Lime Use Alternatives and Impacts on Processing Boehmitic Bauxites

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Abstract

ETI Aluminyum A.S has its own bauxite mines, and has been extracting from two mines out of five to feed its alumina refinery since the 1970's. The refinery was designed to process boehmitic bauxite with a reasonable A/S (Al_2O_3/SiO_2, w/w) ratio of 8.2. Over the years, bauxite quality has decreased and current reserves show an average A/S ratio of 7.0. On the other hand, the characterization studies for the other three mines, which ETI will exploit in a few years, indicate that diaspore and goethite content of these bauxite are significantly higher than current ones. In these circumstances, ETI needs to prepare for bauxite quality changes which can adversely affect operating cost and product quality. The first and most interesting option for examination is lime utilisation, and ETI has focused on studying lime addition in laboratory and plant trials. In the study discussed in this paper, the impacts of lime addition on boehmite/diaspore solubility, goethite conversion, titanium behavior, caustic soda consumption, as well as red mud settling properties and product quality, have been investigated. It has been observed that both the lime dosing point and quantity play an important role on desired process result.

Keywords: Boehmitic Bauxite; Soda Consumption; Lime Addition; Digestion.

1. Introduction

Due to its economics, the Bayer process is still the preferred and most used process globally for producing alumina. Bauxite is the main feedstock of Bayer process. Progressive bauxite quality deterioration is one of the main challenges to the alumina industry. Bauxite mineralogy affects process efficiency through the chemical reactions in the process. Alumina to silica mass ratio (A/S), along with total available alumina and reactive silica contents are the amongst the most economically important parameters describing bauxite quality.

Operating cost was discussed for varying A/S ratios on diasporic bauxite by Z. Baiyong and L. Xinqin [1] and it was found that 8.0 was an inflection point for economic Bayer process application. An A/S ratio lower than 7.0 was considered to be low grade bauxite. L. Zhijian et al. [2], recommends lime addition to the Bayer process when processing low grade bauxite which has an A/S higher than 5.0 and the Sinter process for A/S ratios lower than 5.0.

Lime is widely used in the Bayer process for different purposes and in different forms. Digestion, side stream causticisation and filter aid are the main applications stated by L.A.D. Chin [3]. Digestion lime charge by adding burnt lime (or milk of lime) to the bauxite, bauxite slurry or feeding it directly to one of the digesters are also common uses. The proper selection of the feeding point(s) for digestion lime charge has very high importance [4]. Lime is effective in not only increasing alumina extraction efficiency, but also increasing liquor productivity in the high temperature digestion of diasporic bauxites [5]. Furthermore, significant improvement in caustic soda consumption can be achieved by applying optimum CaO doses (3-4 %) [6] for monohydrate bauxites.

The reactive silica minerals in bauxite react with caustic soda in liquor to form desilication products (DSP) resulting in undesired caustic soda losses. Addition of lime during pre-desilication or digestion can minimise soda losses by forming a new DSP phase with soda content lower than that of sodalite (sodium silicon aluminium hydrate). The soda-free hydrogarnet (HG) or low-soda calcium-cancrinite (Ca-CAN) can both have Na_2O/SiO_2 ratios lower than sodalite DSP and their formation as DSP is beneficial in minimising soda losses [7].

Goethite present in the bauxite adversely affects the settling properties of red mud due to finer particle size and larger specific surface area. Finer red mud can cause considerable caustic soda losses due to insufficient washing efficiency [8]. The addition of lime or calcium-containing additives, such as CaO, $Ca(OH)_2$ and $CaCO_3$, can improve the hydrothermal transformation of goethite to hematite in the Bayer digestion which reduces settling and washing problems [9].

The anatase in bauxite can impede the transformation of goethite to hematite in the Bayer process [9]. In addition, the titanium minerals react with caustic in liquor to form sodium titanates which cause soda losses. Sodium titanate also forms a gelatinous coating on boehmite particles which inhibits further boehmite extraction [10]. With lime fed to high temperature digestion, part of the available CaO reacts with TiO_2 generating perovskite ($CaTiO_3$), which considerably improves the recovery of alumina as well as the performance of goethite to hematite conversion [8].

Lime is an economical raw material generally used in the Bayer process for controlling impurities such as carbonate, phosphorus, fluoride and sodium organics [11].

Bauxite exploration studies were started early 1960’s in Turkey by MTA. As indicated in Table 1, 95 % of Turkish bauxite was formed around Taurus Mountain.

Table 1. Turkey bauxite reserves [12].

Region	**Reserves (x1000 tones)**			**Bauxite Type**
	Proved	**Potential**	**Total**	
Seydişehir - Akseki	35,251	1,253	36,504	boehmite
Zonguldak - Kokaksu	5,900	3,400	9,300	boehmite
Yalvaç - Şarkikaraağaç	-	115,600	115,600	iron rich diaspore
Payas - Islahiye	-	215,500	215,500	iron rich diaspore
Tufanbeyli - Saimbeyli	5,500	6,000	11,500	diaspore
Muğla - Milas - Yatağan	9,400	11,200	20,600	diaspore
Bolkardağı	-	3,900	3,900	diaspore
Alanya	1,300	7,700	9,000	diaspore
TOTAL	**57,351**	**364,553**	**421,904**	

ETI Aluminium A.S. (ETI), the only alumina and aluminum producer in Turkey, owns the Seydisehir-Akseki region bauxite deposits and has been processing these ores since 1973. Although the initial A/S ratio for the alumina refinery design was around 8.20, it has decreased to 7.05 over the years. In the meantime, ETI has faced diaspore and goethite rich bauxite during the processing of new mines such as Arvana and Kaklıktas. Table 2 shows the current mines and their bauxite qualities.

Table 2. ETI bauxite reserves.

