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Natural bitumen hosted uranium mineralization, stability of the radiogenic system and mobility of selected elements in surface conditions.

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Uranium mineralization hosted in sedimentary rocks is exposed in the roadcut. The sediments are of lakustrine origin with a high proportion of organic matter and enriched in uranium and several other potentially hazardous elements. The most remarkable are two mineralized uranium-rich sulphide-bearing bitumen (thucholite) veins with locally high contents of U (up to the order of wt.%). The exposed rock profile in the length of about 250 m was examined by the method of field gamma spectrometry. Uranium-rich zones were documented and sampled. The exposure of mineralization to the atmosphere, precipitation, infiltration and drainage through disrupted mineralization structures causes local oxidation of sulphides and arsenides to release acidic solutions carrying sulphate, arsenate, uranyl, Co2+, Cu2+, Ni2+, Pb2+ and other species. Subsequently, amorphous precipitates and secondary minerals of the mentioned elements can be found on the surface of the crushed loose rocks and the bitumen itself. Specimens with U content and manifestations of S, Cu, Ni, Co, As mineralization were taken in form of secondary minerals. Consequently, optical microscopy, SEM/EDX, XRD, NAA and LA-ICP-MS analyses were carried out to obtain data on the chemical, mineral, and lead isotopic composition of the constituent phases. Microscopy methods revealed structural features which provide evidence of multi-stage evolution of bitumen mineralization accompanied by both ductile and brittle deformations of matrix and embedded uraninite, respectively. Despite complex evolution within a dynamic fault environment and at least one hydrothermal event after the U-mineralization stage, no significant mobilization and migration of uranium occurred. Reaction-diffusion features at the uraninite grain margins did not even exceed the range of alpha particles in bitumen and the only significant uranium migration occurred after exhumation. Newly formed discontinuities in the rigid mature bitumen related to shear stress and volume change (contraction cracks) can serve as pathways for the infiltration of meteoric water-based fluids. Weathering of sulphides locally causes so-called acid mine drainage (AMD) phenomena associated with the production of highly mobile aqueous species of several hazardous elements including uranium. On the other hand, the presence of arsenic and its oxidation to As(V) species effectively inhibits the migration of U(VI) and other heavy metal ions by forming insoluble mineral phases. Ferric hydroxy oxides (FHO) are found to be another scavenger of uranyl and arsenate ions, likely by the sorption mechanism, however, the SEM/EDX investigation reveals that FHO may also serve as a nucleation substrate for U-bearing arsenates. It is assumed that the studied outcrop of uranium-bearing bitumens has the potential as a natural analogue for studies of mobility and environmental behaviour of actinides and other hazardous elements found in the mineral association.

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