An Introduction to Bel Air Bauxite

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Abstract

Bel Air Mining is a new bauxite mine in the Boffa region of Guinea, West Africa, exploiting a new gibbsitic bauxite resource. The Bel Air mine was developed by Alufer Mining Limited for the seaborne bauxite market and shipped its first bauxite in September 2018. Alufer has constructed its own logistics chain including haul roads, stockpile and material handling infrastructure and port facility, through which it can transport and load (via its deep-water trans-shipment capability) up to Capesize vessels. Bel Air is in many ways a typical Guinea bauxite, being gibbsitic, low in reactive silica, but differs from most Guinea bauxites in having little or no boehmite, and containing andalusite. The Chalco Zhengzhou Light Metals Research Institute has performed characterization and processability studies which indicate product quality and suggest optimum low temperature Bel Air processing conditions for desilication, digestion and settling.

Keywords: Bel Air, Guinea, bauxite, mine, gibbsite

Definitions of terms:

Common Chinese alumina refinery terms were used and reported in the Chalco study. Some translations have been made in this paper to more common North American or European terms.

"A/S": the concentration ratio of Al_2O_3 to SiO_2 in liquor.
"N/S": the mass ratio of Na_2O to SiO_2 in the residue, and indicates both the quantity and soda to silica ratio of the desilication product solid.
"α_k": molar ratio of caustic soda (expressed as Na_2O) to Al_2O_3 in liquor.
"Burden α_k": the digestion charge molar ratio (α_k) used to calculate bauxite charge.
"N_k": liquor caustic concentration (as Na_2O).
"N_T": total liquor soda concentration (as Na_2O).
"η_A": Digestion Efficiency (or alumina extraction efficiency), usually presented as % of total alumina extracted in digestion, but presented here as % of available alumina.
"η_{SiO2}": or "Predesilication Efficiency" is the Mass % of bauxite total silica converted into desilication product.
"A/F": is the weight ratio of Al_2O_3 to Fe_2O_3 in solids (e.g. bauxite, digestion slurry, residue), and utilizes iron as a tie element to indicate alumina extraction.

1. Introduction

Bel Air Mining is a new bauxite mine in the Boffa region of Guinea, West Africa, exploiting a new gibbsitic bauxite resource [1]. Figure 1 shows the project is located in Western Guinea, approximately 225 km by road, northwest of the capital Conakry. The closest major towns to the Project are Boffa to the southeast and Kamsar 80 km to the northwest.

Bel Air Mining was developed by Alufer Mining Limited (Alufer) for the seaborne bauxite market and shipped its first bauxite in September 2018. The Joint Ore Reserves Committee

(JORC) resource of 146 million tonnes (mt) presently supports a mine life of more than 15 years at an initial production target of 5.5 million tonnes per annum (mtpa), with a well-developed mine plan to produce consistent product volume and grade for the life of mine.

Alufer has constructed its own logistics chain including roads, stockpile, port and deep-water trans-shipment facilities, through which it can load up to Capesize vessels. The 18 km average distance between mining activities and port is managed by trucking on dedicated haul roads built by Alufer.

Through its community engagement and cooperation programs, Alufer has developed a good relationship with local communities and will bring significant employment and economic activity into a region that presently lacks substantial economic activity.