Mine	Bauxite Reserves, tones			Bauxite Analysis		
	Economic	Sub-economic	Total	Al_2O_3, %	SiO_2, %	A/S Module
Mortaş	1,806,461	0	1,806,461	57.61	9.54	6.04
Doğankuzu (GB)	1,812,563	510,090	2,322,653	56.06	9.30	6.03
Doğankuzu (KB)	4,087,610	0	4,087,610	58.26	6.30	9.25
Doğankuzu (GDB)	0	142,742	142,742	57.07	5.04	11.32
Doğankuzu (Ağaçyolu)	262,772	37,549	300,321	57.20	5.40	10.59
Değirmenlik (GB)	5,000,862	5,070,236	10,071,098	58.29	6.99	8.34
Değirmenlik (KB)	0	1,629,000	1,629,000	51.24	4.47	11.46
Arvana (Çatmakaya)	299,140	500,749	799,889	58.49	5.25	11.14
Morçukur	3,481,829	2,705,057	6,186,886	52.85	11.28	4.69
TOTAL/AVERAGE	**16,751,237**	**10,595,423**	**27,346,660**	**56.39**	**7.99**	**7.05**

Lime addition is the most reasonable solution to deal with the chemical and mineralogical changes in bauxite. Lime effects have been discussed by many researchers examining its specific process effects, generally at laboratory scale. However, published studies on boehmitic bauxite are limited. In this paper, the lime impact on boehmitic as well as diasporic bauxite has been investigated at laboratory and plant scale. An extensive plant trial has been performed applying the lime to different process points. Mineral composition of red mud has differed as lime dose changes. The overall benefit has been determined with respect to lime dose and feed point.

2. Results and Discussion

2.1. Laboratory trials

The studies were executed on two types of bauxite samples. Table 3 and Table 4 show the chemical and mineralogical analysis of bauxites used for digestion and settling tests.

Table 3. Bauxite chemical analysis.

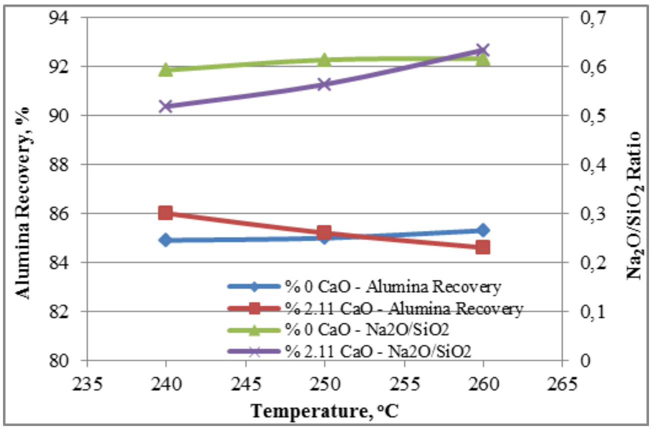
Sample	XRF Analysis, %					A/S Module
	Al_2O_3	SiO_2	Fe_2O_3	TiO_2	CaO	
Bauxite-1	57.14	7.61	17.84	2.59	0.41	7.51
Bauxite-2	59.65	4.06	18.25	2.80	0.32	14.69

Table 4. Bauxite mineralogical analysis.

Sample	XRD Analysis, %												H/G Ratio
	Boehmite	Diaspore	Gibbsite	Kaolinite	Tridymite	Quartz	Hematite	Goethite	Rutile	Anatas	Calcite	Amorphous	
Bauxite-1	60.57	1.21	0.43	10.83	2.33	0.13	16.62	0.82	0.50	2.05	1.15	3.36	20.27
Bauxite-2	13.97	54.31	0.92	2.53	2.23	0.66	6.89	12.83	0.94	1.86	0.57	2.47	0.55

2.1.1. Digestion tests

Bauxite-1 was digested with and without lime addition at different digestion temperatures in Parr bomb reactors. Alumina recovery and caustic consumption values after digestion reactions are given in Figure 1.

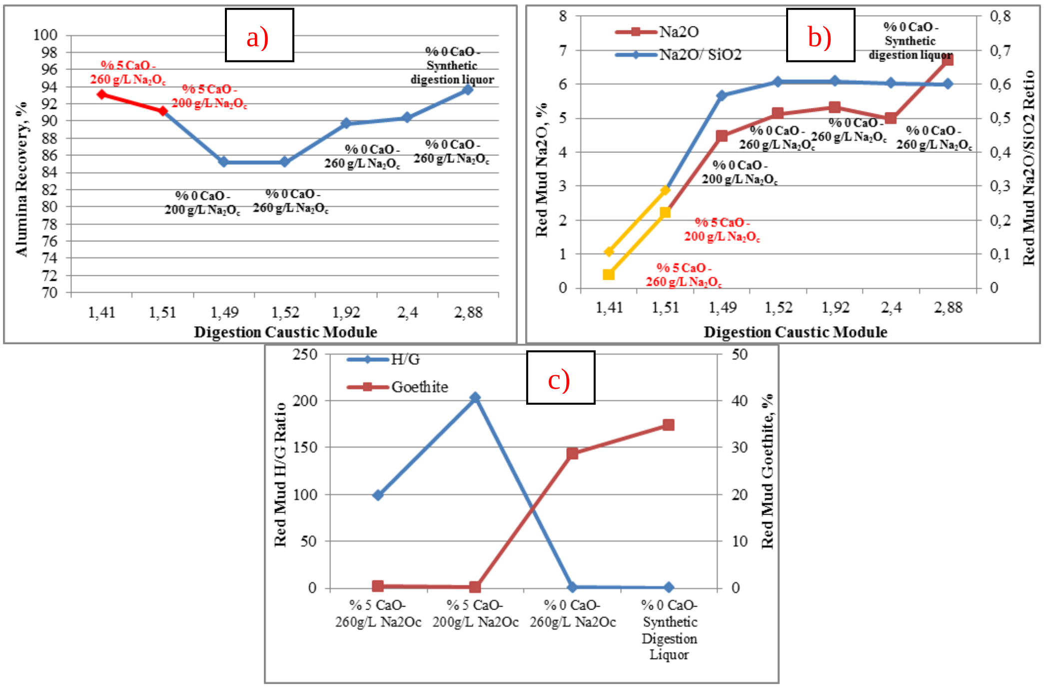


Digestion liquor composition; Al_2O_3 = 112.2 g/L, Na_2O_c = 252.4 g/L, Caustic/Total Soda ratio (C/S) = 0.948, Caustic module (Na_2O_c/Al_2O_3 molar ratio–MR) = 3.70, Lime quality; CaO = 92.0 %, Reaction time = 2 hours.

