

**High Silica Bauxites
APP project (ATF-06-4)**

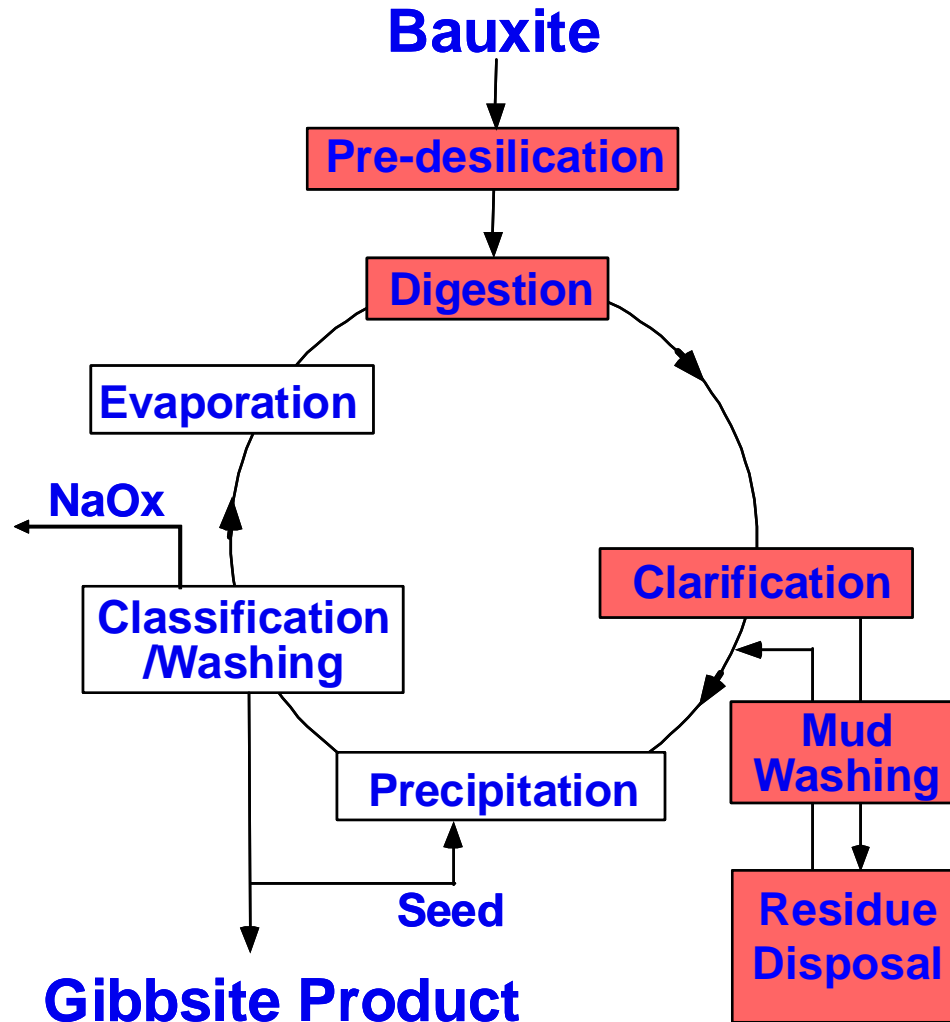
**Economic Processing of
High Silica Bauxites
Existing and Potential Processes**



**Aluminium Task Force - Meeting 5
Sanya, Hainan Province, China
Thursday 4th December 2008**



The Bayer process



Redside

Deals with all aspects of bauxite and residue.
Expect developments in high silica bauxites to be in these areas

Whiteside

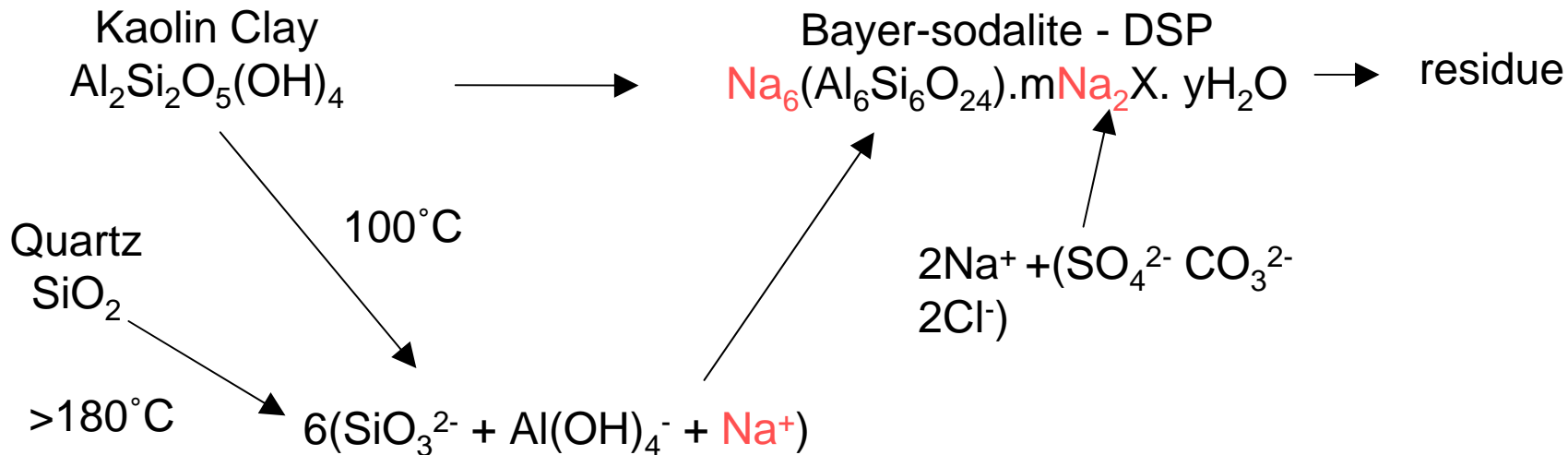
Deals with aspects of gibbsite product and liquor