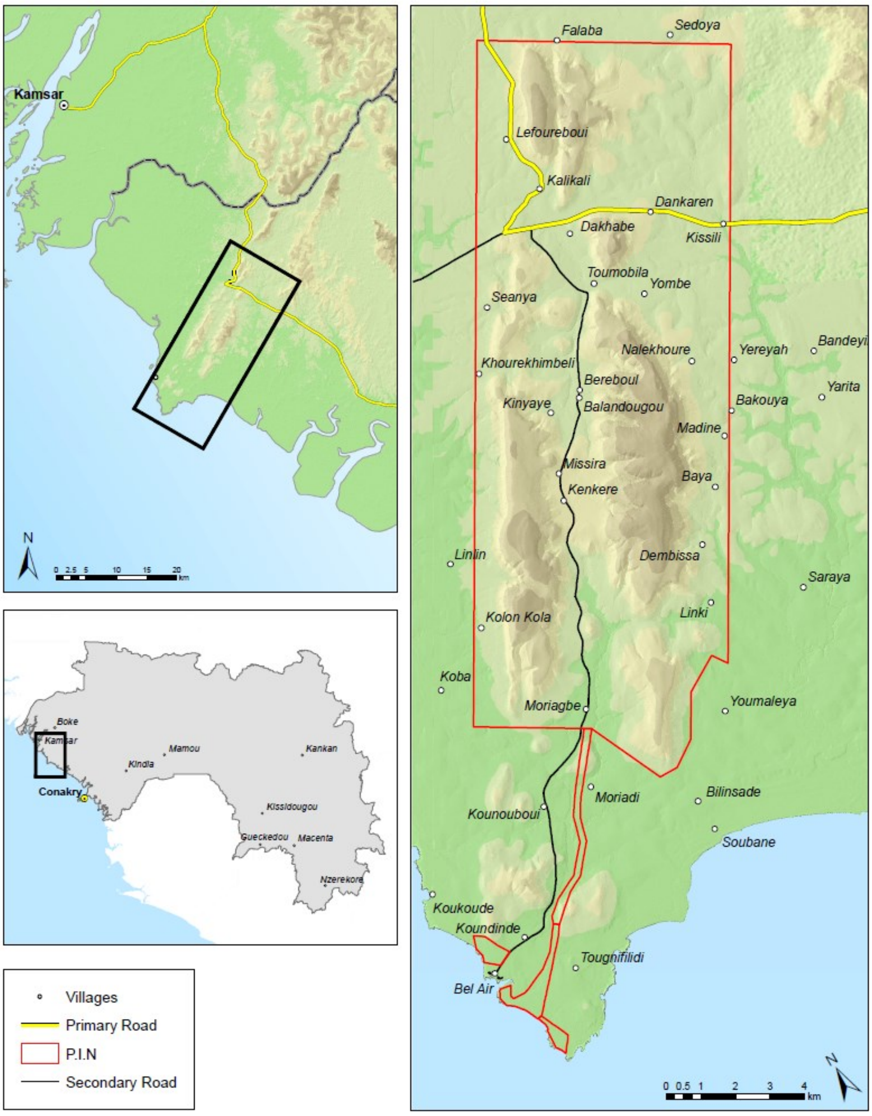

Figure 1. Location map for Bel Air bauxite mine in Guinea.

2. Project History

An exploration permit was granted in 2010. Alufer immediately launched exploration, engineering, social and environment studies and delivered the maiden JORC resource, feasibility study and environmental certification in 2013. These enabled Alufer to convert the exploration permit to an exploitation permit and established the “Bel Air Mining” company. During 2015 and 2016, Bel Air Mining produced and optimized the mining and engineering solution and produced the Definitive Feasibility Study in 2016, a requirement for financial close. In February 2016, Bel Air Mining finalized a Mining Convention with the Government of Guinea, ratified by parliament in June and presidential decree in July.

The project was officially launched by the President of Guinea, Alpha Conde in February 2017, setting in motion an 18-month construction phase. Concurrent to the construction of the project, intensive infill and grade control drilling programs were undertaken to further increase the confidence of the reserve. Detailed mine designs, schedules and blending programs were developed based on the 12.5 m spaced grade control drilling data to ensure consistent product. Figures 2, 3 and 4 show mining, stockpile and barge loading in operation in August 2018 [1].

Figure 2. Surface mining.

Figure 3. Stockpile and causeway facilities.

Figure 4. Barge loading.

3. Geological Setting and Deposit

3.1. Regional Geology

Bauxite has developed on a sequence of flat-lying Palaeozoic sedimentary strata and dolerite sills that have been subjected to tropical weathering subsequent to deposition and emplacement, possibly for millions of years. The bauxite occurs as flat layers capping the plateaus. The combined effects of tropical weathering, good drainage provided by the topography, favorable source rocks and structure have led to a concentration of alumina and iron oxides within the upper few meters of the sub-surface by leaching of most other oxides. Doleritic sills are frequent, in particular within the central part of the region, with thickness averaging between 40 m and 60 m and ranging to between 100 m to 150 m. These intrusives utilized fracture systems developed during the Mesozoic.

During the Cenozoic, prolonged crustal stability punctuated by tectonic activities and dip-slip movement along these faults resulted in the erosion of extensive surfaces creating large plateaus bound by scarps and arranged in a step-like fashion upwards towards the axis of the Fouta Djalon Uplift 100 km to the west. The present drainage system has developed along fault and fracture systems. The favorable geomorphologic conditions, combined with favorable climatic conditions, have resulted in lateritization of rocks of varying ages and compositions, producing widespread lateritic bauxite deposits.

3.2. Local Geology

The Bel Air Project is underlain by sandstones, shales and dolerite sills. The shales and dolerites contain elevated Al_2O_3 (up to 15 % in the shale), and are the source for development of the bauxitic laterites. The structure and drainage patterns in the area are dominated by the north-north-east trending lineament, which essentially splits the project in half. The terrane to the east of the NNE lineament is dipping WNW at approximately 25 degrees. The terrane to the west of the lineament is dipping SW at between 20 and 30 degrees. The exploitation permit therefore resides in a syncline structure with the best bauxite preserved on the eastern limb of the syncline. It is proposed that the western flank of the syncline has been uplifted more than the western flank and been subjected to more erosion. This explains the poorer, ferruginous bauxite occurrence on those western plateaus.

The residual plateaus are generally elongated and sinuous in form, generally trending in a northeast-southwest direction. Moderate to steep slopes define the plateau margins. Plateau tops are typically very gently rolling. The plateaus typically rise 150 m to 200 m above the surrounding valleys. Plateau margins contain thicker and higher-grade bauxite deposits, interpreted to be detrital deposits from erosion of the surrounding plateaus.

The bauxite profile can be separated into distinct zones by grade ranges. The transition between these zones is relatively sharp, however not all zones are consistently developed within the profile. In addition to the zones identified, an upper lateritic zone is occasionally developed and has been modelled as a separate zone for the resource estimation. The broad lateritic sequence rests on clay, which is considered to be the remnant of the weathered footwall lithology.