Figure 1. Alumina recovery and Na_2O/SiO_2 ratio of red muds at different digestion temperatures with/without lime charge (Bauxite-1).

Both alumina recovery and the Na_2O/SiO_2 ratio of red mud increase with increasing temperature where no lime is used. It can be explained by temperature having a significant effect on the dissolution of alumina. Alumina recovery decreases and the Na_2O/SiO_2 ratio of red mud increases with increasing temperature in the presence of lime. The best values have been achieved at 240 °C. Increasing temperature promotes sodium aluminosilicate formation and excess lime reacts with alumina minerals forming calcium alumina silicates which cause lower alumina recovery.

Bauxite-2 was digested with and without lime addition at different caustic concentrations in Parr bomb reactors.



Synthetic digestion liquor composition; Na_2O_c = 127.9 g/L, SiO_2 = 0.48 g/L, Lime quality; CaO = 93.0 %, Reaction temperature = 250 °C, Reaction time = 2 hours.

Figure 2. a) Alumina recovery, b) Na_2O content and Na_2O/SiO_2 ratio of red muds, c) H/G ratio in muds, at different caustic concentrations with/out lime charge (Bauxite-2).

As can be seen in Figure 2a, it is impossible to go to lower molar ratios of Na_2O_c/Al_2O_3 due to diaspore's equilibrium solubility in caustic liquor. The achievable ratio with a lower alumina recovery in case of no lime use is 1.49. Lime addition of 5 % with liquor caustic of 260 g/L Na_2O_c digestion has resulted in approximately the same alumina recovery (93.1 %) as achieved with synthetic liquor. Lime addition of 5 % decreases the Na_2O/SiO_2 ratio of red mud from 0.6 to 0.1 (Figure 2.b). The caustic content of red mud with lime is almost zero. At the same time, the higher the digestion liquor caustic concentration, the higher caustic content in red mud in the absence of lime. With lime addition it is vice versa. 5 % lime addition is sufficient to achieve about 100 % goethite to hematite conversion and to get higher H/G ratio as seen in Figure 2c.

2.1.2. Settling tests

The digested slurry from Bauxite-1 was taken and used for settling tests. Firstly, the mud from each experiment was analyzed for particle size distribution (Table 5). Then they were treated with doses of coagulant and flocculant followed by settling tests.

Table 5. Red mud particle size distribution.

Temperature, °C	CaO Dosage, %	Red Mud Particle Size Distribution, %					
		D50, μm	+149 μm	-149 +74 μm	-74 +44 μm	-44 +20 μm	- 20 μm
240	0	2.74	0.01	2.23	1.85	2.27	93.64
240	2.11	4.02	0.48	3.96	4.27	8.78	82.51
250	0	2.67	0	0	0.02	2.98	97.00
250	2.11	3.26	0.12	1.67	1.50	4.79	91.92
260	0	2.22	0	0	0.20	1.10	98.70
260	2.11	3.01	0	0.61	1.61	6.52	91.26

The settling characteristics of red mud mostly depends on bauxite quality, as well as digestion conditions. Increasing digestion temperature produces finer particles. Lime addition improves the coarseness of the mud even at higher temperatures. Settling rates of mud and suspended solids in overflow liquors are plotted on Figure 3.

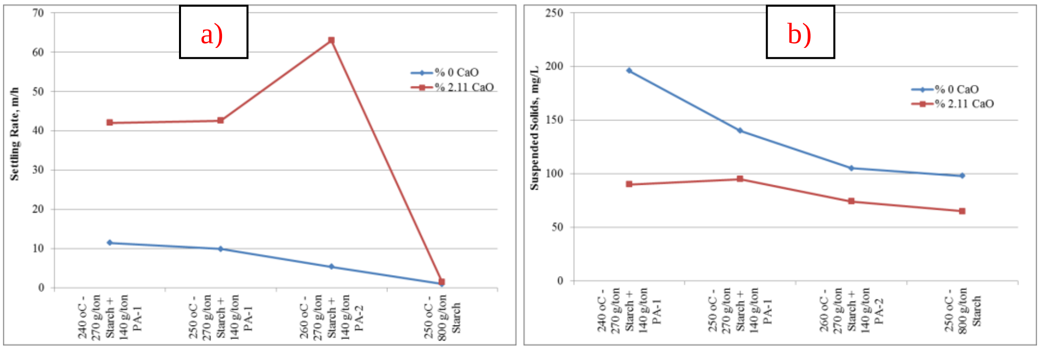


Figure 3. a) Red mud settling rates, b) Overflow liquor suspended solids, with/out lime charge (Bauxite-1).

In the presence of lime, higher settling rates have been observed. While digestion temperature adversely effects the settling in case of no lime usage, there seems to be no large temperature impact when lime is used. PA-2 flocculant gave the best performance with starch as coagulant. Lower suspended solids were achieved with lime usage. The lowest one obtained was with starch only.

2.2. Plant trials

A four month plant trial was run to determine the most efficient dosing points and optimum lime dose. The ETI alumina plant has been processing a boehmitic type bauxite which is digested at 250 °C in autoclaves with 2 hours of reaction time. Test tank has a caustic concentration of about 240-250 g/L as Na_2O. Soft-medium burnt lime was procured with 90 to 93 % CaO content for the trial. The A/S ratio of bauxite fluctuated between 7.60 and 7.80 during the trial. The average chemical and mineralogical analysis of the bauxite used is given in Table 6 and Table 7.

