



IN SITU HIGH-RESOLUTION U-PB GEOCHRONOLOGY OF APATITE: UNDERSTANDING THE ALTERATION-MINERALIZATION TIMING OF THE JAGUAR HYDROTHERMAL NICKEL DEPOSIT, CARAJÁS MINERAL PROVINCE

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RESUMO: In the southwest portion of the Carajás Mineral Province, the Jaguar hydrothermal nickel deposit, is characterized by nickel sulfide mineralization hosted in hydrothermally altered subvolcanic felsic rocks (Jaguar Sul and Jaguar Central), granitoids and mafic intrusions (Onça Preta). The association Magnetite-apatite-actinolite-rich are closely related to nickel mineralization with pyrrhotite-(pentlandite), millerite, chalcopyrite and pyrite. *In situ* high-resolution U-Pb geochronology of hydrothermal apatite analyses were carried out to estimate the timing of alteration-mineralization in the Jaguar deposit related to (i) alteration-mineralization zones hosted by the acid porphyritic subvolcanic rock at the Jaguar Sul orebody; (ii) ultramafic host rock (Onça Preta orebody), where apatite occurs associated with magnetite, talc/cummingtonite and sulfides, mainly pyrite. In the Jaguar Sul orebody, two generations of apatite were dated: (i) fine-grained apatite (I) along foliation defined by biotite orientation (2187 ± 83 Ma; MSWD = 1.6); and (ii) ore-related apatite (II) in dilational structures (1896 ± 62 Ma, MSWD = 1.3; 1882 ± 44 Ma, MSWD = 2.0), associated with chlorite-quartz halos. Both apatite generations have similar chondrite-normalized rare earth element (REE) patterns and pronounced negative Eu anomalies. However, the later generation has lower total REE content, suggesting its formation due to a dissolution-reprecipitation mechanism during ore precipitation/mobilization. The highly radiogenic $^{207}\text{Pb}/^{206}\text{Pb}$ initial ratio (~ 0.951) of the Jaguar Sul apatite is consistent with its metasomatic character, as suggested by the trace elements patterns (Sr/Y and LREE). In the Onça Preta orebody, the apatite II (1840 ± 36 Ma; MSWD = 1.3) has high total REE content, negative Eu anomaly and a slightly fractionated pattern with LREE enrichment concerning HREE. The Sr/Y and LREE resembles apatite chemistry akin to mafic rocks. The geochronological data suggests that the Jaguar hydrothermal system records at least two Paleoproterozoic metallogenetic events. The first, likely related to the McCandless fault zone development at ca. 2.2 Ga, was associated with syntectonic potassic alteration and nickel mineralization controlled by foliation. The second event at ca. 1.84-1.89 Ga was related to the input of channeled hotter fluids, resulting alteration overprinting and ore mobilization. As the high-temperature of the later event may have resulted in resetting of the U-Pb apatite system, the role of each Paleoproterozoic event in the genesis of the Jaguar deposit is still to be revealed.

PALAVRAS-CHAVE: Apatite, laser ablation, *in-situ* analyses, U-Pb dating, Carajás.