Table 1. Bel Air bauxite deposit zones.

Zone	Al_2O_3 (%)	SiO_2 (%)
Bauxite	>37.5	<10
Ferruginous bauxite	30 – 37.5	<10
Lateritic bauxite	>30	>10
Laterite	<30	N/ A

The Bel Air bauxites are largely gibbsitic in nature but are unusual in containing andalusite, which is found in higher concentrations in ferruginous and lateritic bauxites. Spatial analysis indicates that andalusite is found in distinct zones, which are prominent on the edges of the bauxite zones and coincide with steeper slopes, and is concentrated in the hanging and footwall of the bauxite lithology. Andalusite is a low temperature metamorphic mineral and typically forms in contact zones between igneous intrusions and aluminous host rocks. In the Bel Air setting, dolerite sills intruded aluminous shales containing up to 15 % Al_2O_3, and andalusite formed along these contact zones. Andalusite is resistant to chemical weathering in tropical supergene zones, and has been concentrated in the lateritic profile over time.

4. Bauxite Characterization

Bel Air is in many ways a typical Guinea bauxite, being gibbsitic and low in reactive silica [2]. It does however differ from most Guinea bauxites in having very little or no boehmite, and in its andalusite content. Andalusite is an alumino-silicate mineral [3][4] which is largely undissolved under typical low temperature digestion conditions (~145 °C, 1 hour), but like quartz, is substantially dissolved under high temperature conditions [5]. Its chemical composition (Al_2SiO_5) suggests that when dissolved, andalusite is a net contributor to available alumina in Bayer digestion. This is because only half of the contained alumina would be consumed in a typical DSP Al_2O_3:SiO_2 stoichiometry. Because Bel Air is considered a low temperature bauxite, limited high temperature work or andalusite studies have been completed to date.

In addition to the extensive studies of the deposit to produce JORC compliant resource and reserve estimates, the character and processability of the projected mine product was studied to provide predictions for its behavior under typical alumina refinery conditions.

The Chalco Zhengzhou Light Metals Research Institute (ZRI) and Aditya Birla's Belgaum R&D Centre in India were requested to deliver studies with similar scopes. Both are well respected institutions with long experience in bauxite characterization and processability laboratory work. The work focused on low temperature digestion, due to Bel Air's gibbsitic nature and low boehmite content. The program of work delivered and key findings from ZRI are summarized here. The work at Belgaum generally agreed with the ZRI results, subject to lab to lab variability and scope differences.

Included in the scope were the following six aspects of bauxite characterization and processability:

1. Chemical and mineralogical composition;
2. The determination of low temperature Total Available Alumina (TAA) and reactive SiO_2;
3. Predesilication behavior;
4. Digestion behavior;
5. Dilution and desilication behavior of the digestion slurry;
6. Settling behavior of its residue (red mud).

The study suggested processing condition optima, although since individual refinery technology and operating practices can affect these, these are meant as general indicators based on the bauxite test work alone. Not all elements or findings of the work are detailed here, and only key aspects have been presented. Lab characterization and simulation methods used are those widely practiced in the Chinese industry [6] and give comparable results to equivalent methods utilized outside of China.

5. Experimental Materials and Methods

5.1. Experimental Materials

5.1.1. Bauxite and Lime

The bauxite sample used in the test work, representative of the first 12 years of Bel Air mine production, was provided by Alufer. The bauxite was homogenized, representatively divided and ground to target particle size for the test work.

The sample's elemental composition is listed in Table 2, and the results of mineralogical analysis are listed in Table 3. Elemental results were produced by XRF, LOI was determined thermogravimetrically, and carbon values by redox titration. Mineralogical values were determined by various methods, including quantitative XRD, bomb digestion and calculation.

Table 2. Bauxite chemical composition (weight %).

Al_2O_3	SiO_2	Fe_2O_3	TiO_2	K_2O	Na_2O	CaO	MgO	P_2O_5
46.5	4.37	21.6	2.63	0.0022	0.033	0.056	0.06	0.11
ZnO	**Ga_2O_3**	**V_2O_5**	**Cr**	**C Tot.**	**C Org.**	**S**	**LOI**	**-**
0.004	0.008	0.068	0.046	0.19	0.14	0.02	24.5	-

Table 3. Bauxite mineralogical composition (weight %).

gibbsite	hematite	goethite	andalusite	kaolinite	quartz	anatase	rutile
62	10	15	5.5	3	1	1	1.7

Low Temperature TAA and reactive SiO_2 were determined by typical bomb digest methods with suitable analytical finishes. TAA was measured as 39.7 % and Reactive SiO_2 was 1.47 %.

The lime used in testing was sourced from a local alumina refinery, roasted for 30 minutes at 1050 °C. After slaking, it was sieved (100 mesh) to remove coarse particles. The total CaO measured was 95.4 %, and reactive CaO was 94.2 %.

