Chemistry of primary high temperature uranium minerals from central Jordan

H. N. KHOURY[1]*, ELLA V. SOKOL[2] AND I. D. CLARK[3]

[1]Department of Geology, The University of Jordan, Amman – Jordan 11942 (*Correspondence: khouryhn@ju.edu.jo)
[2]Sobolev Institute of Geology and Mineralogy, Siberian Branch of Russian Academy of Sciences, 3 Koptug Avenue, Novosibirsk, 630090, Russia (sokol_ag@mail.ru)
[3]Ottawa-Carleton Geoscience Centre, Department of Earth Sciences, University of Ottawa, 140 Louis Pasteur, Ottawa, Ontario, Canada K1N 6N5 (idclark@uottawa.ca)

New primary calcium uranate phases were identified in the varicolored marble of central Jordan. The calculated structural formulae of the six high temperature phases are Ca_2UO_5, Ca_3UO_6, Ca_4UO_7, Ca_5UO_8, $Ca_3U_2O_9$ and Ca_6UO_9. These results are different from vorlanite ($CaUO_4$, UO_3 84.06 wt%, CaO 16.65 wt %) [1]. Crystallization of calcium uranate phases in central Jordan is the result of oxidation of U^{+4} from the combusted bituminous and P-enriched marl into U^{+6} under high oxygen fugacity. A set of typical pyrometamorphic minerals associated with new identified calcium uranates strongly supports the high temperature event in central Jordan. They are fluorapatite, fluorellestadite, spurrite, fluormayenite, dorrite, tilleyite, brownmillerite (Cr, Ti, Zn-bearing), periclase (Zn, Ni, Co, Cu–rich), perovskite, shulamitite, Ca ferrites, and exotic accessories: lime, CdO (monteponite?), (Ca,Cd)O, (Zn,Cd)O, ZnO, cassiterite, cerianite $(Ce,Th)O_2$, lakargiite $(Ca(Zr,Ti,U)O_3)$. Rock-forming mineral assemblages are similar to those associated with vorlanite and lakargiite in the skarn xenolith of Mt. Vorlan, and the pyrometamorphic rocks of Jabel Harmun, Palestinian Authority, whereas U, Zn, Cd, Th and Ce mineralization is quite unique. The impure calcium uranates with Si, Fe, Al, and F could be related to a later stage of alteration. The high temperature primary minerals could have reacted with the highly alkaline circulating meteoric water to form impure crystals. Case studies from Jordanian natural sites will be useful for predictions regarding the long-term fate of uranium in concrete waste forms.

[1] Galuskin, Armbrusteter, Galuskina, Lazic, Winiarski, Gazeeeev, Dzierżanowski, Zadov, Pertsev, Wrzalik, Gurbanov & Janeczek. (2011), *American Mineralogist*, **96**, 188–196