Caribbean Economic Alchemy
Has Magic Returned to Bauxite?

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Abstract[1]

After a long period of stagnating prices, the global bauxite market is experiencing changes which are expected to drive prices higher. To a large extent, these changes are driven by increasing demand from Chinese manufacturing. However, constraints on exports imposed by major bauxite producers, such as Indonesia and India have affected the supply side as well, and represent an opportunity for Caribbean bauxite exporters to increase their share of a growing market. This Policy Brief provides an overview of the aforementioned changes in market conditions and proposes a new approach to organizing bauxite mining for the Caribbean bauxite exporters.

JEL codes: F10, N50, N56, N70, O13, O19, L61, L72.
Keywords: Exports, International Trade, Trade, Natural Resources, Metals and Metal Products, Mining, Extraction, and Refining: Other Nonrenewable Resources.

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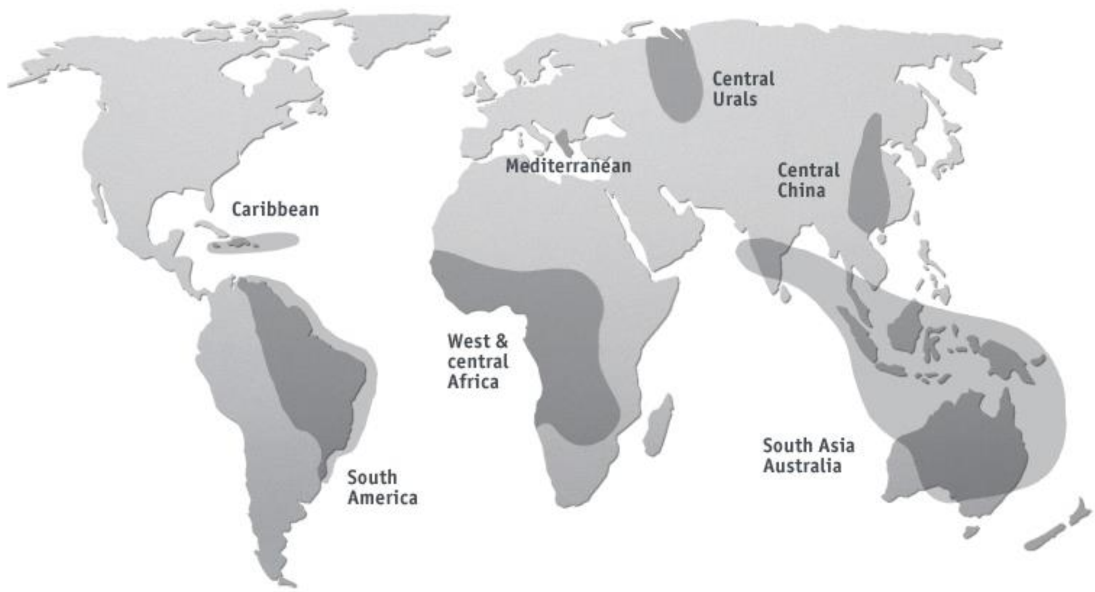
"You are an alchemist; make gold of that."[2]

Or, given the recent changes in market conditions, you could make bauxite instead if you live in one of the countries with vast reserves of the naturally occurring reddish-brown or grayish-white soft rock—the world's main source of aluminum (see Figure 1). Rethinking strategies for exploiting bauxite could be useful especially to the three Caribbean bauxite exporters—Jamaica, Suriname, and Guyana—that collectively account for about 6 percent of global bauxite production (USGS, 2013).

Figure 1. Major Bauxite-Rich Areas of the World



Source: Aluminum leader data from the United States Geological Survey, 2013.

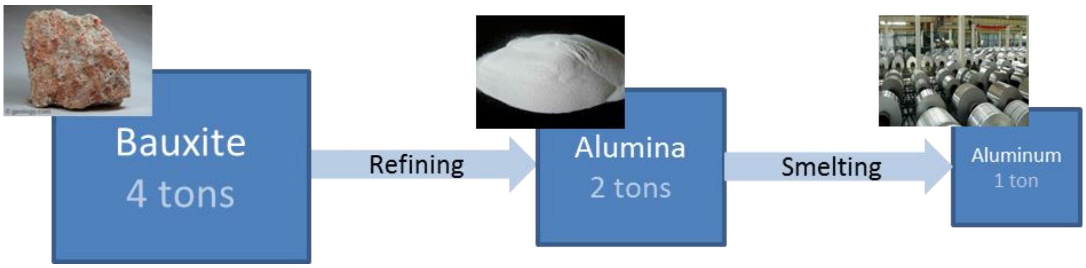
The Growing Market for Bauxite

Because bauxite is the only viable source for primary aluminum production with few other uses, the bauxite market is inextricably intertwined with that of aluminum.[3] As shown in Figure 2, bauxite is used to extract alumina, a white powdery substance that is then used to

[2] From *The Life of Timon of Athens* by William Shakespeare (c.1623).
[3] World supply of aluminum comes from two sources: (a) new production and (b) recycling. Other raw materials such as anorthosite, alunite, coal washery rejects, and oil shales could provide alternative potential sources of alumina for some applications but at higher costs. Almost all of the aluminum that has been produced comes entirely from bauxite. A small fraction of mined bauxite is also used for industrial purposes such as sand-blasting, abrasion and fracking. (See Geology.com, 2014).

produce aluminum. On average, approximately 1 ton of aluminum is produced for every 4 tons of mined bauxite.

Figure 2. Aluminum Production Process



Source: Geology.com. 2014.

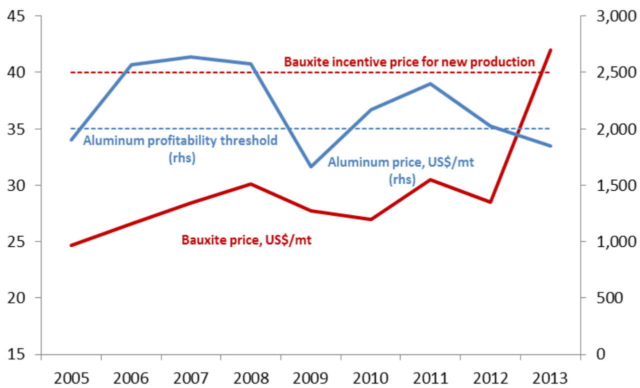
Recently, the bauxite market has been exhibiting optimistic trends after a long period of stagnation. Stockpiling of bauxite and alumina as well as slower-than-expected growth in China—the world's largest consumer of bauxite—has led to several years of declining prices (Rice, 2014). This trend, which has reversed in recent months as a result of changes in the aluminum industry's configuration in response to market conditions and macroeconomic factors, is expected to continue (King, 2014).