5.1.2. Liquor

Test liquor composition (see Table 5) simulated typical soda and alumina concentrations in Chinese low temperature refineries. Spent liquor was prepared with analytical grade sodium hydroxide, sodium carbonate, industrial aluminium hydroxide and deionized water.

Table 5. Spent liquor composition.

No.	Na_2O_T (g/L)	Al_2O_3 (g/L)	Na_2O_k (g/L)	α_k
1	177.53	95.0	160	2.79
2	198..49	106.4	180	2.78
3	217.44	118.0	200	2.79

6. Process Simulations

6.1. Predesilication

Key industrial desilication variables (time, temperature, solids concentration and lime) were examined and optimum conditions evaluated. The influence of residence time, solids and lime addition on predesilication efficiency were tested at 95 °C, solids content of 800 g/L and 250 g/L and lime addition cases of 0 % and 1 %. Spent liquor N_k was 180 g/L. Although not presented here, a few predesilication cases were tested at 105 °C resulting in a roughly 10 % higher predesilication efficiency compared to equivalent 95 °C cases.

Figure 4 presents key results as percent of reactive silica. As expected, predesilication efficiency rises with residence time and is much improved at 800 g/L solids compared to 250 g/L. The tests do not indicate that 1 % lime addition has a positive effect on predesilication efficiency. Figure 5 shows lower liquor silica at the end of digestion and dilution with 800 g/L solids compared to that at 250 g/L under the same conditions of time and temperature.

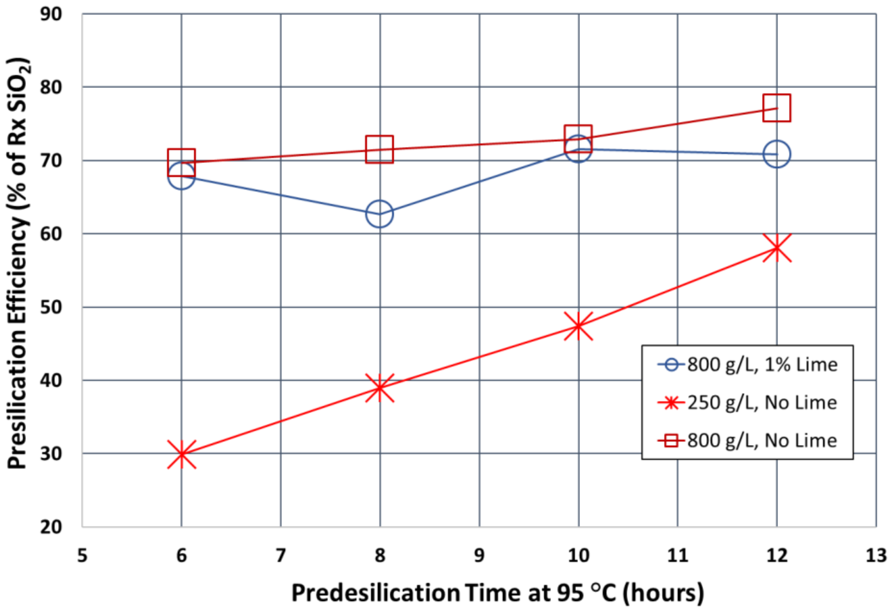

Figure 4. Predesilication efficiency vs. time.

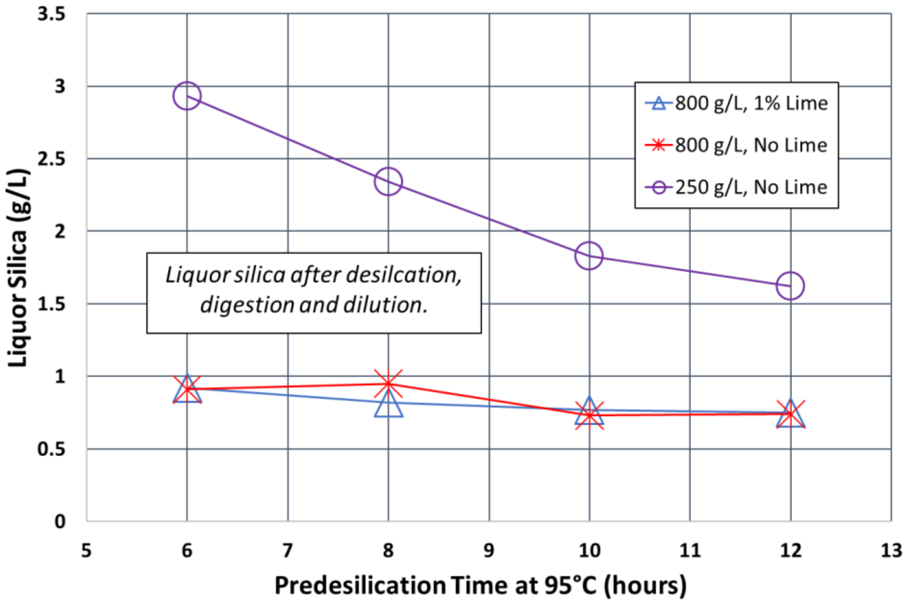

Figure 5. Digestion liquor SiO_2 vs. predesilication time.

