Palaeozoic basement of the Gemeric tectonic unit contains around 1300 siderite-sulphide and quartz-stibnite veins oriented parallel with regional cleavage structure. Origin of the veins has been widely discussed since introduction of modern geochronology methods. Granite source of ore elements and Cretaceous age of the Gemeric hydrothermal deposits was proposed by Varček (1957). Magmatogenic models invoked Variscan granitoids (Ilavský et al. 1977) or deep mafic intrusions of Cretaceous-Eocene age (Rozložník 1989) as the main sources of ore elements. Metamorphicogenetic models favoured mobilization of the ore elements during Variscan (Grecula 1982) or Alpine (Varček 1985) tectono-metamorphic processes.

Žák et al. (1991) and Grecula et al. (1995) proposed a metamorphic-hydrothermal model, according to which precipitation of the Gemeric hydrothermal veins was induced by mixing of Variscan metamorphic fluids with evaporite-leaching meteoric water, which was replaced by residual, halite-fractionated seawater infiltrating the Palaeozoic basement from the periodically swamped and evaporated Palaeozoic basement from the periodically swamped and evaporated Palaeozoic basement from the periodically swamped and evaporated Palaeozoic basement from the periodically swamped and evaporated Palaeozoic basement from the periodically swamped and evaporated Palaeozoic basement from the periodically swamped and evaporated Palaeozoic basin. The contrasting fluid compositions indicate an open-system fluid evolution. In the Cucma stibnite deposit of the southern Gemeric unit, the carbonic fluid is extremely dense (up to 1.197 g/cm³) and admixture of minor CH₄ and N₂ is typical. Fluid inclusion trapping conditions (e.g. Radvanec et al. 2004, Grecula and Radvanec 2005).

Available stable isotope and fluid inclusion data from the Gemeric hydrothermal veins (Hurai et al. 2002, Urban et al. 2006) are controversial with the concept of rift-related metamorphic-hydrothermal origin. Recalculations based on new fluid inclusion and stable isotope data define formation temperature of 177 to 217 °C, paleodepth of 6.0 ± 0.3 km, and thermal gradient of 33.5 ± 5.5 °C/km for the siderite stage of the Droždiak vein in the northern part of the Gemeric unit. The temperatures of 227–263 °C, paleodepth of 11.2 ± 0.6 km, and thermal gradients of 22 ± 3 °C/km have been obtained from the siderite veins in the Rožňava ore field of the southern Gemeric unit. Uniform character of primary fluid inclusions in siderite, i.e. NaCl-CaCl₂-H₂O brines with salinities between 18–25 wt.% NaCl equivalents, and oxygen isotope composition of the parental fluid positively correlated with the metamorphic grade of country rocks (from 5 % in low-grade Permian to 11 % in medium-grade Lower Palaeozoic rocks) are reminiscent of a closed, rock-buffered fluid system. The normal-to-low thermal gradients and paleodepths substantially exceeding available thicknesses of overburden during Permian-Triassic times rule out opening of the vein structures during the extensional tectonic regime incidental with rifting.

Sulphide stage of the Gemeric hydrothermal veins exhibits highly variable fluid compositions, ranging from high salinity (max. 35 wt.% NaCl-CaCl₂-H₂O, CO₂-poor brines to CO₂-dominated aqueous fluids with signs of heterogeneous trapping. The contrasting fluid compositions indicate an open-system fluid behaviour. In the Cucma stibnite deposit of the southern Gemeric unit located near Roznava town, the carbonic fluid is extremely dense (up to 1.197 g/cm³) and admixture of minor CH₄ and N₂ is typical. Fluid inclusion trapping PT parameters in the Klement vein of the Cucma deposit correspond to 183–237 °C, and 1.6–3.5 kbars, possibly up to 4.5 kbars. The PT conditions point to a 15–18 km thick overburden and low thermal gradients, corresponding to only 12–13 °C/km (Urban et al. 2006). These parameters are controversial with the partially molten hot continental crust, and up to 7 km thick overburden at the base of the south-Gemeric basement during the Permian-Triassic rifting. Composition of the gaseous mixture is typical of an externally derived metamorphic fluid, and high-salinity aqueous component probably represents basal brine modified by cationic exchange reactions with crustal rocks.

Fluid Inclusion, Stable Isotope and Geochronologic Evidence of Cretaceous Collision-Related Formation of Hydrothermal Veins in the Gemeric Basement (Western Carpathians)

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U-Pb-Th age of monazite from quartz-tourmaline-white mica assemblage from the Cucma deposit revealed Early and Upper Cretaceous mineral-forming events culminating at 120±9 and 76±12 Ma. The first event is coincidental with thrusting of the Gemeric unit over the adjacent Veporic basement and the formation of the Alpine cleavage structure of the Gemeric basement. The second event corresponds to transpressive shearing and the formation of major trans-Gemeric shear zone.

Geometry of the Gemeric hydrothermal veins together with fluid inclusions, stable isotopes, K-Ar and U-Pb-Th dating support the model of vein opening at gradually increasing thickness of the overriding nappe piles, attaining ~4–5 and 6–7 km during crystallization of early siderite in the northern and the southern Gemeric basement, respectively. A 8–10 km thickness of the overthrusted nappe units must be expected in the south-Gemeric basement to explain high fluid pressures during precipitation of quartz-tourmaline-(white mica-phosphate) assemblage of the quartz-stibnite veins near Roznava (Urban et al. 2006).

K-Ar and U-Pb-Th dating shows short veining interval compared to the age span of the Gemeric cleavage fan formation. The fact that most veins are subparallel to the cleavage indicates $P_{\text{fluid}} > T + \sigma_n$ ($P_{\text{fluid}}$ – fluid pressure, $T$ – tensile strength of rock, $\sigma_n$ – plane-perpendicular stress; Cosgrove 1997). The opening of tensile fracture parallel to the main anisotropy (i.e. Cretaceous cleavage) can be explained in terms of low differential stress ($\sigma_1 - \sigma_3$), corresponding to small difference between horizontal tectonic stress and vertical overburden pressure, and large difference between tensile strengths ($T_p - T_n$, where $T_p$ is parallel to main anisotropy, and $T_n$ perpendicular to it). Cosgrove (1997) showed that the tensile failure occurs parallel to main anisotropy in direction perpendicular to the main compressive stress, if $(T_p - T_n) > (\sigma_1 - \sigma_3)$. Therefore, the veining event in the Gemeric unit might have occurred within a narrow time interval at specific stress conditions marked by building of high overburden pressure (vertical load due to thrusting) and strong horizontal stress (horizontal push related to the formation of the Gemeric cleavage fan).

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