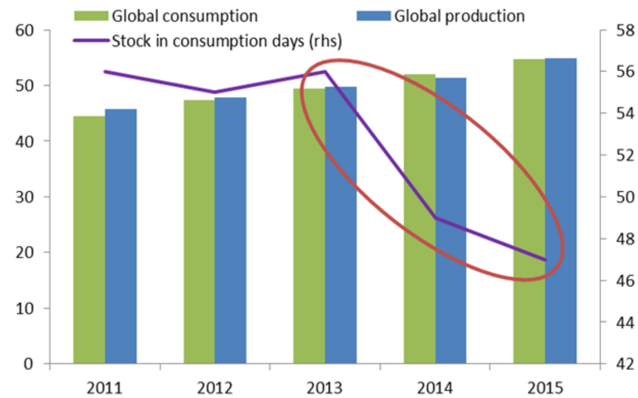
As expected, bauxite prices move closely with aluminum prices (see Figure 3). Aluminum prices recovered lost ground that was caused by the Great Recession, and reached an intramonth postcrisis peak of $2,678 per metric ton in April 2011. By 2014, prices had fallen by 36.7 percent to their lowest postcrisis point at $1,695 per metric ton. Bauxite prices followed a similar pattern and reached a postcrisis high of $30.5 per metric ton. Over the past few months, aluminum prices have increased and are currently around the $2,000 per metric ton profitability threshold (King, 2014),[4] driven by declining consumption stock, which is further expected to fall from 56 days in 2013 to 47 days by 2015. Similarly, bauxite prices have increased and are currently well above the minimum incentive threshold at $42 per metric ton.[5]

[4] Figure 3 shows annualized averages to indicate the broad trends.
[5] The thresholds indicated in the chart are industry standards for profitability for aluminum and for the point where marginal revenue exceeds marginal cost for bauxite.

A medium- to long-term trend of increasingly higher demand in alumina is further expected to reinforce this trend. Estimations from Rio Tinto Alcan, a major primary aluminum company, indicate an almost linear increase in demand for alumina through 2025 (see Figure 4).

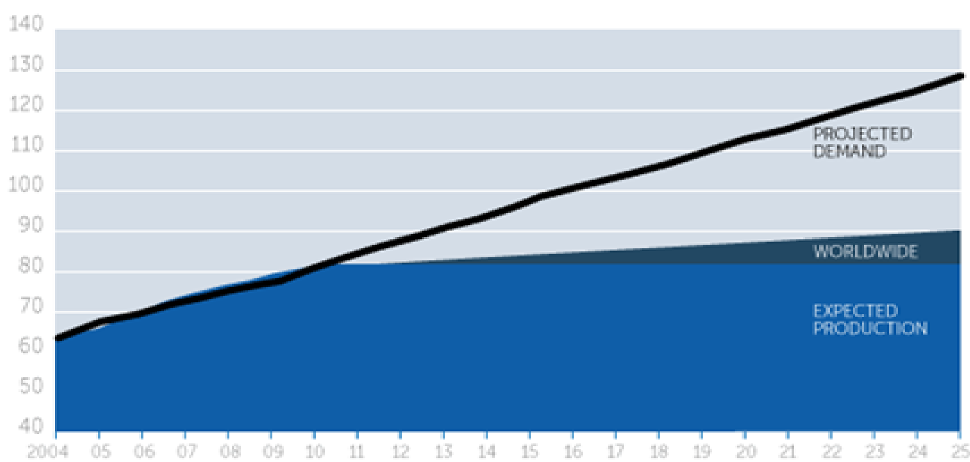
Figure 3. Market Trends





Sources: London Metal Exchange Prices obtained from World Bank Commodity Price Data, July, 2014; Alufer Mining, 2014;United States Geological Survey, 2012; International Aluminum Institute, 2014; and Economist Intelligence Unit, 2014.

Figure 4. Medium- to Long-Term Alumina Market Trends

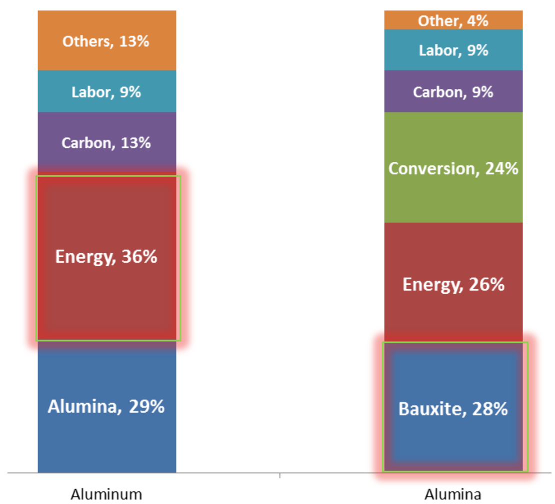


Source: Rio Tinto Alcan, 2013.

As a raw material that feeds more profitable downstream activities, the bauxite market has a naturally complex market structure. Specifically, three characteristics contribute to this complexity:

- First, oftentimes there is a geographic separation between bauxite extraction and aluminum production, which leads to a situation where supply of bauxite is based on mining operations while its demand is mostly driven by global aluminum consumption.
- Second, given the capital intensive nature of extraction production and the associated cost structures, the industry is also characterized by significant economies of scale, which permit only some large companies to stay in business.
- Third, given the geographic distribution of the industry and the value chain illustrated in Figure 2, the bauxite market is subject to several external dependencies.

Figure 5. Cost of Production Breakdown for Aluminum and Alumina



Sources: A.T. Kearney, 2013, and Alumina Limited, 2011.

The geographic separation between the three stages of aluminum production—bauxite mining, alumina refining, and aluminum smelting—is largely driven by cost considerations (see Figure 5). For refining bauxite to alumina, transportation and conversion costs are important; for smelting alumina to aluminum, energy costs are paramount.[6] Aluminum companies choose the location of the refinery with a view to minimize the total cost of alumina production. To do so, they compare the cost of refining close to the mining site—largely energy

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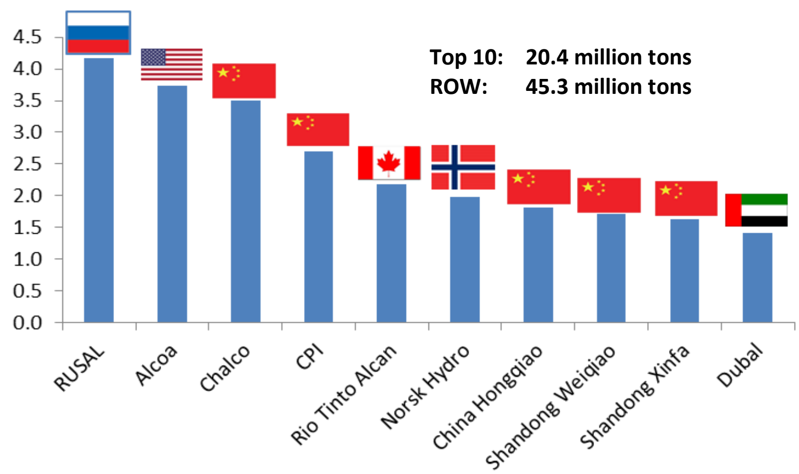
[6] Bauxite is mined using an open pit method whereby bulldozers clear land above deposits; then, the soil is loosened with explosives to bring the ore to the surface. Large earth-movers then remove the bauxite-rich soil and load it into trucks so it can be carried to a processing plant. There, the soil is washed off and readied for transportation to a refinery where it is refined using the chemically oriented Bayer process (see Appendix A) to generate alumina, a white hard powder. The alumina is then transported to smelters where electrolysis is used to transform it into aluminum using the energy-intensive Hall-Heroult process (see Appendix B).

costs—with the cost of refining elsewhere—transportation and energy costs together. Political factors and the specifics of mining agreement with the bauxite-rich country also play a major role in the location decision for the refinery. Similarly, for the next stage, the objective is to minimize the total cost of aluminum production. Here, at 36 percent, the massive amounts of electricity required for the electrolysis make energy a larger portion of the cost. As a result, smelters are strategically located in areas with relatively lower cost of electricity.