The predesilication study highlights that, as is the case with some other low reactive silica bauxites, Bel Air bauxite is more difficult to desilicate compared to (for example) higher reactive silica bauxites [7]. This effect is generally attributed to the small amounts of DSP seed generated and this low seed surface area limiting the desilication rate. In view of this, pre-desilication temperature, residence time in digestion and post-digestion conditions are important considerations to achieve ideal pregnant liquor silica supersaturations. Blending Bel Air bauxite with higher reactive silica bauxites is another possible approach.

6.2. Digestion

6.2.1. Influence of Time, Temperature and Molar Ratio on Digestion

Digestion tests were carried out in steel digestion bombs (approximately 200 mL) heated in a temperature-controlled oil bath. Digestion efficiency (η_A, sometimes referred to as 'extraction efficiency') is calculated here (as is common practice in the Chinese industry) by the change in A/F (weight ratio: Al_2O_3 / Fe_2O_3) between bauxite and residue.

Digestion tests were conducted with a spent liquor N_k of 180 g/L, at 145 °C for 60 minutes. The target molar ratio (α_k) of digested liquor was ~ 1.35. Lime addition rates were 0, 1, 2 and 3 % on a dry bauxite basis. For the preliminary digestion tests, bombs digests were not predesilicated, so liquor silicas were higher at the end of digestion than if had they been predesilicated.

Tests examining the effect of Digestion Time and Temperature on Digestion Efficiency and Liquor Desilication were run at 140, 145, 160 and 180 °C, with a spent liquor N_k of 180 g/L, lime addition of 1 %, digestion α_K of ~1.33, and holding time of 30, 60, 90 and 120 minutes. Test results are presented in Figures 6 and 7. Figure 6 shows that digestion efficiency changes very little with time at 180 °C, but at other temperatures, digestion efficiency decreases as a whole with the extension of holding time. After Digestion Efficiency rises sharply in the first minutes, as gibbsite is largely dissolved, it drops a percent or two with time as desilication proceeds, removing alumina from liquor with the precipitation of DSP. With some bauxites and conditions, significant boehmite reversion might be expected, but under these conditions, analysis suggests little or none with Bel Air bauxite, which is consistent with the very low/no boehmite measured.

Figure 7 shows the progress of liquor desilication with time at 140, 145, 160 and 180 °C with lime addition of 1 %. The results look typical for low temperature processing of gibbsitic bauxite.

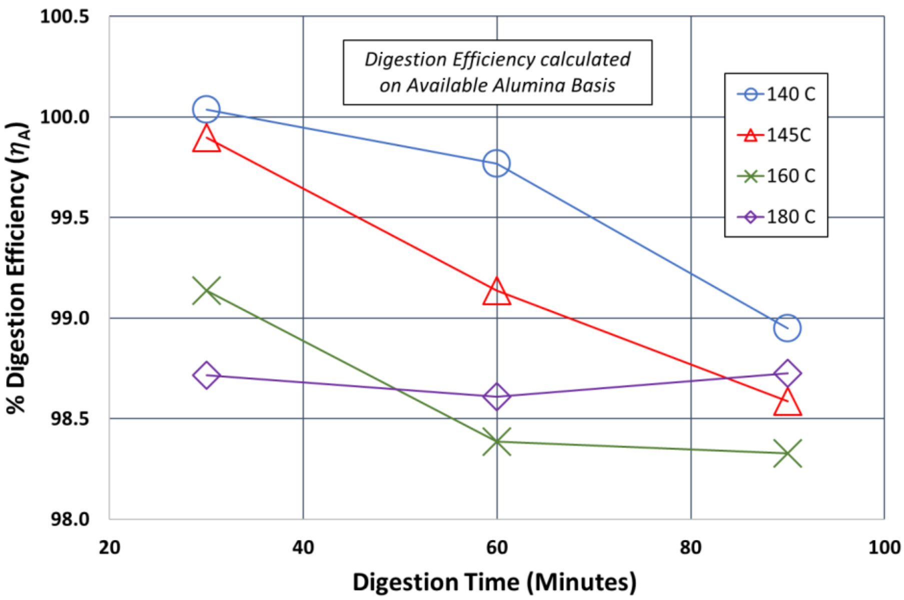

Figure 6. Time and temperature vs. digestion efficiency.

