IOCMS 2026 Conference
The 3rd International Online Conference on Mineral Science
10–12 March 2026 | Online
MDPI

Novel Sustainable Process for the Recovery of Aluminium and Rare Earth Elements from High-Silica Bauxite

Turan Uysal[1*], Mega Muryani[2], Yayat Iman Supriyatna[2], Slamet Sumardi[2], Widi Astuti[2]

[1,*] Department of Mining Engineering, Gümüşhane University, Gümüşhane, Türkiye

[2] Research Center for Mining Technology, National Research, and Innovation Agency Republic of Indonesia (BRIN), Lampung, Indonesia

INTRODUCTION & AIM

Bauxite is the primary raw material for Aluminium (Al) production and represents an important secondary source of Rare Earth Elements (REEs). REEs are critical raw materials widely utilized in strategic sectors such as renewable energy technologies, electric and hybrid vehicles, as well as defense and aerospace industries. The aim of this study is to investigate the recoverability of REEs and Al from bauxite ores that cannot be processed by the Bayer process due to their high silica content, using an innovative and sustainable approach. Within this scope, alkaline roasting, sequential water and acid leaching, and purification of the pregnant solutions by solvent extraction (SX) were carried out.

MATERIAL & METHOD

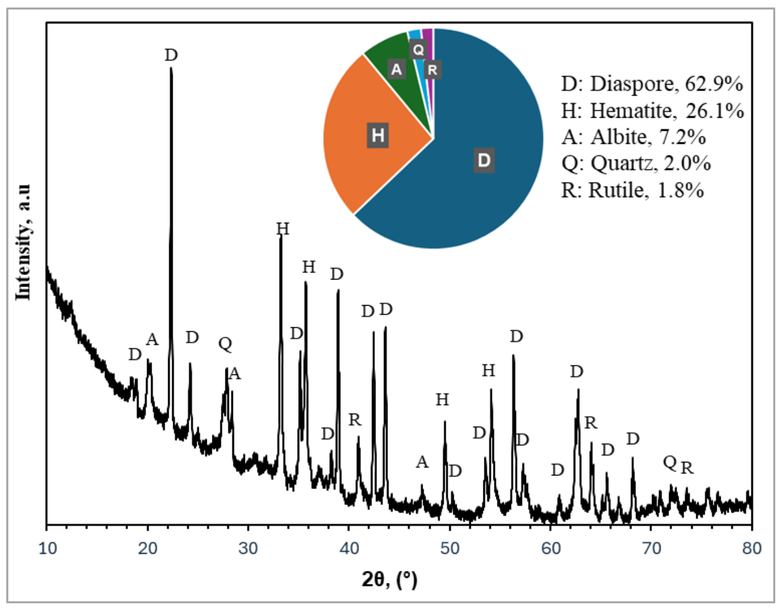

Fig. 1. XRD analysis of Kemiklitepe bauxite ore

Bauxite ore consists mainly of diaspore, hematite, albite and quartz.

Table 1. Chemical content of Kemiklitepe bauxite ore (ICP-OES-MS, Major oxides: %, REE: ppm)

SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	K_2O	TiO_2	LOI
15.6	47.8	22.4	0.40	1.50	0.63	2.43	9.62
Ce	**La**	**Y**	**Nd**	**Sc**	**Pr**	**Dy**	
307	202	148	143	2.4	38.1	23.8	
Yb	**Ho**	**Lu**	**Er**	**Gd**	**Sm**	**Eu**	
15.4	5.0	2.4	15.2	21.7	24.8	4.8	
Tb	**Tm**	**Total**	**Rb**	**Th**	**U**	**Nb**	
3.7	2.4	**1017**	24.2	50.2	7.5	58.4	

It was determined that the silica modulus (Al_2O_3/SiO_2) of the ore was **3.06**, indicating that it is unsuitable for the Bayer process, for which an acceptable silica modulus typically ranges between 7-8, due to its high silica content.

