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Rare earth element, yttrium and zirconium mobility associated with uranium mineralization.

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The Bohemian Massif, a part of the European Variscan belt, hosts a significant proportion of uranium mineralization bounded on brittle shear zones evolved in high-grade metamorphic rock series and/or in granites. The mobility of REE, Y and Zr during the Variscan uranium mineralization event has been investigated in the Okrouhlá Radouň uranium deposit. This deposit is emplaced in a NNW–SEE striking shear zone on the north–eastern margin of the Klenov pluton, which is part of the Moldanubian batholith. Host-rock series are formed by high-grade metasediments of the Moldanubian Zone and by two-mica leucogranites. The shear zone is filled with cataclasites formed by host rocks, altered to clay minerals-rich and chlorite-rich assemblages with uranium mineralization enriched in coffinite, partly also in pitchblende. Disseminated ore bodies of intensively altered rocks with significant enrichment of albite, calcite and hematite adjacent to shear zone form a significant part of the uranium mineralization. The origin of disseminated uranium mineralization can be associated with infiltration of the Permo-Carboniferous basinal water into rocks of the crystalline basement along deep brittle structures that opened during the late Variscan evolution of the Moldanubian Zone. Uranium mineralization comprises three main mineralization stages. The non-productive pre-ore stage is characterised by a widespread albitization, chloritization (origin of chlorite I) accompanied by hematitization of host rocks. Uranium mineralization has been formed during main ore-bearing stage and comprises the origin of coffinite, pitchblende and other hydrothermal minerals, inclusive chlorite II and pyrite. Some samples of coffinite are enriched in Zr (up to 3.90 wt.% ZrO_2) and in Y (up to 2.62 wt.% Y_2O_3). The post-ore stage is represented by newly formed chlorite III, clay minerals (hydromuscovite, kaolinite and smectite), pyrite, sphalerite and chalcopyrite. The bulk concentration of REE in hydrothermally unaffected paragneisses ranges from 54 to 312 ppm. The LREE/HREE ratio (expressed as La_N/Yb_N ratio) in unaltered gneisses ranges between 7.6 and 11.4. The paragneisses display a weak or moderate negative europium anomaly (Eu/Eu* = 0.59–0.86). Barren chloritized and carbonatized gneisses show lower total contents of REE (54–151 ppm) and relatively high LREE/HREE ratios (9.2–17.6). In contrast to the altered barren gneisses, disseminated uranium ore is characterized by high bulk REE values (195–232 ppm). Two-mica leucogranites are highly peraluminous granites (A/CNK = 1.13–1.29) with low bulk concentration of REE (33–135 ppm), low LREE/HREE ratios (4.5–11.4), low contents of Zr (15–72 ppm) and Th (1.6–6.3 ppm). These granites are characterized by absence of the europium anomaly (Eu/Eu* = 0.90–1.14). The hydrothermal albitization of these granites is connected with origin of a prominent negative europium anomaly (Eu/Eu* = 0.11). The distinctly lower LREE/HREE ratio (4.7–5.0) in some of the altered granites is connected with the origin of disseminated uranium mineralization and enrichment of HREE in coffinite. Mineralized granites are partly enriched in Zr (51–88 ppm) and Th (4.6–6.7 ppm). This study was supported by the Ministry of Education, Youth and Sports of the Czech Republic (project No. ME10083).