

# Gold and copper mineralisation in the Saldaña Formation, Natagaima region, Tolima, Colombia

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Jurassic hypabyssal and volcanic rocks of the Saldaña Formation (SF) outcrop west of the Magdalena River, along the border of Tolima and Huila departments, and constitute one of the best exploration targets for large-tonnage disseminated Cu-Au deposits in the Colombian Andes, South America. The SF rocks formed in an aulacogen that extends along the length of the Andes, from Venezuela into Argentina. Mineralisation is known throughout this belt and confirms a continent-wide metallogenic province.

The Natagaima region is located in a small isolated stretch of the Colombian Central Cordillera, between the Saldaña and Magdalena rivers. The SF is a complex volcano-sedimentary sequence of faulted blocks, composed of tuffs, agglomerates, lava flows, continental and shallow-marine sedimentary rocks, and small subvolcanic porphyritic bodies. The size of andesitic to dacitic porphyritic bodies seldom exceeds four km<sup>2</sup>. They are composed of well-formed plagioclase phenocrysts, which are up to a few centimeters long, in a gray-green aphanitic matrix. Petrographically, their compositions vary from tonalite to granodiorite and quartz monzonite, although some grade into diorite and basalt: a few intrusions are syenitic. Numerous augite phenocrysts and abundant amygdules, which are filled by chalcedony, calcite, chlorite, epidote, zeolites and native copper, are evident in the matrix.

In the region covered by this study, the SF covers 1200 km<sup>2</sup> and evidence of fertile intrusive rocks, hydrothermal alteration and mineralisation occur throughout. Approximately 15,400 hectares within this region have high potential to host disseminated gold deposits associated with the upper parts of Cu-Au porphyry systems. The SF was deposited in an aborted rift basin overlying Triassic continental red beds and a carbonate platform. Jurassic subduction caused subsequent magmatism and volcanism. Thick piles of Cretaceous and Tertiary sediments were unconformably deposited above the igneous rocks. Mineral deposits are related to Jurassic porphyritic intrusions that were emplaced along zones of weakness in the tuffs and other units of the SF. Repetitive intrusion produced overprinting hydrothermal alteration and mineralisation. Extensional faults parallel the main branches of the aulacogen and define sites for fluid migration and mineral deposition. Circular structures are not uncommon.

Several types of mineralisation are known in the region, including world-class gold placers, abundant sub-vertical high- and low-sulphidation Au- and Cu-rich epithermal quartz veins, as well as Ag, Cu, Ba, F, Sb, Fe and gypsum deposits that have been exploited at small scale since pre-Columbian times. Disseminated gold and copper mineralisation has been detected in stockworks, quartz-vein breccias, porphyritic bodies, and hydrothermal breccias along the contact between intrusive and volcanic rocks. The region has significant potential for discovery of high- and low-sulphidation epithermal gold, gold and copper porphyries, and Carlin-type, Fe-oxide-Cu-Au-REE and exotic copper deposits. Primary copper mineralisation is generally associated with local zones of intense sericitisation and silicification and a large part of the SF contains secondary copper minerals and epidote. Numerous gossans, with abundant free gold, have been mapped. At least 22 zones that are favourable for large-tonnage gold and copper mineralisation have been identified to date.

The geological environment that generated the SF and its associated mineralisation extends throughout the Colombian Andes, from Guajira to Putumayo, and along the entire Andean chain from Venezuela to Argentina. World-class deposits such as El Silencio, Antioquia; Angostura, Santander; Serranía de San Lucas, Bolívar (Colombia), Nambija and San Carlos, Serranía del Cóndor (Ecuador), Cerro Vanguardia, Patagonia (Argentina) all occur in units correlative with the SF and fall within a similar age span in the continent-wide metallogenic province.