BAUXITE RESIDUE VALORISATION AND BEST PRACTICES CONFERENCE

Leuven 5-7 October 2015

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Selective leaching of rare earths from bauxite residue after sulfation-roasting

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Contents

- Introduction
- Characterization
- Direct leaching
- Slag leaching
- Sulfation-roasting-leaching
  - Acid amount
  - Temperature
  - Leaching duration
  - Sc leaching
- Conclusions

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Introduction

- Karst bauxites are rich in rare earth elements (REEs)
- Report to bauxite residue in Bayer process
- Direct leaching – low recoveries or high iron dissolution
- Problem in downstream processes
- Sulfation-roasting-leaching process – selective recovery
- First study on bauxite residue to recover REEs
- Developed for iron rich nickel ores

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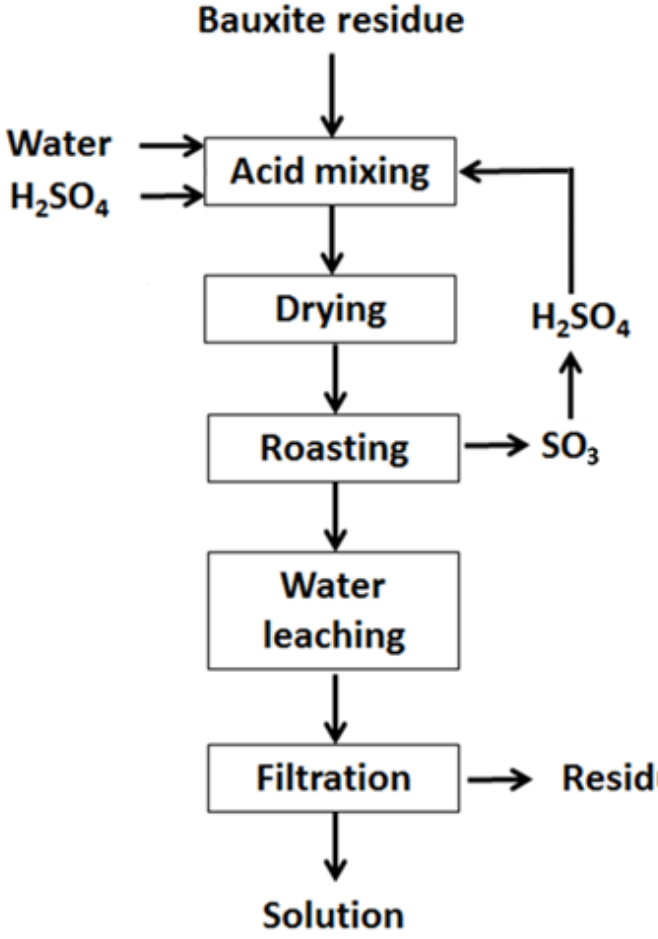
Introduction

- Sulfation - converts oxides to sulfates
- Roasting - decompose to oxides

$$Fe_2(SO_4)_3 \leftrightarrows Fe_2O_3 + 3SO_3 \ (700\ ^\circ C)$$

- REE-sulfatess are stable at that temperature
- Leaching – dissolves stable sulfates leaving behind oxides in the residue



Sulfation-roasting-leaching process

Introduction

Advantages

- Acid regeneration
- High selectivity against Fe, Ti and Al
- No silica dissolution (easy filtration and solvent extraction)
- Lower acid consumption
- Small volumes of effluents
- Neutral pH and low Na content (other applications)

