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Fluid Characteristics of Granitoid-Hosted Gold Deposits in the Birimian Terrane of Ghana: A Fluid Inclusion Microthermometric and Raman Spectroscopic Study

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Abstract

Fluid inclusions in vein quartz from 10 granitoid-hosted gold deposits and prospects in the Birimian terrane of Ghana, as well as from the Sansu mine (Ashanti shear zone type) and quartz veins in the nonmineralized Princess Town granodiorite, were studied by microthermometry and Raman microspectrometry. Fluid inclusions from the granitoid-hosted gold deposits are dominated by aqueous H_2O-CO_2-NaCl type 1 and liquid CO_2-N_2 ± CH_4 type 2, with minor (<10%) aqueous H_2O-NaCl type 3. Type 1 inclusions show large variations in CO_2 phase volume proportions (10–90%) at 25°C and have salinities commonly between 0 and 6 wt percent NaCl equiv. Their bulk densities fall in a major range from 0.62 to 1.11 g/cm3. Type 2 inclusions show no visible H_2O phase at room temperature and have bulk densities between 0.30 and 0.92 g/cm3. Type 3 inclusions, containing 10 to 20 vol percent H_2O vapor, have salinities of 1 to 8 wt percent NaCl equiv and bulk densities of 0.77 to 1.03 g/cm3. In most cases, the three types of fluid inclusions coexist as groups in individual quartz grains of the samples studied. These fluid inclusions are interpreted to be trapped during phase separation of an originally homogeneous H_2O-CO_2 fluid, with low salinity (<6 wt % NaCl equiv) and moderate to high density (0.65–0.95 g/cm3). The type 1 fluid inclusions are suggested to be heterogeneous mixtures of the two end members of type 2 and 3 inclusions. Fluid immiscibility is documented by petrographic characteristics and microthermometric results of the three types of inclusions. Trapping temperatures and pressures, estimated from microthermometry of type 3 inclusions, equation of state, and the P-T-X nature of the H_2O-CO_2-NaCl system, are mainly between 200° and 350°Cand 1 and 3 kbars for the gold deposits.

By contrast, fluid inclusions in the Sansu mine at Ashanti mostly comprise the liquid CO_2-N_2 ± CH_4 type 2. The inclusions are considered to represent postentrapment modifications of trapped fluids. In addition, fluid inclusions in barren vein quartz from the Princess Town granodiorite comprise the low-salinity (commonly <6 wt % NaCl equiv) H_2O-NaCl type 3. Raman microspectrometry shows that gaseous compositions of fluid inclusions from both granitoid- and shear zone-hosted gold deposits are mainly composed of CO_2 (80–95 mol %), with significant amounts of N_2 (2–20 mol %) and CH_4 (0–10 mol %).

The distinct low-salinity H_2O-CO_2-rich fluids from the granitoid-hosted gold deposits are comparable in composition to those from the major Ashanti and Tarkwaian types of gold deposits in the Birimian terrane of Ghana. These fluids are most likely to be metamorphic in origin and associated with the waning stages of the regional Birimian orogeny. Gold deposition within the Birimian granitoids was related to fluid phase separation and sulfidization of host rocks during hydrothermal alteration and mineralization. The present study, together with previous publications, suggests that fluid inclusions are characterized by H_2O-CO_2-NaCl and/or CO_2-N_2 ± CH_4 types in mineralized areas, whereas H_2O-NaCl fluid compositions dominate in barren areas. Fluid inclusion characteristics may, therefore, be a useful tool for regional gold exploration in the Birimian terrane of Ghana.