

RAW MATERIALS UNIVERSITY DAY

Future, needs and opportunities



Bauxite- Alumina-Aluminium

Vicky Vassiliadou

Laboratory and Quality Manager Aluminium S.A.

BAUXITE

Geology of Bauxite

Bauxite ore is the most abundant element found in the earth's crust, although the word bauxite is used to describe any material that contains more than 32 percent alumina.



A Bauxite rock with impurities

http://www.hs.wisd.org/ddaughenbaugh/Pictures/alcoa_aluminum_smelter_and_mine.htm

Geology of Bauxite

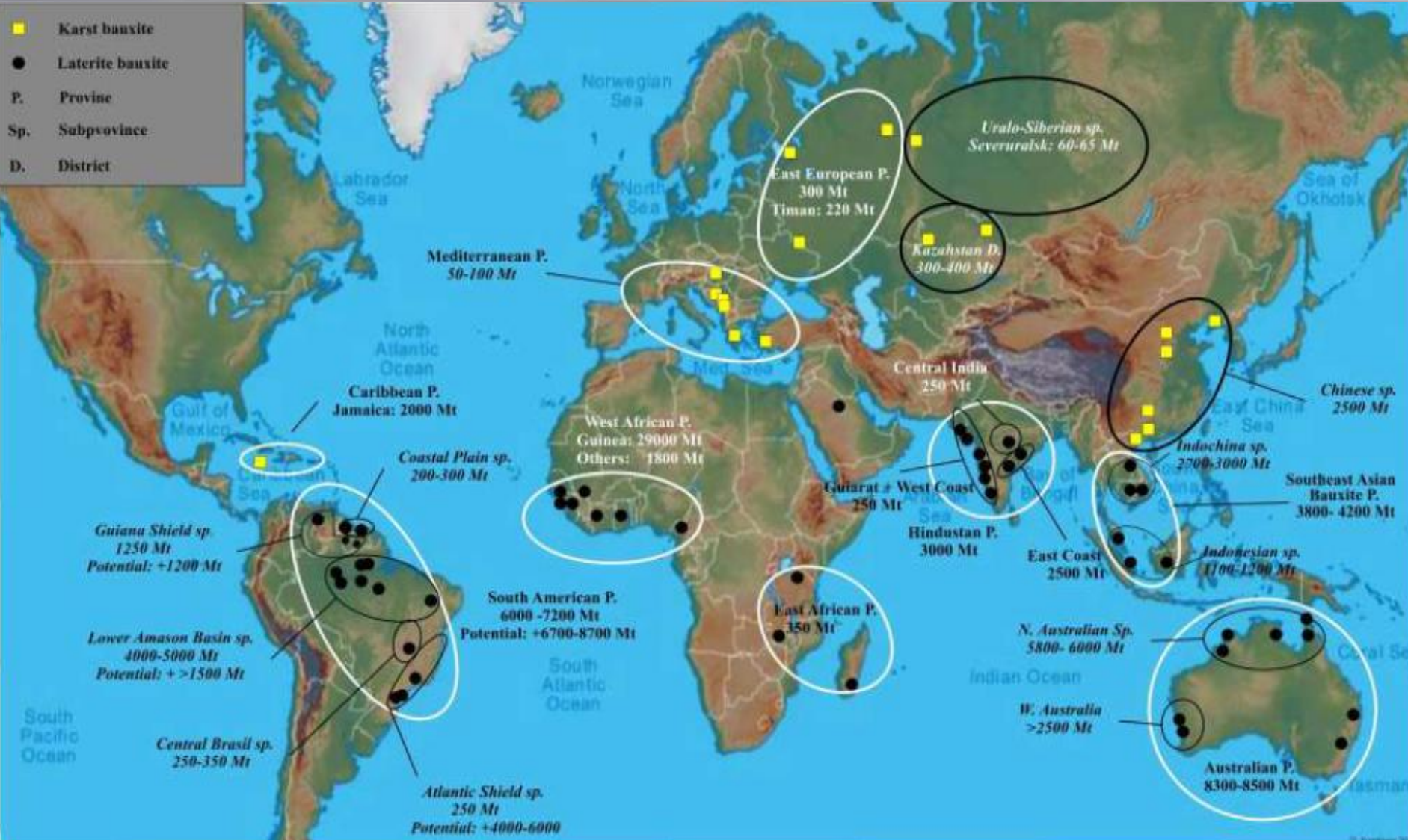
- There are three main structural types of bauxite:
 - » Gibbsite
 - » Böhmite
 - » Diaspore
- Each of these three types of bauxite has different characteristics that make them more or less desirable for mining and metallurgical purposes

Geology of Bauxite

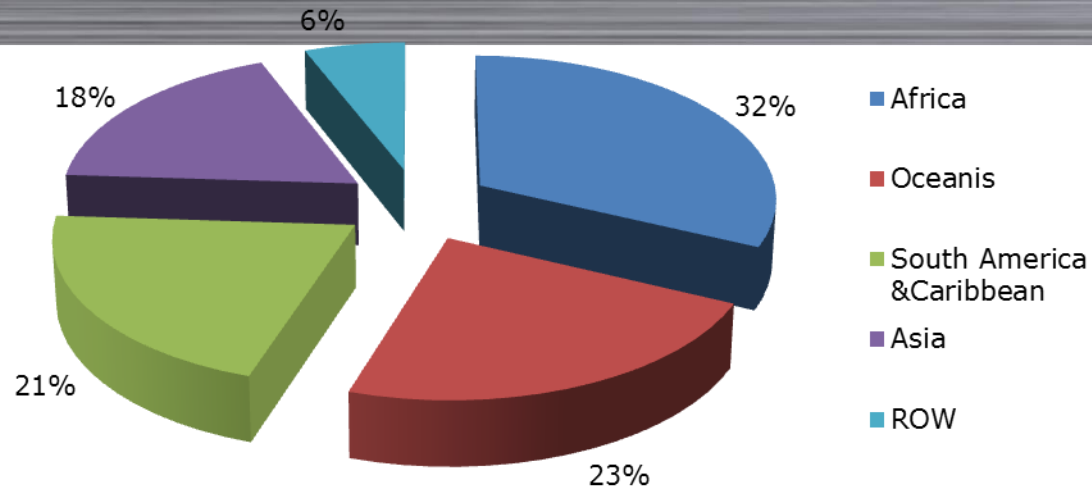
- The three structural differences of Bauxite can be further categorized into two groups, the difference being in the water content of each :
 - » Monohydrates
 - » Trihydrates
- Trihydrates are comprised of mainly gibbsite and böhmite and are found in Latin America and Caribbean areas.
- 90% of the world's bauxite reserves are concentrated in tropical and sub tropical regions flat layers lying near the surface and may cover many miles - the average thickness of these layers is 4-6 meters .