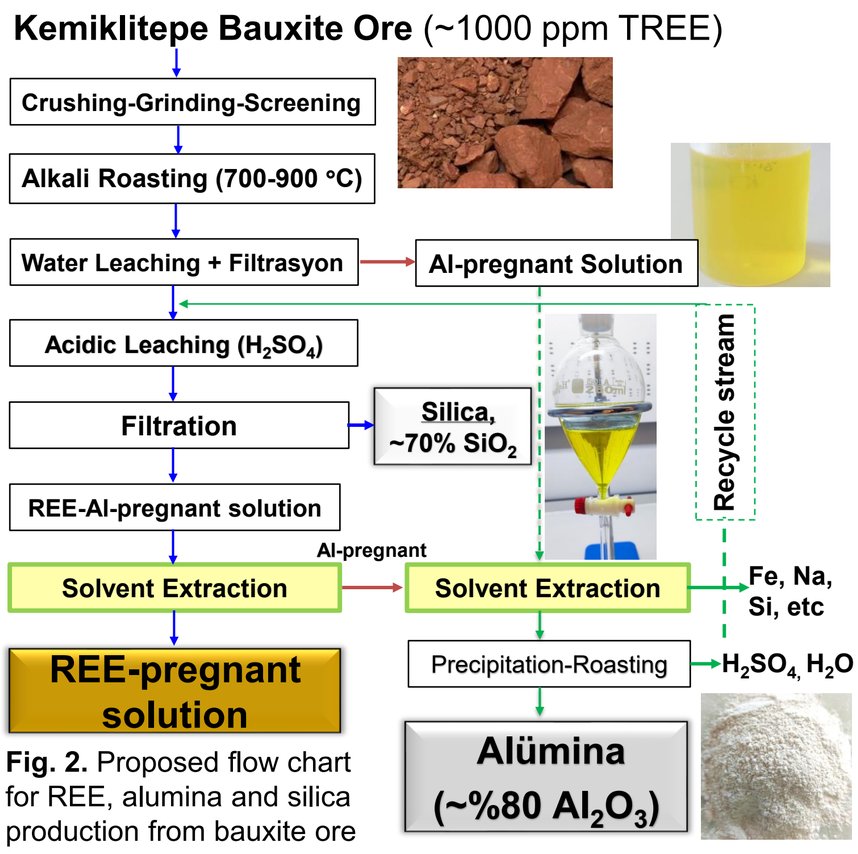

Fig. 2. Proposed flow chart for REE, alumina and silica production from bauxite ore

RESULTS & DISCUSSION

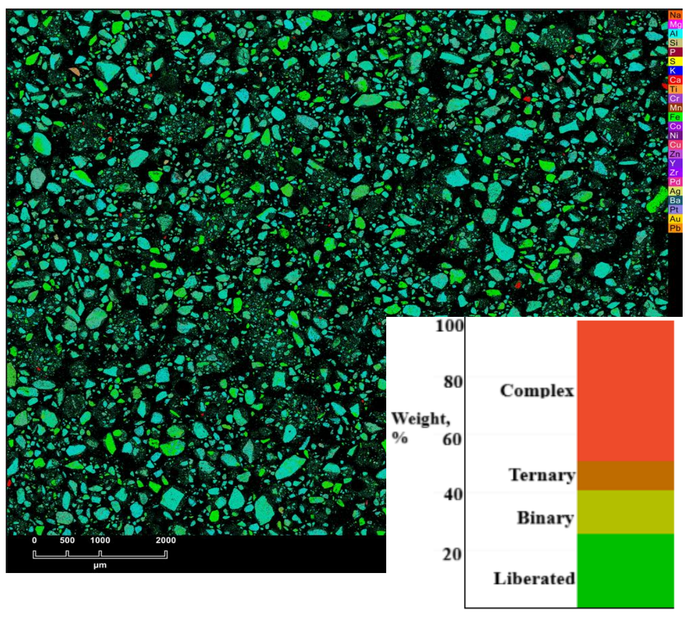

Fig. 3. MLA-based elemental distribution maps and the degree of liberation

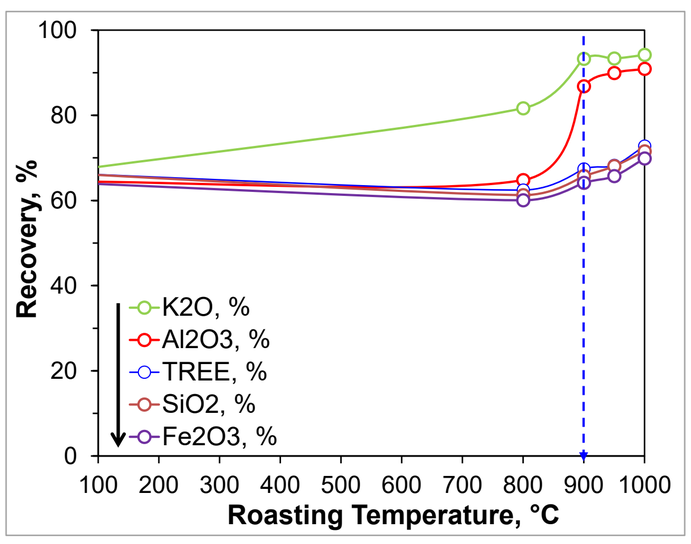

Fig. 4. Recovery of REE and major elements water leaching depending on roasting temperature (75 °C, 15 min, S/O: 15)

