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Uranium in mine waste: a problem with an opportunity

Current uranium mining and associated closure of mine sites pursue traditional linear economic thinking. In such linear economies, a raw material like uranium is mined to make a product, and any mining, mineral processing or metallurgical waste is discarded (e.g. uranium mill tailings are placed into waste repositories). As a consequence, past and present mining practices have generated and continue to generate vast mine waste quantities with associated environmental risks due to the presence of minor uranium and environmentally significant elements as well as radiological hazards. By contrast in circular economies, the use of raw materials is optimized, any wastes are used or reused as raw material resource, and remaining metals and minerals are extracted. The objectives of this study are to establish a global database on uranium mining waste sites, including the spatial, volumetric, geochemical and mineralogical properties of the different waste types, and to provide insights into possible future comprehensive extraction concepts. The study demonstrates that different waste types of conventional uranium resources (i.e. waste rocks, tailings, heap leach residues, mine waters) as well as unconventional uranium resources (e.g. phosphate rock, bauxite) represent potential uranium sources. In addition, the recovery of critical elements (e.g. Co, REE) from uranium mine wastes is an option to increase the resources of such raw materials that are economically significant and have an overall supply risk. Co- and by-product recovery of uranium and related elements, reuse and recycling of wastes, and reprocessing of resource ingredients from uraniferous wastes could be one effective solution for the global challenge to provide mineral resources for humanity well into the 21st century. Yet, "zero waste"concepts are impossible to achieve in the current uranium mining value chain, because poor linear economics prevent the application of reuse, recycling or recovery techniques in the real world. In this study, insights into appropriate levels of contaminants in mine wastes and waters as well as trace resource gradients (e.g. U, REE) in mine wastes could be gained. Such insights may ultimately lead to the valorization of mineral resources, support total resource use of mineral deposits and help the transformation towards an advanced circular economy in uranium mining.

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