Deformation, Metamorphism and Hydrothermal-Metasomatic Alteration of the Neoproterozoic BIF-type Fe-Co-Cu Ore District in Hainan Province, South China: Implications for Mineralization

Deru Xu,[1,*] Zhilin Wang,[2] Huayong Chen,[1] Peter Hollings,[3] and Nonna Bakun-Czubarow[4]

[1]Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China [2]Central South University, Changsha 410083, China
[3]Lakehead University, Ontario, Canada P7B 5E1, [4]Institute of Geological Sciences, Polish Academy of Sciences, 00-818 Warszawa, Poland

*E-mail, xuderu@gig.ac.cn

The Shilu Fe-Co-Cu ore district is situated in the western Hainan Province of South China, and mainly hosted within a low-grade, dominantly submarine siliciclastic and carbonate sedimentary succession of the Neoproterozoic Shilu Group. After deposition between ca. 1.0-0.83 Ga, the Shilu BIFs and interbedded host rocks underwent polymetamorphism and hydrothermal alteration which significantly reworked and/or upgraded the original BIFs. Three types of metamorphism have been recognized: (1) the ca. 830-700 Ma greenschist facies metamorphism ($T \leq$ 300-400 °C and $P \leq$ 3 - 5 kbar) likely corresponding to the Rodinia break-up in South China, (2) the ca. 510-440 Ma amphibolite facies metamorphism (presumed T = 450-650 °C and P = 5.4-6.4 kbar) marked by a mineral assemblage of pyroxene (Px_1) + amphibole (Amp_1) ± garnet (Grt_1) ± monazite likely related to the South China Caledonian orogeny, and (3) the ca. 270-190 Ma, local contact thermal-metamorphism (T =400-600 °C and P =1 - 4.5 kbar) likely resulting from the Indosinian to early Yanshanian plutons emplaced during the closure of the Paleo-Tethyan ocean. The amphibolite facies event was associated with simultaneous structural deformation (D_1) and significantly refined the ore metals Fe, Co and Cu along favorable structural sites such as synclinal cores, foliations and S-C fabrics.

Simultaneous or subsequent to the Indosinian to early Yanshanian intrusions, retrograde metamorphism and related hydrothermal alteration, including a retrograde brittle-ductile deformation event D_2, resulted in the oxidation of magnetite to hematite (Hem_2) and late-stage mineralization of sulfides. The identification of three hydrothermal alteration styles, namely the actinolite-K-feldspar-quartz-rich alteration zone, the epidote-(chlorite)-rich alteration zone, and the calcite-actinolite-(chlorite)-rich alteration zone, indicates that the paragenesis of the alteration minerals can be differentiated into two sub-assemblages. The early, retrograde mineral assemblage of garnet (Grt_2) + pyroxene (Px_2) + amphibole (Amp_2) + feldspar (Fs_1) + Hem_2 + epidote + apatite + allanite ± monazite indicates the presence of a Ca-(Cl)-Fe-Al-rich, highly oxided fluid at ca. 250-210 Ma, whereas the later, retrograde assemblage of amphibole (Amp_3) + feldspar (Fs_2) + chlorite + quartz + calcite + barite (Brt_2) ± sulfides implies a metalliferious, K-S-Ba-rich and reduced fluid likely caused by the late Yanshanian (ca. 130-90 Ma) magmatic thermal event associated with subduction of the Paleo-Pacific plate beneath the South China continent. Hydrothermal alteration most likely occurred at P/T conditions of T = 240-410 °C and P = 1.5 - 2.5 kbar.

Based on the comparison in genesis and host rocks with the worldwide, Neoproterozoic BIFs, the Shilu BIFs is ascribed to a Superior-type BIF but has been reworked and/or upgraded by structural deformation, metamorphism and hydrothermal fluid. Consequently, three types of the Neoproterozoic BIFs in the world, i.e. Algoma-, Rapitan- and Superior-types, have been proposed to elucidate their genesis.