Table 6. Bauxite chemical analysis.

Sample	XRF Analysis, %					A/S Module
	Al_2O_3	SiO_2	Fe_2O_3	TiO_2	CaO	
Bauxite	57.23	7.42	17.12	2.71	0.67	7.71

Table 7. Bauxite mineralogical analysis.

Sample	XRD Analysis, %												H/G Ratio
	Boehmite	Diaspore	Gibbsite	Kaolinite	Tridymite	Quartz	Hematite	Goethite	Rutile	Anatas	Calcite	Amorphous	
Bauxite	60.50	1.08	0.61	11.20	1.77	0.50	16.00	1.27	0.42	2.29	1.17	3.19	12.60

Lime feeding forms and dosing points applied during trial were; a) milk of lime to digestion, b) milk of lime to desilication, c) milk of lime to mill, d) burnt lime to bauxite. Alumina recovery and caustic savings were monitored at varying lime charges and the mineral composition of red mud was closely followed. Apart from the other process benefits, an economic analysis has been made considering the quantity of lime used and its impact on bauxite and caustic consumption.

2.2.1. Digestion results

Different lime doses were applied to the process to see the changes on alumina recovery and the Na_2O/SiO_2 ratio of red mud (Figure 4).

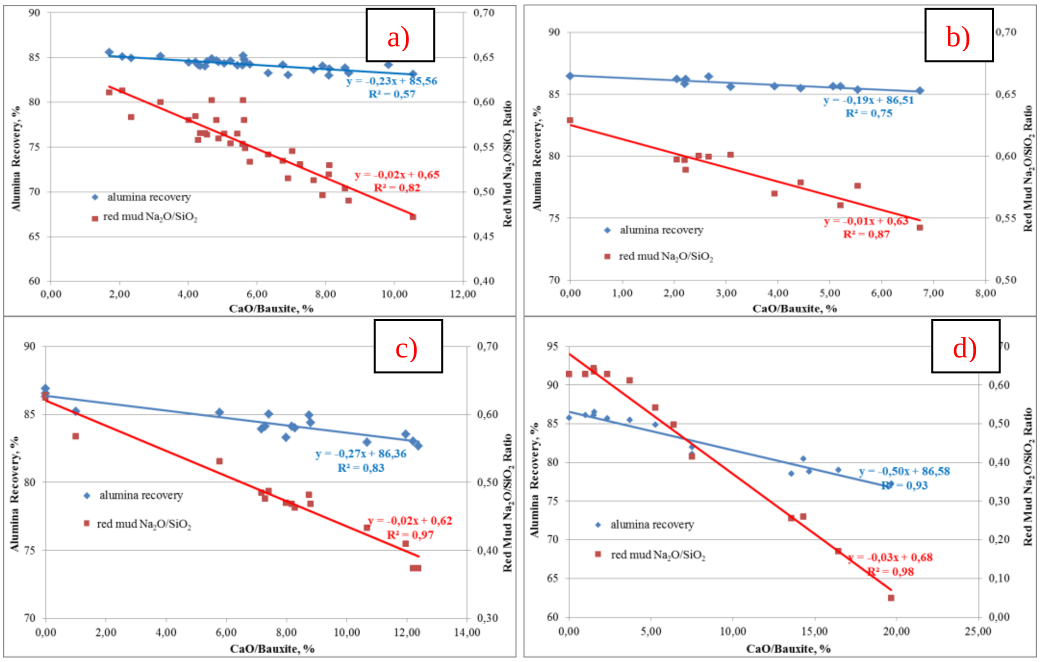


Figure 4. Alumina recovery and red mud Na_2O/SiO_2 ratio values versus lime dose at lime feed to, a) Digestion, b) Dessilication tank, c) Mill, d) Bauxite

Increasing lime dose decreases the alumina recovery at all feeding points. This decrease becomes significant over 6 % lime charge. On the other hand, important caustic savings were observed with increasing lime and an 80 - 90 % saving was achieved when dosed in excess (Figure 4).

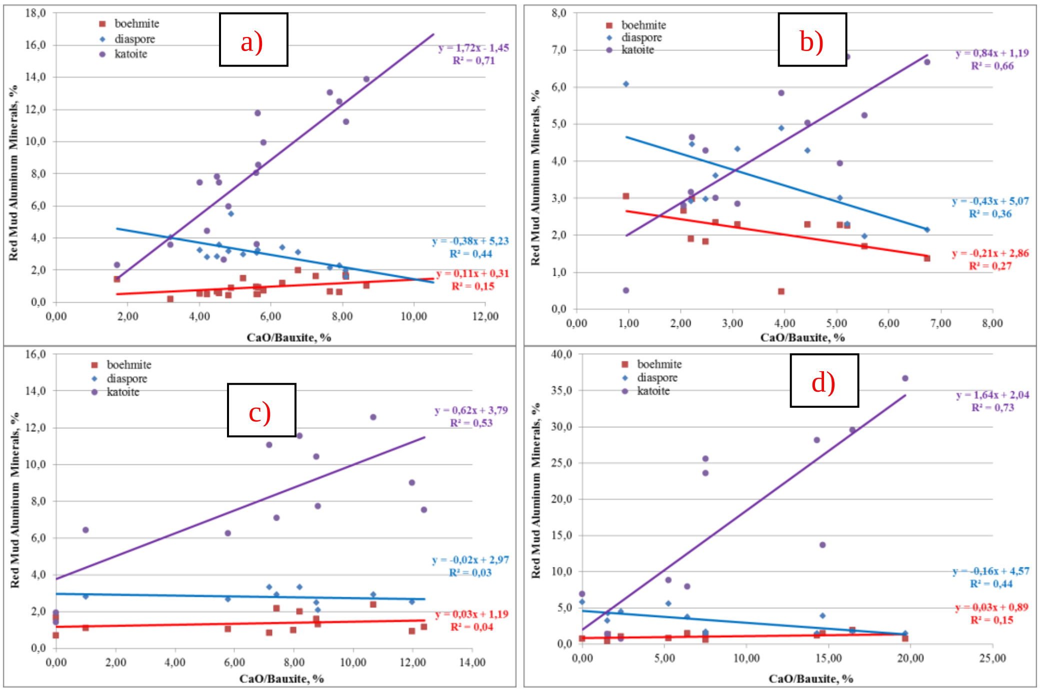
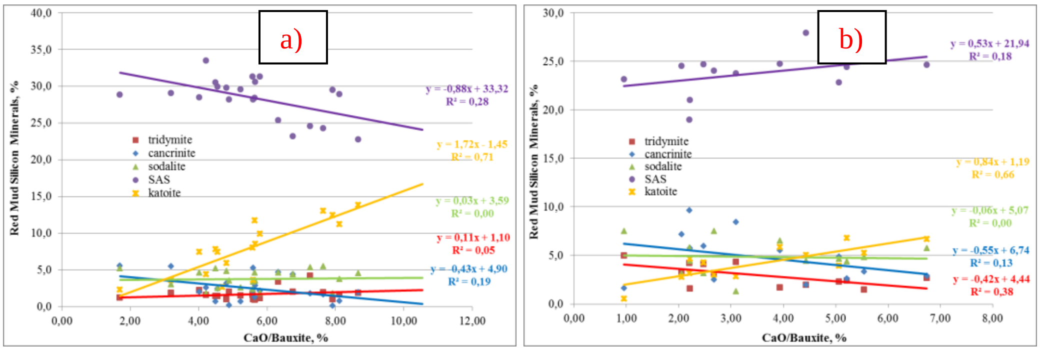


