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Crustal contamination across the crustal ladder: insights from Hf and O isotopes in zircons from the Sesia Magmatic System

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Crustal contributions to magmatic systems are crucial to understand processes such as continental crust formation and the enrichment of critical metals (e.g. Sn, W, Li) in granitic magmas. However, signals from these contributions from varying crustal levels are compounded in magmas that reach the surface, obscuring processes that lead to their formation. The serendipitous occurrence of tilted crustal sections provides the opportunity to unravel the crustal contamination process at different levels of crustal-scale igneous system. One such occurrence is the Sesia Magmatic System (Southern Alps, Italy), a crustal-scale igneous system intruded in the Paleozoic crust in a short interval during the Permian (284-282 Ma, [1]) that is now exposed at the surface following Alpine orogeny.

In this study, we present a new dataset combining O (SIMS) and Hf (LA-MC-ICP-MS) isotopic compositions from zircon across all crustal levels and all lithologies of this Permian igneous suite. As these two isotopic systems are markers for crust-mantle contribution, this dataset allows a quantification of crustal contribution at different levels of a trans-lithospheric magmatic system. Zircon from deeper, amphibole-bearing gabbroic units of a large mafic intrusion display limited d^{18}O (6.2 to 7.7‰) and eHf (-2.1 to 5.1) variability. Analyses of zircon from middle crustal lithologies, which include the upper part of the gabbroic intrusion and small peraluminous granite dikes and sills display a larger range in both d^{18}O (7.6 to 9.9‰) and eHf (-8.5 to 5.7). A similar, broad compositional range (i.e. d^{18}O values from 6.8 to 9.5‰; eHf values from (-11.4 to 4.4) is observed in zircons from the large, composite granitic intrusions emplaced in the upper crust.

Overall, this dataset showcases the variability of contamination across different levels and suggests that the isotopic variability observed in the upper-crustal granitoid intrusions is acquired at middle crustal depths rather than in the lower crust. Specifically, the different isotopic signature might be related to different metamorphic host-rock assemblages. The more restitic lower crustal lithologies (granulites), being refractory to melt loss and hybridization compared to the fertile middle-crustal amphibolite, which appear to contribute significant volumes of crustal melt.

[1] Karakas et al. (2019), *Geology* 47(8), 719-723.