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CHARACTERISTICS OF FLUIDS IN QUARTZ VEINS AND IN THE WALL ROCKS OF THE MURUNTAU AU DEPOSIT (UZBEKISTAN): WHICH FLUID TYPES ARE ASSOCIATED WITH ORE PRECIPITATION?

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The Muruntau ore field in Uzbekistan is located in the southern part of the Tamdytau mountains (Central Kyzyl Kum sub-zone of the Southern Tien-Shan) near the intersection of the Dzhanbulak anticline and the Muruntau-Daughyztau fault (e.g. Kotov & Poritskaya 1992, Drew et al. 1996).
The outstanding large Au resources of the Muruntau deposit (>3,400 t Au) are contained within high grade mineralised "Central" quartz veins, stockworks, and low grade mineralised flat veins. Within the ore contours, metasomatic lithologies also contain economic Au ore concentrations (Shayakubov et al. 1999). In this article, we report the first results of a study focused on a comparison of features of the mineralizations in the Au-quartz veins and the alteration characteristics of the adjacent metasomatic lithologies.
According to microscopic, fluid inclusion microthermometric and geochemical data, as well as cathodoluminescence (CL) and SEM investigations several phases of fluid circulation may be distinguished in the veins. Early, low grade Au mineralization in flat veins has not been considered in this study (for details concerning that stage see Kempe et al. 2000).
Probable primary fluid inclusions characterised by intermediate to high Th values (260 to >350°C), CO_2-(CH_4-N_2) dominated non-H_2O volatile components, and a predominance of NaCl as the cation-anion component in the fluid, may be found in angular fragments of primary zoned quartz crystals in steeply dipping vein types (Graupner et al. 2000). Pseudosecondary inclusions containing a fluid of a similar composition to that trapped in the probable primary inclusions frequently occur in unzoned quartz and in scheelite from the "Central" veins, and in the "stockwork-type" veinlets. Fluid phase separation is indicated for samples from the "Central" ore veins by fluid inclusion observational work, microthermometric data and bulk fluid geochemistry (CO_2/CH_4, CO_2/N_2, and CO_2/C_2- and C_3- hydrocarbon ratios; gas chromatographic analysis; Graupner et al. 2001). Similar trends for volatile-volatile ratios are observed for fluids trapped within the main hydrothermal stage (primary and pseudosecondary inclusions) in all investigated ore bodies and mining levels of the Muruntau deposit.
Late, low temperature (100 to 250°C), low-salinity, aqueous fluids were trapped in secondary inclusions in quartz from all vein types. Very small, low-density fluid inclusions occur along high-angle grain

boundaries between completely recrystallized quartz grains and at recrystallized boundary surfaces between deformed quartz grains or sub-grains; these surfaces also contain numerous newly formed tiny calcite crystals.

Restricted to samples from different vein types from the vicinity of the Southern Fault system, a large number of secondary low temperature brine inclusions (Th: 85 to 115°C) with several daughter crystals (e.g. halite) have been found.

In probable metamorphic quartz from wall rock samples characterised by brownish CL colours, groups of fluid inclusions with gas compositions distinctly different from the composition of gas-bearing fluids trapped in vein minerals, were found. These vapour-dominated inclusions show a very prominent lowering of the triple point of pure CO_2 ($TmCO_2$). The measured $TmCO_2$ values of-66.5 to-68.0°C is in agreement with high CH_4 concentrations determined by laser Raman spectroscopy. Furthermore, some of these inclusions contained small amounts of H_2S. The CO_2/CH_4 ratios for these inclusions of ~0.4 are similar to the CO_2/CH_4 ratios for altered wall rocks measured using bulk gas chromatographic analysis (CO_2/CH_4: < 0.1 to 0.5). Fluid inclusions of this type are rare in the "Central" quartz veins.

In steeply dipping "Central" veins, native Au occurs as groups of inclusions (1) inside highly stressed quartz grains, as well as (2) at boundary surfaces between quartz grains (Fig. 1). According to the results of preliminary microprobe analyses, both types of Au are not distinguishable in chemical composition.