Figure 6. Major Integrated Aluminum Producers, 2012

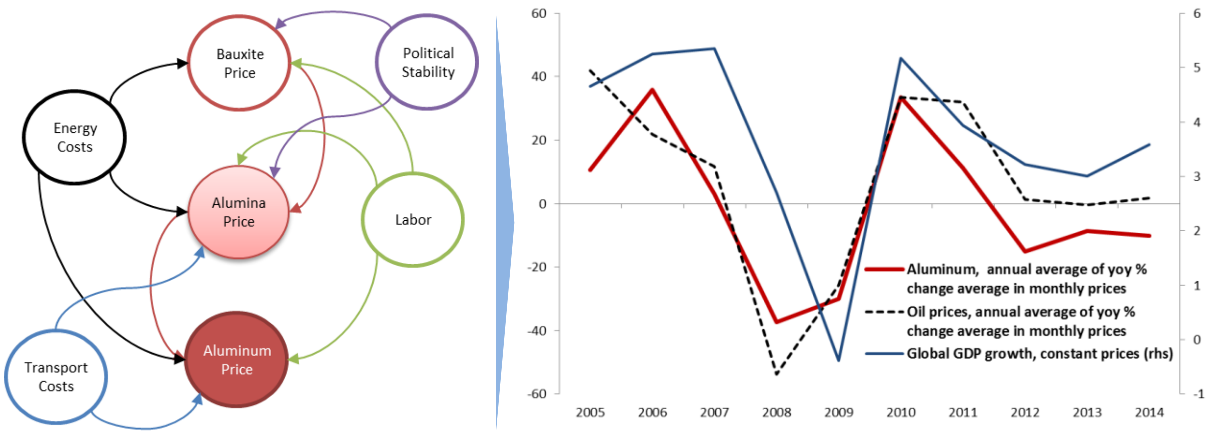


Source: Bell, 2013.

The three phases of production are capital intensive and require large-scale investments, which creates significant barriers to entry for small firms. As a result, the aluminum industry is an oligopolistic market in that the major 10 integrated primary producers account for almost 60 percent of the market share (about 25 million metric tons). Chinese companies dominate the integrated primary aluminum production with more than 45 percent of the top 10 producers shown in Figure 6 (see Appendix C for more details). In the most common industrial setup, large primary aluminum companies buy mining rights and establish operations in bauxite-rich countries. They then either transport the mined bauxite to refineries located elsewhere or refine it into alumina and transport the alumina to smelters.

The bauxite supply is subject to two key types of external dependencies: geopolitics and energy prices. Thus, the creation of the bauxite-alumina-aluminum value chain by multinationals depends not only on capital-intensive factories and transportation mechanisms but also on a stable political environment and manageable energy costs, which allow for interruption-free supply chains (see Figure 7). In addition, internal dependencies revolving around duty and tax concessions and waivers as well as stringency of environmental regulations are important to a multinational's production decision, especially when market prices are near the incentive level.

Figure 7. External Dependencies in the Aluminum Supply Chain



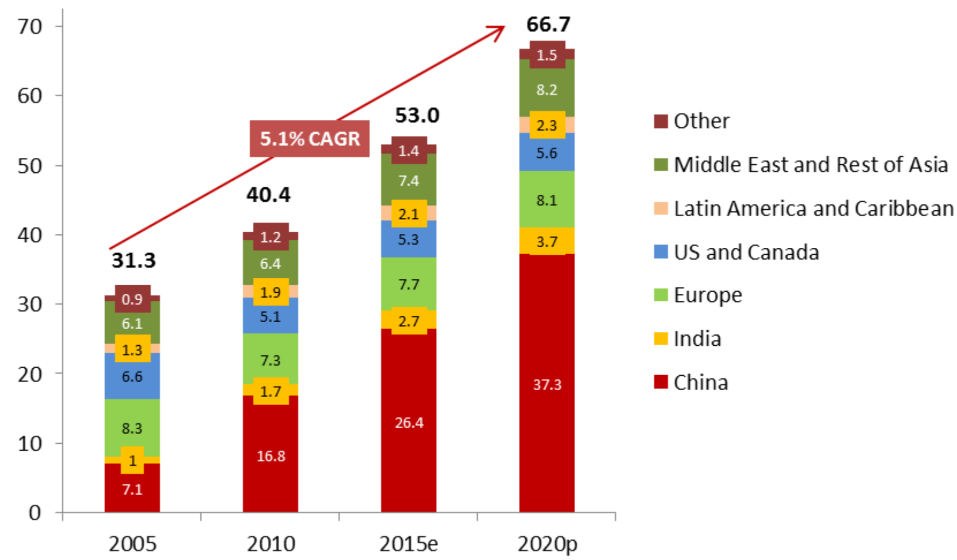
Sources: Staff Analysis and World Bank Commodity Price Data, July, 2014.

Once developed, the bauxite-alumina-aluminum supply chains are not easily changed. This stickiness comes from the fact that refineries and smelters are customized for specific types of bauxite and alumina, respectively. As a result, supply chain stability along with reliable energy sources are of great importance to the global industrial setup, and it explains why most of the aluminum production is usually under the umbrella of a single multinational corporation.

Global consumption of bauxite is on the rise. As one of the largest producers of manufactured goods that use aluminum, China has been driving the demand for bauxite for the past decade. With about 50 percent of the estimated global consumption in 2015 and an estimated 56 percent by 2020, Chinese import demand for bauxite remains the single most important driver behind bauxite demand. India's consumption has also increased rapidly and is expected to grow at about the same rate as China's over the next 5 years (see Figure 8).

To supplement its own large bauxite resources, China imports bauxite from major bauxite exporters. Key among these was Indonesia, which met almost two thirds of Chinese import demand (King, 2014). Other big suppliers of bauxite to China include Brazil and Guinea. All three Caribbean exporters of bauxite—Jamaica, Suriname, and Guyana—also supply bauxite to meet the Chinese demand. Specifically, Guyana, as one of the world's very few producers of refractory-grade bauxite, enjoys a position of relative safety given that its bauxite is globally in high demand.[7]

Figure 8. Geographic Distribution of Demand for Bauxite, 2005–20



Source: A.T. Kearney, 2013.

