Genesis of Uranium-Bearing Phosphorite Layers and Fluorite Veins in the Triassic Platform of Transdanubian Range, Western Pannonian Basin (Hungary)

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The Transdanubian Mountain Range (TDMR), containing uranium-bearing phosphorite layers and fluorite veins with traces of Pb(-Zn) mineralisation in its carbonate-dominated Mesozoic sequence, was situated originally in a transitional position between the Southern and Eastern Alps and pulled out of the Alpine collision zone during the Late Paleognene-Early Neogene (see e.g., Kázmér and Kovács, 1985). The evolution of the TDMR was mainly determined by the opening and closure of the Neotethys Ocean.

In the Middle Anisian, extensional tectonic movements led to development of a small isolated carbonate platform in the middle part of the Balaton Highland, TDMR, resulting in the deposition of typical seamount phosphorite on the top of the drowned platform. The brownish-grey uranium-bearing phosphorite layers appear in three stratigraphic horizons. The main uranium-bearing minerals are carbonate-bearing fluorapatite (CFA) and/or calcite, and individual U minerals have been not observed. Based on the LA-ICP-MS measurements, CFA contains 137–612 ppm U and 113–261 ppm total REE+Y. The phosphorite has a U-Pb age of 237 ± 11 Ma, which coincides well with the stratigraphic age of the host limestone. The redox-sensitive element geochemistry suggests no detrital influence at the studied area. The phosphorite formed under anoxic conditions as an inorganic seamount phosphorite. Slight diagenetic change is detected, while the Y/Ho ratios and Y anomalies suggest predominant seawater source for the CFA. The monsoon-derived upwelling played a role in the formation, but the contemporaneous volcanic activity could also have an effect.

The extensional tectonics of the Neotethyan realm (i.e., rifting) produced some fluorite veins and traces of galena mineralisation in Triassic limestone, dolomitised limestone, and Variscan granite of the TDMR. Triassic fluid mobilisation event (232–209 Ma) with epigenetic Pb-Zn sulphide mineralisation (similar to MVT deposits Radnig, Bleiberg, Mežica) was found in Variscan granite in the Velence Mts. (Benkó et al., 2014), while formation of the other occurrences was not studied before. Euhedral deep purple fluorite grains are found both in the Balaton Highland and Velence Mts., and their petrographical and chemical characteristics (colour, REE content, formation conditions) are similar. Fluorite was crystallized from a high salinity $NaCl+CaCl_2+H_2O$ fluid, based on fluid inclusion microthermometry study of homogeneously trapped primary, two phase (L+V) fluid inclusions. The minimum formation temperature varies between 75 and 169°C and 90 and 142°C while the salinities vary between 17.4 and 22.4 NaCl equiv wt % and 4.2 to 19.2 NaCl equiv wt % in the Balaton Highland and the Velence Mts., respectively. The Raman spectroscopic analyses confirmed the measured data and detected H_2 gas in the vapour phase of the fluid inclusions from Balaton Highland. The formation conditions are typical to hydrothermal, MVT Pb-Zn deposits, which suggests the possibility of the existence of a Triassic regional fluid circulation system (Schroll, 2008). The galena occurrences of the Transdanubian Mountain Range may also support this hypothesis.