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TECHNICAL LECTURE SERIES

# COMPARATIVE FEATURES OF INDIA'S EASTERN GHATS AND GUINEA BAUXITE DEPOSITS

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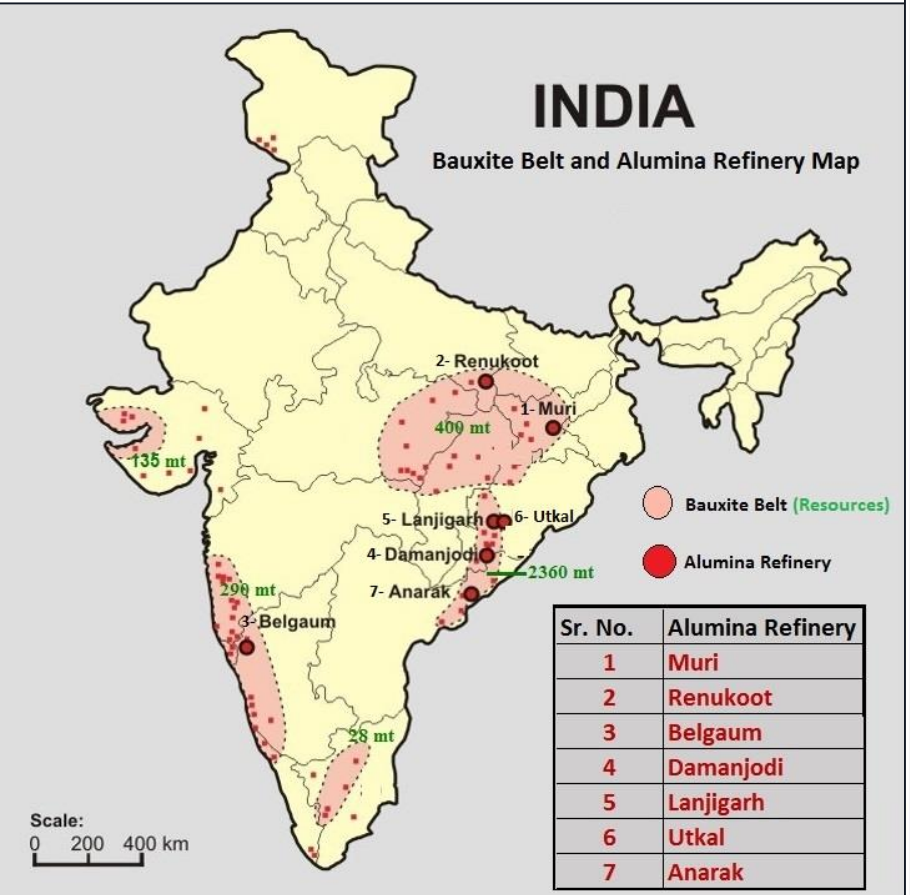
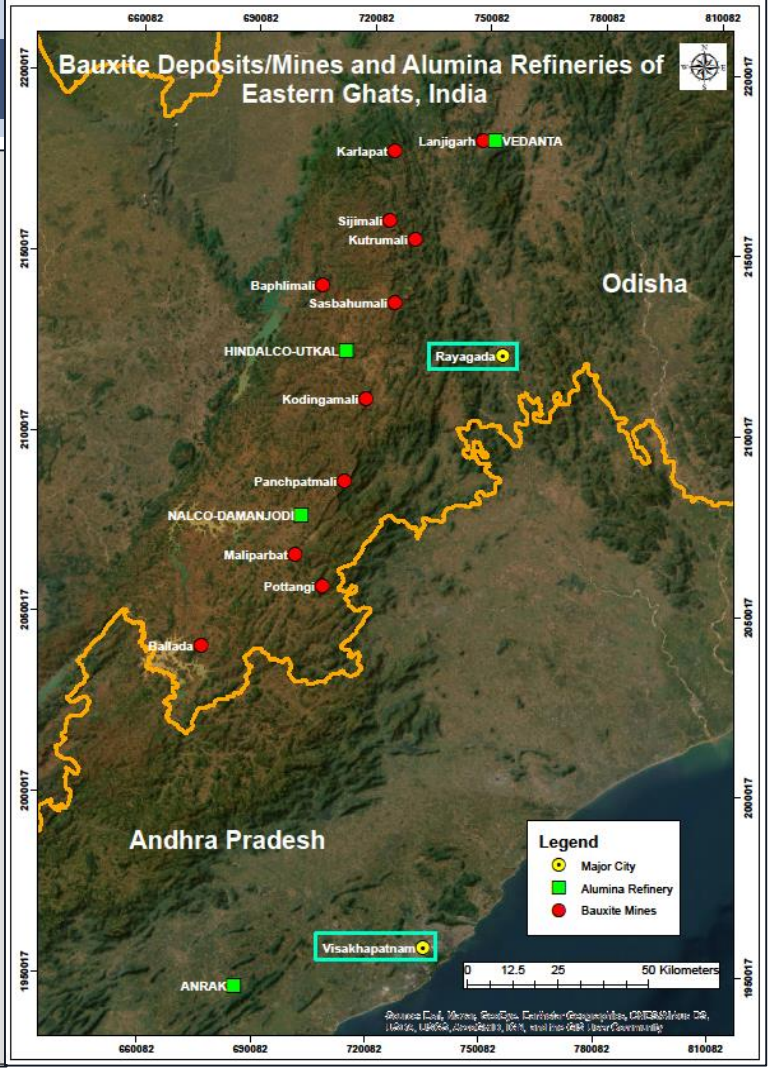
# INTRODUCTION