Figure 5. Changes of aluminium minerals in red mud versus lime dose at lime feed to, a) Digestion, b) Dessilication tank, c) Mill, d) Bauxite

The most notable change was observed was of the katoite mineral [$Ca_{2.93}Al_{1.97}(Si_{0.64}O_{2.56})(OH)_{9.44}$] (Figure 5). The highest katoite formation occurred with lime feed to bauxite. Boehmite dissolution does not have a good correlation with lime charge. However, there is a slight improvement below 6 % lime. Diaspore dissolution has a reasonable relationship with lime charge, especially to digestion, mill and bauxite feed where katoite formation is effective.



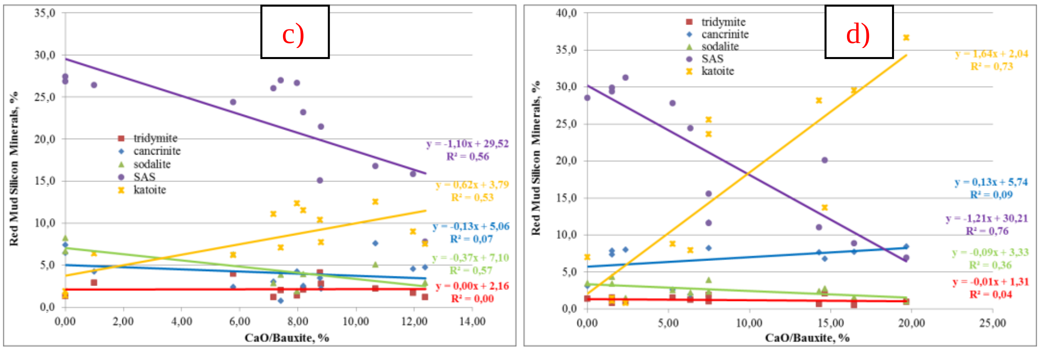


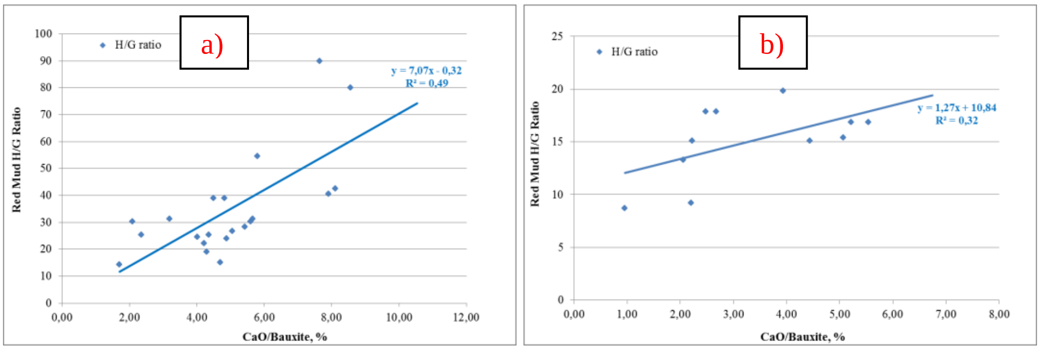
Figure 6. Changes of silica minerals in red mud versus lime dosage at lime feed to, a) Digestion, b) Dessilication tank, c) Mill, d) Bauxite

Katoite, sodium aluminum silica hydrate (SAS), sodalite and cancrinite were identified as DSP minerals in ETI red mud (Figure 6). SAS, [$3(Na_2O.Al_2O_3.2SiO_2).mNa_2X.nH_2O$] which is abundant in red mud, is a type of hydroxysodalite compound where m=0 and n=4. Sodalite is again a type of hydroxysodalite where $X=2Cl^-$, m=1 and n=0. Cancrinite can be formulated as $3(Na_2O.Al_2O_3.2SiO_2.aH_2O).2NaOH$ where a=0.

Sodalite formation was limited due to the low impurity level in liquor. Furthermore, the effect of other impurities such as sulphate, carbonate and fluoride on DSP formation could not be observed. Carbonate which is the highest concentration impurity in liquor, preferred to precipitate with calcium as calcite in red mud instead of silicon . Katoite and SAS compounds were the main DSP products which increased in response to lime feed. Katoite formation remarkably increased at all lime feeding points with increasing lime dosage.

