Methane in Carlin-type gold deposit fluid inclusions

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We measured methane and other major volatiles in fluid inclusions in bulk from the Lone Tree, Getchell, Twin Creeks, and Pipeline Carlin-type gold deposits in Nevada by quadrupole mass spectrometry. Ore-stage fluids are characterized by CO_2/CH_4 ratios that typically are < 10. Fluid inclusion methane concentrations generally are between 0.1 and 0.5 mol.%; other gaseous species show much wider ranges in composition. Also associated with gold mineralizing fluids are concentrations of H_2S at or above amount that would be in equilibrium with pyrite-magnetite, and N_2/Ar ratios > air. Methane strongly partitions into a vapour phase, but we can find no evidence that measurement of high methane concentrations is a consequence of bulk analysis of inclusion material bearing trapped vapour.

We can see no reason why methane is required for the transport of gold. High N_2/Ar ratios indicate a magmatic volatile component in the fluids, but it is hard to explain the methane source as magmatic. It could be that methane is accidental to gold ore fluids and a consequence of the environment of gold ore fluid formation rich in carbonaceous rocks. High concentrations of methane lower the oxidation state of gold ore fluids to the point that pyrrhotite is stable. Methane could be important kinetically in the oxidation-reduction couple required for gold deposition when gold is complexed with bisulfide. A possible reaction is:

$$8AuHS + 5CH_4 + 3CO_2 = 8C + 8Au + 8H_2S + 6H_20$$

which also explains the common occurrence of small amounts of carbon in gold ores. Methane-rich fluids can explain deposition of carbon that is common in greenstone-hosted and Carlin-type ore deposits.

Conversely, methane might be important in the deposition of gold. Gold solubility reactions that include methane, like that above, indicate that an increase in methane fugacity will act to precipitate gold. A possible scenario for gold ore formation is addition of methane to gold ore solutions by interaction with carbonaceous metasediments and volcanics.

We conclude that methane is a common but enigmatic constituent of Carlin-type gold ore fluids, and can explain the occurrence of carbon in gold ores. Its occurrence may be accidental, or methane may be a critical factor in the deposition of gold.