1. **Large Guinea Bauxite mines can be compared with Eastern Ghats deposits of Odisha and Andhra Pradesh.**
2. **Although Geologically and Geomorphologically Guinea bauxite deposits are different from Odisha, they are all gibbsitic lateritic bauxite and suitable for low temperature alumina refineries.**
3. **Guinea have 15 times more resources (about 40 Billion tons) compared to about 3 billion tons concentrated in Odisha and Andhra Pradesh.**
4. **At present Guinea is mining and exporting about 95 million tons high quality gibbsitic bauxite per annum, whereas Eastern Ghats is producing only 18 Mtpa bauxite.**

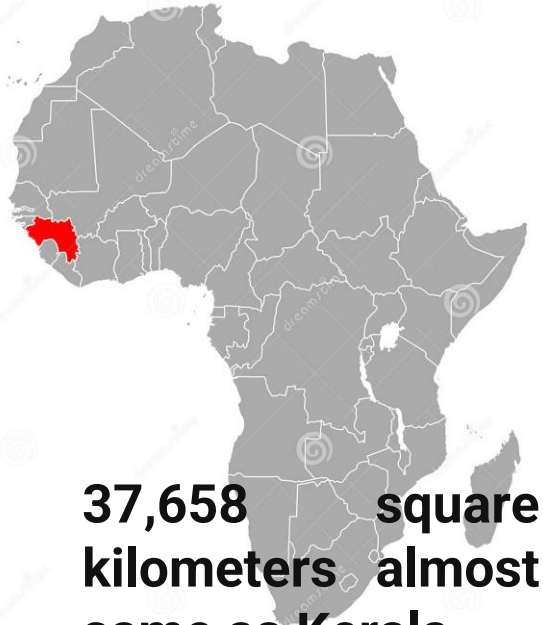
# EASTERN GHATS INDIA




| Sr. No. | Alumina Refinery |
|---|---|
| 1 | Muri |
| 2 | Renukoot |
| 3 | Belgaum |
| 4 | Damanjodi |
| 5 | Lanjigarh |
| 6 | Utkal |
| 7 | Anarak |



