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Radiolytic alteration of organic matter in uraniferous environments studied by artificial irradiations

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The natural organic matter present in uranium deposits (coal, amber-like fossil resins, bitumen) plays an important role in the transport, accumulation and mineralization of uranium in sediments, and it is also a sensitive marker allowing characterization of the depositional and diagenetic history of sedimentary formations. The energy transferred by ionizing radiation to organic matter can induce a complex series of reactions generating and altering organic matter. The radiolytic alteration is usually interpreted as a process spatially localized within reach of the emitted alpha particles, observed as, e.g., typical halos around uranium mineral inclusions. Structural changes observed in the bulk organic matter beyond the range of the alpha particles may be ascribed to fine dispersion of uranium and its daughters within the organic matrix, or by radon diffusion. Despite lower ionizing efficiency of beta and gamma radiation produced in the uranium decay chain, their radiation effects caused by interaction with natural organic matter may participate in mild structural alterations observed beyond the reach of alpha particles.
To simulate and study natural irradiation of organic matter associated with uranium mineralization, artificial irradiation of model samples was carried out with 5-10 MeV electrons accelerated at the MT-25 microtron, and with 4.8 MeV He+ ions accelerated at Tandetron 3140 MC accelerator. The effect of increasing cumulative dose was studied. Irradiation was followed by FTIR analysis of original and irradiated samples. For electron-irradiated samples, GC/MS analyses of sample extracts and gases released from samples upon irradiation were carried out. The observed chemical and structural changes were compared with alteration observed in the natural organic matter with uranium mineral inclusions.
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Primary author: MIZERA, Jiří (Nuclear Physics Institute, Academy of Sciences of the Czech Republic)

Co-authors: STRUNGA, Vladimír (Nuclear Physics Institute, Czech Academy of Sciences); Dr MACHOVIČ, Vladimír (University of Chemistry and Technology Prague); Dr HAVELCOVÁ, Martina (Institute of Rock Structure and Mechanics, Czech Academy of Sciences); CHVÁTIL, David (Nuclear Physics Institute, Czech Academy of Sciences); ROMANENKO, Oleksandr (Nuclear Physics Institute, Academy of Sciences of the Czech Republic)

Presenter: MIZERA, Jiří (Nuclear Physics Institute, Academy of Sciences of the Czech Republic)

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