Investigation and comparison of scandium species in different European bauxite residues by combination of novel analytical tools

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Abstract

In recent times, as the need for new high-tech materials is growing steadily to fulfil future sustainability goals, more and more looks turn towards industrial waste streams as potential sources of valuable metals. Bauxite residue (BR), accumulating during alumina production, is one of the major waste streams in the metal industry [1]. Suitable re-use possibilities for BR are intensively investigated [2] including approaches for the recovery of scandium (Sc) [3]. This transition metal, even though rarely recognized by the broader audience yet, has recently gained the interest of e.g. aerospace industries and SOFC-producers since its use is strongly improving the performance and durability of the respective materials.

Even though many sources classify Sc as one of the REE, there are many aspects, such as its ionic radius, which significantly differentiate Sc from the REE and cause its behaviour to be distinct as well [4]. The large ionic potential (radius/charge) causes Sc to be incompatible in most rock forming minerals, which results in generally low concentrations in the earth's crust [4] and rare occurrences of natural Sc-deposits.

The general occurrence of enriched concentrations of Sc in some BRs compared to the earth's crust is known for some time now and has especially been investigated for Greek materials [5,6,7]. However, the (geo)chemical and mineralogical behaviour, the Sc speciation, the association and the variation of Sc occurrences in BRs of different origin is still not fully understood. This study aims to gain better knowledge on the different kinds of Sc-occurrences and their possible impact on future recovery schemes. We therefore apply a diverse set of analytical methods including novel measurement techniques such as X-ray absorption near edge structure (XANES) spectroscopy as well as standard techniques such as electron microprobe analyses, and Raman spectroscopy on BRs from Germany, Hungary and Greece. Information on

the local distribution of Sc is determined by high-resolution laser ablation – inductively coupled plasma – mass spectrometry (LA-ICP-MS) mappings.

Sc in Greek BR seems to have an affinity towards Fe-Phases such as Goethite and Hematite. However, whereas some of these phases show distinct enrichment of Sc, others are particularly barren, which might be a result of the different input materials. By means of XANES measurements it was possible to show that Sc in the Greek samples occurs adsorbed on the surface of those Fe-Phases, likely in the form of amorphous Sc-hydroxide or -oxyhydroxide or can be incorporated into the crystal lattice as well (Fig. 1). The general affinity of Sc to those kinds of phases has been reported for natural rocks such as laterites before, where similar investigations were made using the XANES method [8]. Likewise, the Fe-association has been observed for Greek BR by Vind et al. [7]. Hungarian BRs show similar results as the Greek samples and LA-ICP-MS mappings show distinct Sc enrichment rims surrounding mineral particles. In German BR, Fe as well as Ti-phases occur to be partially enriched in Sc. Depending on the original primary bauxite, the source rock of the bauxite and the bauxite processing route, it is likely that many different parameters influence the occurrence and species of Sc in the BR. Theoretically, it either can therefore remain within its original carrier or can be partially or fully redistributed within the BR. Since the processing of the bauxite involves elevated temperatures, pressure and dissolving reagents, it is however very likely that some of the Sc will be redistributed and adsorb on mineral surfaces of smaller and larger particles, making beneficiation steps rather ineffective.

The study shows that there is no general rule defining how Sc is associated mineralogically or chemically within BRs. Therefore, the effective development of a recovery method needs a case specific background knowledge on the Sc-species present in the BR of interest. *This research has received funding from the European Community's Horizon 2020 Programme SCALE (H2020/2014-2020) under grant agreement n° 730105.*

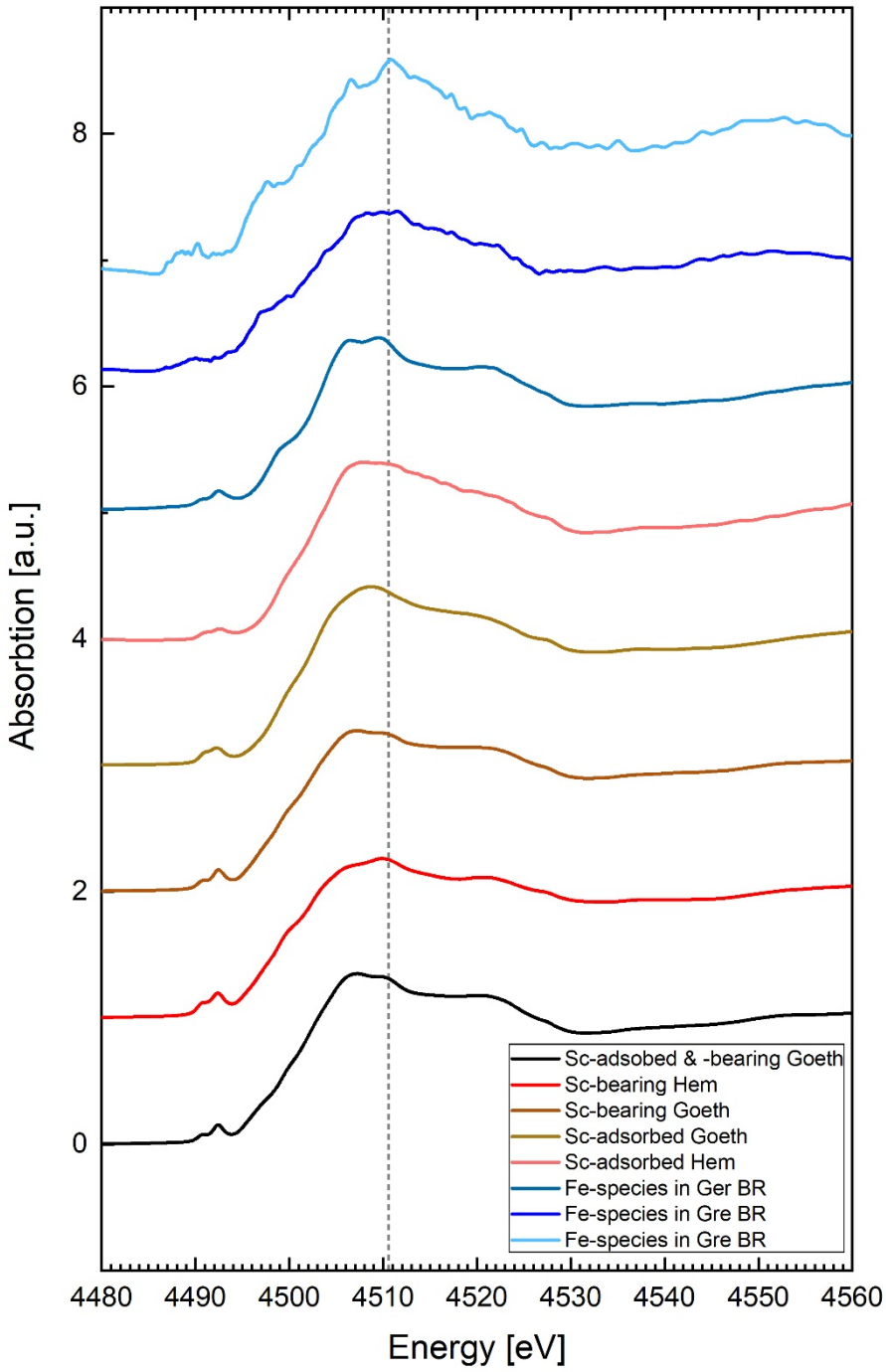

Figure 1: K-edge XANES spectra of various different Sc-bearing or adsorbing references of Goethite (Goeth) and Hematite (Hem) ,compared to three spectra measured on iron-species in German (Ger) and Greek (Gre) bauxite residue (BR).

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