# GUINEA – WEST AFRICA

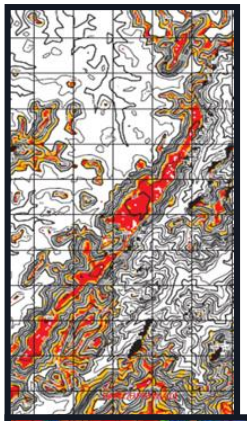


**37,658 square kilometers almost same as Kerala**

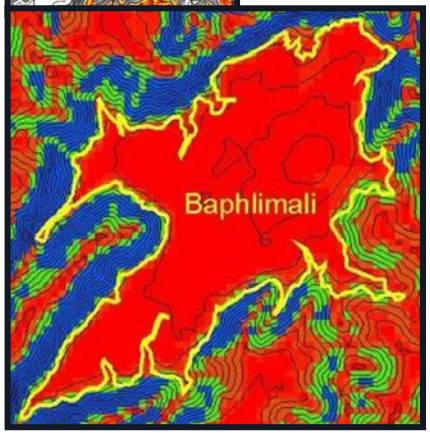
# COMMON FEATURES

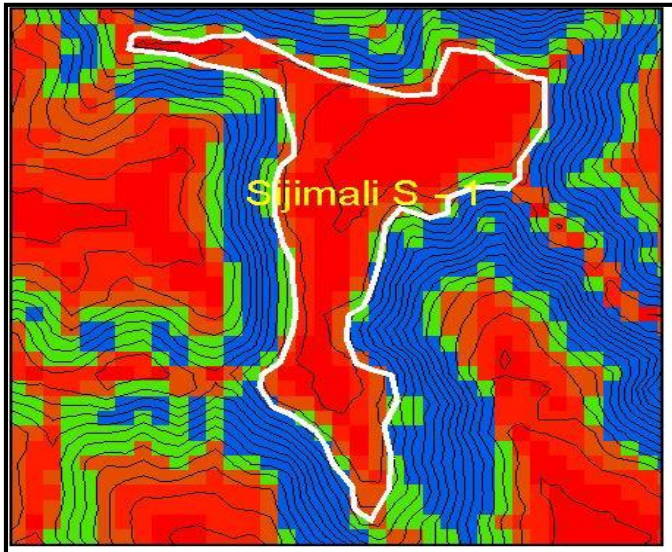
- **Both Guinea and Eastern Ghats Bauxites are lateritic in origin and occurs from surface with thin soil cover.**
- **Physically both the ore looks similar and grade improves with decrease in iron content.**
- **Chemically both bauxites are free from contamination of minor oxides with low organic carbon content.**
- **Simple mineralogy and suitable for low temperature alumina refinery. Only 1 to 3% alumina is locked up in Boehmite.**
- **Guinea and Odisha have large open cast bauxite mines, however, there is only one old alumina refinery (Fria) in Guinea compared to 4 large plants in Eastern Ghats.**

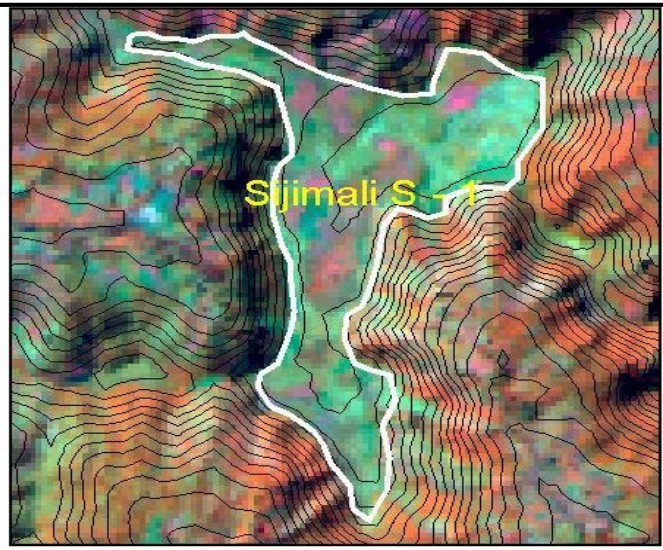
# Eastern Ghats Bauxite Deposits / Mines, India



NALCO Panchpatmali



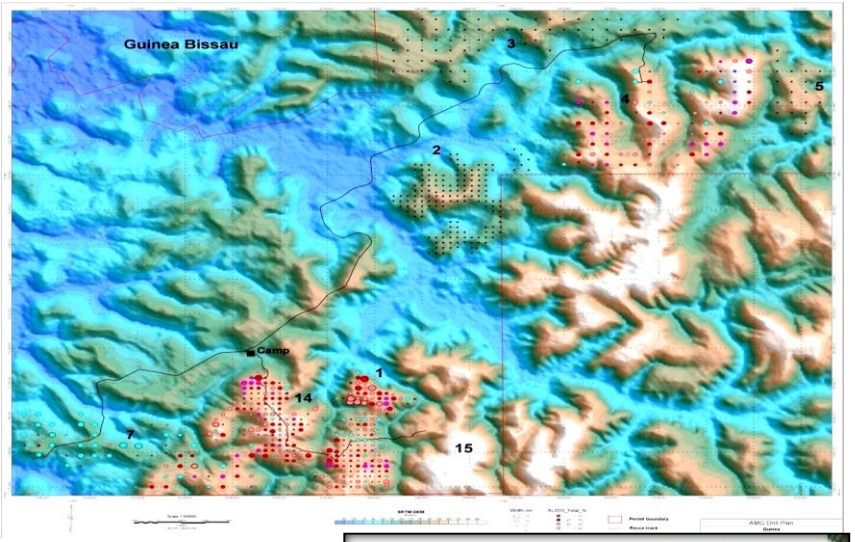

Slope

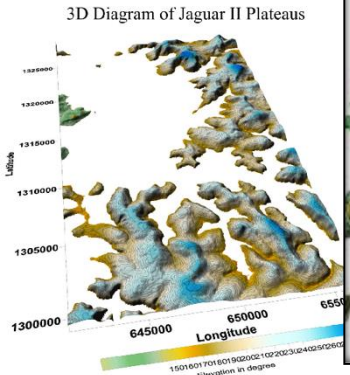
0° - 5° 5° - 10° 10° - 15° 15° - 20° 20° -