The problem



- Clays in the bauxite dissolve and the silica re-precipitates as DeSilication Products (DSP). DSP is discarded with residue. The soda in DSP comes from the recirculating Bayer liquor and is therefore lost.
- The loss of caustic soda is directly proportional to the reactive silica (clay) content of the bauxite.
- In a 4Mt refinery that processes bauxite with reactive silica of ~5%, the cost of replacement caustic is ~US\$300M per year.
- At reactive silica contents above ~7%, the ore is not considered economical to process in western refineries.

Desilication – the bad (and the good!!)



The bad

- removes NaOH from liquor (kaolin)
- removes NaOH AND Al_2O_3 (quartz)

The good

- Sequesters inorganic impurities
- Keeps silica in liquor low

Strategies for caustic loss minimisation



Strategy One

Reduce the input of reactive silica to the process.

- Beneficiate (physically remove silica)
- Pre-treat to make silica unreactive

Strategy Two

Modify the process to produce a lower soda residue.

- Reduce the fraction of reactive silica transforming to DSP
- Form alternative DSPs with lower soda content

Strategy Three

Recover soda from DSP.

- Re-process residue or DSP concentrate
- Leach processed solids to return caustic to the liquor

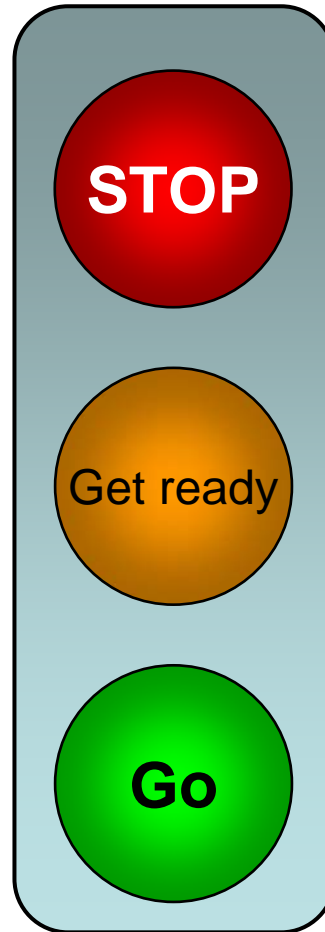
Progress in the Project



- Contract with DRET signed Jun '08 ✓
- Report on progress at this meeting Dec '08 ✓
- Stage I *general review* to be submitted by 30 Dec '08 *on track*
 - A vast amount of literature has been covered and summarised
 - Seeking input from Harato and others
 - Unlike the residue scenario, much of the information is fixed in time
 - Worthwhile including bauxite data into BRaDD for a complete picture
 - Will seek comment and input from all APP participant countries
- Stage I *detailed review* including assessment of economic viability and development of priority list May '09
- Stage II Research phase May '10
- Stage III Identification of partners and pilot trials commences Nov '10

Assessing the potential of new technology -Traffic Lights

This is a process or technology area with some potential. There are technical, economic or ecological hurdles



This is a process or technical area of limited potential. Either technically difficult or economically unfavourable

This is a process or technology area with significant potential. There may be hurdles but the way forward is clear

The following three slides are a summary of some of the possible technologies which are described in the General Literature Review

