Unusual uranium mineralization from central Jordan

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Uranium Mineralization

Unusual uranium resources are widely distributed in central Jordan. The outcropping rocks consist mainly of organic-rich bituminous limestone and marl (oil shales) that overlie phosphorite beds and underlie the varicolord marble. The sequence is overlain by travertine and regolith deposits of Pleistocene – Recent age. The rocks are unusually enriched with reduced sensitive elements (U, Cr, Ti, Mn, Ni, Cr, Cu, Mo, V, Ba, Ag, Cd, Zn, Zr, Cl, F, Se and REE).

Discussion of Results

Secondary yellow uranium minerals (uranyl vanadates) together with unique green smectites (Cr-rich smectite/volkonskoite) are hosted by the thick altered varicolored marble, travertine and regolith either as encrustations, impregnations, or filling joints and cavities [1].

Tyuyamunite $Ca(UO_2)_2V^{5+}{}_2O_8 \bullet 3(H_2O)$-strelkinite $Na_2(UO_2)_2V_2O_8 \bullet 6(H_2O)$ solid solution series (uranmica) are the major components. The surficial uranium deposits in central Jordan have resulted from the interplay of tectonic, climatic, hydrologic, and depositional events. The deposits are related to the highly alkaline circulating water (hydroxide–sulfate type) enriched with redox sensitive elements among which were U and V [1].

The varicolored marbles are strongly altered in fractured and weak zones, where high-temperature minerals are partially or totally replaced by secondary Ca-carbonate, CSH's, and sulfate minerals (most often gypsum, barite, hashemite and ettringite). New primary calcium uranate phases ($CaUO_4$, Ca_2UO_5, Ca_3UO_6, $Ca_3U_2O_9$, Ca_4UO_7, Ca_5UO_8, and Ca_6UO_9), U-bearing lakargiite $Ca(Zr,Ti,U)O_3$, tululite (Ca-zincate-aluminate), Ca-Cd Oxide, oldhamite (Ca S), Fe-Ni phosphides were identified in the varicolored marble [2]. Primary calcium uranate phases are the result of combustion of phosphorus-rich bituminous marl and the oxidation of U^{+4} at high temperature into U^{+6}under high oxygen fugacity. The varicolored marbles closely resemble cement-immobilized waste, exposed to supergene weathering and alteration over time spans are considered as unique natural analogs.

[1] Khoury et al. (2014) Applied Geochemistry, 43, 49–65. [2] Khoury et al. (2015) Canadian Mineralogist, 53(1), 61–82