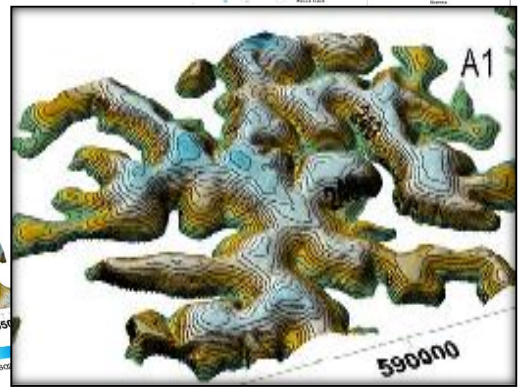
0 500 1 000 1 500 2 000 2 500 m

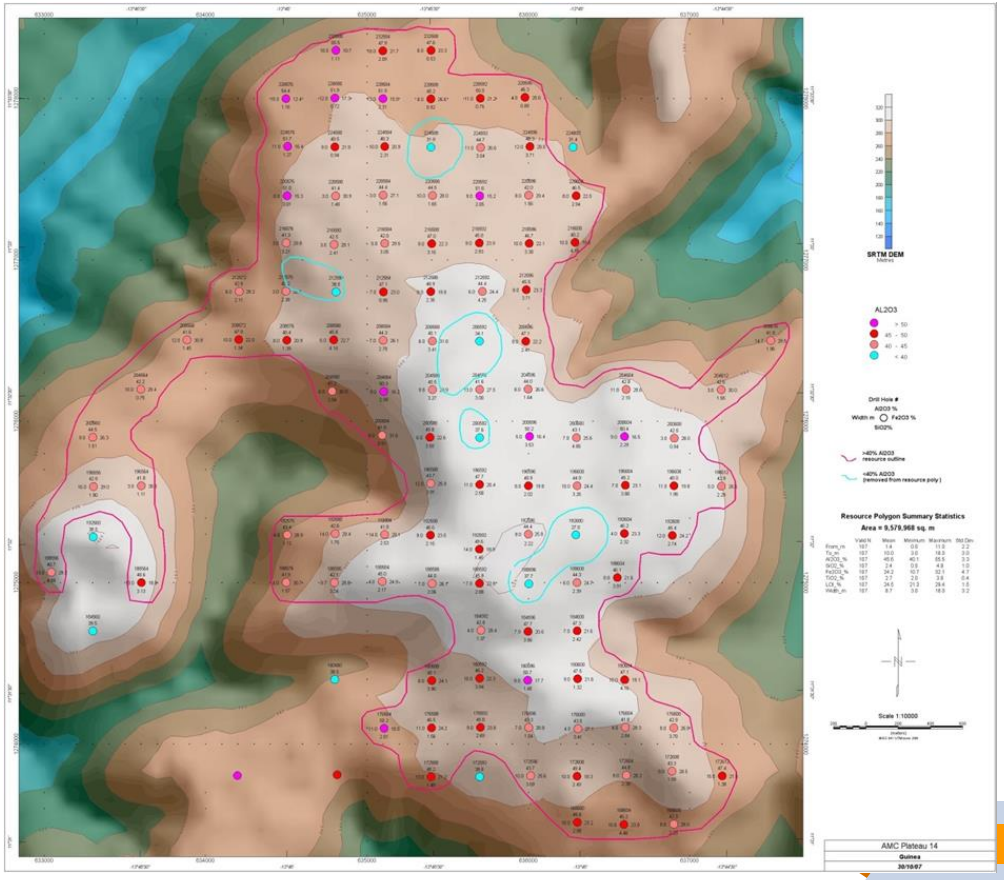
Baphlimali Bauxite Deposit of UTKAL Alumina HINDALCO

