compromising them for U–Pb isotope analyses.

[1] Peverelli et al. (2023), Lithos 460-461, 107391.
[2] Peverelli et al. (2024), Eur. J. Mineral. 36, 879-898.
[3] Zapata et al. (2024), Tectonics 43, e2024TC008340.