On the supply side, global production of bauxite is increasing as well but not at the same pace as consumption, creating an upward pressure on prices. At a global level, approximately 260 million metric tons of bauxite were mined in 2012. Australia was the biggest producer of mined bauxite, with China and Brazil in second and third places, respectively. However, in January 2014, the government of Indonesia banned all raw mineral ore exports, including bauxite to encourage miners to domestically process the ores before exporting so that the sector can increase profitability over time and the country can benefit more from its natural resources (see Reuters, 2014). A second supply-constraining event took place when the

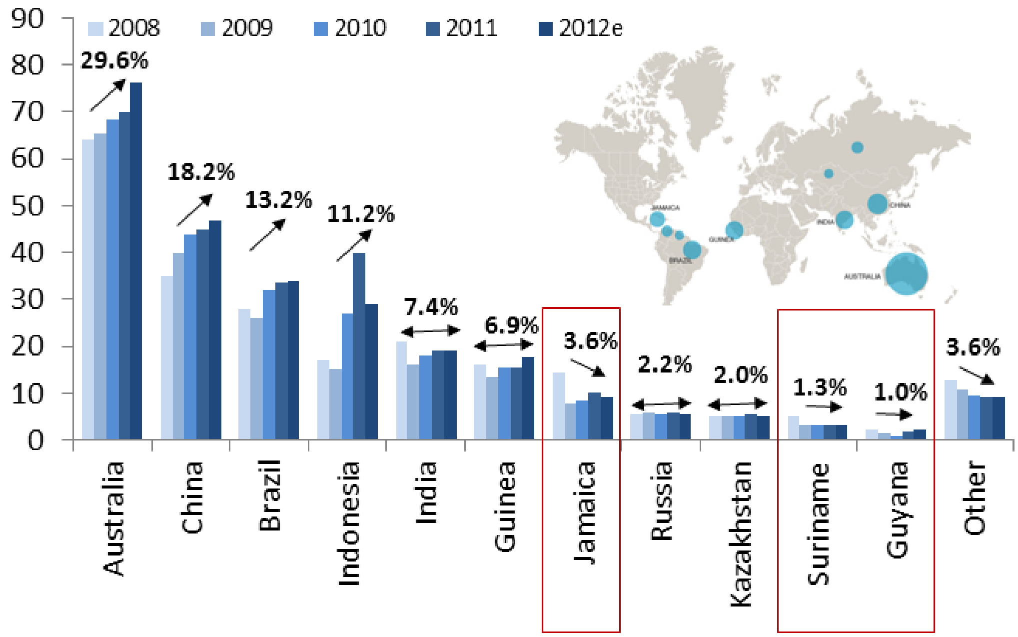
[7] Other than Guyana, refractory grade calcined bauxite is produced mainly in China, India, and the United States. Approximately 70 percent of the refractory use is in the iron and steel industries with most of the remainder being used in cement kilns and the glass industry (see ABx, 2014).

government of India decided to double the export duty on bauxite in May 2014 (see Mukherji, 2014).

The Indonesian ban on raw bauxite ore exports and the increase in export duty in India, both aimed at incentivizing more profitable downstream operations, have also led to a short-term decline in global supply, thereby creating an opportunity for other bauxite producers to increase their share of the global raw ore market. It is worth noting that Australian miners have already started boosting their production including investing in technology that will make bauxite mining and alumina production cheaper and faster (Probert, 2014). Since 2008, the top three producers of bauxite—Australia, China, and Brazil—have seen double-digit increases in their production with a change of 19, 34, and 21 percent from 2008 to 2012, respectively (see Figure 9). Although such supply-constraining actions are often imbued with political involvement, industry observers believe that these changes will remain in place over the medium-term (Reuters, 2014).

Three countries from the Caribbean—Jamaica with 3.6 percent of global bauxite production, Suriname with 1.3 percent, and Guyana with about 1 percent—have consistently ranked among the top bauxite exporters in the world but have seen declining shares in a global market that increased by 14 percent overall between 2008 and 2012. Jamaica declined from 6.4 percent in 2008 to 3.6 percent in 2012, thereby losing 2.8 percentage points in market share. Similarly, Suriname lost 1 percentage point and declined from 2.3 to 1.3 percent, and Guyana lost 0.1 percentage point and decreased from just above 1 percent to just below 1 percent of total. A combination of dependence on financially struggling multinational mining companies during a time of price stagnation, relatively higher extraction and transportation costs primarily driven by energy, and an appreciation in the real effective exchange rate appear to be the primary drivers behind this disturbing trend.

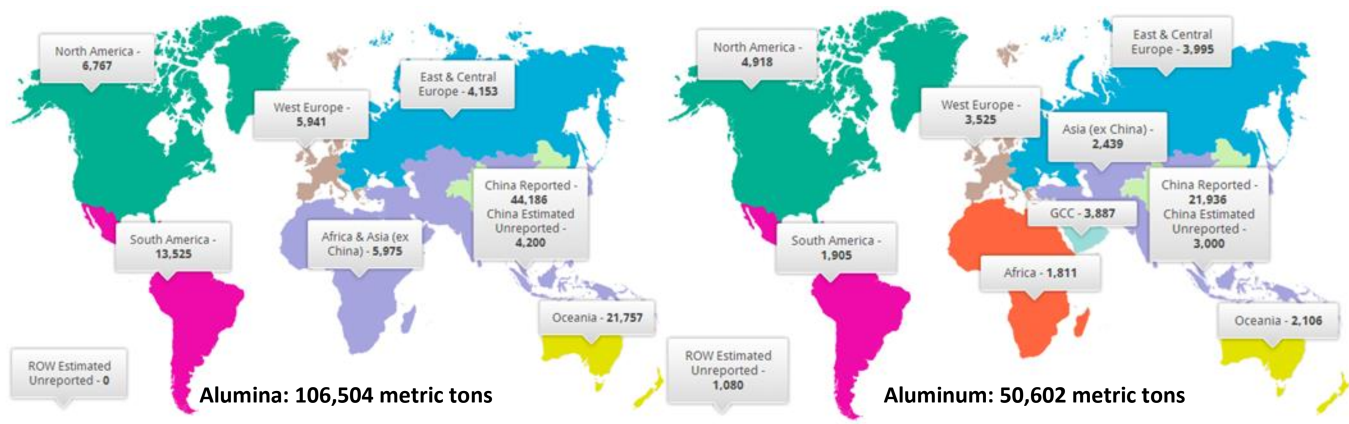
Figure 9. Global Supply of Bauxite, 2008–12



Source: United States Geological Survey, 2013.

The geographic distribution of both alumina and aluminum production remained consistent with the bauxite production trends (see Figure 10). About 106,504 metric tons of alumina was produced in 2013. Including estimated unreported data, China accounted for 42.6 percent of global alumina production, Australia accounted for 20.4 percent, and Latin America and the Caribbean accounted for 12.7 percent. Similarly, the distribution of aluminum production was in line with expectations with global production standing at 50,602 metric tons. China accounted for 49.3 percent of global aluminum production, with North America in second place at 9.7 percent, and Gulf Cooperation Council countries at 7.7 percent.

Figure 10. Global Alumina and Aluminum Production, 2013



Source: International Aluminum Institute, 2014.

So How Can the Caribbean Ride This Alchemical Wave?

With Chinese demand for bauxite on the rise and uncertainties around supply from major geographically close producers such as India and Indonesia, Caribbean countries have opportunity to increase their market share. Given an increased bauxite import demand over the medium to long term, China is looking to replace the lost Indonesian supply. With India's recent move to double export duty on bauxite (Mukherji, 2014), Caribbean bauxite exporters may capitalize on this if they are able to use the supply crunch to increase market share (see Figure 11).