Limitation

- High energy consumption

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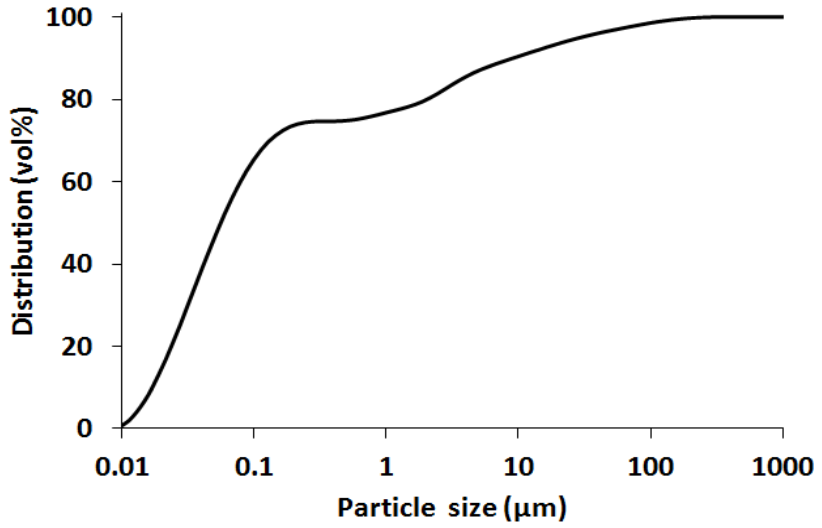
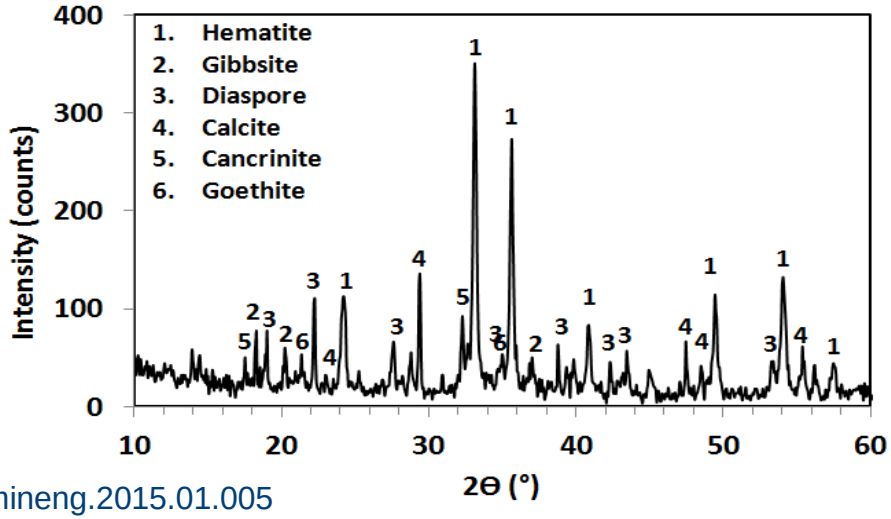
Characterization

Greek bauxite residue

Compound	wt. %
Fe_2O_3	**44.6**
Al_2O_3	23.6
CaO	11.2
SiO_2	10.2
TiO_2	5.7
Na_2O	2.5

Element	Concentration (g/tonne)
Sc	**121±10**
Y	75.7±9.6
La	114±15
Ce	368±68
Pr	28.0±3.9
Nd	98.6±7.0
Sm	21.3±2.3
Eu	5.0±0.9
Gd	22.0±1.9
Tb	3.5±0.6
Dy	16.7±0.7
Ho	3.9±0.6
Er	13.5±1.8
Tm	1.9±0.3
Yb	14.0±1.9
Lu	2.4±0.3

