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Very low-grade metamorphism and very well preserved epithermal mineralization in the Paleproterozoic Uatumã LIP, southern Amazonian craton, Brazil

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The Amazonian craton is divided into geochronological provinces, result of successive ocean–continent orogenies, named as Carajás–Imataca (3.1−2.53 Ga), Central Amazon (>2.5 Ga and 1.88^{-1}.70 Ga magmatism), Tapajós−Parima (∼2.10-1.87 Ga), Rio Negro (1.86^{-1}.52 Ga), Rondonia−Juruena (1.76^{-1}.47 Ga), K'Mudku (1.33^{-1}.10 Ga) and Sunsás (1.33−0.99 Ga). Migration of the Late Paleoproteozoic magmatic arc to the Xingu−Iriri region has been interpreted as related to a flat subduction stage.

The magmatic Uatumã event constitutes a Large Igneous Province (LIP) formed between 2.0–1.87 Ga, which cover at least 1,200,000 km2. It is represented by calc-alkaline intermediate to felsic volcanic/volcaniclastic sequences and porphyries, and anorogenic rhyolites, ignimbrites and granites. These rocks were not affected by subsequent orogenic events, showing exceptional preservation of the volcanic mineralogy, textures and structures. These units host several large paleo-hydrothermal centers, including very well preserved Au, Cu and Mo epithermal high- and low-sulfidation and porphyry mineralization, which have been recognized in two major areas: the Tapajós Gold Province (TGP) and the São Félix do Xingu–Iriri region (SFXI).

In TGP, located in the Tapajós−Parima Province, the Uatumã event is mainly represented by the 1.88 Ga Iriri Group. It represents the result of large nested ash-flow caldera complexes genetically linked with late- to post-tectonic calc-alkaline batholiths of the Parauari Intrusive Suite. The pre-caldera units are mainly composed of andesitic, rhyolitic and ignimbritic flows; the syn-caldera units consists of several large ash-tuff eruptions, and the post-caldera units are represented by rhyolite and ignimbrites, which encompass ring composite volcanoes and domes. Tuffs, epiclastic sandstone and lacustrine sediments form the intra-caldera deposits. Intrusion of granophyric stocks and dikes of rhyolitic and rhyodacitic porphyry marks the end of the caldera evolution. Intense hydrothermal alteration in ring volcanoes, responsible for epithermal high- and low-sulfidation mineralization, is related to these intrusions.

In the SFXI, located at the eastern border of the Central Amazon Province, Uatumã effusive and explosive volcanic and associated subvolcanic and plutonic rocks are represented by the basal 1.88 Ga Sobreiro Formation, composed of high-K calc-alkaline andesites and dacites, and the upper 1.87 Ga Santa Rosa Formation, formed by A-type rhyolites and ignimbrites, in part related to fissure controlled eruption, and associated porphyries and granites.

Only a very low-grade regional metamorphism, with chlorite, pumpellyite, prehnite (?), carbonates, quartz, sericite, albite, epidote, sulfides and clay-mineral, similar to that observed in modern geothermal fields, affected the volcanic rocks in both areas. Gradations to greenschist facies were identified towards the paleo-hydrothermal centers. Deformed rocks occur mainly within shear zones. In the volcanic rocks, vesicules and vuggs of leached minerals are partially preserved or filled by quartz with very small aqueous fluid inclusions with rare gas bubble, suggesting a diagenetic cementation.

In the TGP, high-sulfidation (quartz−alunite) gold mineralization occurs in hydrothermal breccia pipes affected by advanced argillic alteration with alunite enveloped by argillic and propylitic hydrothermal alteration zones and covered by hematite-rich silica cap. In deeper zones, sericitic alteration predominates associated with porphyry dikes. Geological setting of the low-sulfidation (adularia−sericite) Cu–Mo–(Au) mineralization is very similar to that of the high-sulfidation. Low-temperature epithermal mineralization with diaspore and large paleo-hydrothermal centers with very intense sericitic alteration associated with hydrothermal breccias dikes and porphyry stocks have been recognized at SFXI.

Ar−Ar ages for TGP alunite of 1.86 Ga, with recrystallization in shear zones in 1.8 Ga and weathering in 51.3 Ma, have been obtained. Stable isotopes (H, O, S) in alunite indicate contribution of magmatic fluids with mixing trend with meteoric waters similar to those characterized in modern epithermal systems, and crystallization

temperatures from 130 to 420 oC. Noble gas in alunite show a primitive mantelic derivation.
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