Bauxite Resources

- Karst bauxite
- Laterite bauxite
- P. Province
- Sp. Subprovince
- D. District



Bauxite Resources (source: USGS 2014)



Bauxite resources are estimated to be 55 to 75 billion tons with the depicted distribution

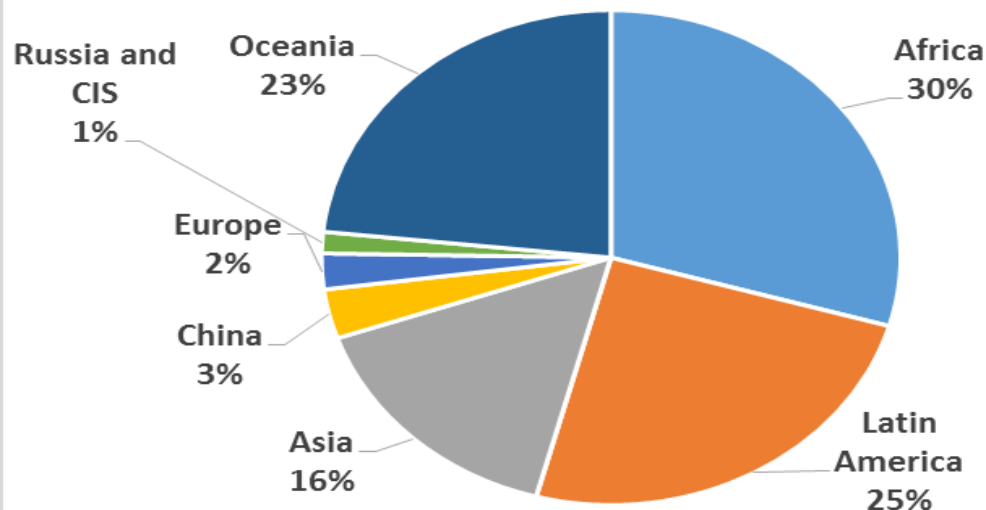
***World Resources:* in Africa (32%), Oceania (23%), South America and the Caribbean (21%), Asia (18%), and elsewhere (6%).**

World Bauxite Reserves

Bauxite reserves (UGSG 2014) are about 28 billion tons

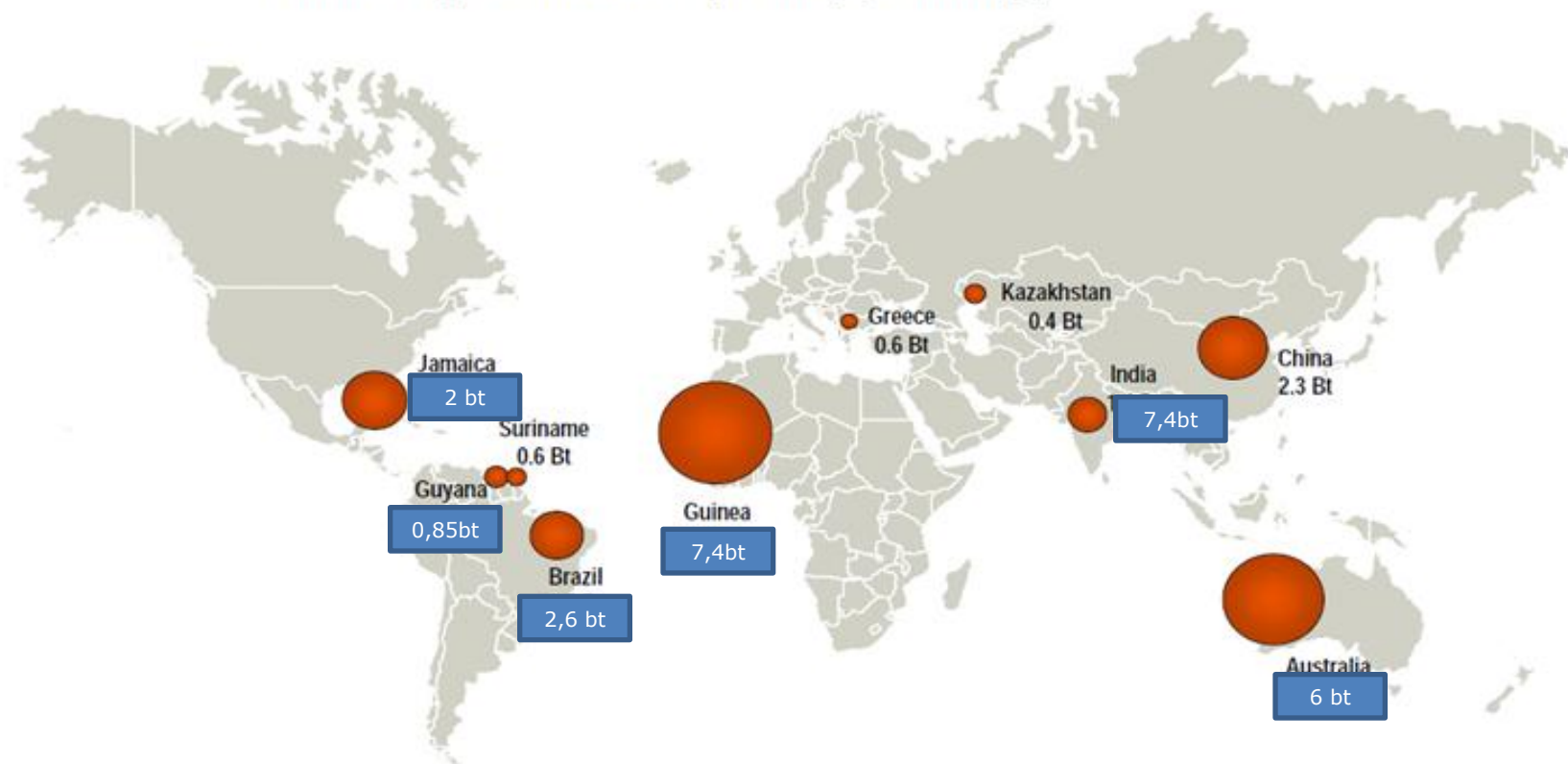
The world's bauxite reserves are concentrated in a small number of countries.

