

Distinguishing primary vs. alteration signatures among Jack Hills zircons and their mineral inclusions

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Detrital zircons from Jack Hills, Western Australia are the best known >4 Ga terrestrial mineral record. Various aspects of their trace element and isotopic geochemistry as well as their quartz- and muscovite-dominated mineral inclusion assemblage have been interpreted as evidence for their origin in relatively low-temperature, hydrous, granitic magmas. As their ca. 3 Ga host quartzite experienced several documented Precambrian metamorphic events, it is unsurprising that various alteration features have been suggested or identified in the zircons, ranging from suspiciously high LREE contents to phosphate inclusions with ages <3 Ga. We have surveyed both the mineral inclusion assemblage and the trace element geochemistry of the Jack Hills zircons, using a combination of literature data and new imaging and analyses of >1000 grains, with particular attention to possible alteration features. Association with cracks or metamict regions were found to be the best predictor of apparent alteration. Clear alteration signals along some cracks include high P, Ti, Fe, and LREE and low HREE/MREE; these effects are similar but more pronounced in metamict regions. This likely indicates a similar mode of alteration among cracks and metamict regions, probably related to fluid ingress. Some cracks, however, do not appear to be altered. Inclusions filling (secondary), intersecting, and isolated from cracks differ in their modal mineralogy; selective loss of certain phases (e.g., feldspar, apatite) along cracks but only minor inclusion replacement away from cracks is seen. Thus the isolated assemblage appears primary. It is dominated by muscovite and quartz and also includes very rare (found in <0.2% of >3.8 Ga zircons) graphite. No diamond was identified. Better quantification of the effects of fluid ingress along cracks and radiation-damaged regions will better constrain the primary magmatic chemistry of the zircons and may help to identify regions and inclusions along cracks that still retain their primary chemistry.