Au-rich fluid inclusions in gold-bearing quartz from the Kola superdeep borehole (SG-3)

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In the core of the Kola super-deep borehole (SG-3, 12262m depth) gold-enriched rocks of Archaean age were located at depths between 9.5-11.0 km. These rocks were overprinted by Proterozoic regional epidote-amphibolite facies metamorphism at 500-650 °C and 3.5-6 kbar.

We have studied fluid inclusions (FI) in quartz from a vein, located at a depth of 9907.5m, within the gold enriched interval of the stratigraphy. The quartz contains 3 types of FIs: 1) gas inclusions of dense CO_2, 2) vapour-liquid two-phase aqueous inclusions, and 3) three-phase inclusions with NaCl daughter crystals. CO_2 inclusions homogenized into the liquid phase at temperatures ranging from +21.2 to -6.1 °C with T_mCO_2 from -57.1 to -58.9 °C and density of 0.76 to 0.96 g/cm^3. The salinity of the water phase of vapour FI is 3.4-4.1 wt. %-eq. NaCl. Microthermometry showed that the two-phase inclusions are brines containing chlorides of Ca and Na with Te from -55 to -74 °C and $T_m$ice from -33 to -63 °C, corresponding to salinities of 25.9 to 30.2 wt. % -eq. $CaCl_2$, T_h was between 137-185 °C. Three-phase inclusions have $T_h$halite between 231-123 °C and $T_h$vapour 107-185 °C. They also contain Na and Ca chlorides with T_e of c. -64 °C and salinities of 28.7-33.5 wt. %- eq. NaCl.

Individual FI compositions were analysed by LA-ICP MS. Elemental ratios of the 3-FI types are reasonably consistent and confirm the major cations are Na, K and Ca, with several 100's to a few thousand ppm of Fe, Cu, Zn, Pb in the higher salinity fluids. There are extremely high concentrations of Au in all FI types. In the high salinity FI's the average concentration is c. 300 ppm and as high as 1500 ppm. Thermodynamic simulations indicate such high Au concentrations correspond to a saturated solution of Au in the chloride complexes at temperatures above 500 °C. We suggest these fluids could be a precursor of "Orogenic gold fluids" which at these Au concentrations would reduce the requirements for large volumes of metamorphic fluids to form such ore deposits.