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Geology and Fluid Characteristics of the Mina Velha and Mandiocal Orebodies and Implications for the Genesis of the Orogenic Chega Tudo Gold Deposit, Gurupi Belt, Brazil *

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Abstract

The Chega Tudo gold deposit is located in the Gurupi belt of northern Brazil. Gold mineralization in the Mina Velha (upper level) and Mandiocal (intermediate and lower levels) orebodies is hosted in highly strained Paleoproterozoic (2148–2160 Ma) felsic to intermediate metavolcanic rocks and schists that record greenschist facies metamorphism. The orebodies are broadly concordant with the regional northwest-oriented foliation, and mineralization comprises thick quartz vein sets and small quartz-carbonate-sulfide veinlets and enclosing hydrothermally altered host rocks. The hydrothermal mineral assemblage is postpeak metamorphism, syn- to late tectonic, and includes quartz, calcite, chlorite, white mica, pyrite, subordinate chalcopyrite, and traces of sphalerite and galena.

Free-milling gold occurs in sulfide-poor veins in the upper and lower zones of the deposit, whereas refractory gold was deposited in fractures of pyrite and quartz in the more gold-enriched intermediate (±lower) level. Fluid inclusion and stable isotope (O, H, C, and S) data indicate that the two styles of gold deposition were produced by a combination of fluid immiscibility, fluid-rock reactions (sulfidation, carbonatization), and probably mixing, occurring in two discrete stages within a single mineralizing event associated with fluid flow within and around an active shear zone under fluctuating pressure conditions.

The refractory gold was deposited at 340° to 370°C from a CO_2-CH_4-H_2O–NaCl fluid having salinity of 5.8 ± 2.7 wt percent NaCl equiv, variable CO_2 contents (typically 12–22 mol %), and up to 6 mol percent CH_4. The $\delta^{18}O$ and δD values of this fluid are 7.9 to 9.4 per mil and –29 to –37 per mil, respectively, indicating a metamorphic origin. Carbon isotopes show contrasting values in fluid inclusion CO_2 ($\delta^{13}C$ = –24.1‰) and calcite ($\delta^{13}C$ = of –3.8‰). The strongly negative value of fluid inclusion CO_2 is interpreted to be an organic signature acquired at the site of deposition by reaction of the deeply sourced ore-forming fluid with carbonaceous schists present in the deepest part of the deposit. The higher value for calcite probably records a crustal source. Oxygen fugacities calculated for the whole range of T-P-XCO_2 conditions yielded $\log f_{O_2}$ between –28.7 and –30.5, indicating reduced conditions for the fluid, which is in agreement with the mineral paragenesis, fluid inclusion compositions, and sulfur isotope values.

The second fluid, responsible for the deposition of the free-milling gold in veins and probably part of the gold of the lower zone of the deposit, had a lower temperature (330°–340°C). This CO_2-H_2O–NaCl fluid had a salinity of 1.6 to 2.5 wt percent NaCl equiv and contained 11 to 13 mol percent CO_2. The $\delta^{18}O$ and δD values of this fluid are 5.3 to 7.2 per mil and –12 to –30 per mil, respectively, also indicating a metamorphic source. The $\delta^{13}C$ value of fluid inclusion CO_2 is –6.9 per mil, likely representing a mantle-derived carbon source. Log f_{O_2} values between –30.5 and –31.5 also indicate slightly more reduced conditions for this fluid. Both fluids had near-neutral pH, between 5 and 6.2, and $\delta^{34}S$ values of H_2S between –0.2 and –1.0 per mil, interpreted to reflect derivation of sulfur from magmatic sulfides.

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The Mina Velha and Mandiocal orebodies represent different mineralization styles of the Chega Tudo deposit, and the determined conditions of ore formation may be related to two distinct events or to a single event with sequential stages of hydrothermal alteration and gold mineralization. The corresponding fluid properties, hydrothermal alteration, structural control, tectonic setting, geology, and metamorphism are analogous to those of orogenic gold deposits.