

The petrographical and geochemical characteristics of the BIFs in the Hotazel Formation from Transvaal Supergroup: Implications for redox and hydrothermal contributions in their depositional environments.

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The surface environments on the earth have evolved from anoxic to oxic. The oxidation has occurred discontinuously mainly at two times throughout the earth history: the Neoproterozoic to the Paleoproterozoic and the Neoproterozoic. The first oxidation event is known as “the Great Oxidation Event (GOE)”. In the Paleoproterozoic Hotazel Formation of the Transvaal Supergroup, South Africa, there are the manganese ores hosted by the banded iron formations at the three stratigraphic horizons, which is one of the most conspicuous evidences for GOE.

Previous studies in the Hotazel Formation have focused only on their metallogenic studies of the Mn ores such as post-depositional alterations (e.g. Gutzmer and Beukes, 1997). On the other hand, their sedimentary environment changes responsible for depositions of the manganese rocks and the BIFs have not been constrained fully. In this study, we tried to estimate redox and hydrothermal contributions in the sedimentary environments from the lowermost BIFs to the lowest Mn-rock layer based on stratigraphic variations of some geochemical proxies (some major element contents such as Mn, Ca and Fe, and REE + Y patterns).

In the studied strata, the Mn/Fe ratios and Ca/Fe ratios from the lowermost BIFs to the lowest Mn rocks show increasing trends, suggesting that precipitations of Mn-oxide minerals and Ca-carbonate minerals were becoming prevailed relative to that of Fe-oxide minerals in the sedimentary environments. These trends suggest that the sedimentary environments were becoming more oxic and shallower.

Whole-rock REE + Y contents in the BIFs show weakly positive correlations with Fe contents and strongly positive correlations with phosphorus (P) contents. Moreover, micro-scale elemental imaging in the lowermost BIFs shows that apatite occur as spots in the Fe-oxide bands, and REE + Y is concentrated in those spots. Those REE + Y distributions in the BIFs suggest that REE + Y might have been primarily derived from adsorbents on Fe oxyhydroxide and secondarily moved into phosphorous minerals at the diagenesis. On the other hand, REE + Y in the lowest Mn-rock layer is positively correlated with Mn contents, suggesting that those elements might have been derived from adsorbents on Mn oxyhydroxide. However, secondarily movement of REE + Y associated with the diagenesis forming apatite might be less influential on REE + Y patterns because anomalous behaviors of Eu and Ce are seen regardless of P contents. PAAS-normalized REE + Y patterns show that the lowermost BIFs overlying the Ongeluk Formation show positive Eu anomalies characteristics of high-temperature hydrothermal fluids (e.g. Bau and Dulski, 1999). On the other hand, the Mn rocks show negative Ce anomalies similar to modern oxic seawater (e.g. Alibo and Nozaki, 1999).

Above stratigraphic variations of Mn/Fe, Ca/Fe ratios and REE + Y patterns in the analyzed strata suggest that the Paleoproterozoic ocean was composed of double-layered structure. The deep ocean was anoxic and subject to contributions of hydrothermal fluids, resulting in precipitations of Fe-oxide minerals (the BIFs). On the other hand, the shallow ocean was oxic with active primary productions, resulting in Mn-oxide and Ca-carbonate minerals.

Keywords: Banded Iron Formations, Manganese rocks, Rare Earth Elements