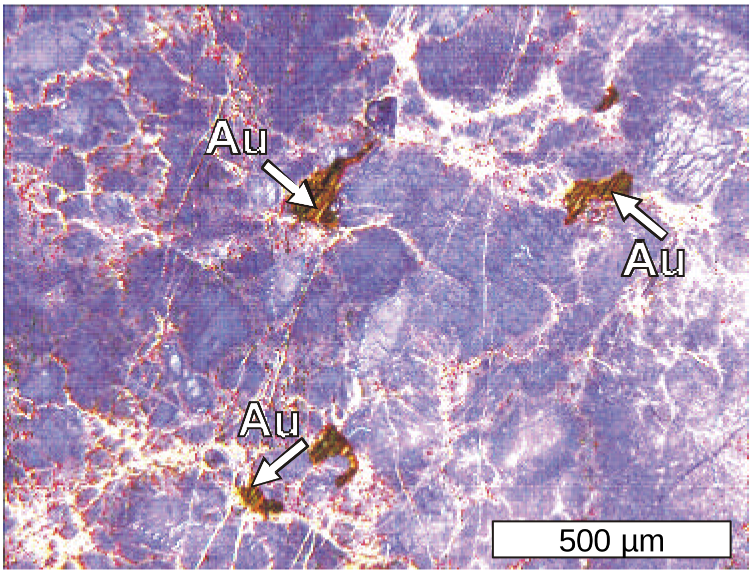

Figure 1. Cathodoluminescence image of quartz ("Central" ore vein) showing the distribution of Au grains (arrows) within a network of recrystallization related microstructures.

Wall rock alteration resulted in heterogeneous mineral assemblages changing their characteristics on a metre or, in several cases, even on a millimetre scale. Deformation textures indicate a tectonic mixture of different precursor rocks in the host rock suite (the so-called "Variegated" Besapan); these observations confirm the results of Mukhin et al. (1988). According to the chemical and mineralogical compositions, several types of altered rocks may be distinguished:

(1) K-feldspar-rich rocks with high K_2O (>3.0 wt %) and Au (2-20 ppm) contents. A sub-group of this type consists of angular rock fragments hosted by quartz breccia at the vein margins of the large "Central" veins;
(2) Biotite-rich rocks enriched in K_2O (>3.0 wt %), $Fe_2O_{3\ tot}$ (>3.5 wt %), MgO (>2.0 wt %), Al_2O_3 (> 14.0 wt %), and Au (0.2-30 ppm);
(3) Albite-rich rocks with high Na_2O (>3.0 wt %) and SiO_2 (>70.0 wt %), and with low K_2O (<2.5 wt %) and Au (0.04-2.0 ppm) contents;
(4) Carbonate- or apatite-rich rocks with high CaO (>5.0 wt %) and L.O.I. (>3.5 wt %), and with low SiO_2 (<65.0 wt %) and Au (<1.0 ppm) contents.

Au contents are usually high: (1) in samples occurring adjacent to "Central" veins; (2) in samples characterised by contents of more than 180 ppm As, 3 ppm Sb, and 20 ppb Hg (however, no correlation was found with W); and (3) in samples enriched in K_2O and depleted in Na_2O (r=-0.775 for log K/Na–log Au).
Alteration processes recognised in the samples studied are: (1) replacement of Ca-plagioclase by biotite or (2) by albite; (3) formation of K-feldspar; (4) replacement of ilmenite by titanite and (5) of biotite by chlorite, and (6) formation of calcite and pyrite.
The results indicate an enrichment of Au in the altered wall rocks during early, high-temperature formation of K-rich metasomatic rocks. However, precipitation of Au in the "Central" and "stockwork-type" veins cannot be assigned to the circulation of K-rich fluids hitherto. On the other hand, evolution of an CO_2-enriched fluid seems to have caused Au precipitation in the veins, whereas carbonate alteration of wall rocks and late calcite precipitation in the veins did not result in any visible Au enrichment.
Further investigations to clarify relations between fluid evolution, wall rock alteration, and precipitation of Au and W in the veins and wall rocks at Muruntau are in progress.

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