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Petrochronology unravels the Paleoproterozoic tectono-metamorphic event controlling IOCG mineralization in the Southern Carajás Mineral Province, Brazil

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The Carajás Mineral Province (Brazil) hosts world-class iron oxide-copper-gold (IOCG) deposits within two regional high-strain zones. The Canaã high-strain zone (CHSZ), the focus of this study, formed during regional migmatization at 2.89–2.85 Ga and was reactivated during the Carajás Basin opening with coeval magmatism (2.76–2.73 Ga) and a late transpressional event that shaped the region [1]. However, the age, P-T conditions, and kinematics of the late event, as well as its association with IOCGs, remain poorly constrained, relying on 2.72–2.68 Ga U-Pb ages in monazite handpicked from mineralized breccias [3].

We conducted a petrochronological investigation of sheared metagranites and IOCG breccias with well-constrained paragenesis [3] along the CHSZ to unravel its evolution and fluid interaction timing. This approach integrates structural and mineralogic analyses with *in situ* dating and trace element geochemistry of zircon, titanite, apatite, allanite-epidote, and biotite.

The metagranites exhibit steep S-dipping foliation and S-SE-plunging stretching lineation. Shear sense indicators suggest South-side-up kinematics with subordinate dextral component. Microstructural evidence supports deformation under amphibolite-facies conditions, while Na alteration (scapolite, albite), apatite textures and chemistry indicate coeval fluid mobilization. The IOCGs occur as lens-shaped chalcopyrite-rich breccia bodies surrounded by steep S-dipping mylonites. The breccias exhibit incipient S-C-C' fabrics and mylonites display chalcopyrite-rich bands, suggesting that mineralization was coeval with shearing.

Zircons are typically igneous, displaying preserved zoning and low Ti and LREE. U-Pb ages for biotite metagranites yield 2.86–2.85 Ga, while biotite-hornblende metagranites yield 2.75–2.73 Ga. Titanite in less deformed rocks yields U-Pb ages equivalent to zircon, but in highly deformed rocks, it also records ages of 1.99–1.98 Ga. U-Pb in apatite and Rb-Sr in biotite also yield young ages (1.99–1.92 Ga). Allanite-epidote (U-Pb) and apatite (U-Pb and Lu-Hf) ages for the IOCG breccias coincide with those from the metagranites (1.99–1.95 Ga).

Combined, our data reveal that the dominant deformation in Southern Carajás was a South-side-up transpression at 1.99–1.92 Ga, under amphibolite-facies conditions (500–600°C) accompanied by brine mobilization and IOCG mineralization. This tectono-metamorphic event, previously unrecognized, decouples IOCG mineralization from contemporaneous magmatism.

[1] Trunfull et al. (2020), Ore Geology Reviews 10, 35-56.

[2] Moreto et al. (2015), Economic Geology 110, 809-835.