Fluid origin and evolution at the Sweet Home Mine, Alma, Colorado

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The Sweet Home Mine is located in the Alma mining district on the eastern slope of central Colorado's Mosquito Range. The mineralization comprises an early quartz-muscovite-pyrite-fluorite-huebnerite stage followed by a main ore stage with various sulfides and a subsequent carbonate stage with unique rhodochrosite and some fluorite crystallization. Hydrothermal activity ended with the precipitation of apatite and calcite.

K-Ar and Rb-Sr dating of sericite demonstrate that early hydrothermal activity occurred ca. 30-27 Ma ago, possibly including several pulses. U-Pb ages of huebnerite and apatite cluster between 26-25 Ma. Unusual high $^{87}Sr/^{86}Sr$ values of 0.73 to 0.75 in fluorite from different mineralization stages and rhodochrosite are much more radiogenic than those of the regional granites (0.705 to 0.711), suggesting that the hydrothermal fluid acquired a significant part of its Sr budget from incongruent wall rock leaching, notably from muscovite, biotite, and alkali feldspar. However, fluorites from the early stage show Y/Ho ratios typical for fluorites derived from, and deposited near, igneous rocks. Minerals from the sulfide stage are characterized by Y/Ho ratios that are considerably higher than chondritic values indicating fluid migration in a much larger scale.

Fluid inclusions in quartz and fluorite from the early stage yield homogenization temperatures between 300 and 360°C and salinities of about 5 wt.% NaCl equiv. The fluids contain minor CO_2. Minerals from the main ore and rhodochrosite stages also host CO_2-bearing inclusions but show lower homogenization temperatures (250–300°C) and slightly lower salinity (2-4 wt.% NaCl equiv.). Laser-ablation ICPMS analyses reveal rather uniform fluid solute contents with Na and K as major cations in the fluids and trace amounts of Li, Zn, Pb, Cu, As, Mn, W, B, Sr, and Rb. Rhodochrosites display an unusual wide range of $\delta^{18}O_{VSMOW}$ values from -1.0 to +10.9‰ and rather constant $\delta^{13}C_{VPDB}$ values of -8.5±0.6‰ indicating the presence of magmatic and meteoric water during rhodochrosite formation and a single magmatic (?) source of carbon, consistent with fluid trace element signatures.