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Geochemistry of banded iron formations and their host rocks from the Central Eastern Desert of Egypt: A working genetic model and tectonic implications

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ABSTRACT

Banded iron formations (BIF) occur intercalated with Neoproterozoic volcanosedimentary units in 13 localities in the Egyptian Central Eastern Desert (CED). These units are characterized by magnetite and hematite-rich layers alternating with quartz-rich layers containing andradite–rich garnet, epidote, ± calcite in the southern parts of CED, and chlorite ± stilpnomelane, and calcite in the north. Localized hydrothermal alteration affected most deposits and is manifested by secondary Ca–bearing minerals. All BIFs and their host rocks were strongly deformed and metamorphosed under greenschist to epidote amphibolite facies conditions during the collisional stage of the Pan African orogeny.

Geochemically, CED BIFs have higher Fe/Si compared to Algoma, Superior, or Rapitan BIF types. All BIFs have rare earth element – Y patterns similar to those of modern day oceanic water, with a few samples displaying a weak positive Eu anomaly. All BIFs have high SiO_2/Al_2O_3 and Fe/Ti, and low Al/(Al + Fe + Mn), which suggest a hydrogenous origin with hydrothermal contributions and low detrital component. Geochemical trends, Y/Ho, and Pr/Yb values suggest deposition of Wadi El Dabbah BIF closest to land and Um Nar and Wadi Kareim closest to hydrothermal vents. Host metavolcanic and metavolcaniclastic rocks show chemical signatures indicative of an immature oceanic arc setting with MORB affinities for the southern areas and back- or fore-arc basin affinities for the northern localities.

These results lead to the conclusion that CED BIFs and their host rocks formed in small intra-arc basins and sloped or terraced silled basins in the back- and fore-arc areas surrounding an immature island arc. Restricted circulation of hydrothermal fluids in these basins concomitant with arc volcanism increased Fe^{+2} and Si in solution. During periods of arc quiescence, oxidation of Fe^{2+} led to deposition of Fe-oxyhydroxide. Diagenesis formed fine-grained magnetite, whereas subsequent hydrothermal alteration and metamorphism formed porphyroblastic magnetite and specularite.

1. Introduction

Banded iron formations (BIFs) are widely accepted as products of chemical precipitation of Fe^{2+} and Fe^{3+} oxides and hydroxides, Fe-rich silicates (± carbonates and/or sulfides), and silica in a marine environment, followed by significant diagenetic and metamorphic modifications (e.g. James, 1992; Klein and Beukes, 1993a). Because most BIFs are Archean to Palaeoproterozoic in age (Abbott and Isley, 2001; Huston and Logan, 2004; Klein and Beukes, 1993a), their abundance versus paucity have been used by many authors to constrain the timing of the Great Oxygenation Event (GOE) at *c.* 2.4 Ga (e.g. Garrels et al., 1973; Klein, 2005a,b; Simonson, 2003). The occurrence of a few relatively small-sized BIFs deposited 850–700 Ma (e.g. Ilyin, 2009; Klein and Ladeira, 2004; Yeo, 1986) has therefore been attributed to the global glaciation hypothesis known as Snowball Earth (e.g. Hoffman et al., 1998; Kirschvink, 1992). Other authors attribute the formation of these Neoproterozoic BIFs to specific tectonic and/ or volcanic events (e.g. Basta et al., 2011; Freitas et al., 2011; Eyles and Januszczak,

Abbreviations: ANS, Arabian-Nubian shield; BIF, banded iron formation; BSEI, back scattered electron image; CED, Central Eastern Desert; Fh, ferrihydrite; ga, gahnite; Goe, goethite; hc, hercynite; Hem, hematite; Ilm, ilmenite; jd, jadeite; mg #, Mg/(Mg + Fe); NED, northern Eastern Desert, PPL, plane-polarized light; ps, pistacite, REE, rare earth elements; RL, reflected light, SED, Southern Eastern Desert; sp, spinel; usp, ulvospinel; X_i, mole fraction of component "i"

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