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Contribution of Environmental Radiochemistry to Geochemistry

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In our review on Environmental Geochemistry of Radionuclides (Environmental Radiochemistry) in 3rd edition of the Treatise on Geochemistry, we described recent advances and topics in the environmental geochemistry of radionuclides. First, a brief summary and history of this field and of nuclear science in general was given from various aspects, including both good and bad things. The good things mentioned in this aspect are (i) radionuclides or nuclear energy can be a huge source of energy that can support the human society, (ii) an accurate clock for the history of our planet and life, and (iii) a very effective tool to overcome cancer and other diseases, while the bad thing is that (iv) they are very harmful to any creature with strong radiation effects, especially by internal exposure. Consequently, a better understanding of the chemical processes that control the environmental behavior of radionuclides is essential.

Practically, two topics, (i) studies on the migration of radionuclides emitted by the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident in 2011 and (ii) the development of XAFS spectroscopy and its application to the geochemical processes of radionuclides, have been highlighted. The former topic must be summarized from various scientific and engineering perspectives, and the various geochemical processes and migration behavior of radionuclides learned from these studies are important for predicting the behavior of radionuclides in the terrestrial environment. The latter topic is important for a comprehensive understanding of the environmental behavior of all elements, which is also related to the first topic, because the highly sensitive analytical tool for the speciation of trace elements is necessary in all fields of environmental geochemistry. The high sensitivity method can be achieved by high energy resolution detection of fluorescent X-rays using either a crystal analyzer or a high energy resolution detector such as a transition edge sensor (TES). In particular, high energy resolution fluorescence detection XANES (HERFD-XANES) provides more speciation information than conventional XANES, which needs to be applied in a wide range of geochemistry in the future.