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Mineralogy and formation conditions of the Au-Ag epithermal deposit Nová Baňa (Slovakia)

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The Nová Baňa epithermal Ag-Au deposit is located in the peripheral zone of a large Miocene andesite stratovolcano within the Central Slovak volcanic field. This epithermal system spans over an area of about 4 km^2 and contains more than 20 veins with a length of up to 1 km, thickness of up to 2 m, and a vertical extent of around 300 m.

According to bulk chemical analyses, Au content reaches up to 116 g/t and Ag up to 1110 g/t at shallower levels. High base metal (Pb+Zn+Cu) contents up to 5900 ppm exist at deeper levels. The Au contents are highest in the central part with an average of 2.8 ppm, whereas the south-western part of the system is rich in Ag with the highest average Ag content of 40.3 ppm.

Hydrothermal alteration comprises early silicification and adularization, followed by argillic alteration (interstratified illite/smectite), which reflects a hydrothermal fluid with near-neutral pH. Illite/smectite geothermometry showed that the fluid had temperatures between 144 and 216 °C during the argillic alteration. Later, steam-heated acid-sulfate water resulted in a kaolinite overprint.
Ore mineralization occurs in extensional or stockwork-like veins, and as disseminations in partly brecciated rhyolite and andesite or their pyroclastics. The ore mineral assemblage reflects a temporal and vertical zoning. The early disseminated pyrite is followed by base-metal sulfide mineralization, which is dominant at the deeper levels and consists of pyrite, sphalerite, chalcopyrite, and galena. The next stage is characterized by precious metal mineralization, which is restricted to the shallower levels and dominated by Ag-rich tetrahedrite-tennantite, polybasite-pearceite, proustite-pyrargyrite, miargyrite, and electrum (Au-Ag alloy) with Au contents mostly ranging from 60 to 74 wt.%. The late supergene stage is developed especially in the southwestern part of the system and is characterized by abundant acanthite, uytenbogaardtite, and petrovskaite in association of Fe-oxide and -hydroxides.

Analyses of fluid inclusions in vein quartz indicate fluids with a low salinity (0-5 wt.% NaCl eq.). Homogenization temperatures varied mostly between 160 and 260 °C, depending on the part of the vein system. Abundant co-existence of liquid- and vapor-rich inclusions indicates boiling of the fluid, which is additionally evidenced by a frequent occurrence of vein adularia with a pseudo-orthorhombic habit, and indirectly by hydrothermal breccias. Boiling was the likely reason for the precipitation of the precious-metal minerals. Assuming hydrostatic pressures, boiling occurred from 9 to 44 bars, corresponding to paleodepth of boiling 80 to 430 m, reflecting variable erosion level of individual parts of the vein system.

Isotopic composition of vein quartz ranged from 4.5 to 10.3 ‰ $\delta^{18}O$ (mostly 5.3 to 5.8 ‰), while illite-smectite from wall-rock alteration had 1.9 to 6.9 ‰ $\delta^{18}O$ and -66 to -98 ‰ δD. Composition of fluids in equilibrium with quartz (-5.9 to -3.0 ‰ $\delta^{18}O$) and illite-smectite (-5.5 to -0.6 ‰ $\delta^{18}O$; -80 to -46 ‰ δD) indicate mostly meteoric origin of fluids affected by isotopic re-equilibration with country rocks.