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Hydrothermal Calcite Veins and the Origin of Caves in the Lower Paleozoic of the Barrandian Basin, Czech Republic : Evidence of Extensive (Post?) Variscan Fluid Flow

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Silurian and Devonian carbonate and shale sequences of the Barrandian basin contain abundant bed-normal, northsouth-trending calcite veins of syn- to post-tectonic origin. Petroleum inclusion-rich quartz crystals occur as a light coating on the walls of some thin veins and subvertical joints, however, most of the thicker veins are filled with massive calcite, dolomite, chalcedonic silica, minor sulphides, asphaltic pyrobitumen, and a variety of manganese minerals (psilomelane, todorokite etc.). Fluid inclusion homogenization measurements on calcite samples indicate precipitation of the veins from NaCl-KCl-$CaCl_2$-$MgCl_2$ brines of variable salinity (0.35 to 22.4 wt. % NaCl equiv.), at 55-115 °C. These temperatures roughly correspond to burial depths of approximately 2 km or more, which were attained after the middle Devonian. On a standard plot of $\delta^{13}C$ vs $\delta^{18}O$ with respect to PDB all investigated vein calcites plot within a region defined by the co-ordinates, +1.9 to –6.4 ‰ $\delta^{13}C$ and –11.3 to –7.4 ‰ $\delta^{18}O$. These stable isotope signatures indicate that the vein-forming fluids may have been either deep circulating meteoric waters or, more likely, basinal fluids ascending from deeper sections of the basin (Žák *et al.*, 1987 ; Cílek *et al.*, 1994 ; Zeman *et al.*, 1997).

Field observations show that the process of veining was accompanied by an extensive dissolution of enclosing carbonate sequences. This is evidenced by a number of corrosive and dissolution features that penetrate limestone wallrock immediately close to the calcite veins. Some of the largest dissolution cavities developed close to the calcite veins are coated with black Mn-rich encrustations and contain a sequence of Tertiary to pre(?) Upper Cretaceous clastic and clayey sediments which place stratigraphic constraints on the age of hydrothermal alteration (Zeman & Suchý, 1996).

Structural analysis reveals that NS-trending calcite veins and fractures control the occurrence of many, if not most, caves in Barrandian carbonate sequences. Hydrothermal origin of at least some caves in the area appears to be also supported by a common occurrence of so-called "Koneprusy rosettes". These represent unusual, cauliflower-shaped spelean carbonates composed of alternating layers of chalcedonic silica and carbonate that precipitated on the walls of some Barrandian caves. We speculate that the "Koneprusy rosettes" may have originated from warm slightly mineralized solutions in a way similar to hydrothermal siliceous geyserites or "Carlsbad popcorn" to which they are strikingly similar.

Our observations provide a growing pile of evidence that the sedimentary sequences of the Barrandian basin have seen an extensive alteration by warm fluids that circulated through the fracture network. The age of the veins remains uncertain but combined sedimentological and structural data suggest that the alteration may have occurred during the late stage of Variscan orogeny.

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