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# Thorium recovery as a co-product of processing rare earth element deposits

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Intrusion-related deposits of rare earth elements (REEs) are typically enriched in thorium (Th). The REEs and Th are "incompatible elements", so-named because they form high-charge ions that do not readily fit into common igneous minerals. They concentrate in differentiated magmas, such as melts that form alkaline intrusions and carbonatites, common hosts for REEs. Thus, high-grade Th deposits are often high-grade REE deposits. Consequently, Th can be a co-product of developing REE deposits if a market emerges for Th as a nuclear fuel. Currently, Th within REE deposits in the United States is treated as a radioactive contaminant, not as a potential commodity.

Three examples presented here illustrate the potential for obtaining Th from residue streams of REE production. First are the Mountain Pass operations of MolyCorp in southeastern California, the only active REE mine and processing facility in the United States. The orebody is a carbonatite reportedly containing 16.7 Mt of proven and probable reserves grading 7.98 percent total REE oxides. The primary ore mineral is bastnaesite. Monazite (REE-Th-phosphate) is an accessory mineral, imparting an average Th content of about 0.03 percent. After the carbonatite is processed and REEs separated, the Th moves with other residues into the tailings impoundment.

A second example is the Bear Lodge project of Rare Element Resources in northeastern Wyoming, currently in an advanced stage of permitting for their mine and processing plant. The deposits occur in a hydrothermally altered carbonatite-alkaline intrusive complex, with total measured and indicated resources of 15.2 Mt of ore averaging 3.11 percent total REE oxides. The primary REE ore minerals are ancylite and REE-fluorocarbonates. Important Th-bearing accessory minerals are monazite and cerianite (Ce-Th-oxide). The ore averages about 0.12 percent Th. In a press release of January 23, 2014, the company announced their processing technology will "selectively isolate and economically remove thorium".

As a third example, UCore Rare Metals plans to mine REE-rich vein deposits within the Bokan Mountain alkaline intrusive complex in southern Prince of Wales Island, southern Alaska. The target vein deposits are enriched in the heavy REEs, which comprise about 40 percent of the total REEs. Inferred resources for the veins are 5.2 Mt averaging 0.65 percent total REE oxides. These structurally controlled "vein-dikes" show evidence of early alkaline magmatic injection followed by later hydrothermal alteration. Detailed mineralogical study of this vein-dike system by the USGS revealed that Th and U are dominantly sited in thorite and a complex suite of Th±U±Ti±Nb±Y oxide minerals, including fergusonite, polycrase, and aeschynite. The oxide minerals along with Y-silicates are the primary heavy REE-bearing minerals of the deposit. Limited sampling revealed Th contents of about 0.15 percent. In the processing of these ores, Th and its radioactivity will need to be addressed. Separation and stockpiling of Th from the residue streams provide a possible economic solution in all three examples.

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