Potential technologies

Strategy One: Restrict Reactive Silica input

| Technology | Description / Assessment |
|---|--|
| Ultra-fine grinding | Bauxite is ground with lime to very fine size. The energy of grinding collisions produces hydrogarnets (Ca, Al, Si) which reduces soda loss. Unproven technology with some technical questions. |
| Magnetic separation | Can be used if reactive silica disproportionates into magnetic and non-magnetic streams and each stream is processed differently. Very much dependent on individual bauxite. |
| Silica flotation | Successfully used in China to separate kaolin (and other reactive silicates) from alumina values to increase Alumina/Silica ratio. Dependent on bauxite phase liberations. Unlikely to work for lateritic bauxites where silica and alumina are closely mixed. |
| Bio-leaching of silicates | Some claims for separation of silicate minerals on the lab scale, but no commercial application. Hurdles include time for reaction (~5 days) and solid-liquid separation issues. |
| Washing, screening and gravity sep'n | Washing and screening is used where bauxite is pisolitic (eg Weipa) and small pisolites contain higher silica than large ones. Gravity separation of e.g. quartz not feasible due to closeness of densities. |
| Roast-leach (Thermochemical activation) | Roast bauxite to "split" kaolin and pre-treat to leach silica from alumina. Desilicated bauxite sent to Bayer process. Has potential but is energy inefficient and resulting alumina minerals are harder to extract. |

Potential technologies

Strategy Two: Change Digestion

| Technology | Description / Assessment |
|---|--|
| Bauxite sinter | Bauxite calcined to $>1000^{\circ}\text{C}$ with lime or lime/soda. Al values transformed to Ca/Al and Na/Al salts which leach easily. Still used, robust, but despite many advances, energy inefficient. |
| Bayer-sinter (Combination process) | Traditional Bayer process is followed by lime/soda sinter of residue. Robust and still used extensively in China, but energy inefficient – little scope to reduce energy consumption to compete with Bayer. |
| Bauxite activation (and Double Digestion) | Low temp ($\sim 550^{\circ}\text{C}$) roasting of bauxite to amorphitise Al minerals. Reduces boehmite digestion temperature, reducing quartz attack. Double digest uses countercurrent flows to also reduce digest temperature. |
| Low-soda DSPs | Change of process to encourage hydrogarnet or cancrinite production. “Lime Bayer” process already used in China but expensive on lime. Low Na DSP stoichiometries offer good promise, but new technology needed. |
| Hydrothermal lime treatment | After digestion, residue is separated and re-digested in low Al high NaOH caustic + lime at $280^{\circ}\text{C}+$. Calcium silicates produced are very efficient, but needs low Al, high caustic stream. Technical difficulties. |
| Sumitomo process | Rapid ($\sim 130^{\circ}\text{C}$) digestion of bauxite leaches gibbsite but leaves some kaolin un-dissolved. Needs efficient pressure decant technology. Other issues of liquor desilication and washing. Applies to gibbsitic bauxites only. |

Potential technologies

Strategy Three: Recover soda

| Technology | Description / Assessment |
|--|--|
| Ultra-fine grinding | Residue, or a DSP concentrate is milled with/without lime in weak caustic. Milling energy amorphitises DSP structure and breakdown liberates Na and Al. Unproven, with some fundamental questions, but worth further evaluation. |
| Mud causticisation (complex causticisation) | 1970's Hungarian technology. First stage lime addition to DSP forms hydrogarnets and liberates Na. Second stage reacts the hydrogarnets with Na_2CO_3 to liberate Al. Still unproven mechanism, worthy of further evaluation. |
| Ion exchange in DSP | A resin in pulp technology is used to exchange H for Na in DSP in weak acid. The loaded resin is stripped to produce sodium sulphate which is limed to recover NaOH. Known technology but significant problems. |
| Acid leaching of DSP | Weak acids proposed to leach Na from DSP. Sulphurous acid from SO_2 is used to dissolve then precipitate SiO_2 . Lime treatment is used to regenerate NaOH. |
| Lime sinter of DSP concentrate or integrated red mud/coal sinter | A patented RioTinto process to produce a DSP concentrate and thereafter to apply standard red mud sinter. Energy gain from the sintering of a 100% concentrate. Also Russian proposal to use coal to sinter red mud and offset energy costs. RioTinto process may become economic if optimisation of the sinter products can be developed. |

Initial comments on options



- **Strategy one** (restrict input) options are weak and bauxite dependent.
- **Strategy two** (change the process) options are the most likely to yield step changes but may require significant capital outlay.
- **Strategy three** (soda recovery) options are higher risk but potentially more efficient, and are generally bauxite independent.

Next steps in delivery



- The extensive literature review is in an advanced state of preparation and will be delivered to DRET by end Dec '08.
- From this review the technologies with the highest potential will be identified, together with the remaining knowledge gaps and hurdles to implementation.
- Following on from this analysis, further laboratory work will be needed to close the knowledge gaps and provide data for detailed assessments of options.

Advances made and collaboration sought



- Significant advances have been made in synthesizing an analysis of the open literature and an exposition of technologies and relevant chemistries. The review will discuss the difficulties and opportunities ahead in one convenient summary document.
- Our *May 2009* milestone (review of economic viability of the process options) **should incorporate input from China and India.**
 - After reading the general literature review (Dec '08) **please nominate technical contacts who will liaise with Dr Peter Smith.**
 - Other APP countries are invited to do the same.

Contact details for further information



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Thank you for your attention