- Guinea and Australia alone account for almost half of the world's bauxite reserves.
- With Jamaica and Brazil, those four countries hold almost two-thirds of the world's bauxite reserves.
- China, Europe, Russia/CIS and the rest of Asia account for less than one-quarter of the world's reserves.



Bauxite Reserves (source: USGS 2014)

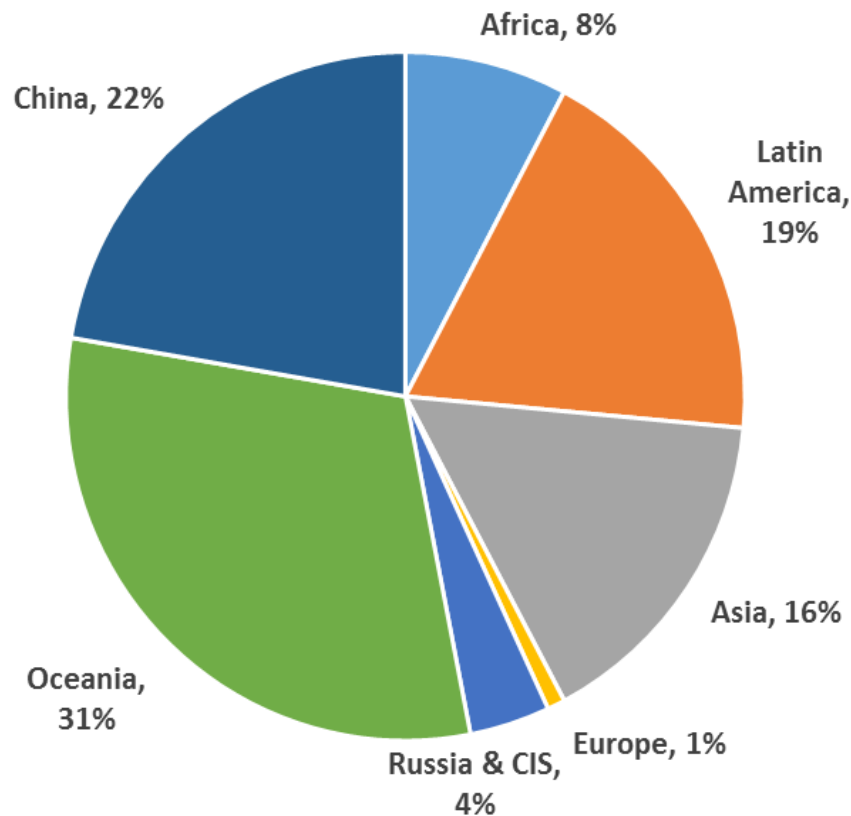
World's top 10 bauxite deposits (By country)



Source: USGS

Greece is included in the world's top 10 countries with the biggest bauxite reserves, estimated to 600 Mt

Global Bauxite production



- Global bauxite production for 2013 is around 300Mt (10times more than 50 years ago).
- Over the past decade there has been a profound change in the structure of the bauxite market.
- Competition for obtaining identified deposits or identifying new deposits prospecting better and better resources in favorable geographical position is an everyday practice.

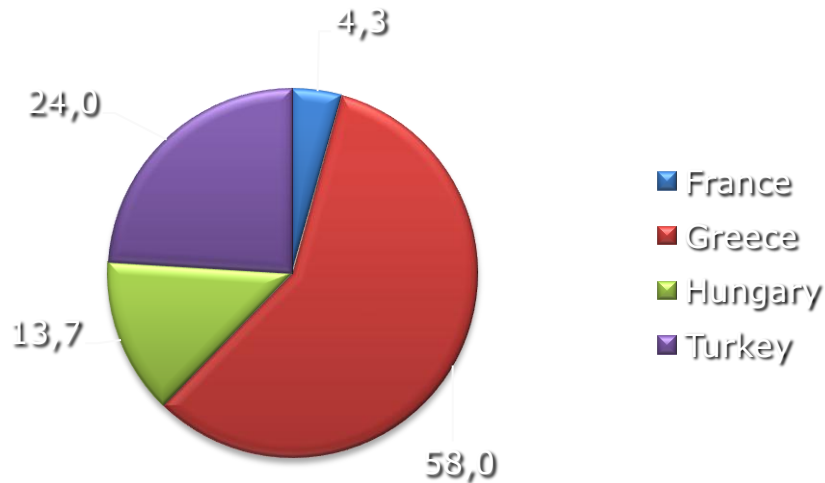
European Bauxite production

EU27 produced 1.15% of world bauxite and EU33 produces 2% of world bauxite

Greece is ranked

1st in EU27 with 85% and also 1st in EU33 with 58%

12th in the world with 1%



Bauxite Uses – Global (source: Ramintech for 2010)

| End Use Market | Distribution |
|---------------------------|--------------|
| Aluminum production | 86% |
| Non-metallurgical alumina | 10% |
| Refractories | 0,9% |
| Portland cement | 0,7% |
| Abrasives | 0,7% |
| Mineral fibers | 0,7% |
| Steel | 0,3% |
| Calcium aluminate cements | 0,3% |
| Other uses | 0,4% |

Mineral Resources Mapping in Greece



Bauxite Resources

Bauxite in Greece

The exploitation of bauxite a fundamental field of mineral wealth of Greece.

