Secondary origin for 'primary' mineral inclusions in detrital zircons from Jack Hills, Western Australia

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The Hadean crust has long been regarded to comprise mainly primitive mafic and ultramafic rocks. However, detrital zircons up to 4.4 Ga from Jack Hills, Australia, have been used to infer the existence of extensive granitic crust during the Hadean. Mineral inclusions in these zircons have been interpreted to be primary and magmatic, and therefore to provide important clues about the chemistry of the early crust.

In situ U-Pb dating of monazite and xenotime inclusions in detrital zircon grains from Jack Hills, shows that the inclusions are much younger than their zircon host, and formed during episodes of regional metamorphism at 2.68 Ga or 0.8 Ga. Monazite-xenotime thermometry of intergrowths in the inclusions and the quartz-muscovite rock matrix constrain temperatures to ~450°C, corresponding with conditions during peak metamorphism. Evidence from inclusions in zircon from other localities indicates that the replacement of primary inclusions may commence in the granite host-rock and continue after deposition through to high-grade metamorphism. In metasedimentary rocks, the inclusion assemblage in detrital zircon may increasingly resemble the composition of the rock matrix. In Jack Hills, the most abundant minerals filling inclusions are also the main matrix minerals (quartz and muscovite), consistent with their formation during metamorphism.

Our results show that detrital zircon is not impermeable to post-depositional fluids. We suggest that many of the primary inclusions were replaced by secondary minerals during metamorphism, raising doubts about the use of mineral inclusions in zircon to infer magma chemistry.

Integrating climate and landscape controls on regolith depth, chemistry and mineral assemblage

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Linkages among climate, erosion and mineral weathering are central to pedogenesis and critical zone evolution. We approach these linkages through synthesis of climate, erosion and regolith geochemical data for upland terrain, coupled with detailed studies on climate and landscape position controls on pedon-scale regolith weathering patterns across the steep semiarid climate gradient encompassed by the Santa Catalina Mountain (SCM) Critical Zone Observatory in southern Arizona, USA. Climate forcing was quantified in terms of effective energy and mass transfer (*EEMT*), that includes energy flux to the subsurface critical zone in the form of primary production and effective precipitation, whereas chemical depeletion and mineral transformation were quantifed using a combination of geochemical, isotopic and mineralgocial analyses. The regional synthesis indicated regolith chemical depletion increased exponentially with water availability and *EEMT* for sites with annual temperature greater than 5°C and erosion rates greater than 10 $g/m^2/yr$, suggesting first order control of climate on chemical depletion, and second order control of temperature and erosion. SCM geochemical and mineralogical data indicated strong linkages among *EEMT*, phyiscal erosion, regolith depth, chemical depletion and mineral assemblage. Specifically, divergent landscape positions demonstrated a pattern similar to that in the regional synthesis of increasing chemical depletion with increasing *EEMT*. In contrast, convergent landscape positions demonstrated minimal mineral mass loss and relatively greater content of neogenic secondary mineral phases. Solution chemistry data suggest the convergent positions concentrate soluble weathering products from adjacent divergent positions, thus resulting in locally reduced mineral-solution weathering gradients and promotion of neogenic mineral precipitation. The coupled datasets indicate that timing and amount of available water is a central control on regolith weathering with strong local-scale modification related to landscape position.