While there is no significant change to sodalite and SAS formation during the lime feed to digestion and desilication, appreciable decreases were observed with mill and bauxite feed. Contrary to that, cancrinite decreased particularly at digestion feed and remained stable at mill and bauxite feed.

Tridymite is a type of clay which, similar to quartz, partially reacts with caustic solution at high temperatures. There was generally no difference in tridymite concentration with the presence of lime. However, the tridymite content of red mud unexpectedly decreased when lime was fed to the desilication tank. This can be explained by lime being fed to the desilication tank enhancing tridymite dissolution and results in an increase in SAS ratio, causing extra caustic losses. Lime has the lowest efficiency in terms of caustic savings when fed to the desilication tank.



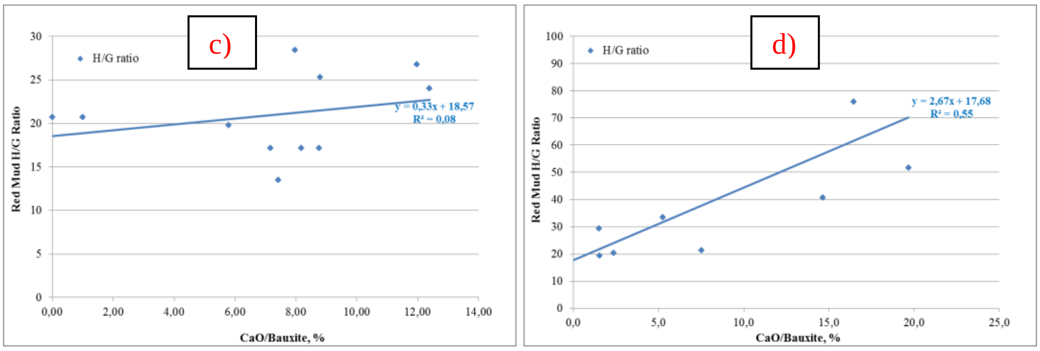


Figure 7. Changes of H/G ratios in red mud versus lime dosage at lime feed to, a) Digestion, b) Dessilication tank, c) Mill, d) Bauxite

Hematite is the most abundant mineral in ETI red mud. Although goethite content is low, H/G ratio has been being monitored to keep over 10 to avoid settling problems through the clarification process (Figure 7). The lowest goethite content and highest H/G ratio were obtained with digestion lime feed. Satisfying results were observed at lime feed to bauxite when lime dosage was more than 10 %. Calcium titanate concentrations were high at both feeding points that had correspondingly higher H/G ratios.

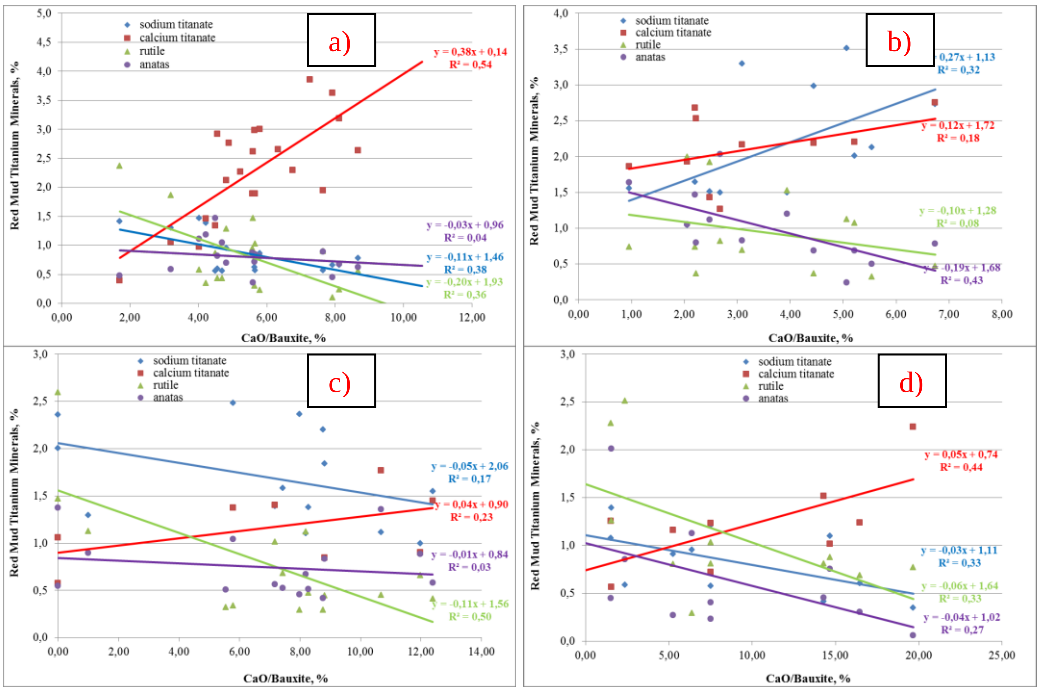


Figure 8. Changes of titanium minerals in red mud versus lime dosage at lime feed to, a) Digestion, b) Dessilication tank, c) Mill, d) Bauxite

The lowest sodium titanate and the highest calcium titanate results were achieved when lime was fed to digestion (Figure 8). Lime fed to bauxite gave good results when lime dose is higher than 10 %. The results of lime fed to mills were not satisfactory. Sodium titanate and calcium titanate compounds surprisingly increased together when lime was fed to desilication. It seems that lime in desilication promotes anatase dissolution. Except in the desilication tank, rutile dissolution increased with increasing lime charge while anatase dissolution remained almost stable. However, anatase dissolution sharply increased when lime charge was more than 15 %. A significant increase in rutile dissolution was observed when lime charge was more than 8 %.