# GUNIEA BAUXITE DEPOSITES



# DISTINGUISHING FEATURES

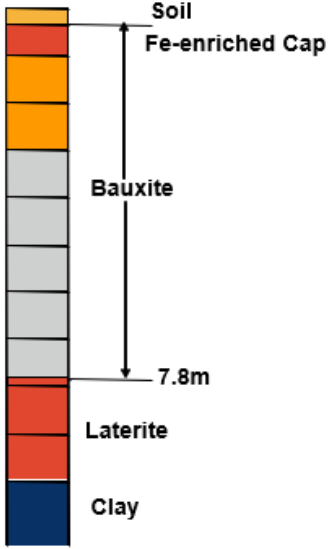
- **Guinea bauxite occurs in series of small plateaus at elevation of around 200 to 300m from MSL, whereas individual Odisha bauxite deposit is mostly confined in a large single high level plateau of 1000 to 1400 m.**
- **The orebody of Guinea deposits run almost parallel to the topography of plateau, whereas Eastern Ghats deposits have highly undulating roof and floor.**
- **Strangely in most of Guinea deposits silica content remains low even with low alumina, whereas in Odisha silica content shoots up at the upper and lower contacts with non-ore.**

# GUINEA - OVERVIEW

1. **Low Lying Bauxite Plateaus about 200 to 300m above MSL compared to Odisha and Andhra Bauxite, located at 1000m and above.**
2. **Widespread occurrence, easy access and lateritic bauxite is available within 15 meter from surface.**

# GUINEA BAUXITE- OVERVIEW (CONTD)

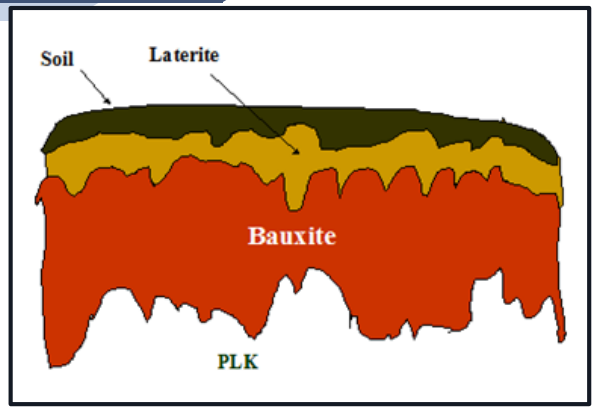
| Depth m | $TAl_2O_3$% | $Fe_2O_3$% | $TSiO_2$ |
|---|---|---|---|
| 1 | 37.94 | 33.4 | 3.32. |
| 2 | 41.30 | 29.88 | 2.04 |
| 3 | 43.33 | 27.53 | 1.25. |
| 4 | 46.02 | 23.44 | 1.44 |
| 5 | 48.52 | 20.32 | 1.59 |
| 6 | 49.22 | 19.01 | 1.55 |
| 7 | 49.15 | 19.05 | 1.52 |
| 8 | 46.83 | 22.78 | 1.56 |
| 9 | 35.02 | 34.71 | 7.14 |
| 10 | 34.70 | 36.24 | 7.81 |
| 11 | 33.95 | 16.93 | 31.84 |




**Guinea**

# EASTERN GHATS BAUXITE - OVERVIEW

1. High level mostly elongated plateaus located at 1000m and above MSL.
2. Highly undulating roof and floor




# GUINEA & EG BAUXITE- OVERVIEW (Contd.)

1. Guinea bauxite can be easily accessed and mined by surface miner or drilling – blasting. Presently Odisha bauxite are only exploited by drilling-blasting.
2. The normal bauxite thickness is only 8 meter in Guinea, whereas Eastern Ghats bauxite has average thickness of 12 to 14m.
3. Guinea bauxite is amenable to simple dry beneficiation process and iron, particularly in the form of Goethite and silica as Kaolinite can be partly removed by rejecting fines. Not much beneficiation work has been done on Odisha bauxite.
4. Guinea bauxite is slightly harder and have bond work index of about 11 to 12 kWh/ton compared to 9-10kWh for Panchpatmali bauxite.

# Drill Blast vs Surface Miner

# GUINEA & EG BAUXITE- MINERALOGY

1. **Some of the sedimentary bauxite of Guinea have fairly high boehmite (4-5%) content and about 2 units of alumina locked up in this mineral. EG bauxite has low boehmite and about 1unit Al2O3 is locked up in alumo-goethite.**
2. **About 50% silica is found in the form of Kaolinite (reactive) in Guinea compared to 80% in EG. Therefore, Guinea bauxite is preferred by alumina plants.**
3. **There is high Goethite-Hematite ratio in Guinea causing settling issues in alumina plants and consumption of specialty chemicals / flocculants increases.**
4. **Some Guinea bauxite also has Andalusite, Sillimanite and Pyrophyllite, which decreases value of ore.**

