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Use of REE geochemistry to constrain the nature of the hydrothermal fluid in magnetite–apatite mineralization in Pathargora, Singhbhum Shear Zone, eastern India

SUBHADIP ADAK[1] AND DIPAK CHANDRA PAL[2]

[1]Indian Institute of Science Education and Research (IISER), Bhopal
[2]Jadavpur University

Magnetite-apatite veins occur in hydrothermally altered deformed and metamorphosed rocks at Pathargora, Singhbhum Shear Zone, India. Using REE geochemistry of magnetite and apatite this study aims to understand the nature of the hydrothermal fluid associated with the ore mineralization.

Most of the hydrothermal magnetite and apatite from magnetite–apatite bearing veins are enriched in REEs (mean ∑LREE are 6.4 ppm and 608 ppm vs. mean ∑HREE are 2.7 ppm and 640 ppm in magnetite and apatite) than respective chondrite values indicating that the hydrothermal fluid was extremely enriched in REEs, as minor amount of REEs in magnetite itself implies REE-enriched nature of the fluid. Both magnetite and apatite are characterized by negative Eu anomaly (Eu/Eu*< 1.0) and positive Ce anomaly (Ce/Ce*>1) which suggest that the REE anomalies are controlled by the nature of the hydrothermal fluid. A previous compilation by [1] from a broad spectrum of depositional environments ranging from mafic, intermediate to rhyolite suite as well as apatite samples from IOA–IOCG deposits showed that Eu/Eu* ≥ 0.5 is generally associated with the oxidizing condition and apatites belonging to hematite zone are associated with values ≥ 0.5 and sometimes ≥ 1. The observed Eu/Ce anomalies can thus be explained by moderately reducing hydrothermal fluid. Furthermore, high V (1966 ppm - 3604 ppm) and negligible concentration of Sn (mostly below the detection limit of LA-ICPMS) in magnetite validates the reducing nature of the fluid as V in reduced +3 state and Sn in +4 oxidized state are most compatible in magnetite. Accompanying apatite is fluorapatite (F content 3.5 to 4%) containing negligible Cl suggesting that the fluid was F-dominated. Converging evidence comes from the high Y/Ho ratios (average Y/Ho in magnetite and apatite are 21.62 and 26.48 respectively), as it is known that in F–ligand-rich fluid, Y preferentially fractionates over the other lanthanides including Ho due to the higher stability constant of YF_2^+. Integrating all observations it is reasonable to infer that the hydrothermal fluid that precipitated magnetite and apatite was reduced, F-rich and enriched in REEs.

1. Mercer, C. N., Watts, K. E. & Gross, J. Ore Geol. Rev. 116, (2020).