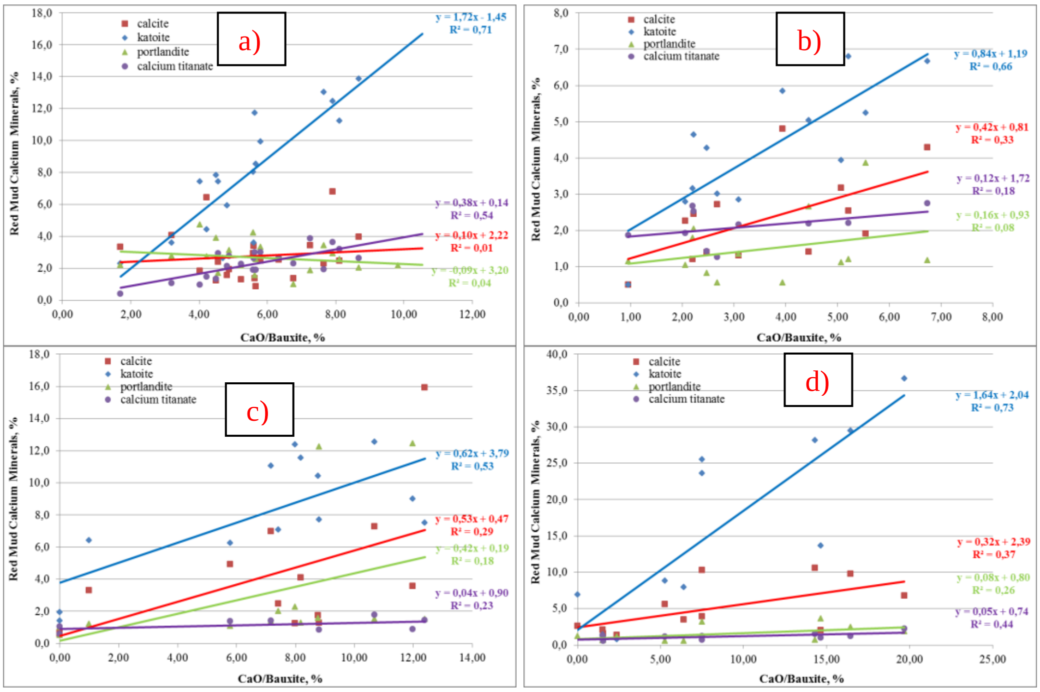


Figure 9. Changes of calcium minerals in red mud versus lime dosage at lime feed to, a) Digestion, b) Dessilication tank, c) Mill, d) Bauxite

Katoite, calcium titanate, calcite and portlandite minerals were the calcium compounds formed in ETI red mud (Figure 9). Katoite is an indicator of caustic savings via the replacement of sodium in DSP with calcium. While the Na:Si molar ratio is 1.0 in SAS and 1.33 in sodalite and cancrinite, the Ca:Si molar ratio is 4.58 in katoite. While 4.58 moles of calcium is theoretically needed to replace 1 mole sodium in SAS, 3.44 moles are needed in sodalite and cancrinite. Similarly, while the Al:Si molar ratio is 1.0 in all SAS, sodalite and cancrinite structures, it is 3.08 in katoite. Clearly, alumina losses should be considered in calculating caustic savings, and be optimized for the best economic result.

It was observed that calcite formation removed carbonate from liquor. Calcium titanate minimizes the negative effect of sodium titanate formation and assists the conversion of goethite to hematite. Katoite is the most abundant calcium compound formed at all lime feeding points, but the highest resulting contents were seen with bauxite and digestion lime feed points. Calcite formation increased with increasing lime at all feed points except digestion. The highest calcite content was observed when lime was fed to bauxite. Portlandite [$Ca(OH)_2$] is an indicator of whether lime utilization is efficient. Its formation remained stable with lime fed to digestion and desilication, but slightly increased with lime fed to the mill and bauxite.

2.2.2. Clarification results

Higher underflow solids (UF) were achieved both in the settler and washers during the lime trial. Overflow (OF) solids of the settler were slightly higher during all lime feed trials. Caustic in last washer was higher when lime was fed to bauxite. Although digestion molar ratios were similar, higher auto-precipitation was observed during lime feed except to digestion (Table 8).

Table 8. Lime effect on clarification.

Process Parameter	Unit	Analysis Factor	Period Without Lime	Period With Lime			
				Lime Feed To Digestion	Lime Feed To Dessilication Tank	Lime Feed To Mill	Lime Feed To Bauxite
Settler Mud H/G Ratio	-	Average	23.3	28.9	14.3	23.5	44.8
		Standart Deviation	5.9	13.0	3.7	10.3	21.9
Settler Amperage	amp	Average	8.09	8.06	7.99	8.05	8.16
		Standart Deviation	0.18	0.16	0.12	0.11	0.12
Settler UF Solids	g/L	Average	383.6	399.3	391.8	423.5	426.1
		Standart Deviation	31.2	25.4	45.5	41.3	77.5
Settler OF Solids	mg/L	Average	61.9	74.0	65.0	72.2	76.8
		Standart Deviation	43.1	42.4	35.8	31.4	66.3
Last Washer Na_2O in Liquid	g/L	Average	2.55	2.64	2.65	2.58	3.33
		Standart Deviation	0.58	0.17	0.15	0.49	0.58
Last Washer UF Solids	g/L	Average	399.4	411.5	413.4	416.2	452.4
		Standart Deviation	20.4	28.4	11.1	23.2	49.1
Digestion Caustic Module	-	Average	1.34	1.36	1.35	1.36	1.35
		Standart Deviation	0.02	0.02	0.03	0.02	0.04
Alumina Losses Through Clarification	%	Average	1.83	1.24	2.37	2.0	2.66
		Standart Deviation	0.48	0.67	0.65	1.01	1.07

2.2.3. Alumina product quality

Significant improvements were obtained in alumina product iron and titanium contents. Calcium remained stable. The changes in other impurities are within the normal range for product. Table 8 shows the chemical analysis of alumina produced during lime feed.

