

REE and Y compositions of Archean and Paleoproterozoic Banded Iron-Formations

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Rare earth element (REE) concentrations in marine precipitates, including banded iron-formations (BIFs), have been used as proxies to study secular trends in Precambrian ocean chemistry. Complete REE plus yttrium (Y) datasets of some Archean chemical sediments, including those from the Warrawoona Group (3.45 Ga) and the Isua Greenstone Belt (ca. 3.7-3.8 Ga), have shown compositional features indicating that they precipitated as marine sediments and that they reflect paleo-ocean conditions at the time of precipitation. Here, we present new REE+Y data for ca. 2.75 Ga and ca. 2.45 Ga samples of the Temagami and the Dales Gorge BIFs, respectively. We compare the shale-normalized REE patterns of these Neoproterozoic and Paleoproterozoic BIFs to those of modern seawater, other Paleoproterozoic BIFs, and early Archean chemical sediments, in order to quantify the similarities and/or differences in the REE and Y patterns. To avoid any crustal contamination, samples were selected on the basis of extremely low, if any, Th, Zr, Hf and Sc concentrations and lack of co-variations of Zr vs. Y/Ho, Y/Ho vs. Ce/Ce* and Th vs. La/La*. All the samples display similar REEY patterns with depleted LREE relative to MREE and HREE, while MREE are slightly depleted relative to the HREE. In addition, they show strongly positive La, Eu and Y anomalies. Except for differences in the Eu and Ce anomalies, the latter being absent in all the samples analyzed here, they have similar trends to present day seawater in terms of their overall REE patterns. Furthermore, the REEY values are similar to those obtained for Kuruman and Penge BIFs and Archean chemical sediments, especially BIF from Isua Greenstone Belt. In comparison to other Archean and Paleoproterozoic BIFs, the redox-sensitive REEs, Eu and especially Ce, do not show any significant difference. Thus, oxygen levels in the Paleoproterozoic atmosphere as late as 2.4 Ga appear to have been low enough to prevent the oxidation of Ce(III) to Ce(IV).

Hydrothermal zircons: A tool for ion microprobe U–Pb dating of ore mineralization in polyphase deposits

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Hydrothermal zircons from polyphase Tamlalt–Menhouhou gold deposit (Eastern High-Atlas, Morocco) and Zgounder silver deposit (Anti-Atlas, Morocco) were examined in order to define the age of sodic metasomatism (i.e. albitization), which is assumed to be related to the gold and silver mineralization.

In the Tamlalt–Menhouhou gold deposit, magmatic and hydrothermal zircons were distinguished in albitized banded rhyolitic metatuffites (BRM) on the basis of petrographical associations, mineralogical character and REE signature. Petrographical observations and geochemical data indicate that hydrothermal zircons crystallized as a result of release of Zr stock from the pristine BRM (Zr>300 ppm) during sodic metasomatism. SIMS U–Pb analysis provides Ediacaran (569 ± 8Ma) and Late Ordovician (449 ± 8Ma) ages for magmatic and hydrothermal zircons respectively.

In the Zgounder silver deposit, high-U zircons (up to 2.4% UO₂) were identified in albitized microgranites dykes and plugs. Zircons exhibit two different phases on SEM: (i) a “bright-BSE” phase with REE signature typical of magmatic zircons crystallized from an evolved silicate melt (Ce/Ce*> 90, Sm_N/La_N> 50 and Eu/Eu*< 0.07) and (ii) an hydrothermal “dark-BSE” phase linked to dissolution-reprecipitation of the magmatic phase. The hydrothermal phase is enriched in Ca, Fe, Mn, K, Mg, U, Th, LREE, and its REE signature indicates crystallization from reduced high temperature fluid (Ce/Ce*< 3 and Sm_N/La_N<10 and Eu/Eu*> 0.3). SIMS U–Pb geochronology performed on magmatic and hydrothermal phases provided an average ²⁰⁷Pb/²⁰⁶Pb age of 578 ± 4Ma and 564 ± 15Ma respectively.

Identification of a late Ordovician mineralizing event in the Tamlalt–Menhouhou deposit, and of an upper Neoproterozoic hydrothermal event in the Zgounder deposit underlines the potential of zircons to record strong hydrothermal events, and the value of these phases for reconstructing ore-forming process in polyphase deposits.