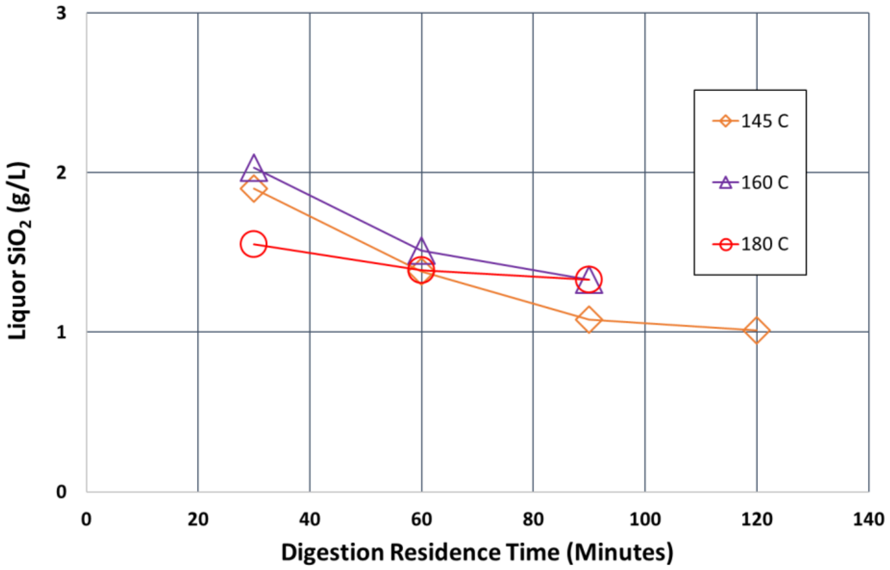

Figure 7. Time and temperature vs. digestion silica in liquor.

To determine the best compromise between maximum digestion efficiency (for most efficient bauxite utilization), and lowest liquor molar ratio (for highest liquor productivity), the optimum digestion molar ratio target was studied. The test was conducted using spent liquor with an N_k of 180 g/L, at 145 °C for 60 minutes, and with lime addition of 1 %.

Digestion efficiency versus "Burden α_k" (Target Molar Ratio) is plotted in Figure 8. The curve indicates a "Break Point" around an α_k of 1.20, while an optimum target α_k for digestion efficiency is more like 1.30 – 1.36. This result is also typical for a low/no boehmite gibbsitic bauxite, indicating relatively high liquor productivities are possible with relatively low alumina losses.

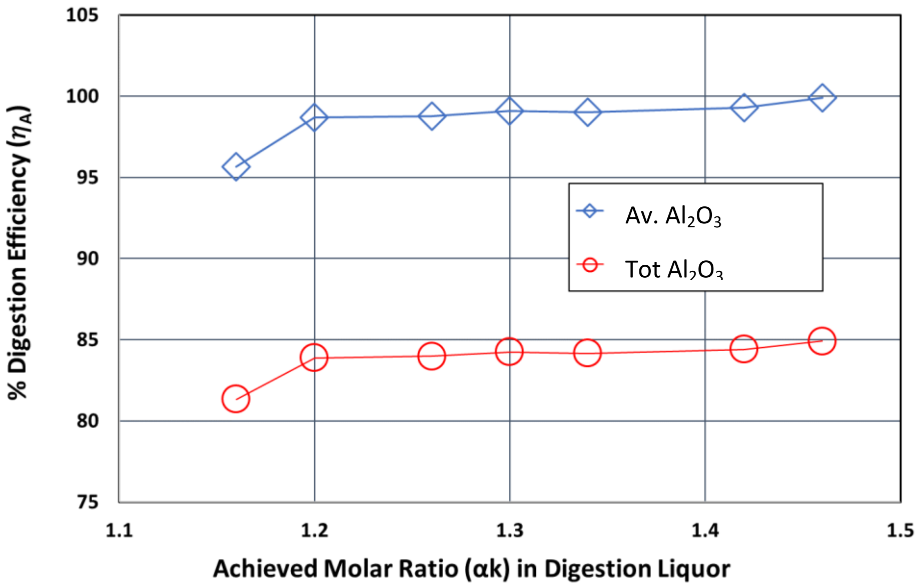

Figure 8. Digestion efficiency (η_A) vs. molar ratio (α_k) of digestion liquor at 145 °C on available and total alumina bases.

These results indicate typical low temperature conditions (~145°C, 60 minutes) are suitable for cost efficient processing of Bel Air bauxite and that digestion molar ratio targets (α_k) can be reasonably aggressive while maintaining high extraction efficiency.

6.2.2. Influence of Lime on Digestion

The effect of lime addition at rates up to 3 % (dry bauxite basis) was studied to determine the effect on digestion efficiency, desilication, and in subsequent tests, settling behavior. The test results (Figure 9) show that under these conditions and in the range 0 – 3 %, digestion efficiency decreases with increasing lime addition. Some alumina is consumed in the formation of calcium aluminates under usual digestion conditions, in addition to lime not generally providing significant digestion efficiency benefits under low temperature conditions. The residue soda to silica ratio (N/S) does not appear to be much reduced (also Figure 9) by lime addition, and this is consistent with the general observation that lime addition has a lower impact on soda to silica ratios in low temperature digestion, compared to its effect in high temperature [7], [8].