Exploitable deposits of bauxites are areas of mountain Parnassos, Giona and Helicon (central Greece) is estimated at 100 million tonnes.

Economically significant bauxite occurrences are mountains Kallidromon, Iti and Othrios, Evia, Skopelos, Eleusis, etc.

The mineralogical composition of bauxites area of mountain Parnassos-Giona is:

- Diaspore 20-50%,
- Bohemite 10-30%,
- Hematite 20-25%,
- Calcite 1-5%,
- Kaolinite 1-5% 1-2% quartz, and 0.5-2% anatase.

Bauxite production in Greece

- Greece is the 12th bauxite producer worldwide, but also the largest in E.U. zone with an annual production of about 2×10^6 metric dry tons.
- The producer companies are:
 - S & B Industrial Minerals S.A .
 - DELPHI DISTOMON
 - ELMIN S.A.

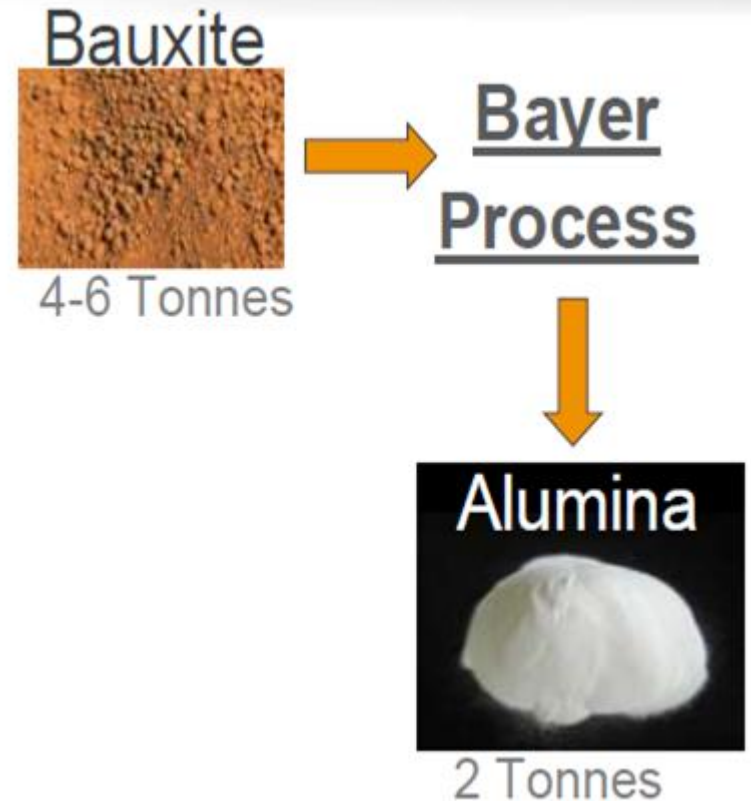
ALUMINA

Alumina Processing Method

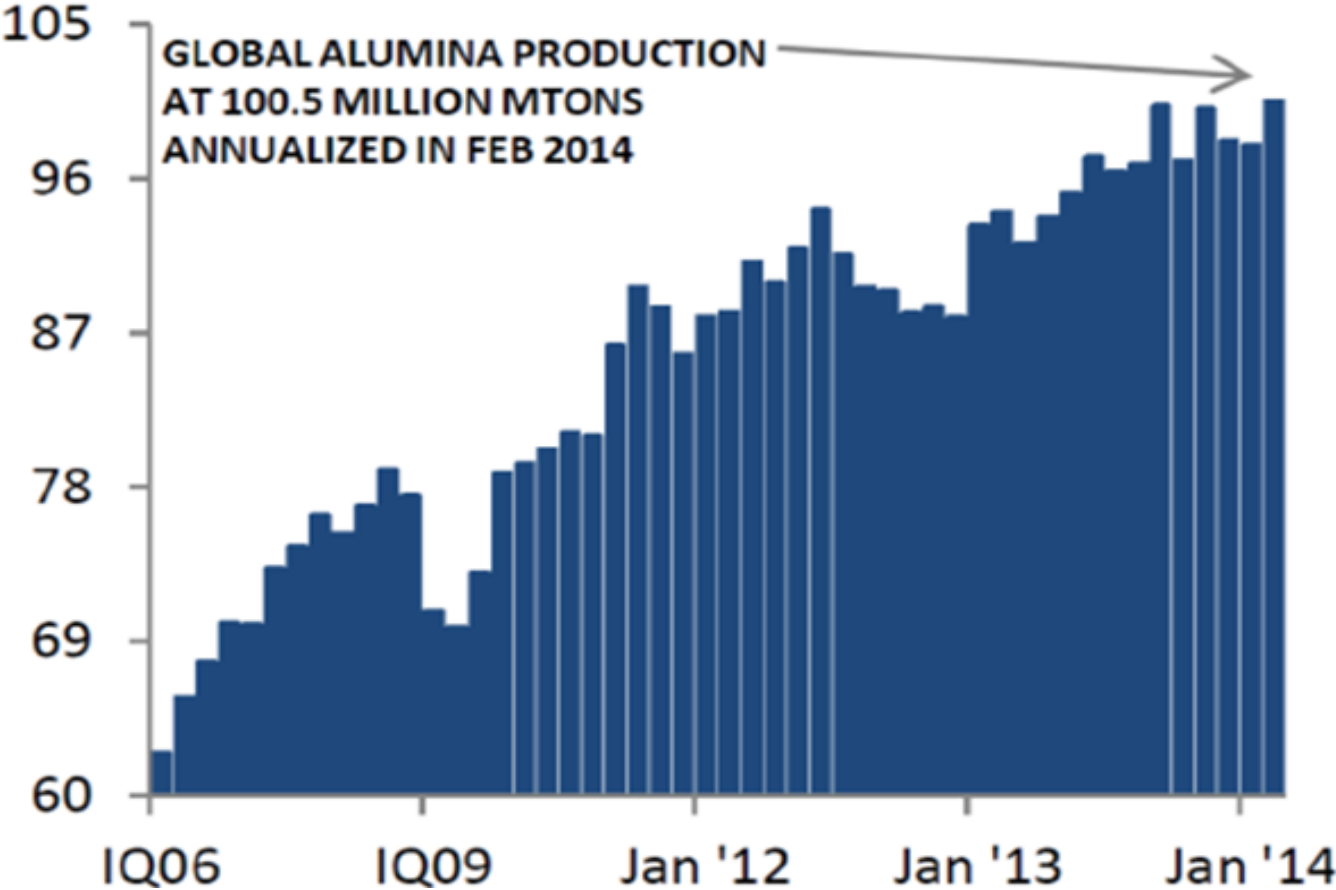
The universal industrial production practice for the production of high grade metallurgical alumina (Al_2O_3) is the Bayer process .