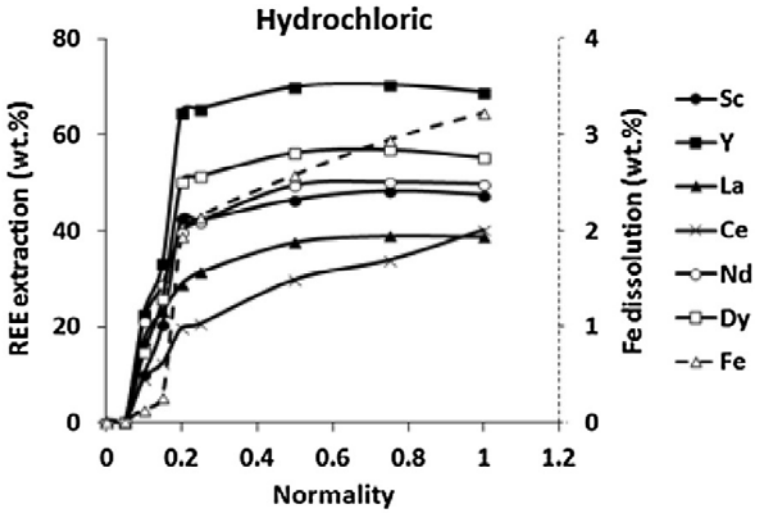




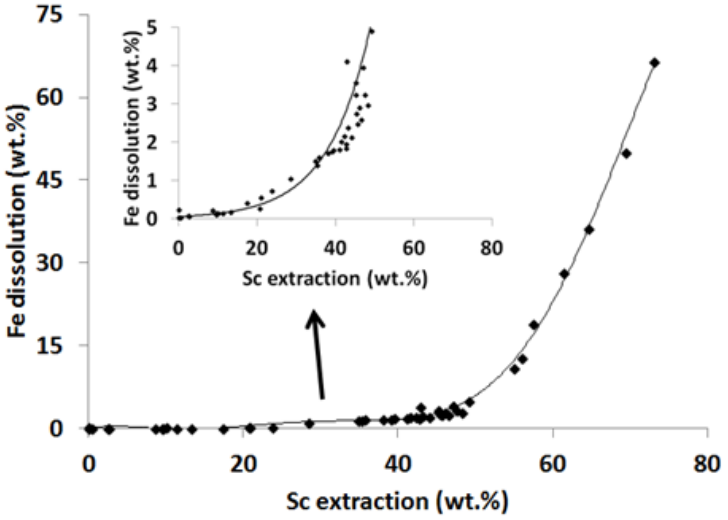
C.R. Borra et al. Miner .Eng. (2015), 76, 20-27, doi: 10.1016/j.mineng.2015.01.005

Direct leaching

- Direct acid leaching of REEs yields low recoveries
- High HCl acid concentrations increase the recovery but then high amounts of iron also dissolve
- High iron in the solution requires large amount of reagents during recovery
- Iron can be removed from BR by pretreatment



(T: 25 °C, L/S: 50, t: 24 h)



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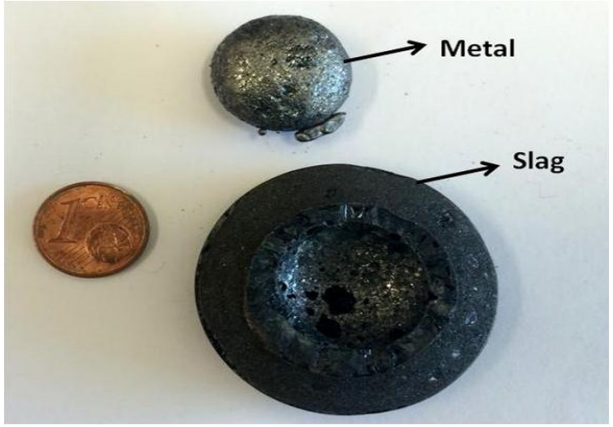
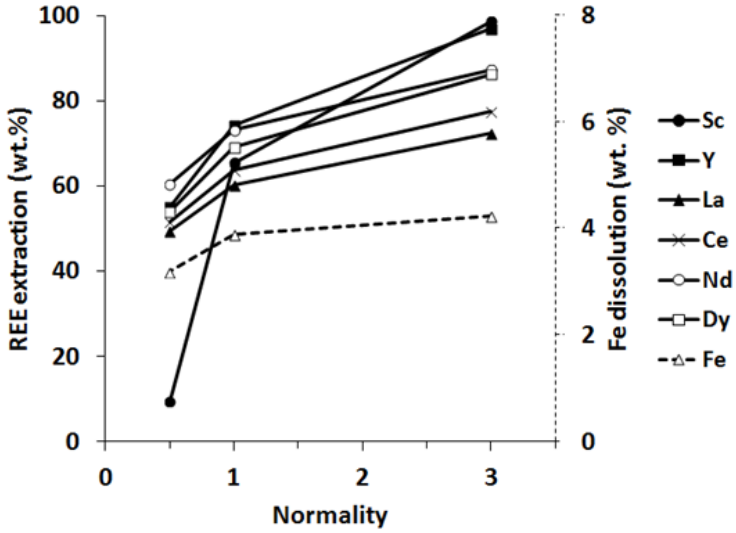
Slag leaching

- Fe was removed by smelting
- High recovery of REEs with low Fe compared to direct leaching
- High temperature leaching
- High acid consumption
- High amount of impurities in the leach solution
- Still high amount of Fe in the solution



