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Is there life left in Akilia – novel approaches to an old controversy

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For almost two decades, an enigmatic iron-rich quartz-amphibole-pyroxene (QAP) rock unit hosted in granulite-facies TTG gneisses on Akilia, SW Greenland has been claimed to be either a chemical sediment containing >3.84 Ga biogenic remnants [1] or a younger product of polyphase metasomatism and metamorphism of an ultramafic protolith [2,3]. Although in recent years Akilia has therefore been largely ignored in the investigation of early Earth environments, constraining the true protolith of these rocks remains an important goal because the very earliest (known) rock record on Earth is typified by poly-metamorphic, poly-deformed lithologies, some of which may indeed preserve evidence of early biological activity. We present new whole-rock Fe-isotope data and zircon Lu-Hf data from the Akilia QAP unit, additional isotopic tools that may be used to constrain protolith.

The $\sim$5m-wide QAP unit on Akilia exhibits lithological variation from pure quartzite to ultramafic rocks, of which the $\sim$3 cm thin, finely banded unit that yielded purported C-isotope evidence for biological activity, has been considered by some as the most likely candidate for a chemical sediment. Previous Fe isotope studies of QAP have yielded δ^{56}Fe$_{IRMM}$ up to c. +1‰ [4], at one end of the -3‰ to +1‰ range typically exhibited by chemical sediments [5]. Our Fe-isotope analyses reveal similar, positively fractionated Fe-isotopes, but importantly also from ultramafic layers within the QAP unit that are apparently of igneous origin. Finely banded QAP has yielded metamorphic zircon, predominantly $\sim$2.7 Ga in age, but with rare cores of $\sim$3.6 Ga. Hf isotopes in these zircons are exceedingly radiogenic and heterogeneous, ranging in ε_{Hf}(2.7) from +38 to +231, while the single $\sim$3.6 Ga zircon has ε_{Hf}(3.6) of +18.7. Whole-rock ε_{Hf}(2.7) for the QAP rocks are also very radiogenic, ε_{Hf}(2.7) ranging from +39 to +103, while a thin ultramafic layer has ε_{Hf}(2.7) of +37. In contrast, ultramafic and amphibolite rocks adjacent to the QAP unit are near-chondritic.

Models for the origin of QAP require an explanation for both the highly fractionated Fe-isotopes and Lu/Hf, not just in the finely-banded "BIF candidate" but also in igneous ultramafic components of QAP. These models include extreme metasomatic redistribution of elements during two (3.6 and 2.7 Ga) high-grade events in an originally igneous protolith, or wholesale chemical and isotopic overprint of an originally mixed lithology whose protoliths are beyond recognition.

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