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Laser ablation Lu-Hf geochronology of mafic igneous apatite and detrital apatite.

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Solid Earth geochronology has largely been focused on the U-Pb systematics of the mineral zircon. However, zircon does not readily crystallize in low SiO_2 rocks, which has made dating mafic rocks challenging. Other minerals that can occur in mafic rocks, such as zirconolite or baddeleyite, are often in very low abundance or too small to date. Apatite is relatively more abundant in mafic lithologies, and is, consequently, often the only dateable accessory mineral. However, the U-Pb system in apatite has a relatively low closure temperature (~350° - 550° C) and may be reset in response to post-magmatic thermal or metasomatic events [1]. Here, a recently developed laser ablation Lu-Hf dating method, using reaction-cell mass-spectrometry [2], has been applied to rapidly date apatites from mafic rocks. The Lu-Hf closure temperature is more robust to thermal resetting (empirically established closure temperature of ~660° - 730°C [3]), increasing the chances of obtaining primary apatite crystallization ages. We compare apatite Lu-Hf and U-Pb systematics for mafic rocks using case studies from three study areas: the Superior Craton, the Fennoscandian Shield and the SW Yilgarn Craton. In some cases, both isotopic systems reveal primary crystallization ages. In other cases, the apatite U-Pb dates record a secondary overprint while the apatite Lu-Hf system remains undisturbed. In addition, we have applied the laser ablation Lu-Hf method to detrital apatite from the Pilbara Craton, which yielded U-Pb dates of ~2.8-2.9 Ga. In contrast, the Lu-Hf dates for the same grains are much older, up to Eoarchaean in age. Eorachaean zircon grains are only rarely observed in the Pilbara Craton, suggesting a primary lithology that did not crystallize zircon but did grow apatite. Both studies demonstrate the power of the novel laser ablation apatite Lu-Hf method to (1) obtain primary crystallization ages in rocks where zircons are absent, and where the U-Pb system records thermal overprinting, and (2) to obtain mafic provenance information to complement detrital zircon dating.

References:

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[2] Simpson et al., (2021) *Chemical Geology* 577: 12029

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