Furthermore, in addition to benefiting from an increased market share, Caribbean bauxite exporters can also try to increase the profitability of the bauxite sector in their countries by focusing on higher margin downstream activities. By comparing the geographic distribution of alumina and aluminum production around the world, it is evident that there some are regions with little or no bauxite deposits but with well-developed aluminum businesses, such as the Gulf Cooperation Council countries, which have taken advantage of their geography and low energy costs to effectively compete in the smelting business (A.T. Kearney, 2013). Given their control over bauxite, the Caribbean countries can also strategically place themselves in the more profitable part of the bauxite-alumina-aluminum supply chain.

A two-pronged approach aimed at enhancing the profitability of the bauxite sector in each of the Caribbean exporters while reducing the counterparty risk associated with having a strategic reliance on only one multinational corporation could be used. The first part would include diversifying the bauxite sector's activities to include downstream operations that carry more profit[8], and the second part would require engagement with multiple multinationals as opposed to just one, with a view to engender supplier competition while reducing counterparty risk. As an example of such counterparty risk, Alcoa recently decided to close down operations in Jamaica and Suriname. Although these moves may have been catalyzed by weak bauxite prices in the recent past, this largely represents a strategic shift in emphasizing their more profitable downstream business as they have been under financial stress (Katz, 2014).

On the first part of the suggested approach, each of the Caribbean bauxite exporters would use technical and financial support from multilateral development agencies such as the Inter-American Development Bank (IDB) to repackage existing mining contracts into multiparty public-private partnership (PPP) operations with a specially created state-owned domestically domiciled company serving as the sponsor and overseer (see Figure 12). The financial contributions from multilaterals will reduce the capital costs burden and reduce risks for any new projects and may encourage the incumbent multinationals to consider becoming part of such a scheme. The multilateral support would ensure that best practices for mining industries will be used for the creation of this public-private partnership. It would also contribute to transparency and good governance, as well as regular monitoring and evaluation including adherence to environmental, social, and corporate governance best practices.[9] Further, the multilateral involvement will mitigate the most common risks associated with complex PPP projects: i) poor legal framework and enforcement; ii) weak institutional capacity and PPP strategy; iii) unrealistic revenue and cost estimations; iv) lack of thorough financial and

[8] An important related enabler of enhancing profitability is low cost energy. Strategic investments, with the help of mulitlaterals like the IDB, that are aimed at cheap, clean and reliable energy will have a cost-reducing effect on the bauxite ecosystem.

[9] While it is admittedly difficult to convince an incumbent multinational to renegotiate any existing contract, especially given a history of giveaways and corporate-favored mining rights (see Box 1), governments can still use various tactical strategies to bring an incumbent firm to the table. For example a combination of i) a credible exclusion from rights to new mines may serve as a strong motivator; ii) if the incumbent multinational does not cooperate, the government could sell part of its share to another multinational, thereby carving a path for them into the country; and iii) public discussions aimed at moral suasion may help.

economic analysis; v) inappropriate sharing of risks; vi) lack of competitive procurement; and vii) public resistance (see Cuttaree, 2008).

Second, we recommend negotiating the public-private partnership in the context of performance-based multi-party mining agreements with two or three mining companies for each mine: a mining public-private partnership cooperative.[10] The idea behind this approach is for the state-owned company to make use of the monitoring and evaluation framework to periodically evaluate mining companies' relative performance on the basis of various factors including investment in local community, environmental issues, dealings with labor, and the creation and profitable operation of downstream operations. Within preagreed bands, the higher scoring mining companies will acquire increased rights for bauxite extraction for the next period (see Figure 11). Multinationals such as Rio Tinto Alcan and some of the new Chinese companies should be invited to discuss opportunities. Taking a hypothetical case, had there been a setup similar to this in Jamaica or Suriname where more than one multinational was involved in operating the same mines, Alcoa's financial troubles and strategic shift driven by their global corporate efficiency model may have affected the bauxite sectors a lot less because the other mining company, who would already be engaged in production, would fill in the void.

On shifting the focus to downstream activities, governments can require as part of the public-private partnership negotiation that mining companies invest in developing new technologies and creating new operations. One powerful way in which the new technologies can be developed is by building relationships with local universities and providing targeted research incentives, such as prizes, to students who can develop cheaper ways to produce and/or conserve energy, or new financially and environmentally low-cost ways to increase alumina yields. Low-cost operations could be focused on midstream activities such as producing primary aluminum. In Jamaica, these operations could also leverage the tourism sector by building a recycling facility for aluminum cans and other containers.

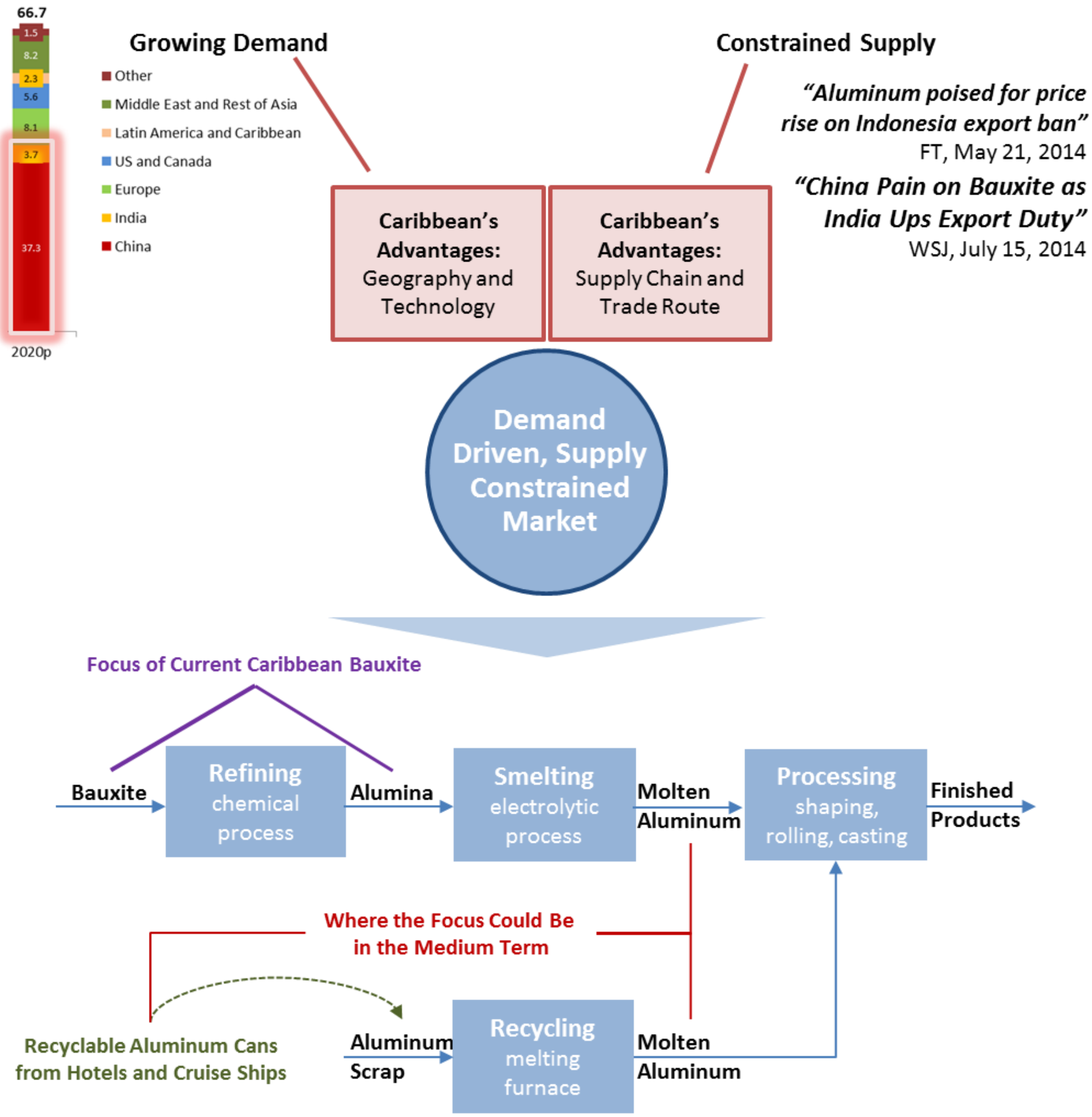
Supply-side challenges with the Caribbean countries may create significant hurdles for implementing the proposed solution. Specifically, political cycles involving substantial

