THE MORRO DOS SEIS LAGOS Nb (Ti, REE) DEPOSIT, AMAZONAS, BRAZIL.

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The Morro dos Seis Lagos carbonatite body occurs in a main E-W structure intersected by NE-SW and NW-SE structures. U-Pb dating (MC-ICP-MS) of zircons yielded 1828 ± 09 Ma in the gneissic host rock. Carbonatite samples provided 3 groups of ages: 1826 ± 5 Ma, 1525 ± 21 Ma, and 1328 ± 58 Ma. The mineralogical features of the ~1.3 Ga zircons have some affinity with carbonatite. The younger age represents the maximum age of the carbonatite. The host rock was affected by K-fenitization (phlogopite and orthoclase, minor monazite, F-apatite and bastnäsite). The complex consists only of siderite carbonatite (SC) of three types: a brecciated and oxidized core SC [siderite (up to 95 vol.%) and hematite with minor Ce-Ba-pyrochlore, Nb-brookite, Ti-maghemite, and thorobastnäsite]; a REE- and P-rich variety of the core SC (siderite and hematite, with minor Ce-Ba-pyrochlore, monazite and bastnasite); a border SC (siderite, barite and gorceixite with minor rhabdophane and Pb-Ba-pyrochlore). The core SC is the richest in Fe yet recognized and has high contents of Nb, Mn, Ba, Th, Pb and LREE. The average REE_2O_3 concentrations are 0.70 wt% (core SC) and 1.48 wt.% (P-rich zone). The high Nb/Ta ratio is compatible with residual liquids derived by fractional crystallization. Fluid inclusion and C and O isotopic data indicate that the core SC and the REE-rich type are related to a late-magmatic-to- hydrothermal process and the border SC is carbo-hydrothermal. The $^{87}Sr/^{86}Sr$ and $^{144}Nd/^{143}Nd$ isotopic data suggest the carbonatite has a mantle origin with no crustal contamination and is younger than the maximum age of 1.3 Ga. The lateritic deposit (> 100m in thickness; 2897.9 Mt at 2.81 wt% Nb_2O_5) is affected by E-W and NNW-SSE structures which control valleys, ridges, and karst processes with basin formation. It is divided into six types of laterites (from the top to the base): pisolitic, fragmented, mottled, purple, manganiferous, and brown. All the laterites are composed mainly of goethite (lower and upper types) and mainly hematite (intermediate types). The upper laterites were reworked, resulting in goethite formation with florencite-(Ce). In the manganiferous laterite, the Mn-oxides (hollandite and pyrolusite with cerianite) occur as veins formed in a late event closer to the water table. The main Nb ore mineral is Nb-rich rutile (with up to 22.23 wt% Nb_2O_5) formed from a former secondary pyrochlore, together with Ce-pyrochlore, Nb-rich goethite and cerianite. Nb-rich brookite formed from Nb-rich rutile occurs as broken spherules with an ‘‘oolitic” texture. The paragenesis results of lateritization have been extremely intense. Rutile and brookite incorporate Nb following the $[Fe^{3+}+(Nb, Ta) = 2Ti]$ substitution. The laterites have an average TiO_2 content of 5.00 wt% and average Ce_2O_3 of 1.02 wt% (in the lower part) and 1.41 wt% (in the manganiferous laterite). At the Esperança Basin (233m thick) the REE mineralization in the lower package (breccia rich in SC fragments) and in the intermediary package (rythmites rich in ferruginous materials related to the early stages of siderite carbonatite alteration) is clastic (monazite and florencite). In the upper package (0-73m, avg. REE_2O_3 of 1.72 wt%), formed by carbonaceous clay rich in organic matter, which marks the relief inversion, the mineralization [authigenic florencite-(Ce)] is formed by dissolution of minerals from the reworked laterites and deposition in an alkaline environment rich in Al and P.