

## Au-PORPHYRY SYSTEMS AND THEIR OUSTANDING FLUID PROPERTIES – EXAMPLE FROM THE BIELY VRCH DEPOSIT, SLOVAKIA

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Au porphyries are a relatively new type of porphyry deposit of increasing importance. Common properties of these systems are significantly lower Cu content (< 0.25%) than Cu-Au porphyries, low amounts of sulphides and enrichment in magnetite. They are thought to originate at shallow depths (< 1 km) from magmatic fluids affected by decompression (MUNTEAN & EINAUDI, 2001). EMED Mining Ltd. recently discovered a typical Au-porphyry mineralisation at six localities in the Neogene Javorie stratovolcano, forming a new Au-porphyry province. The Biely Vrch deposit is centred on a diorite to andesite porphyry stock, emplaced into andesitic volcanic host rocks. Stockwork of quartz veinlets mark the area of economic Au mineralisation. Alteration is dominated by intermediate argillic (IA) that variably overprints earlier K-silicate at shallow and Ca-Na silicate alteration at deeper levels. Propylitisation forms an outer alteration zone. Ledges of advanced argillic (AA) alteration are the youngest alteration type. Several generations of veinlets are dominated by quartz. Veinlets are often banded with botryoidal textures. Gold grains of several generations are of high fineness and occur in altered rock next to the quartz veinlets (KODĚRA *et al.*, 2010).

Vapour inclusions dominate (> 95% of inclusions) in all generations of vein quartz. Especially A-type quartz veinlets also host inclusions with a green anisotropic solid and variable proportions of vapour, but no aqueous liquid, interpreted as inclusions of hydrous salt melt and vapour. Microthermometry showed quick melting of the solid in the range 320–380°C, but total homogenisation (Th) was never reached prior to 900°C, indicative of heterogeneous trapping and/or post-entrapment modification due to  $\alpha$ - to  $\beta$ -quartz transition. Rarer, vapour-free, salt melt inclusions with tiny opaque grains and trails or clusters of opaque sulphides (sulphide melts in origin?) are also sometimes associated. LA ICPMS microanalysis showed that vapour as well as salt melt bearing inclusions contain major elements Fe-K-Na-Cl in relatively stable proportions ( $\text{FeCl}_2 > \text{KCl} > \text{NaCl}$ ) with charge balance between major cations and Cl ranging from 0.5 to 1.6 (median 1.1). Due to very high Fe-K content and high total salinity, crystallising salts incorporated all available water forming hydrous salt melts in addition to a much bigger volume of vapour. Low-density vapour, accompanied by extreme “brines”, resulted from fluid heterogeneisation at very low pressures (deduced from phase relations in the NaCl–H<sub>2</sub>O system). Shallow emplacement of the parental intrusion is also suggested by rapid supersaturation

of SiO<sub>2</sub> in fluids inferred from banded veinlets, likely resulting from rapid fluid decompression. Most of the inclusion assemblages had similar or even lower Cu/Au ratio as it is the average ratio of the deposit (0.023 wt% Cu/ppm Au; HANES *et al.*, 2010), except of a sample of a quartz xenolith showing significantly higher ratios in inclusions. This indicates that deeper and/or earlier fluids had significantly higher Cu content than shallow/earlier fluids. Gold is preferentially concentrated in vapour (in respect to total salinity of inclusions). Most of Au precipitated from vapour together with secondary feldspar and Fe-oxides but without abundant sulphides, due to the effective stripping of the stabilising hydration sphere of gold complexes in a high-T but low-P subvolcanic fumarole environment (WILLIAMS-JONES & HEINRICH, 2005). Cu and Ag do not show preferential concentration except of the quartz xenolith sample. Rare liquid-rich inclusions are mostly secondary, trapped from late fluids (~0–5 wt% NaCl eq., Th 230–260°C).

Oxygen isotope data from vein quartz and magnetite showed very little variation from surface down to ~700 m, indicating isotopically homogenous, purely magmatic fluid source. Both minerals were in equilibrium with the fluid at ~672°C. Missing thermal gradient of magmatic fluids is consistent with decompression in shallow depth. Fluids in equilibrium with illite-smectite from the IA alteration also contained a significant meteoric component. Several generations of gold point to significant remobilisation of gold in the system by later aqueous fluids in the clay mineral stability field, composed of mixture of magmatic and meteoric fluids. Isotopic composition of fluids in equilibrium with minerals from the AA alteration indicate subsequent mixing of magmatic and meteoric fluids upon cooling. A temperature of crystallization of coarse-grained alunite 294°C was calculated based on isotope fractionation between SO<sub>4</sub> and OH groups in alunite. Sulphur isotope data for alunite ( $\delta^{34}\text{S}$  10.6 to 15.6‰) are suggestive of a magmatic-hydrothermal origin.

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### References

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