# Typical Chemical and Mineralogical Composition of Guinea Bauxite

| Chemical Constituent | Typical Value% |
|---|---|
| Total $Al_2O_3$ | **45.2** |
| Total $SiO_2$ | **2.2** |
| $Fe_2O_3$ | **23.5** |
| $TiO_2$ | **2.0** |
| LOI (105 to $1000^0C$) | **24.6** |
| Available Alumina | **40** |
| Reactive Silica | **1.2** |
| Organic Carbon | **0.09** |
| Moisture ($105^0C$) | **9.5** |

| Constituent | Mineral Phases | Distribution% |
|---|---|---|
| **%$Al_2O_3$** | Gibbiste | **40.5** |
| | Boehmite | **2.1** |
| | Kaolinite | **0.6** |
| | Alumogoethite | **1.9** |
| **%$SiO_2$** | Kaolinite | **0.7** |
| | Quartz | **1.5** |
| **%$Fe_2O_3$** | Hematite | **4.5** |
| | Alumogoethite | **19.0** |
| **%$TiO_2$** | Rutile | **0.5** |
| | Anatase | **1.5** |
| **%LOI** | Gibbiste | **21.5** |
| | Boehmite | **0.4** |
| | Kaolinite | **0.2** |
| | Alumogoethite | **2.5** |

# Typical Chemical and Mineralogical Composition of Pachpatmali EG Bauxite

| Chemical Constituents | Typical Value % |
|---|---|
| Total Al2O3 | **44.3** |
| Total SiO2 | **2.3** |
| Fe2O3 | **26.0** |
| TiO2 | **2.2** |
| LOI (105 to 1000°C) | **23.9** |

| Constituents | Mineral Phases | Distributions % |
|---|---|---|
| % Al2O3 | Gibbsite | **41.5** |
| | Kaolinite | **2.0** |
| | Alumogeothite | **0.8** |
| % SiO2 | Kaolinite | **2.3** |
| % Fe2O3 | Hematite | **16.0** |
| | Alumogeothite | **8.9** |
| % TiO2 | Rutile | **0.3** |
| | Anatase | **0.8** |
| % LOI | Gibbsite | **22.0** |
| | Kaolinite | **0.7** |
| | Alumogeothite | **1.1** |

# GUINEA & EG PROCESSING CHARACTERISTICS

1. Guinea bauxite with 40 to 44% A.Al and 1.2-1.5% R.Si can be considered best raw ore in the world for alumina production.
2. The main processing issues of Guinea bauxite are high Goethite-Hematite ratio, which causes settling issues in the refinery and require use of special settling aids /chemicals.
3. As about 50% silica is in the form of Quartz in Guinea bauxite, this causes abrasion in pipelines in refineries.
4. EG bauxite on the other hand have 80% silica as R.Si and this vary from 3 to 4% in feed bauxite causing high caustic consumption.
5. Silica content shoots up in EG bauxite if proper care is not taken while mining in the floor.

# Bottom Bench of Typical Eastern Ghats Bauxite

# GUINEA BAUXITE MINES

| S.No. | Bauxite Mine | Resources (Approx.) | Present Mining Capacity in Mt/annum | Quality ROM %Al2O3/ %SiO2 | %Available Alumina / %Reactive Silica | Infrastructure | Shipment Sizes in Tonnes | Market Value / FOB Cost/Present Selling Price US$/tonne (Approx.) |
|---|---|---|---|---|---|---|---|---|
| 1 | CBG, Sangareddi | 8000 | 18.0 | 48-50/1.5-2.0 | 42-46/1.2-1.6 | Rail Line & Port | 60,000 | High value/23/34 |
| 2 | CBK, Kindia | 200 | 3.1 | 44-45/3-3.5 | 40-41/1.5-1.8 | Rail Line & Port | 50,000 | Medium value/20/31 |
| 3 | Fria Bauxite Mine | 700 | 1.0 | 44-45/2-2.5 | 41-42/1.4-1.6 | By Trucks to Plant | Alumina | Reserved for Alumina Plant |
| 4 | GAC/EGA, Boke | 1400 | 3.0 | 45-47/1.8-2.2 | 41-43/1.2-1.6 | Rail Line & Port | 60,000 to 100,000 | Medium value / 16/32 |
| 5 | COBAD, Boke | 2000 | 3.0 | 46-48/1.8-2.2 | 42-44/1.4-1.6 | Barges & Rail Line | 60,000 to 100,000 | High value/22.7/33 |
| 6 | Alufer, BelAir | 200 | 3.0 | 45-45/5-6 | 38-39/1.4-1.6 | Near sea coast, loading by barges | 100,000 to 200,000 | Low value/16/30 |
| 7 | SMB, Winning Group | 700 | 30 | 44-45/1.8-2.4 | 40-42/1.2-1.6 | Road & River jetty with large barges | 180,000 to 300,000 | High value /12/31 |
| 8 | CHALCO | 500 | 12 | 44-45/1.8-2.4 | 40-42/1.2-1.6 | Road & River port | 180,000 to 300,000 | Medium value/18/32 |
| 9 | AGB2A | 320 (GBT+Axis) | 3 | 46-48/3.0-3.5 | 43-45/1.2-1.4 | Trucks & River Port | 100,000 to 220,000 | Medium value/20/30 |

