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Spectral analysis of hydrothermal alteration at the Marmato gold deposit, Colombia

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The Marmato deposit occurs in one of the premier mineral provinces of Colombia: the Middle Cauca Gold Belt. It is hosted by a porphyry stock, which comprises five magmatic pulses of late Miocene age, named P1 to P5 from oldest to youngest, where P1, P2 and P5 are dacites, while P3 and P5 are andesites. Porphyry P1 is the largest and the most important one, since it hosts the bulk of the gold mineralization. The Marmato deposit is characterized by two zones with different styles of mineralization. The Upper Zone comprises mainly epithermal veins associated with two ore phases: a low epithermal sulfidation state and an intermediate epithermal sulfidation state, while the Lower Zone consists of disseminated and stockwork veinlet mineralization. A clear transition zone occurs between the Upper and Lower zones where the different ore styles and the crosscutting relationships between the mineralization-alteration events are observed.

A total of 953 points were recorded by spectral analysis on six drill holes, which display five alteration sets, associated to three mineralization events: 1) regional pervasive propylitic alteration consisting of iron-magnesium chlorite and epidote with disseminated pyrrhotite; 2) weak and local potassic alteration with secondary biotite in veinlets and disseminated within the matrix; 3) albite and fine-grained muscovite alteration rimming veinlets of quartz+ pyrrhotite+ bismuth minerals± chlorite± epidote; 4) argillic alteration associated with illite/montmorillonite of potassium composition associated with quartz+ adularia+ pyrite+ arsenopyrite± chalcopyrite± sphalerite± galena veinlets and veins; and 5) kaolinite dominated alteration associated with ankerite/calcite + pyrite+ marcasite+ tetrahedrite± sphalerite veins and veinlets.

The alteration types 1, 2, and 3 are only related to the deep mineralization, hosted by the Lower Zone, and formed in an early mineralization stage. The propylitic alteration, which widely affects the porphyry stock, represents the background of the spectral analyses. The potassic alteration, in the assemblage 2, occurs locally, and becomes predominant towards the deepest intervals of the drill cores, indicating an approximation to a higher temperature zone. The albite and fine-grained muscovite alteration occurs in the Lower Zone, and forms a halo rimming the veinlets with a maximum 10 cm in thickness. The fine-grained muscovite with a high crystallinity index indicates a high-temperature event above 300°C. In addition, the chlorite associated with the major ore event is more magnesium-rich compared to the propylitic one.

The argillic alteration is associated with the low sulfidation stage, which overprints the early alteration stages producing pervasive alteration halos of very strong alteration up to 1 m thick. It is important to emphasize the illite/montmorillonite proportions, which indicates temperatures below 300°C for the low sulfidation stage. The former assemblage is related to the intermediate sulfidation event, and is dominated by high-crystallinity kaolinite, which overprints all previous alteration assemblages, obliterating the original texture of the rock. This last alteration suggests a

circulation of lower temperature fluids with temperatures close to 150° to 200°C, and a slightly more acidic pH.