In the Bayer process, bauxite is digested (leached) with a solution of sodium hydroxide NaOH , at high temperature , under pressure.

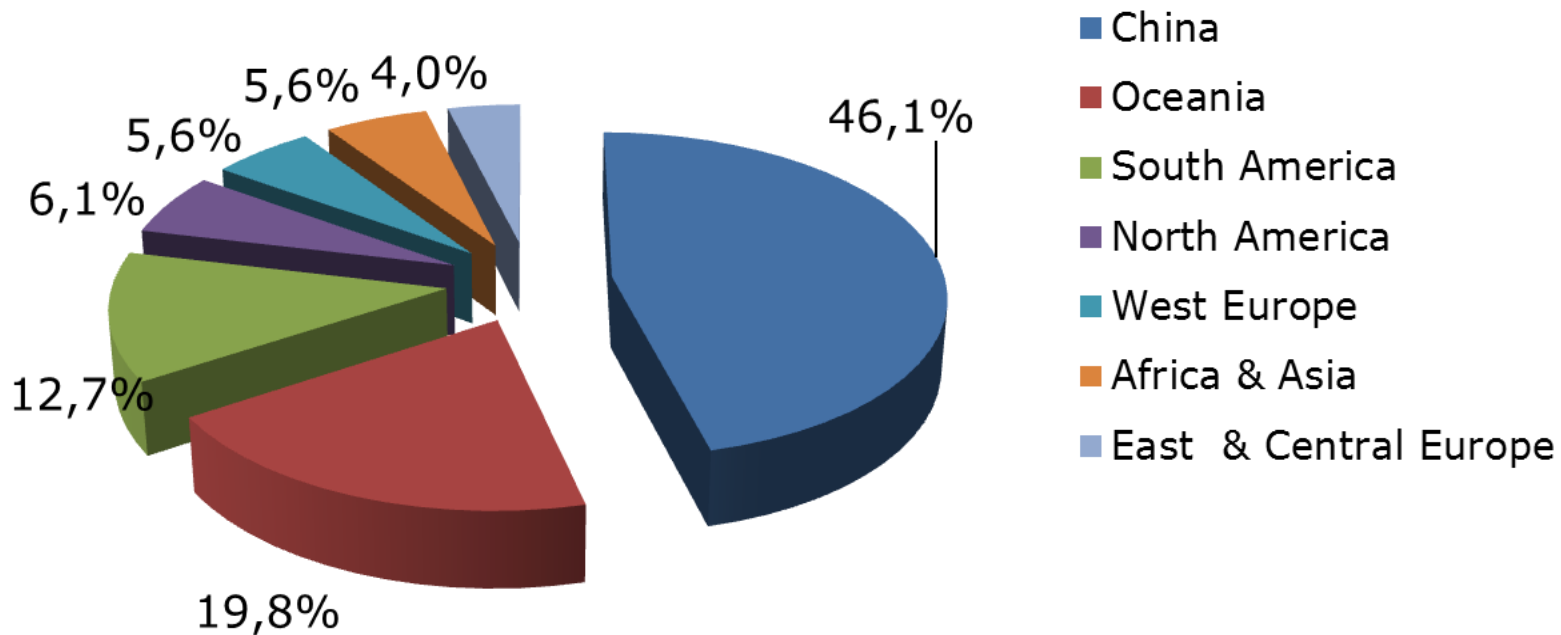
Depending of the bauxite grade the temperature varies between 145 -260 °C



Global Alumina production



Alumina global production



Greece is now considered to be the 16th alumina (Al_2O_3) producer in the world and the 4th among the European Union member-states, related to the exploitation of Al-ore (bauxite) deposits by Greek mining companies.