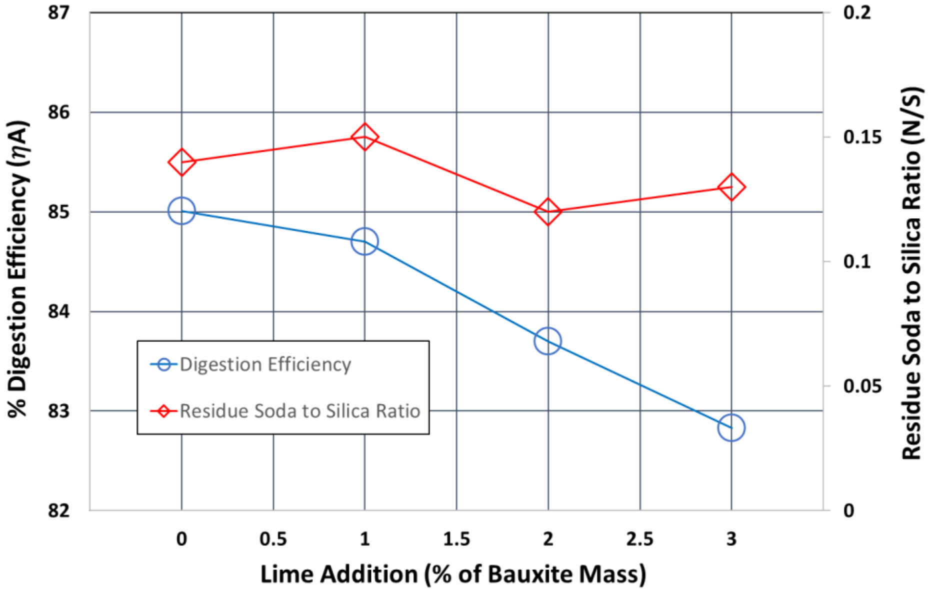

Figure 9. Lime vs. digestion efficiency and residue soda to silica ratio (N/S).

The effect of lime addition during digestion was also examined and results are presented in Figure 10. Lime addition lowered the liquor silica concentration progressively by about 0.3 g/L at a 3 % addition rate. This effect can be discounted a little by the lower alumina (3 g/L) resulting from the 3 % lime addition, but the effect is still significant. Whether the cost of lime addition in terms of lime, dilution and alumina loss at this addition rate is worth the desilication benefit, would need to be evaluated by individual refineries. It should be remembered that these digestion tests were not predesilicated, and that tests that were, achieved liquor silica values of around 1.0 g/L.

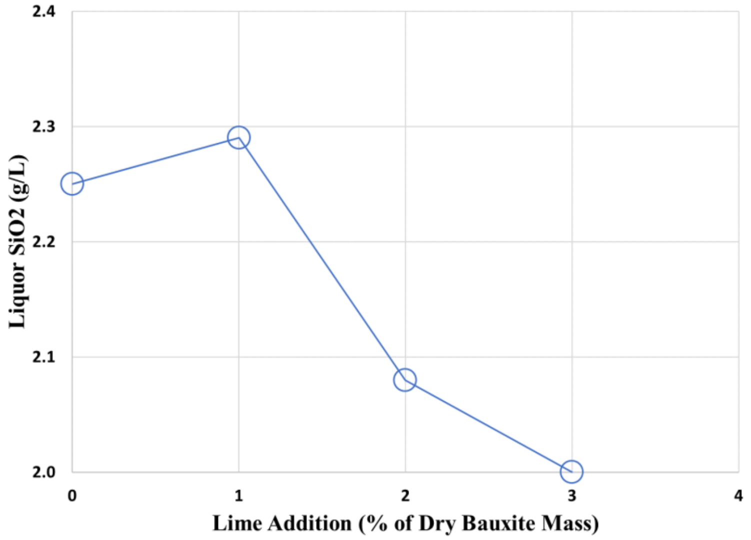

Figure 10. Lime vs. Digestion Liquor Silica.

6.2.3. Influence of Bauxite Grind Size on Digestion

To investigate the influence of bauxite grind size on key digestion parameters, three different particle sizes distributions (-20 mesh, -30 mesh and -50 mesh) were digested at 145 °C for 60 minutes. The spent liquor N_k was 180 g/L, lime addition was 1 % and α_k was ~1.33. Sample particle size distributions and digestion efficiencies achieved are shown in Table 6, where: 1#: -20 mesh, 2#: - 30 mesh, 3#: - 50 mesh. As with the previous digestion tests, these simulations were not predesilicated, and higher liquor silica values are a consequence. Key digestion test results are shown in Table 7.

Table 7 shows a deterioration in digestion efficiency and improved desilication with the finest grind. The better desilication may be explained by faster reactive silica dissolution and the lower digestion efficiency to the more advanced desilication (and therefore alumina precipitation with DSP). Considering the capital and operating/operating cost implications of a finer bauxite grind, the value of a finer grind than -20 mesh would need to be evaluated.

Table 6. Particle size distribution of bauxite for testing.

Mesh No.	**+30**	**-30 +50**	**-50 +100**	**-100 +200**	**-200+325**	**-325**
	>600μm	<600 – >300μm	<300 – >150μm	<150 – >75μm	<75 – >45μm	<45μm
1#	15.49	19.53	14.31	9.54	6.82	34.32
2#	0.00	24.49	17.68	11.19	8.34	38.30
3#	0.00	0.00	23.82	16.66	8.90	50.61

Table 7. Effect of grind on digestion efficiency.

