

Reconstructing hydration events of Archean komatiites: In situ U-Pb dating of monazite and titanite, and Rb-Sr dating of biotite, hornblende and calcite

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Hydrous alteration of oceanic lithosphere (e.g., serpentinization, carbonation) plays a crucial role in Earth's water and carbon cycles. This is widely observed today in ultramafic mantle rocks exposed at or near to the seafloor, forming secondary minerals such as serpentine, chlorite, talc, and carbonates. However, there is a paucity of knowledge regarding the timing of hydration processes of ultramafic volcanic rocks widespread on the early Earth; hydration could have occurred either on the ocean floor or during subsequent metamorphic events. The Barberton Greenstone Belt of the Kaapvaal Craton, South Africa, provides a well-preserved pre-3 Ga terrestrial record and hosts hydrated mafic and ultramafic volcanic units that erupted as oceanic plateaux ~3.48 Ga ago. This makes it an ideal setting to investigate the hydrothermal alteration of Archean ultramafic rocks, including komatiites.

We present LA-ICP-MS geochronology data from samples of the ICDP drill core BARB1, recovered from the Komati Formation's ultramafic lavas at depths of 112.65 to 113 meters, which have remained shielded from surface alteration throughout geological history. We dated several mineral phases found at the contact between the chilled margin of a komatiite flow and an overlying mafic tuff, all in textural equilibrium with the secondary (metamorphic) mineral assemblage (serpentine, chlorite, calcite and albite). U-Pb dating of titanite yielded an age of 3140 ± 49 Ma, while monazite exhibited a bimodal age distribution of ca. 2900 and ca. 1800 Ma. In-situ Rb-Sr dating of biotite, hornblende and calcite in the tuff layer produced errorchrons in line with Paleoproterozoic metamorphism.

We interpret titanite to record greenschist facies metamorphism during craton-wide granite emplacement at 3.1 Ga, while monazite and biotite appear to have been reset during thermal overprinting events, likely linked to widespread emplacement of mafic dykes in the Mesoarchean and Paleoproterozoic. Textural equilibrium of titanite with pervasively recrystallized carbonate resembles features of modern hydrated oceanic lithosphere on the seafloor, suggesting titanite formation occurred alongside carbonate recrystallization. While the 3.1 Ga age reflects a metamorphic event, initial hydration likely occurred earlier, potentially contemporaneous with komatiite eruption and cooling on the Archean ocean floor.