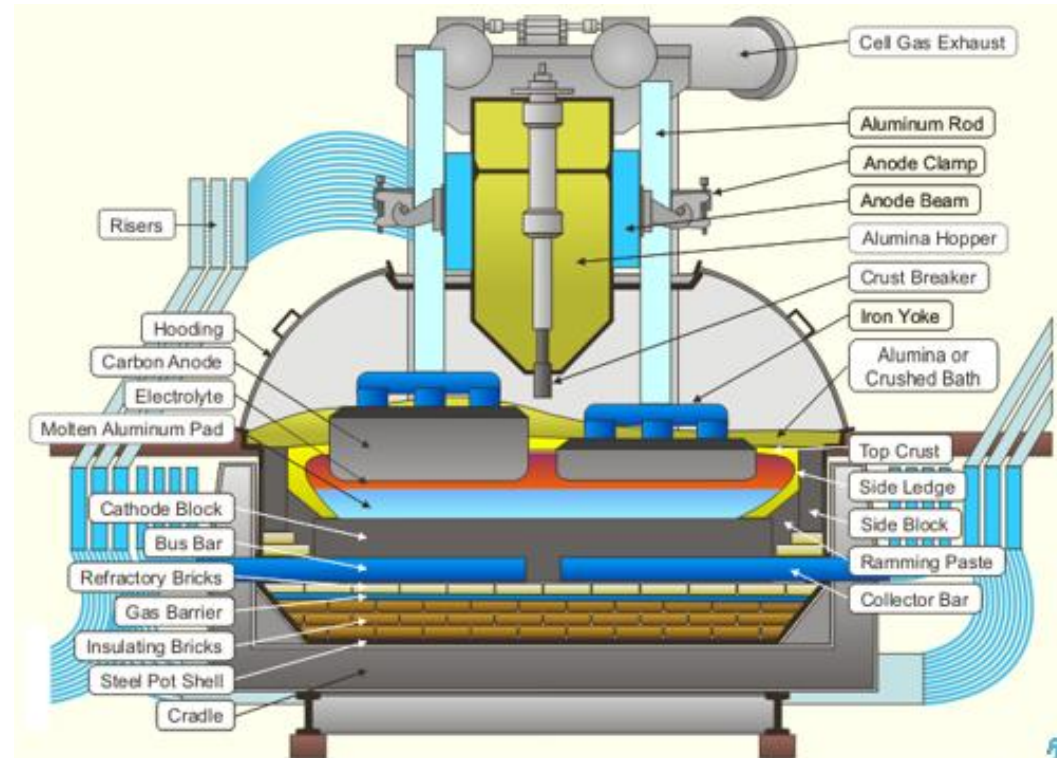
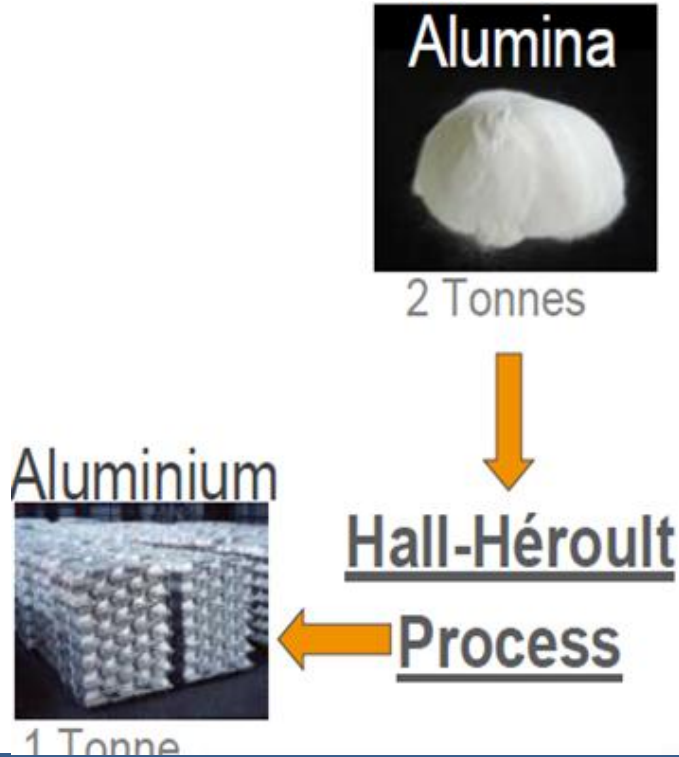
Except Greece refineries exist in Bosnia Herzegovina, France, Germany, Hungary, Ireland, Italy, Romania, Slovakia and Spain.

