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Trace element signatures of iron oxides in BIF-style iron deposits of the Middleback Ranges, South Australia

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Banded iron formation (BIF)-style mineralization occurs in the Middleback Ranges deposits in the southeastern region of the Gawler Craton, South Australia. The >20 discrete deposits form a ~60 km-long N-S-striking belt which is characterized by the Lower Middleback Iron Formation (LMIF) and the Upper Middleback Iron Formation (UMIF). Tectonothermal events leading to formation and deformation of the Gawler Craton span the Archean to the Mesoproterozoic, and have impacted the iron formations (e.g. [1]). Such events may be recorded in the trace element signatures of iron oxides from these related iron deposits. Here, we provide the first LA-ICP-MS trace element analyses of magnetite and hematite from samples representative of different deposits throughout the Middleback Ranges. The aim is to understand whether the distinct trace element signatures in oxides of different provenance and age can be used to support the development of genetic and space-time evolution models.

Iron deposits in the Middleback Ranges are hosted predominantly within the LMIF, which consists of a 'mixed' basal sequence, a lower iron carbonate unit, a middle iron talc unit and an upper iron silica unit, all grading up sequence and laterally [2]. Deposit sequences themselves can be complex, as exemplified in the Iron Magnet deposit. Magnetite mineralization is hydrothermal and occurs as layer replacement (from laminae to beds), matrix to breccias and clasts within breccias, and within veins and fractures [2]. At higher levels, hematite textures are varied, but martitisation is a common feature throughout all deposits. In massive ores, hematite occurs as lamellar or anhedral, fine-grained aggregates with abundant vugs, often with dusty inclusions of gangue minerals. In more oxidized samples, iron hydroxides replace hematite.

LA-ICP-MS data for magnetite and hematite show measurable concentrations of a broad range of minor and/or trace elements. Of these, some are common in BIF-style ores (e.g. Al, Si, Mn and P) but others present here are sparsely reported in analogous ores. Examples include rare earth elements and yttrium (REY), Zn, Cu, As, Sb, Ti, Zr, and most interestingly, U (tens to hundred(s) ppm in samples from the central part of the belt). Moreover, chondrite-normalised REY fractionation trends can vary within individual samples and from one deposit to another, with changes in the sign of Ce-, Eu- and/or Y-anomalies, overall slope (from flat to LREE-enriched), and increase in ΣREY over 1-2 orders of magnitude. Such changes are observed in magnetite showing deformation, related to martitisation or transformation of hematite into Fe-hydroxides. Magnetite tends to be lower in ΣREY than hematite, which is enriched in LREE, and generally has positive Eu- and Y-anomalies. Intriguingly, Fe-hydroxides are still richer in the same trace elements than precursory hematite in any given sample.

Recognition of measurable U and Pb in Fe-oxides in Middleback Ranges raises the alluring possibility of applying U-Pb geochronology to date sedimentary iron ores. U-bearing hematite is suitable for Fe-oxide geochronology, and was found to be a robust tool that could be successfully applied to give Pb-Pb ages for U-bearing hematite in the Olympic Dam deposit [3]. Dating of U-bearing hematite from the present study would be critical in deciphering the geological evolution of the Middleback Ranges.

References:

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