Table 9. Impurity level of alumina

Alumina Impurities	Unit	Analysis Factor	Period Without Lime	Period With Lime			
				Lime Feed To Digestion	Lime Feed To Dessilication Tank	Lime Feed To Mill	Lime Feed To Bauxite
Na_2O	%	Average	0.114	0.099	0.112	0.124	0.138
		Standart Deviation	0.017	0.010	0.006	0.008	0.020
Fe_2O_3	%	Average	0.0112	0.0088	0.0081	0.0081	0.0098
		Standart Deviation	0.0012	0.010	0.0007	0.0005	0.0007
SiO_2	%	Average	0.0092	0.0099	0.009	0.0095	0.0099
		Standart Deviation	0.0014	0.0019	0.0012	0.0008	0.0007
CaO	%	Average	0.0052	0.0035	0.0046	0.0047	0.0064
		Standart Deviation	0.0048	0.0017	0.0012	0.0011	0.0009
TiO_2	%	Average	0.0039	0.0032	0.0028	0.0028	0.0034
		Standart Deviation	0.0004	0.0003	0.0002	0.0004	0.0003
ZnO	%	Average	0.0024	0.0024	0.0025	0.0029	0.0025
		Standart Deviation	0.0002	0.0001	0.0002	0.0002	0.0001
Ga_2O_3	%	Average	0.0091	0.0093	0.0089	0.0091	0.0091
		Standart Deviation	0.0008	0.0006	0.0005	0.0005	0.0003
V_2O_5	%	Average	0.00049	0.00054	0.00053	0.00061	0.00061
		Standart Deviation	0.00014	0.00014	0.00009	0.00014	0.00012
Total Impurity	%	Average	0.156	0.137	0.148	0.162	0.179
		Standart Deviation	0.019	0.011	0.007	0.009	0.021

2.2.4. Economic analysis

Considerable caustic savings can be achieved in all lime feed cases, however the amount of lime used and bauxite losses should be considered. Figure 10 shows how efficiently lime saved 1 ton of caustic. Increasing lime charge achieves higher caustic savings at all lime feeding points.

Assuming the unit prices of lime, caustic and bauxite as 55, 400, 15 US dollars respectively, lime feed to bauxite looks more economic than the other feed points. While 6 % lime charge is sufficient to move into profit with lime feed to bauxite, 10 % and 14 % is necessary for mill and digestion feed respectively. Lime feed to desilication tank has the poorest economics.

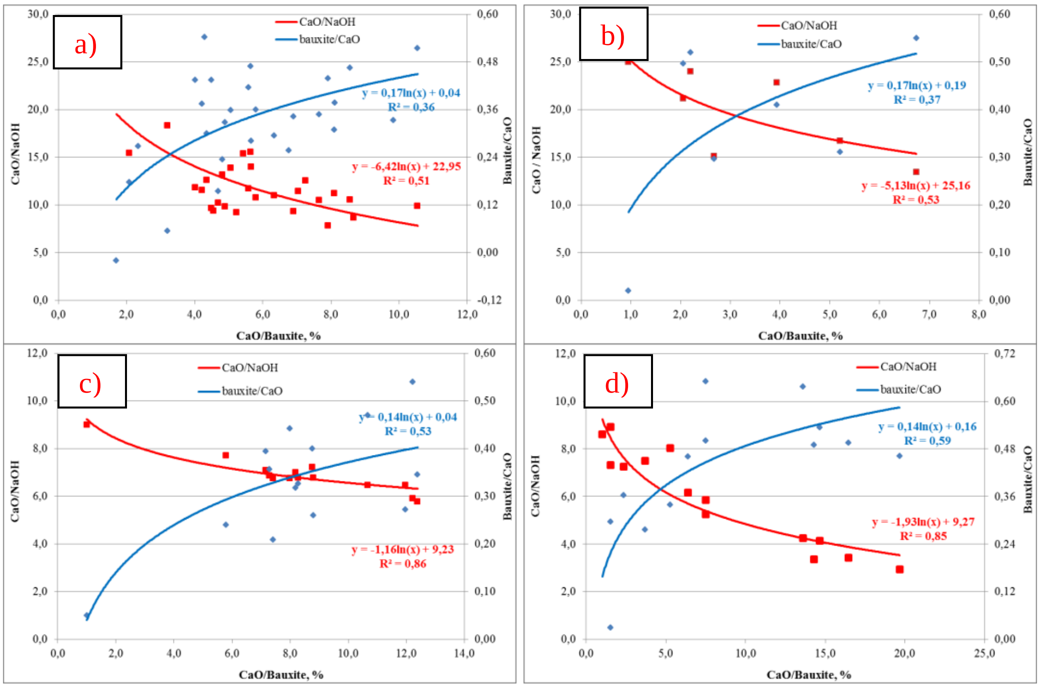


Figure 10. Lime efficiency when feeding to, a) Digestion, b) Dessilication tank, c) Mill, d) Bauxite

3. Conclusion

Lime is much more efficient when fed to boehmitic bauxite as burnt lime in terms of caustic savings. Due to high silica in bauxite, higher lime doses are needed. Diaspore dissolution during both plant trials and laboratory studies is enhanced, especially above 5 % lime charges. Katoite and SAS compounds were the main DSP products that increased substantially with lime feed. Tridymite and anatase contents of red mud were little changed in the presence of lime, while they interestingly decreased when lime was fed to the desilication tank. An explanation may be that lime fed to desilication promotes their dissolution and results in extra caustic losses. Lime has a big impact on goethite to hematite conversion. The lowest goethite content and highest H/G ratio were obtained with digestion lime feed. The lowest sodium titanate and the highest calcium titanate formation were achieved when lime was fed to digestion.

Lime feed to digestion looks the most efficient point according to clarification parameters. A significant decrease in both iron and titanium in alumina product was obtained wherever lime was dosed.

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