Geophysical Research Abstracts
Vol. 20, EGU2018-2095-1, 2018
EGU General Assembly 2018

Origin of Late Cretaceous ironstones Deposits, Northern Oman Mountains, Oman: REE geochemistry approach

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In this paper, we examined the REE geochemistry of ironstone deposits that developed on the top parts of the lateritic soil of the Northern Oman Mountains during the early Cretaceous time. This lateritic soil developed on a layered gabbro or serpentinized harzburgite of the Semail ophiolite. The main objective of this study is to reconstruct the conditions and the paleo-environment of deposition of ironstone beds based on REE results. To carry this study, we collected about 30 samples of ironstone from different seven sections of laterite.
The ironstone within the study area varies in thickness from few meters to up 13 m and it is composed of hematite, magnetite, and goethite as the main iron minerals, in addition to some silicates, carbonates, and inherited chromite and authigenic chlorite.

Geochemical investigation of ironstone shows that the content of $Fe2O_3$ (t) ranges from 31.14 Wt % to 83.84, $Al2O_3$ from 1.38 to 15.5, SiO_2 from 2.23 to 38.0, MnO from 0.02 to 2.52, MgO from 0.27 to 4.94 wt %), CaO from 0.13 to 30.31 wt %. This fluctuation in geochemistry reflects changes from Si-Al-poor ironstones formed by direct chemical precipitation processes to Si-Al-rich ironstones that might have significant detrital component inputs and later diagenetic processes

The total REE's abundances of the ironstone vary from 1.55 ppm to 373 ppm and the PAAS normalized patterns show an enrichment in heavy rare earth elements (HREEs) relative to light REEs (LREEs). The Yb/La ratio is about 0.75 to 4.13. The patterns also show negative and positive anomalies in Ce (0.4 to 2.9) and a slight positive anomaly in Eu (1.12 to 1.29).
The positive and negative Ce anomalies might reflect a fluctuations in depth of basin water during transgressions and regression episodes.

Average REE ratios of all samples are: La/Sm = 0.73 (ranging from 0.35 to 1.35), La/Ce = 1.13 (ranging from 0.32 to 2.82), Eu/Sm = 1.26 (ranging from 1.12 to 1.41), Sm/Lu = 0.60 (ranging from 0.35 to 1.07). These ratios are much higher than those calculated for ironstone beds in previous studies. Both ratios La/Sm and La/Ce are higher than those calculated for the whole laterite profile (about 1.4 and 1.13 respectively) while for Eu/Sm and Sm/Lu ratios, values are lower than those of laterite deposit. Such ratios between REEs suggest the inputs of rare earth elements from an external source.
In the diagram Ce/Lu ratio versus Ce/Sm ratio, ironstone samples plot between two end members which can be related to seawater (Ce/Lu = 0.015 and Ce/Sm=0.074).

The lack of significant Eu positive anomaly suggests that the contribution of hydrothermal fluids in the deposition of ironstone is negligible.

Similar to many other ironstone deposits described in the literature, the provenance of the present ironstone beds can be attributed to mafic rocks interacted with sea water without any contribution of hydrothermal system in a shallow environment. The geochemical characteristics suggest inputs from a detrital source.