[10] Creating competition in this manner represents best practice in strategic sourcing and procurement (see Laseter, 1998).

change in internal power dynamics (for example, one where the opposition wins by a large margin) may create unpredictability for large global mining companies and serve as a barrier. To overcome this, a national commitment, irrespective of who is in power, needs to be made and communicated. Concrete actions, such as creating permanent positions for members of both the government and the opposition, could alleviate this issue.

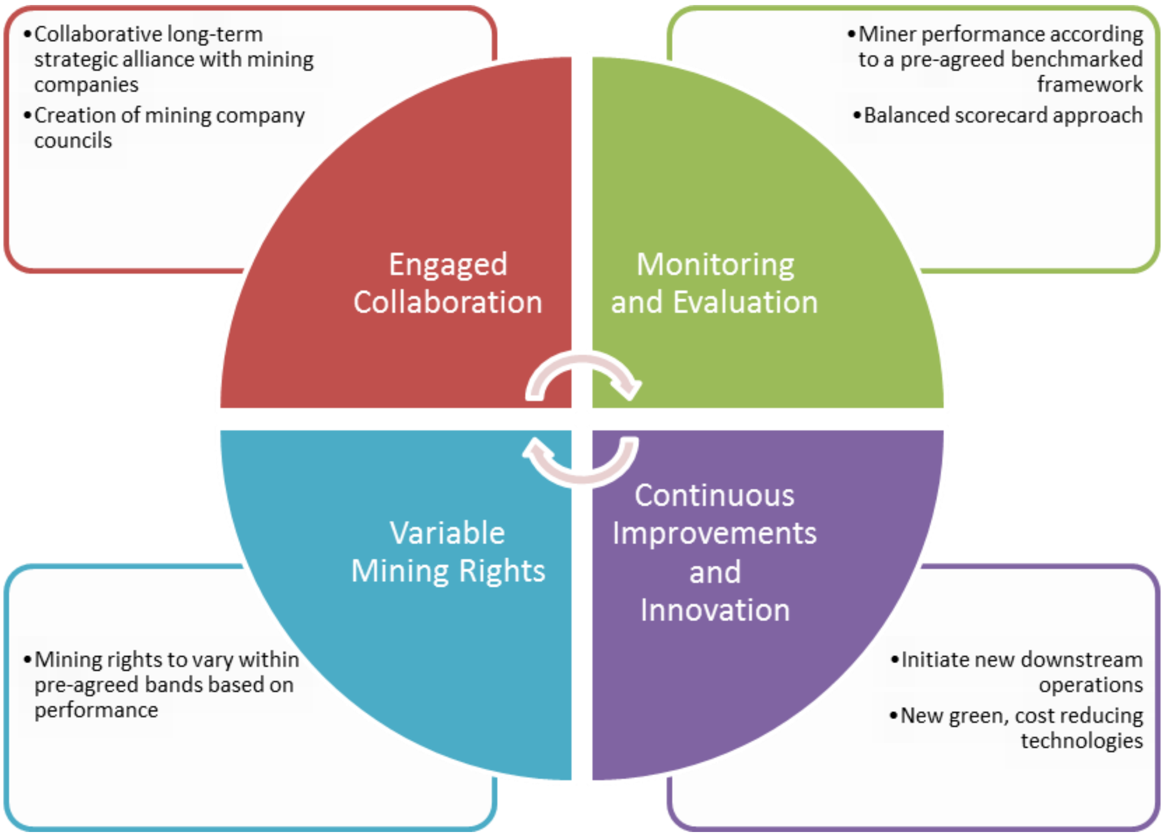
Caribbean governments would fare better if they can find a way to cooperate with mining multinationals while maintaining a position of strength given the bullish market. From the perspective of multinationals, it can be tedious to do business in the Caribbean. Thus, continuing with efforts to improve Doing Business Indicators as well as facilitating the resolution of disputes quickly can create a relatively stable political economic environment, which would help generate confidence in making long-term investments outlined earlier (Ruprah, Melgarejo, and Sierra, 2014).

Figure 11. Caribbean's Opportunity to "Make Bauxite of That!"



Source: Author's analysis.

Figure 12. Concept for Creating a Cooperative Mining Public-Private Partnership



Source: Author's analysis.

Tactical Next Steps…

A Task Force on Bauxite comprised of senior officials from various relevant ministries and national bauxite company could be appointed and tasked to implement the new framework. This process could begin by a senior government official acting as a "champion" for the change who would then begin a systematic outreach to garner support from other authorities and relevant stakeholders. Relevant stakeholders could include senior management at the incumbent multinationals, labor unions, NGOs focused on environmental issues associated with bauxite mining, and university faculty.

The Task Force could prepare and publicly release a report that provides relevant conceptual details for the new framework, makes the case to implement it, and lays down a high level implementation plan (see Figure 13). An international organization like the IDB can support this initiative by providing technical support. The Task Force report could be used as a public document to generate public support and interest in the idea. The report could be disseminated widely to ensure that it gets attention from the media as well as other third parties.

The Task Force could then engage with the incumbent multinational in the country to obtain their buy-in and make them a stakeholder in the success of the new framework. The engagement could use a combination of identifying potential benefits of the new set up as well as use leverage. The potential benefits will largely revolve around reduced capital costs and risks associated with embarking on new projects. Individual government's leverage could come from: i) their equity in the national bauxite company, which it could sell to another multinational in order to create another corporate presence in the country; ii) rights to participate in new mining opportunities; and iii) moral suasion by conducting these discussions openly so that the incumbent multinational takes into account the public discourse on the topic.

