# OPTIMIZATION OF MINERAL ACIDS LEACHING PROCESS FOR THE RECOVERY OF RARE EARTH ELEMENTS FROM GREEK RED MUD

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## Introduction

Rare earth elements (REEs) present a wide range of properties and applications in modern technology. Due to thorium co-existence in their main ores, attention has been drown to exploitation of alternative resources such as apatite, bauxite, red mud, phosphates, mine tailings, etc. Red mud (RM), the byproduct of alumina's production from bauxites by Bayer process, is a material produced in huge quantities up to 750.000 tons/year from Aluminum of Greece (AoG) with a content of ~1kg REEs/ton RM, including about 190 g scandium oxide/ton RM. A novel integrated procedure for the selective separation of REEs has been performed based on an over 20 years of experience [1, 2]. In this study leaching experiments aiming to the selective recovery of REEs were conducted and co-evaluated with previous research in order to optimize the process.

## Results and Discussion

Different acids such as HCl, $HNO_3$, aqua regia and $H_2SO_4$ were tested as leaching solutions. The extraction yield of REEs varied from 30% to 90% depending on the element, the conditions and the acids used. The effect of several variables on the leaching efficiency was thoroughly investigated by determining representative REEs, as La (for light REEs), Yb (for heavy REEs), Y and Sc. Iron recovery was also tested. Percent recoveries for selected acids concentration as well as liquid to solid ratios are presented in Table 1. As it resulted, using aqua regia and HCl as leaching agents the high recoveries of REEs were associated with an increased dissolution of iron, rising up to 16 and 12% respectively. Sulfuric acid, although more environmentally friendly, revealed lower yield of REEs. Nitric acid was considered as the most suitable agent combining high recovery of REEs (80% for Sc) with low amount of Fe (up to 4%).

Liquid to solid ratio was proved quite important since it affected the % recovery but also the concentration of the final leachate solution. Acid concentration was tested within a wide range for all acids . Final pH of the leachate solution seems to be the

decisive parameter even when using different acid concentration and L/S ratio. Final pH value has to fall within the range of 0 to 0.5 in order to obtain high % recoveries. The results presented, refer to tests conducted in ambient conditions for 60 min. Higher temperature, longer reaction time and different agitation modes showed no significant improvement.

**Table 1:** Recovery of iron and REEs for different acids concentration and liquid to solid ratio. Reaction time 60 min, ambient conditions, lab scale

| Acid | Liquid /Solid | Concentration(M) | % recovery | | | | |
|---|---|---|---|---|---|---|---|
| | | | La | Yb | Y | Sc | Fe |
| $HNO_3$ | 10 | 0.5 | 22 | 44 | 64 | 43 | 3 |
| $HNO_3$ | 50 | 0.5 | 34 | 67 | 88 | 78 | 3 |
| $HNO_3$ | 50 | 1.5 | 32 | 72 | 88 | 79 | 4 |
| HCl | 10 | 0.5 | 17 | 29 | 25 | 40 | 10 |
| HCl | 50 | 0.5 | 37 | 57 | 80 | 68 | 11 |
| HCl | 50 | 1.5 | 46 | 54 | 75 | 77 | 12 |
| $H_2SO_4$ | 50 | 0.5 | 32 | 52 | 77 | 55 | 3 |
| aqua regia | 3 | N/A | 68 | 74 | 68 | 79 | 16 |

The whole process was also scaled up to a pilot plant using $HNO_3$ as leaching agent, with comparable results [3, 4] . Subsequent leaching stages applied on large scale using $HNO_3$, improved the recovery resulting to more concentrated leachate solutions. Sc showed the highest increment of 50% additional recovery after two leaching stages. Comparing the results achieved during the over 20 year ongoing investigation it was concluded that the initial composition of red mud had a crucial impact on REEs recovery, which depends not only on the Bayer process but even more on the bauxite deposit used as raw material. Nitric acid leaching process led to higher recovery when applied on RM samples produced prior to 1991 when the raw bauxite was originated from the 3rd bauxitic horizon of the Parnassos-Giona mountains without any addition of tropic bauxite.

## References


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