Sample	**Digestion Efficiency (% of AvailableAl_2O_3)**	**Liquor SiO_2 (g/L)**
1#	99.0	2.29
2#	99.1	2.02
3#	97.8	1.94

6.2.4. Recommended digestion conditions

For Bel Air bauxite, test results indicate that typical low temperature digestion conditions (140 – 145 °C, 60 minutes, spent liquor N_k of 160~200 g/L, Lime addition of 0 – 1.0 % and a digestion molar ratio (α_k) of 1.30 –1.36 are appropriate. A bauxite grind size of - 20 mesh appears to give good results with sufficient predesilication. Under the above conditions, digestion efficiency of alumina is ~85 % on a total Al_2O_3 basis, or ~99 % on an available alumina basis and produces a residue with soda to silica ratio (N/S) of ~0.13.

6.3. Settling Behavior of Digested Bel Air Bauxite

The settling of digestion slurry is an important aspect of a bauxite's processing behavior. The influence of lime addition, types and doses of flocculants, solid content on the settled solids and clarity of the settler overflow were all examined in the ZRI test work.

6.3.1. Influence of Flocculant and Solids on the Settling of Digestion Slurry

Digestion slurry was prepared by first predesilicating bauxite at 100 °C for 10 hours, with a spent liquor N_k of 180 g/L and lime addition of 1%. The settling test conditions utilized were 98 °C, N_k of diluted slurry was ~165 g/L, and solid contents of ~85 g/L, 90 g/L and 100 g/L. Flocculants used were SNF258, with NALCO 9779 and DX-77 co-dosed. The test results were similar, so only the 85 g/L set is shown in Table 8.

Table 8. Various flocculants and settling results for Bel Air digestion slurry (85 g/L solids).

Flocculant(s)	Flocculant dose (g/t dry solids)	N_k (g/L)	Slurry solids (g/L)	Settling velocity (m/hr)	Supernatant solids (g/L)	U/F L/S (w/w) after 30 mins.
SNF258	280	165	86	8.06	0.14	3.42
SNF258	339	165	85	10.3	0.18	3.39
SNF258	377	165	85	11.0	0.18	3.86
SNF258	429	165	86	12.1	0.18	3.66
9779+DX-77	97	168	83	8.9	0.39	3.26
9779+DX-77	111	168	86	11.5	0.39	3.15
9779+DX-77	130	168	86	12.7	0.25	3.00
9779+DX-77	149	168	86	17.6	0.36	3.13

As shown in Table 8, under the test conditions, doses of SNF 258 between 280 – 377 g/t dry solids were required to achieve settling velocities of 8 – 11 m/hr. L/S in the settled solids after 30 minutes achieved was 3.42 – 3.86, and measured solids in the supernatant were 0.14 – 0.18 g/L.

When flocculants NALCO 9779 and DX-77 were co-dosed (97 – 130 g/t), settling velocities of 8.9 – 17.6 m/hr were measured. L/S in the settled solids after 30 minutes were 3.00 – 3.26, and supernatant solids were 0.25 – 0.39 g/L.

On the basis of this test work, Bel Air bauxite requires higher flocculant doses if only polyacrylate flocculants are used. Co-dosing achieved acceptable settling rates, underflow solids density and supernatant clarity. Although its relatively high goethite content suggests Bel Air will be a more difficult bauxite to settle [9,10], the study indicates that acceptable results can be achieved.

During the test work, it was observed that the filtration of digestion slurry improved with the addition of 1 % lime, and it is suggested that lime added to digestion or to the settler may improve settling and liquor filtration in operations.

7. Conclusions

Bel Air is a new bauxite mine in the coastal Boffa region of Guinea, commencing bauxite exports through its wholly owned and/or controlled mining, transport and ship-loading infrastructure in the second half of 2018. After ramp-up, the Bel Air mine and infrastructure is designed to produce and export bauxite at 5.5 million tonnes/year.

Bel Air is a gibbsitic bauxite with low reactive silica and low or no measurable boehmite. A bauxite sample representative of the first 12 years of mine plan was measured to have a Total Alumina content of ~ 46.5 %, Total Fe_2O_3 content of 21.6 %, Total SiO_2 of 4.37 % and TiO_2 content of 2.63 %.

The main aluminium mineral is gibbsite (~62 %); the main iron minerals are alumino-goethite (~15 %) and hematite (~10 %); the main silicon minerals are andalusite (~ 5.5 %), kaolinite (~3 %) and quartz (~1 %), the main titanium minerals are anatase (~1 %) and rutile (~1.7 %). Total Available Alumina of the Bel Air bauxite sample was determined as 39.74 %, reactive SiO_2 was 1.47 %, using a typical bomb digestion method.

Although Bel Air is in many ways a typical Guinea bauxite, it is unusual in containing andalusite, an alumino-silicate mineral (Al_2SiO_5), which makes a small contribution to reactive silica under low-temperature digestion conditions, but like quartz, is substantially dissolved under high temperature conditions. Bel Air's mineralogy means optimum processing is achieved under typical low temperature conditions (145 °C, 1 hour). Desilication generally requires more attention than higher silica bauxites, as does attention to flocculant selection and dosing regimen for good settling. With attention to its processing specifics (as with many bauxites), Bel Air is an important addition to the alumina industry's low temperature bauxite supply.

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