ALUMINIUM

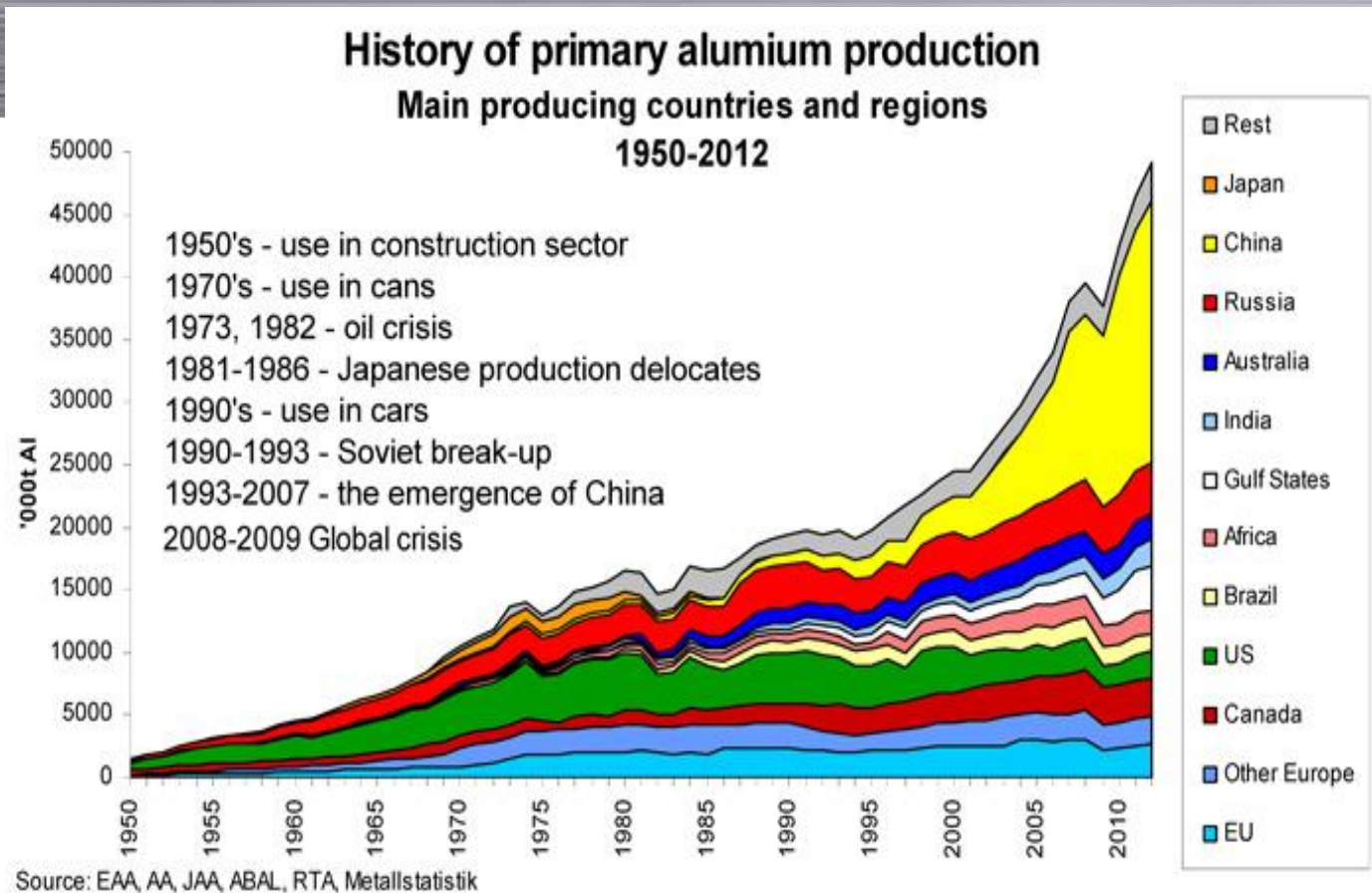
Alumina Processing Method

Aluminum Electrolysis Cell (Hall- Héroult)

The universal industrial production practice is the Hall- Héroult process which consists in the electrolytic reduction of alumina to aluminum in molten cryolite baths.

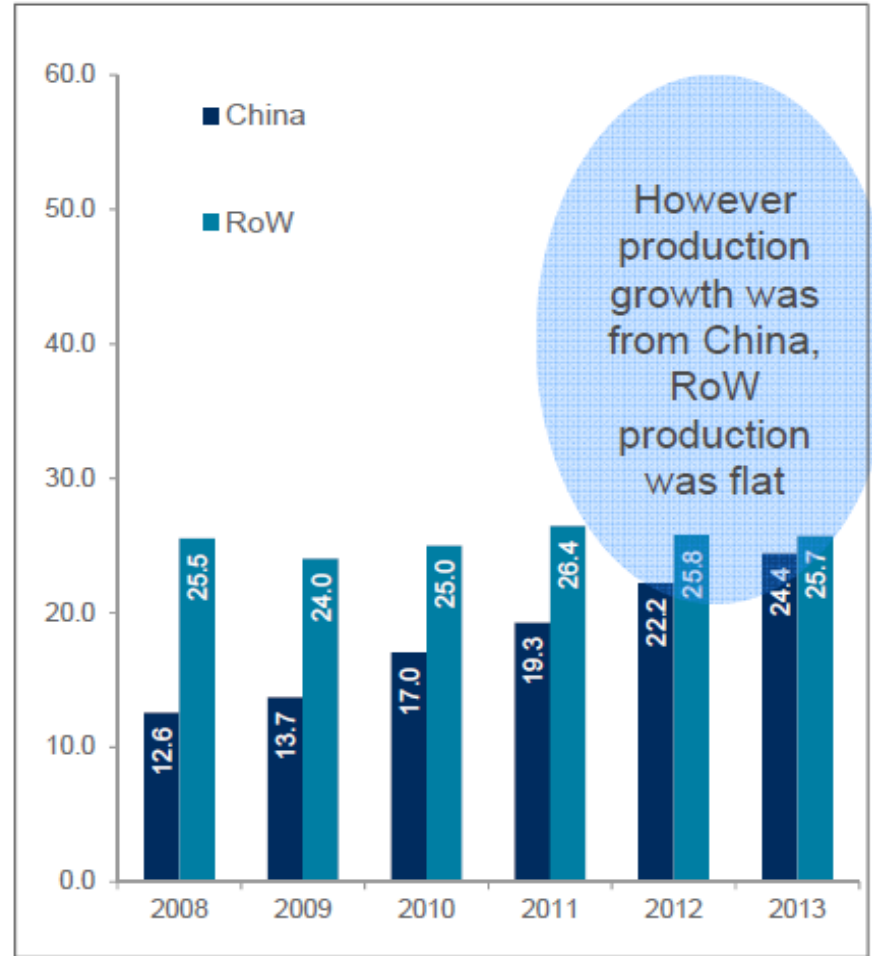
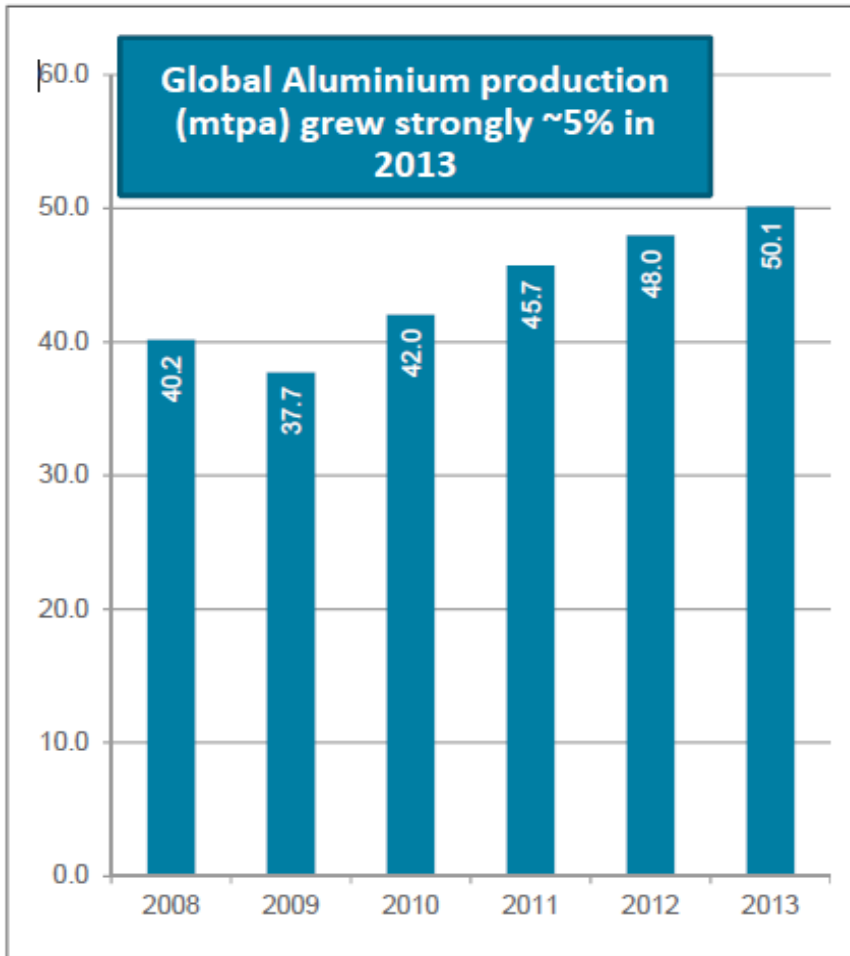