(20% wollastonite, 5% graphite, 1500 °C)



(HCl, T: 90 °C, t: 1 h, L/S: 50)

C.R. Borra et al. J. of Sustain. Metall. (2015) in press, doi: 10.1007/s40831-015-0026-4

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Sulfation-Roasting-Leaching

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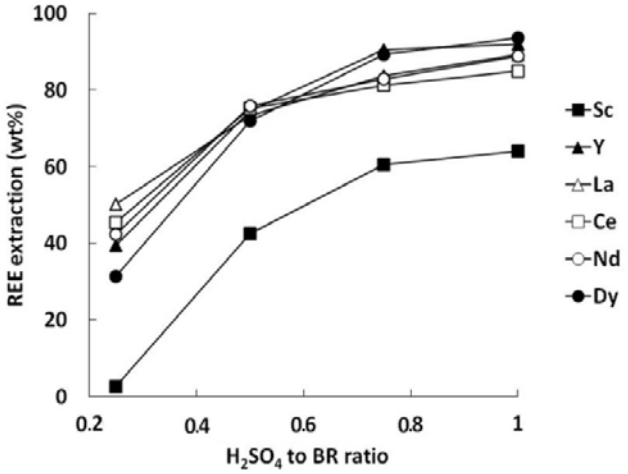
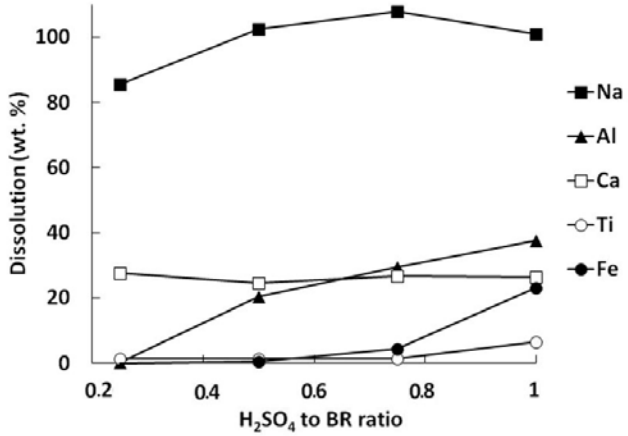
Acid amount

- Increase in acid amount increases the recovery
- No increase in REEs recovery beyond H_2SO_4 to BR ratio 1
- REE dissolution except Sc is >80%. Sc dissolution is max. 65%
- Increase in recovery Al, Ti and Fe with increase in acid amount
- No change in the Na and Ca dissolution with acid amount
- Ca dissolution is low due to solubility limit