Ce, %	La, %	TREE, %	Al_2O_3, %	Fe_2O_3, %	TiO_2, %	CaO, %
89.41	88.85	89.21	65.80	89.25	88.10	87.41

Table 2. Major oxide and REE recovery values obtained after acid leaching (Roasted at 900°C, 2M H_2SO_4, -212 µm, room temperature, 15min, S/O: 10)

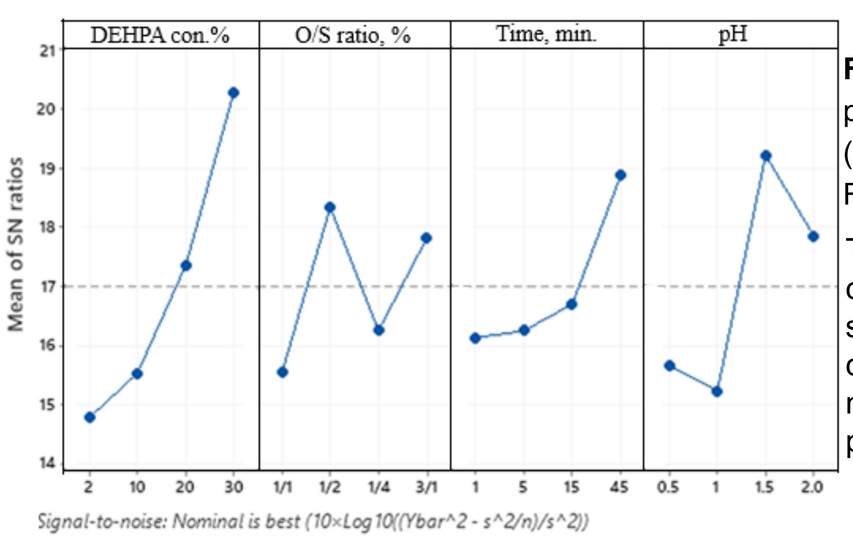

Fig. 5. Main effects plot for SN ratios (Taguchi Design, RSM)

The DEHPA concentration was significant at 95% confidence and the most influential parameter.

Table 3. Model summary

S	R-Sq	R-Sq(adj)
0.351	97.34%	86.70%

ANOVA results indicate that the model adequately represents the effect of variables on the SN ratio with a high R^2.

FUTURE WORK / REFERENCES

The acid leaching residue should be comprehensively characterized to investigate its potential utilization as a silica source. In addition, the production of REOs through oxalic acid precipitation followed by roasting of the purified pregnant solution obtained via SX should be investigated in a separate study. Furthermore, a life cycle assessment (LCA) and techno-economic analysis (TEA) of the proposed integrated process should be conducted to comprehensively evaluate the potential of the developed methods for the sustainable utilization of other high-silica bauxites.

-Sun Y, Pan A, Ma Y, Chang J. Extraction of alumina and silica from high-silica bauxite by sintering with sodium carbonate followed by two-step leaching. RSC Advances. 2023;13:23254-23263.

CONCLUSION

- The ore has an average total REE content of 1017 ppm, which is quantifiable. Al recovery rose from 64% to 87% after roasting at 900°C, a **23% improvement**, with REE recovery increasing ~2%, 900°C is the optimal roasting temperature.
- As a result of acid leaching, the total REE recovery was determined to be 89.21%, while the Al recovery was 65.8%.
- Considering both process economics and SN ratios, the suitable operating conditions were determined as 25% DEHPA concentration, an O/S ratio of 1/2, a contact time of 30 min, and a pH of 1.5. Under these optimum conditions, the REE loading and stripping efficiencies were determined to be approximately **90%**.
- In conclusion, REEs and Al can be efficiently recovered, a sustainable approach using alkaline roasting-water leaching-acid leaching-SX is proposed.