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Exploring the evolution of the Earth's crust through a multi-layer isotopic lens

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Individual radiogenic isotope systems provide distinct (often complementary) constraints on geological processes and reservoirs. Isotope maps at the terrane to continent scale, e.g., neodymium, hafnium, strontium, or lead, allow a powerful image of the (covered) crystalline basement to be resolved. Determining isotopic signatures from different material scales (e.g., single mineral, mineral populations, to whole rock) can further elucidate geologic processes from mineralisation to global secular changes in crustal evolution. Extending the determination of a variety of isotopic system signatures to different analytical scales, may allow fractionation processes to be tracked and inform on extents of secondary alteration. For example, hydrothermal alteration may greatly affect the rubidium - strontium system when investigating the whole rock; however, initial isotopic compositions may be retained i) within specific minerals (e.g., apatite initial strontium) un-affected by alteration or recrystallization; or ii) within different isotopic systems such as the samarium - neodymium system that is typically undisturbed by secondary processes. Furthermore, expanding the tool kit to different isotopic systems obtained at different material scales with dissimilar detection limits permits for a more complete spatial coverage.

Compiling literature with newly acquired isotopic data, we present the results of a case study from a suite of granitic samples across the Ida Fault in the Yilgarn craton, Western Australia. Utilizing the power intrinsic to differing sensitivities of isotopic systems to geologic processes, we aim to derive cumulative maps that provide new insights into crustal evolution and thus inform on the mechanisms that control mineralisation. By identifying inconsistencies or similarities in isotopic behaviour at the terrane scale from a variety of radiogenic isotope systems determined at the crystal to whole rock scale and comparison to geochronology layers (e.g., uranium-lead) provides the framework for the 4D understanding of a wide range of natural processes.