**%Available Alumina / %Reactive Silica** At low Temperture & Medium Pressure

# CBG: Compagnie des Bauxites de Guinee

- **Guinea's oldest Bauxite Mine, with resources of about 8 billion tons of high-grade bauxite (Alumina 48-50% and SiO2 18-2.2%)**
- **Alcoa, Rio Tinto Alcan, Dadco and Govt. of Guinea are shareholders with 49% by GoG. The GoG also owns the transport infrastructure including railway, through ANAIM, and SOGUIPAMI has the right to market about 300,000 tons bauxite per annum.**
- **Well developed mines, rails and Kamsar port infrastructure slowly increasing production and exporting about 22 million tons bauxite per annum.**
- **Bauxite quality, shipment size and prices are well known by alumina refineries all over the world.**
- **Bauxite is mainly exported to North American and European Alumina refineries and occasional shipments are traded to India, China and other countries.**
- **Only company in Guinea that can dry bauxite and supply ore with 6% moisture content throughout the year.**
- **CBG's mines may run for decades or more, although high grade Sangaredi sedimentary bauxite has been depleted.**

# CBK: Compagnie des Bauxites de Kindia

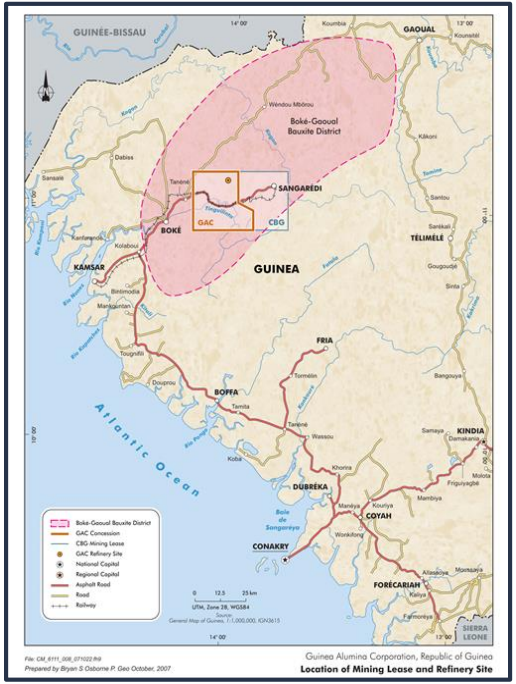
- **Second oldest bauxite mine, 100% owned and operated by RUSAL.**
- **Kindia bauxite is slightly different from Boke bauxite: lower alumina content (44-45%) and higher silica (about 3%); however, this is a soft bauxite, devoid of any boehmite.**
- **Annual production capacity of 3.1 million tons of bauxite. 65 percent of total bauxite output earlier supplied to the Nikolaev alumina refinery in Ukraine. Now the project is in trouble.**
- **The high-grade bauxite resources are depleting. However, CBK has a large license area and is exploring new deposits.**
- **Bauxite is transported by railway to Conakry, then exported from the port through maximum shipment sizes of 60,000 tons.**
- **The Conakry port would require important improvements to welcome large capsized vessels.**
- **RUSAL has a 25-year term to operate CBK mines, until 2026.**

# FRIA BAUXITE MINE & ALUMINA REFINERY

- **This is also one of the oldest bauxite mines and only alumina refinery of Guinea, presently run by RUSAL.**
- **Fria's bauxite mine has resources of more than 700 Mt. However, the requirement of alumina refinery is only about 1 million ton per annum.**
- **Fria alumina refinery was built in 1960 by Aluminium Pechiney (AP), France and alumina is produced by atmospheric digestion process, which is now obsolete. Present plant capacity is only 0.40 Mtpa.**
- **AP had built one of the alumina plants in India (NALCO) based on the same technology in 1982. The technology has since improved and NALCO now produces 2.1 Mtpa, expanding to 3.1 Mtpa Alumina.**

# GAC: Guinea Alumina Corporation / EGA: Emirates Global Aluminium'

- GAC/EGA now owns a former part of the CBG concession, initially developed by Global Alumina and BHPB to build a large alumina refinery.
- The bauxite resources of GAC deposits are in the order of 1.4 billion tons. GAC currently exports about 12 Mtpa bauxite with 46-47% alumina and 2.5% silica.
- GAC has developed a multi-user port terminal and a commercial quay in Kamsar. It improved the rail network connecting the mining sites.
- GAC began bauxite exports to India and China in 2019, and presently expanding mines.
- EGA has built a 2Mtpa alumina refinery in Abu Dhabi based on bauxite from CBG.