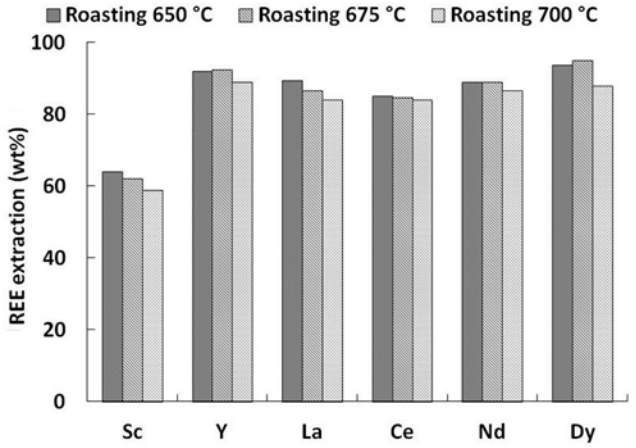


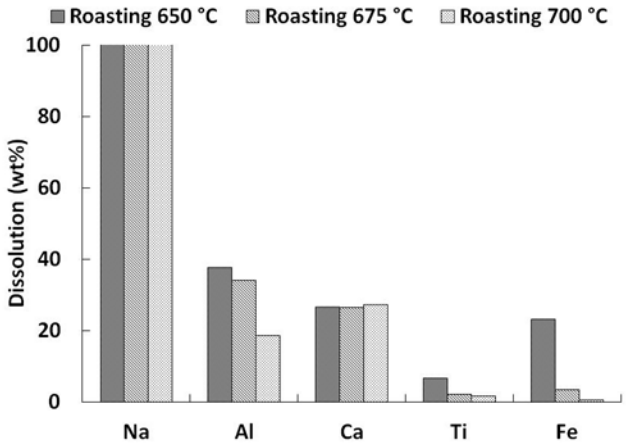


T_R: 650 °C, t_R: 1 h, L/S ratio: 50, t_L:7 days

Roasting temperature

- Increase in temperature improves the decomposition of ferric sulfate
- REEs slightly decreases with increase in the temperature
- Dissolution of Al, Ti and Fe drastically decreases with increase in temperature
- Fe and Ti dissolution is < 1% at 700 °C. Al dissolution is ~20% at 700 °C
- No change in the Na and Ca dissolution with temperature

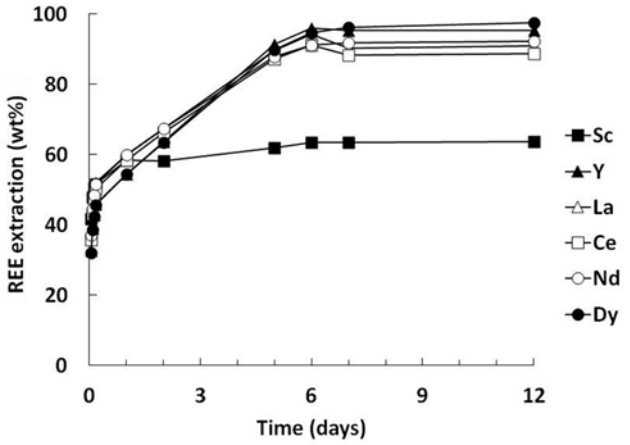


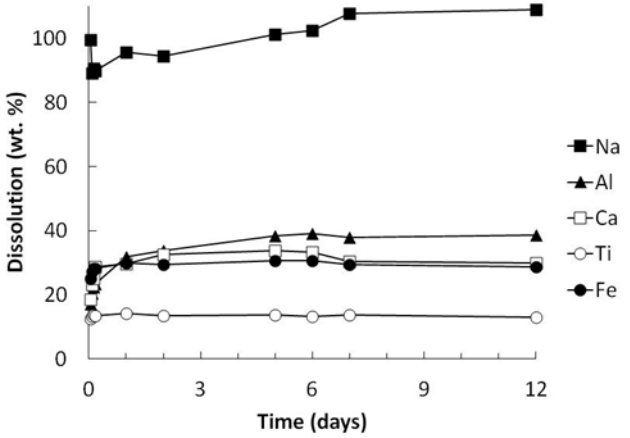


t_R: 1 h, H_2SO_4/BR: 1, L/S ratio: 50, t_L:7 days

Leaching duration

- No significant improve in the leaching of REEs with increase in the leaching temperature
- Leaching with agitation also requires 2-3 days for maximum recovery
- Leaching without agitation can leach maximum REEs in 6 days
- Max leaching of major elements and Sc can be obtained in 1 day
- pH of the leach residue is close to neutral. Low in Na. Contains $CaSO_4$. It can be used in building materials





T_R: 650 °C, t_R: 1 h, H_2SO_4/BR: 1, L/S ratio: 50

Sc leaching

- Sc Leaching is not increasing beyond 65%
- It may be due to Sc entrapment in Fe
- It is also due to the pH of the solution
- pH of the solution depends on $Fe_2(SO_4)_3$ amount
- Small gap between the Fe & Sc hydrolysis in Pourbaix diagram
- Sc recovery is lower compared to other REEs due to its different chemical behavior

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Conclusions

- REEs can be selectively leached from bauxite residue by sulfation-roasting-leaching
- Increase in acid amount increases the dissolution of REEs and other elements
- Increase in temperature decreases the dissolution of REEs (to a minor extent) and other elements (to a major extent)
- Roasting Temp. 700 °C, acid to bauxite residue ratio 1 and non agitated leaching for 7days yields Sc recovery ~ 60%, other REEs >80%, Fe and Ti dissolution < 1% and Al dissolution ~20%.

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https://www.kuleuven.rare3.eu/

Thank you