Application of Synchrotron-based µXRF mapping and high-resolution U-Pb geochronology to unravel the timing of mineralization at the Pedra Branca IOCG deposit, Carajás Province, Brazil

Sanches, J.M; Moreto, C.P.N.; Galante, D; Silva, M.A.D.; Melo, G.; Xavier, R.P.; Corrêa, A.I.C.M; Perreira M.A.M; Castro, P.T.; Franca E.; Costa, L.C.G., Silva, M.A., Araújo, J.

The Pedra Branca copper mine (18 Mt @ 1.6% Cu & 0,41 g/T Au), located in southeast Carajás Domain and under operation by OZ Minerals/BHP, is mainly hosted by: i) Mesoarchean metasyenogranites related to the Cruzadão Granite with crystallization age of 2895 ± 36 Ma (U-Pb in zircon, SHRIMP IIe); and ii) banded orthogneisses with amphibolites enclaves of the Mesoarchean Xingu Complex. Hydrothermal alteration zones and related Cu (-Ni) mineralization are structurally controlled by a nearly E-W shear zone (N75E/85SE) with N20E/75SE oblique to downdip mineral lineation, related to the Canaã Shear Zone. The Cu (-Ni) mineralization (Chalcopyrite-Pyrrhotite-Magnetite-Millerite ± Pentlandite) occurs as subvertical lensoidal breccia bodies within the shear zone foliation. The ore breccias are matrix-supported with a sulfide-rich matrix, although subordinate massive sulfide bodies and disseminated sulfides may also be part of the mineralization styles at the deposit. Three hydrothermal alteration halos are recognized: i) regional sodic alteration (Albite-Hastingsite) particularly developed in the metagranites; ii) calcic alteration (Actinolite-Titanite-Tourmaline ± Apatite) controlled by the strike of the shear-zone, and iii) a more restricted calcic-ferric alteration (Magnetite-Titanite-Actinolite-Tourmaline) that envelops the mineralization. Some of the U-bearing minerals (i.e. zircon, titanite and monazite) show signs of hydrothermal alteration, or hydrothermal origin. Based on synchrotron µXRF elemental maps, zircon crystals from the albitized metagranite display U, Th and Y-rich cores with Hf-enriched rims, which, combined with textural features suggest they were affected by the hydrothermal fluids. Titanite crystals associated with the Ca and Ca-Fe alteration stages have hydrothermal textures, and monazite crystals occur as inclusion within ore-related apatite. The main mineralizing event likely occurred ca. 2.7 Ga, as suggested by ages obtained from hydrothermal titanite (2668 ± 5.6 Ma and 2717 ± 4.7 Ma – U-Pb, LA-ICP-MS) and hydrothermally altered zircons from the orthogneiss (2753 ± 35 Ma, U-Pb, SHRIMP IIe). These ages are coeval to the formation of the Canaã Shear Zone and other deposits in the Southern Copper Belt (e.g., Sequeirinho-Pista, Cristalino and Bacaba). Ages at ca. 2.5 Ga were obtained in monazite (four individual $^{207}Pb/^{206}Pb$ ages ca. 2499 Ma – LA-ICP-MS) and titanite (2511 ± 48 Ma – U-Pb, LA-ICP-MS), and a later superimposed hydrothermal event was also identified at ca. 2.0 Ga in monazite (2010 ± 16 Ma – U-Pb, LA-ICP-MS) and titanite (2094 ± 89 Ma – U-Pb, LA-ICP-MS). In the northern copper belt, ages at ca. 2.5 Ga register an important IOCG-forming event responsible for the genesis of multiple deposits such as Salobo, Igarapé Cinzento/GT46, Grota Funda and Igarapé Bahia/Alemão. At Pedra Branca these ages suggest either the influence of this event in the southern sector of the Carajás Domain, or indicate a partial resetting of the dated U-bearing phases at 2.0 Ga, leading to hybrid ages between 2.7 and 2.0 Ga. The Rhyacian/Orosirian event is also recognized in the Bacaba and Borrachudo IOCG deposits and is likely related to a barren (?) hydrothermal event associated with the Trans-Amazonian orogeny.