U-Pb Dating of Hematite in Banded Iron Formation: A Step Closer to Depositional Age?

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Résumé

Banded Iron Formations (BIFs) are exceptional marine deposits that can be used to study past oceanic environments and paleoclimate from the Archean to Neoproterozoic. BIFs typically alternate silica and iron oxide-rich layers. One of the main challenges in studying BIFs is the lack of direct and absolute dating methods. This poses a major problem for placing these formations in a timeline and fully understanding their depositional environment. Currently, most BIFs are dated indirectly using interstratified metavolcanics, detrital zircons' maximum ages from host sedimentary units or directly using whole rock Sm/Nd or Lu-Hf dating on apatite and Ar-Ar on rare accessory minerals like cryptomelane.
Recent research has shown the potential of in-situ U-Pb method on hematite by LA-ICP-MS, but also its limitations, especially due to the lack of a reliable and certified U-Pb hematite standard, and the nature of hematite that incorporates common Pb and only a few ppm of U. We applied U-Pb dating on hematite on three targeted areas: Yerbal BIF (Uruguay), Wanimzi BIF (Morocco) and Aït Ahmane BIF (Morocco). A LA-HR-ICPMS, Element 2 XR coupled to an Excimer Analyte G2 Teledyne Cetac was used with a 110 μm spot size. Three distinct reference materials were tested as primary standards: One zircon 91500, one rutile R10, one uncertified hematite MRHFO.

Here we optimized the method by performing statistical tests to determine which standard to use. We evaluated their downhole fractionation behavior and chose the standard that had the closest fractionation to that of our samples as our primary standard (i.e. 91500). Data were reduced using Iolite v4 and lower intercept age calculated using IsoplotR. We obtained an age of 729 ± 33 Ma (Aït Ahmane BIF), close to the time of deposition (753-640 Ma). However, certain conditions are needed, 91500 or R10 can be used as primary standard, spot size must be at least 110 μm and multiple samples from the same BIF have to be analyzed to ensure significant U-Pb data spread. These results highlight the potential of hematite as a direct geochronometer in BIFs and offer new perspectives for refining the depositional age of Precambrian iron formations.

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