Characterization of coal related matrices and assessment as a source of rare earth elements

V. Lopes[1,2], A.R. Ferreira[1,2], S. Peters[2], F.J. Pazzaglia[2], N. Couto[1,2], S. Pamukcu[3], A.B. Ribeiro[1]

[1]CENSE, Departamento de Ciências e Engenharia do Ambiente, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Campus de Caparica, 2829-516 Caparica, Portugal
[2]Department of Earth and Environmental Sciences, Lehigh University, 1 West Packer Avenue Bethlehem, PA 18015, United States of America
[3]Department of Civil and Environmental Engineering, Lehigh University, 1 West Packer Avenue Bethlehem, PA 18015, United States of America

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Presenting author email: abr@fct.unl.pt

Introduction

Rare earth elements (REE) are crucial for modern technologies and key ingredients for industrial magnets, electric vehicles and a variety of other machines, batteries, liquid crystals and phosphorous features for lightning. There is a geo-strategical dependency of REE, with China being the world largest REE producer (Figure 1). REE faces a risk of supply shortage with serious consequences for the industry and value chain.

For both Europe and the United States of America, REE are strategical materials due to their economic and industrial importance and potential supply risk. Owing to high costs and technical issues related to use of substitute materials and the recycling rates for REE, finding alternative sources for REE have become urgent (Jowitt *et al*, 2018).
According to the US Geological Survey, the estimated value of rare-earth compounds and metals imported in 2017 was $150 million, a significant increase compared to the $118 million imported in 2016 (minerals.usgs.gov, accessed 2018). Europe is 100% dependent on REE imports. The light REE (LREE) and the heavy REE (HREE) substitution indexes are low, typically at 0.89 and 0.93 on a scale of 0 and 1, where 1 is non substitutable, and the recycling rates are at 3% and 8%, respectively.

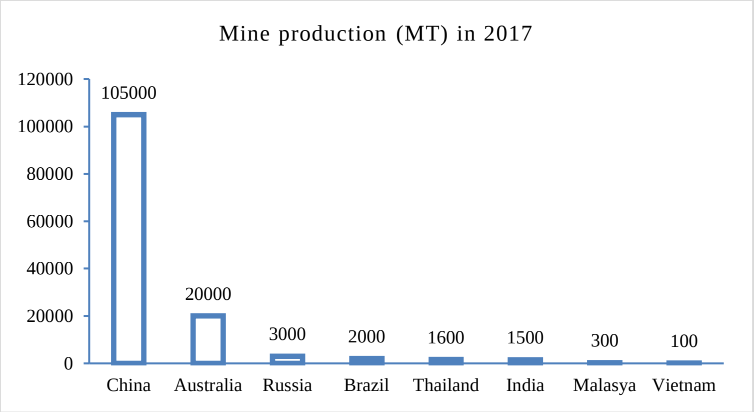

Figure 1 - Mine production of REE primary resources. Adapted from (investingnews.com, accessed 2018)

There is no substitutability of REE for 45% of the applications, while the substitutable portion suffers from high costs and/or loss of performance (Garcia *et al*, 2017). Therefore, there is a need of investment in REE recovery from secondary sources, in addition to primary mining.

Yttrium, terbium, dysprosium, neodymium and europium are considered the most critical REE (NETL, 2018) justifying the need of a selective recovery.

The economic feasibility of REE recovery from coal ash is still uncertain. This is due to lack of a thorough understanding of the quantity and quality of the REE content of different types of coal ash produced across the U.S. and how the ash characteristics are related to extractability of these REEs. The work presented in here is aimed to address part of this issue. Various anthracite and bituminous coal ashes were characterized for REE content by Scanning Electron Microscopy (SEM), X-Ray Diffraction (XRD), REE total concentration and pH desorption tests.

Experimental

Figure 2 – Coal sources

Two sources of carbon were used to prepare test coal ashes: anthracite and bituminous (Figure 2).

The ashes were characterized by SEM-EDX and XRD analysis and REE concentration via ICP-MS analysis. The latter part of the work is still under progress; hence results are not available at the time of this abstract. For REE content, coal fly ash (0.2 g) was added to lithium borate flux (0.9 g) and fused in furnace at 1000 ºC. The resulting melt was cooled and dissolved in a 4% HNO_3/2% HCl to be analyzed by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS).

The effect of pH on REE desorption is being carried out by suspending 2.5 g dry ash in 25 mL HNO_3 or 25 mL NaOH with concentrations ranging between 0.01 M and 1.0 M. After filtration (0.45 µm), the REE concentrations are measured in the liquid phase by ICP-MS.

Partial results and Conclusions

Figure 3 shows the anthracite (a) and bituminous coal (b) fly ash particles analyzed by SEM-EDX.

The preliminary results suggest REE concentrations in the order of ppm, potentializing the use of coal related matrices for target REE recovery.

The pH desorption tests will provide the most suitable pH range for the extraction and subsequent treatment aiming to selectively recover target REE, identified by EU and USA needs.

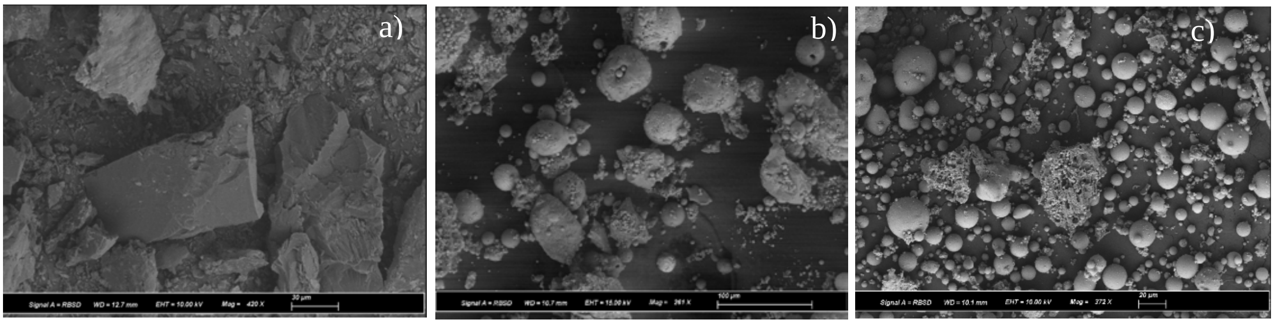

Figure 3 – SEM picture of a) anthracite; b) bituminous fly ash 1; c) bituminous fly ash 2

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