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The Nature of Thorium in Bauxite and Bauxite Residue from Greece

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Rare earth elements (REEs) are considered strategic metals as they are incorporated in a wide range of materials (e.g., permanent magnets, metal alloys and catalysts) that constitute the often unnoticed matrix of daily-life applications today (e.g., high-efficiency turbines, electric motors in cars and mobile phones). This has led to a growing demand from high-tech industries and REEs supply risk, in view of China’s REE export restrictions regardless its recent plans to eliminate export quota for REEs, has propelled research towards the use of alternative resources. Bauxite residue (BR), originating from the refining of alumina ore (bauxite) through the Bayer process, has been identified as a promising source. In this case, REEs and Sc, are of particular interest, and efforts to develop an extraction process also have to provide a clear and safe management strategy for the accompanying actinides, as well. In particular, the environmental significance is critically arising due to the co-existence of Th together with REEs in bauxite and BR. However, the exact nature of Th in them has been unknown until the recent studies, constituting the basis of this abstract. Thus, it is crucial to determine Th hosting phases in order to try to separate them, creating a “clean” stream for subsequent REE extraction. To meet this need, we applied electron microscopy (TEM) and synchrotron-based spectroscopy (EXAFS) to understand the nature of Th in the Greek bauxite and BR. Th in bauxite has been found to be hosted in LREE-minerals (mostly bastnäsite/parisite-group), zircon (ZrSiO4) and, especially, in anatase (TiO2) in microscale. The Th LIII-edge EXAFS spectra gave evidences that Th4+ may not replace Ti4+ in distorted [TiO6] octahedral units of anatase lattice (CN=6). The occupation of either extraframework sites of higher coordination (CN=6.9 or even CN=7.4) or defected/vacant (□) sites is more probable. On the other hand, TEM study of BR revealed that Th4+ is hosted into a novel perovskite-type phase with major composition Ca0.8Na0.2TiO3. The Th LIII-edge EXAFS spectra demonstrated that Th4+ ions, which are hosted in the nano-perovskite, occupy Ca2+ sites, rather than Ti4+ sites. We consider that the study of Th, in bauxite and BR, can redound to a sustainable supply of strategic metals and oxides, contributing to a more sustainable “modus operandi”.