Simultaneously, the Task Force could also engage with other multinationals who may be interested in establishing operations in the Caribbean. Outreach to other mining corporations, particularly the new Chinese entrants (see Appendix C), may prove to be helpful in creating momentum around implementing the new framework. Multilateral support, garnered at an earlier stage, would facilitate this outreach.

Engaging with local universities and small businesses to focus on innovations that support downstream activities will help create an ecosystem around the new framework. In particular, the Task Force could generate government support for low energy smelting innovations through sponsored university research which would enhance the profitability of such operations. The Task Force could also connect with the tourism sector by supporting innovative startups focused on efficiently using recycled aluminum containers obtained from cruise ships and other tourism related activities.

The Task Force could transition towards implementation of the new framework once the relevant stakeholders have agreed to a specific plan of action. This implementation would include: i) creating the relevant PPP legal structures, ii) staffing the new organizations, and iii) turning over execution responsibility to the PPP operators. The Task Force could then be dissolved but some members who are not directly involved with the PPP operation could be made part of a Monitoring and Evaluation Committee that would oversee the PPP operations.

Conclusions

The analysis shows that recent changes in the bauxite market have opened up an opportunity for the Caribbean bauxite exporters to markedly increase their market share as well as improve the profitability of the sector domestically over the long run. While meeting the increased demand (primarily China) amidst contracting supply (Indonesia and India) could help with improving market share, achieving continued enhanced profitability will require a strategic realignment by shifting focus to downstream activities.

A performance-based, multi-party public-private partnerships cooperative framework is presented that combines best practices in PPP organization with those from supplier management. Implementing this framework will have three main benefits for Caribbean bauxite exporters. First, this mechanism will reduce counterparty risk from the country's perspective by getting more than one multinational mining company engaged in production. Second, the performance-based sharing of mining rights will force market-based checks on complying with environmental and labor standards, as well as corporate contributions to the broader development of the mining communities. Third, the cooperative approach will reduce the capital costs and risks associated with expanding current operations as well as undertaking new mining projects for multinationals.

Finally, an actionable sequence of initial tactical next steps is presented for Caribbean governments that could help them in moving towards developing and implementing the new framework. These tactical steps involve creating a Task Force comprised of government officials and other relevant stakeholders, and mandating it with the responsibility to implement the new framework.

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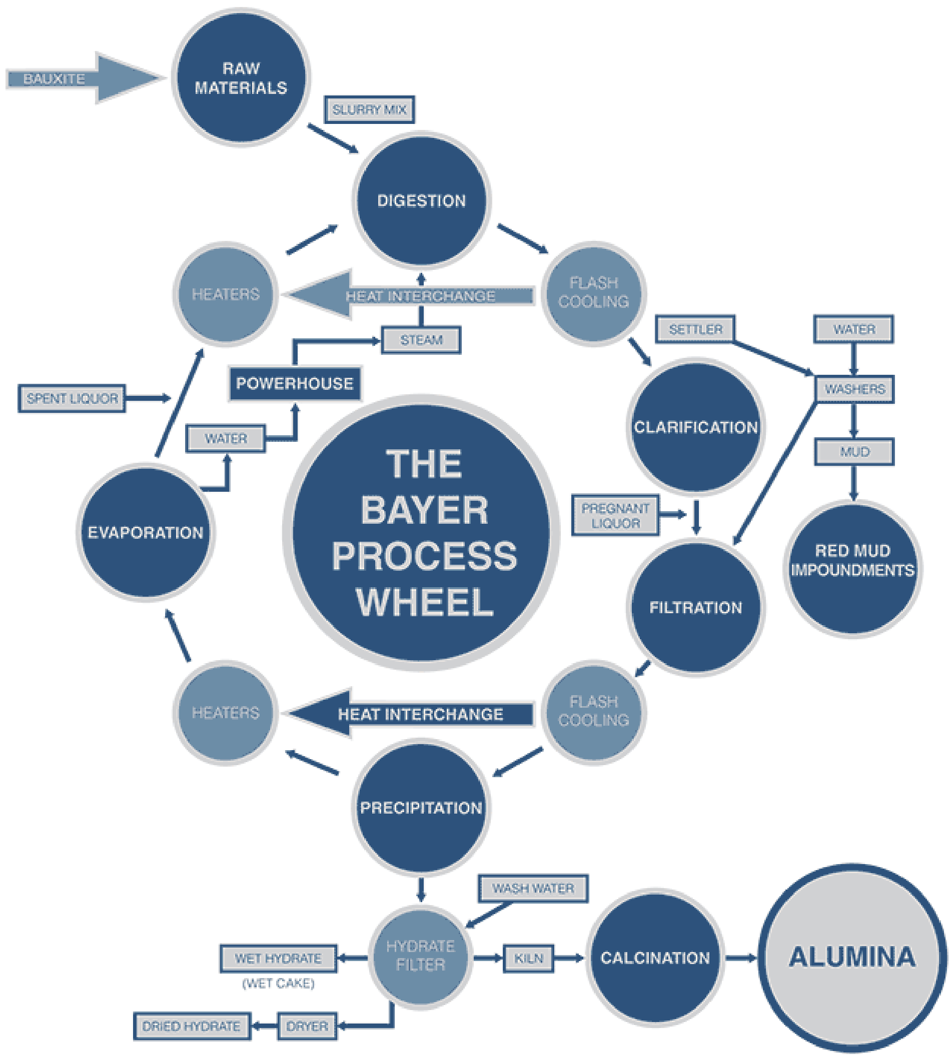
Appendix A. The Bayer Process[11]

The Bayer Process is the main industrial method of producing alumina. It is named after its inventor, the Austrian chemist Karl Bayer, and was patented in 1889. Today, it is used to produce almost all of the world's alumina supply. At a high level, the process involves



Source: Noranda Aluminum, 2011

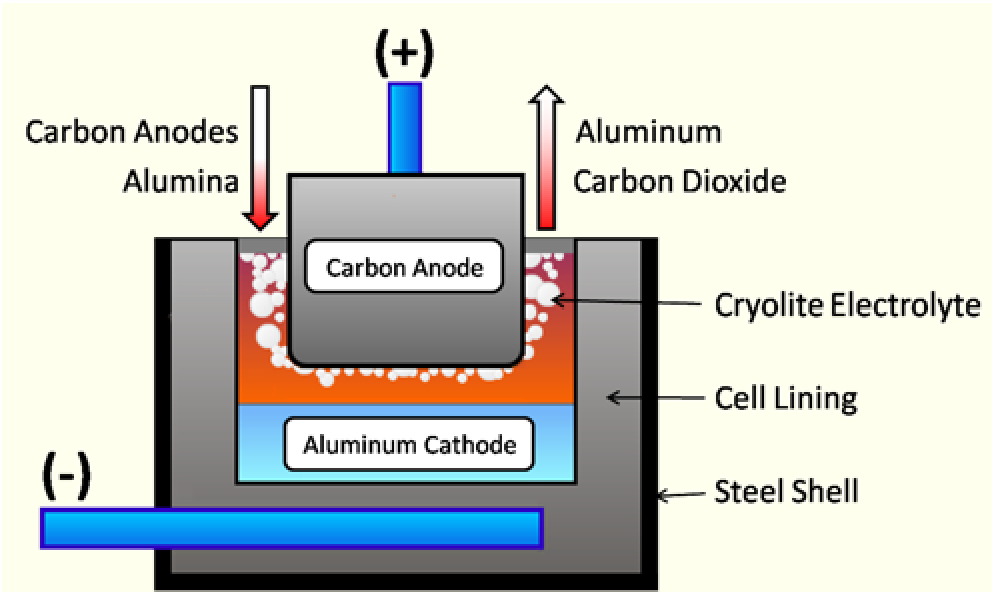
dissolving the aluminum component of bauxite ore in hot caustic soda, then removing any impurities from the solution, followed by precipitating alumina trihydrate, and then calcining it to aluminum oxide or alumina.