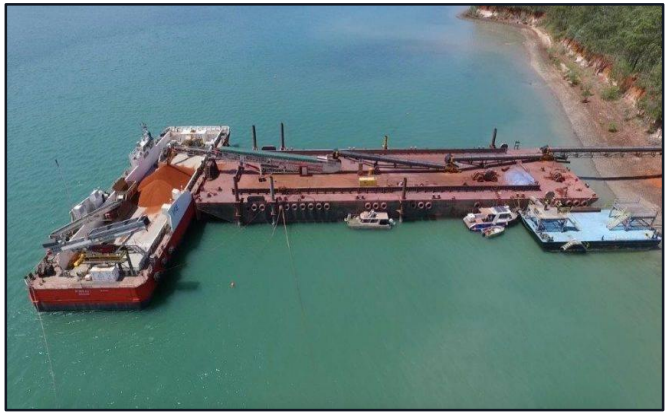


# SMB: Société Minière de Boké

- **Formed in 2014, the SMB Winning Consortium has completely changed the landscape of bauxite mining in Guinea.**
- **SMB has developed 3 large river jetties and today exports more than 35 Mtpa.**
- **SMB started with low grade bauxite and now exports 45-46% alumina and <2% silica bauxite at the lowest production, transportation and freight costs. Acquired some high grade deposit (Houda) also.**
- **Thanks to economies of scale and the use of large cape size vessels, it is estimated that their FOB bauxite cost may not exceed US$ 12 per ton.**
- **SMB mainly supplies bauxite to Weiqiao's own alumina refineries, but also third-party alumina refineries in China.**

# CHALCO

- **CHALCO built bauxite mining and export operations in Boffa after taking over mining licenses formerly developed by BHP Billiton.**
- **CHALCO started bauxite mining in 2018 and presently exporting about 12 Mtpa to their Chinese alumina refineries.**
- **CHALCO is also using large capsized (about 200,000 tons) time charter vessels and exporting fair quality bauxite (Alumina 45% and <2% silica).**
- **Its large river jetty is located near the bauxite mines, so the FOB cost of bauxite must be less US$15 per ton.**



# AGB2A: Association Guinéenne de Bauxite, d'Alumine et d'Aluminium

- **AGB2A, a Guinea based company, produces one of the best metallurgical grade bauxite (46-48% Alumina and <3% silica) by dry beneficiation process involving crushing and screening of ore.**
- **In the process of beneficiation about 50% high silica fines are generated and thus mining cost of this bauxite is quite high compared to other operations.**
- **AGB2A had started bauxite export from its Kokaya port (Boffa) with an agreement to extract minerals from the nearby concession of GBT and Axis Minerals. However, operation is closed at present.**


# SUGGESTIONS- DEVELOPMENT OF EG BAUXITE

1. The third-party sale of bauxite can be challenging for alumina industry as each plant have specific processing parameters and changing quality harms the productivity. Captive bauxite mine for each alumina plant not only helps in improving production and productivity but also conserve valuable resources.
2. Use Natural cut off values of alumina and silica to demarcate the orebody in EG Deposits.
3. All the overburden, aluminous laterites and high silica bauxite can be used after the dry beneficiation.
4. In order to increase the reserves in mine and conserve resources, bauxite quality for refinery should be reviewed and fixed every year.
5. Use solar drying system to bring down the moisture content in bauxite as being practiced in Brazil.

# CONCLUSIONS

1. **Guinea is endowed with large bauxite resources and offer good opportunity for export of quality bauxite and set up alumina refinery.**
2. **A systematic development of Eastern Ghats bauxite offers an opportunity to produce 40 to 50 Mtpa compared to 90Mtpa in Guinea.**
3. **Going forward it will be necessary to use all the overburden, aluminous laterites and high silica bauxite of EG by adopting suitable beneficiation process.**
4. **A grade control drilling, systematic quality control system and long / short term mine plan can reduce day to day fluctuation in bauxite quality supplied to refinery.**

# Thank You

**Dr. Ashok Nandi, President**

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