[11] From http://www.norandaaluminum.com/bayer-process.php

Thus, a Bayer Process plant is a facility designed to heat and cool a large recirculating stream of caustic soda solution. Bauxite is added at the high temperature point, red mud is separated at an intermediate temperature, and alumina is precipitated at the low temperature point in the cycle.[12] The heating requirement of the process makes it energy intensive.

[12] Bauxite usually consists of two forms of alumina—a trihydrate form gibbsite (Al2O3·3H2O) and a monohydrate form Boehmite (Al2O3·H2O).

Appendix B. The Hall-Heroult Process[13]



***Source*:** Entner, 2014.

The Hall-Heroult process is used to produce aluminum in an electrolytic cell using alumina as the key input. Alumina is dissolved in molten cryolite and decomposed between carbon and aluminum electrodes at about 950° C to aluminum and oxygen. The carbon anode is continuously consumed by reacting with the oxygen to give carbon dioxide. The typical features of the electrolysis cells in an aluminum plant are described. Technical cells are operated with a current intensity of 100 to 500 kA, thus making this process energy intensive, and are equipped with devices to operate the cells in an automated fashion. The waste gases of the process are collected and thoroughly cleaned before being exhausted to the atmosphere.

[13] From http://www.peter-entner.com/e/theory/PrincHH/PrincHH.aspx

Appendix C. Primary Aluminum Majors, 2013 (see Bell, 2013)

1. **Russian Aluminum (RUSAL)**

   Rusal was founded in 2000 and, after its merger with SUAL and the acquisition of alumina assets from Glencore, emerged as a global leader in the integrated primary aluminum industry in 2007. The company currently operates 15 alumina smelters, 12 alumina refineries, and owns eight bauxite mines. See www.rusal.ru/en for details.

2. **Aluminum Company of America (Alcoa)**

   The Aluminum Company of America (Alcoa, Inc.) was founded in Pittsburgh, Pennsylvania, in 1888 and now operates in 31 countries worldwide. The company has interests in 25 primary smelters, accounting for about 7 percent of global production. Although Alcoa's output decreased slightly in 2012 to 3,775,000 metric tons, it moved into second place from third among primary producers. Key aluminum assets include the Fjardaál smelter (Iceland); Alcoa World Alumina and Chemicals (Australia); the Baie-Comeau and Becancour smelters (Canada); the San Cibrao smelter (Spain); and smelters in Newburgh (Indiana), Ferndale (Washington), and Rockdale (Texas). See www.alcoa.com for details.

3. **Aluminum Corporation of China (Chalco)**

   The Aluminum Corporation of China Ltd. (also known as Chalco or Chinalco) is China's largest refined aluminum producer. Chalco is a state-owned enterprise that is listed on the Shanghai, Hong Kong, and New York Stock Exchanges. The company employs more than 100,000 individuals and also has operations related to copper refining, carbon products, gallium, and rare earths. Major aluminum assets include the Shandong Aluminum Company, Pingguo Aluminum Company, Shanxi Aluminum Plant and the Lanzhou Aluminum Plant. See www.chalco.com.cn for details.

4. **China Power Investment (CPI) Corporation**

   The biggest mover on the list this year, China Power Investment Corp. (CPI) increased its total output by 95 percent—from 1.38 million metric tons to nearly 2.7 million metric tons. The state-owned company is a comprehensive investment group that holds assets in power generation, coal, aluminum, railways, and ports. Founded in 2002, CPI has an installed aluminum production capacity of 2.77 million metric tons. Major aluminum assets include the Ningxia Qingtongxia Energy and Aluminum and CPI Aluminum International Trading Co. Ltd. See eng.cpicorp.com.cn for details.

5. **Rio Tinto Alcan (RTA)**

   A Canadian mining industry giant, RTA owns and operates bauxite mines and alumina refineries in Brazil, Australia, Guinea, and Canada. Its primary aluminum smelters are located in Canada (eight smelters), Cameroon, France, Iceland, Norway, and the Middle East. To power its smelters, RTA owns 11 power stations, which supply 36 percent of the electricity that the smelters consume. See www.riotintoalcan.com for details.

6. **Norsk Hydro (Hydro)**

   This Norwegian company is a major producer of bauxite, alumina and refined aluminum products, and employs 22,000 people worldwide. Hydro has plants in Rjuken, Raufoss, Vennesla, Karmoy, Hoyanger, Ardal, Sunndalsora, Holmestrand, and Magnor (all in Norway). However, its major bauxite and alumina refining operations are in Brazil, which it acquired from Vale, a large global mining company, in 2011. Qatalum, located in Qatar, is a 50–50 joint venture with Qatar Petroleum and Hydro and has an annual capacity of 585,000 tons of primary aluminum. See www.hydro.com for details.

7. **China Hongqiao (CH)**

   China Hongqiao, a subsidiary of China Hongqiao Holdings Limited, is a new entrant to the top 10 primary aluminum producers. The company was founded in 1994 and is headquartered in Zouping, Shandong Province, China. CH's aluminum products consist of molten aluminum alloy, aluminum alloy ingots and aluminum alloy processing products. Its total output capacity is roughly 2.2 million metric tons. See www.hongqiaochina.com for details.

8. **Shandong Weiqiao (SW)**

Shandong Weiqiao is the second newcomer to the list of top primary aluminum producers. Headquartered in Bizhou, Shandong in China, SW's current output capacity is roughly 1.8 million metric tons. See www.alu.com.cn for details.

9. **Shandong Xinfa Aluminum and Electricity Group (Xinfa)**

Xinfa is one of China's largest private aluminum companies. Founded in 1972, the company now has over 50 subsidiaries and 15,000 employees working in power generation, alumina and aluminum refining, carbon production and downstream aluminum product manufacturing. Major assets include Chiping Huaxin Aluminum Industry Co. Ltd., the Shandong Xinfa Hope Aluminum Co. Ltd. (East Hope Group) and Guangxi Xinfa Aluminum Co. Ltd. See www.xinfa.cnal.com for details.

10. **Dubai Aluminum (Dubal)**

Established in 1979, Dubal owns and operates the Jebel Ali aluminum smelter, one of the largest primary aluminum production facilities in the world. With an annual output reaching 1.42 million tons in 2012, the complex operates a 2,350 megawatt power station, a large carbon plant, a desalination plant, and casting operations. The company also owns a 50 percent share in Emirates Aluminum (EMAL) in Abu Dabi, where production capacity is expected to reach 1.3 million metric tons in 2014. See www.dubal.ae for details.

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