Aluminum World Production and Trends (source: EAA)



While from 2006 to 2012 World production increased by 22% in EU27 a decrease of 21% is reported this time period

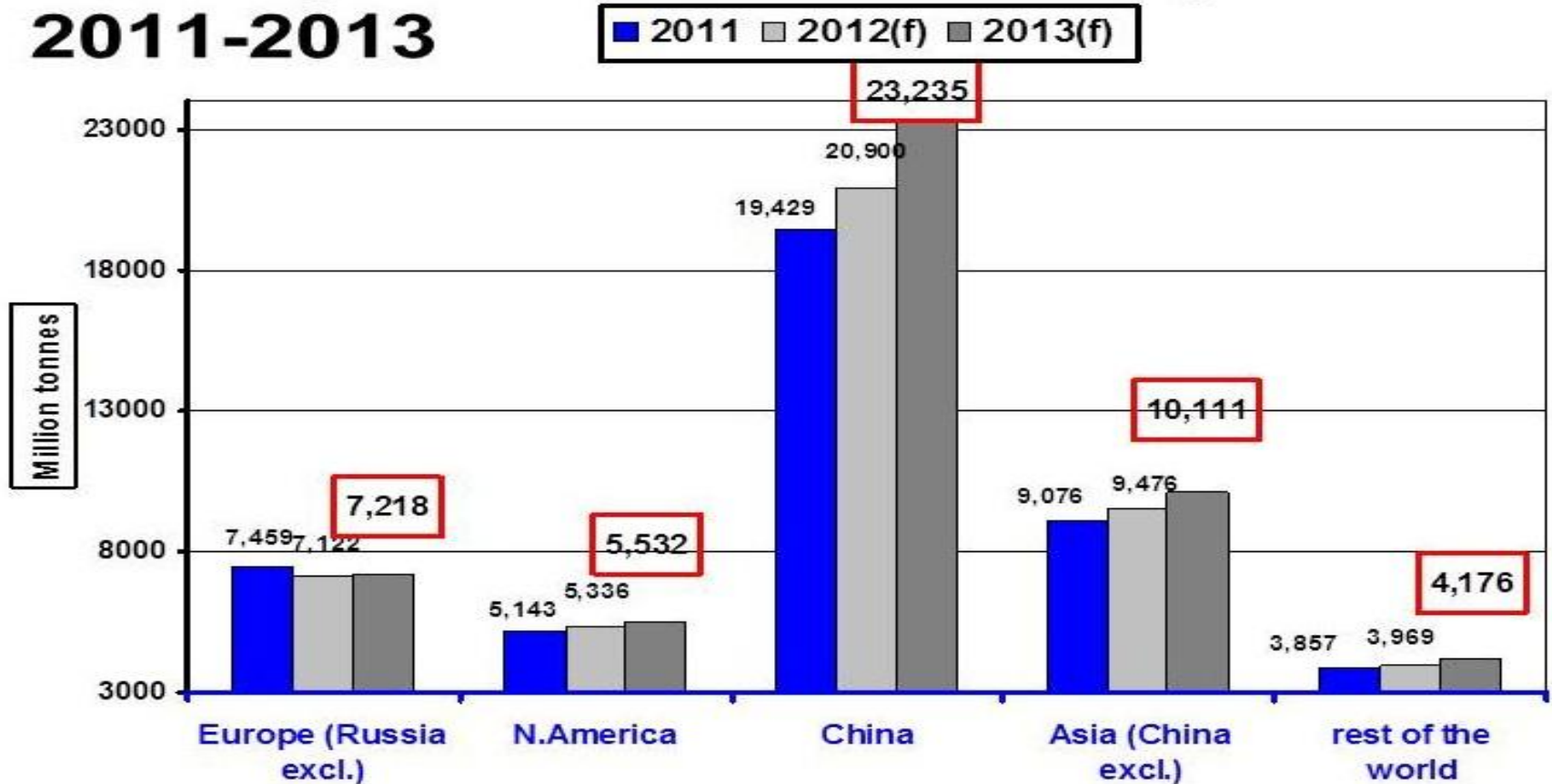
Aluminum World Production and Trends (source: CRU)



Source: CRU

Primary Aluminum World Consumption (source: EAA-CPU)

Primary Aluminium Consumption 2011-2013

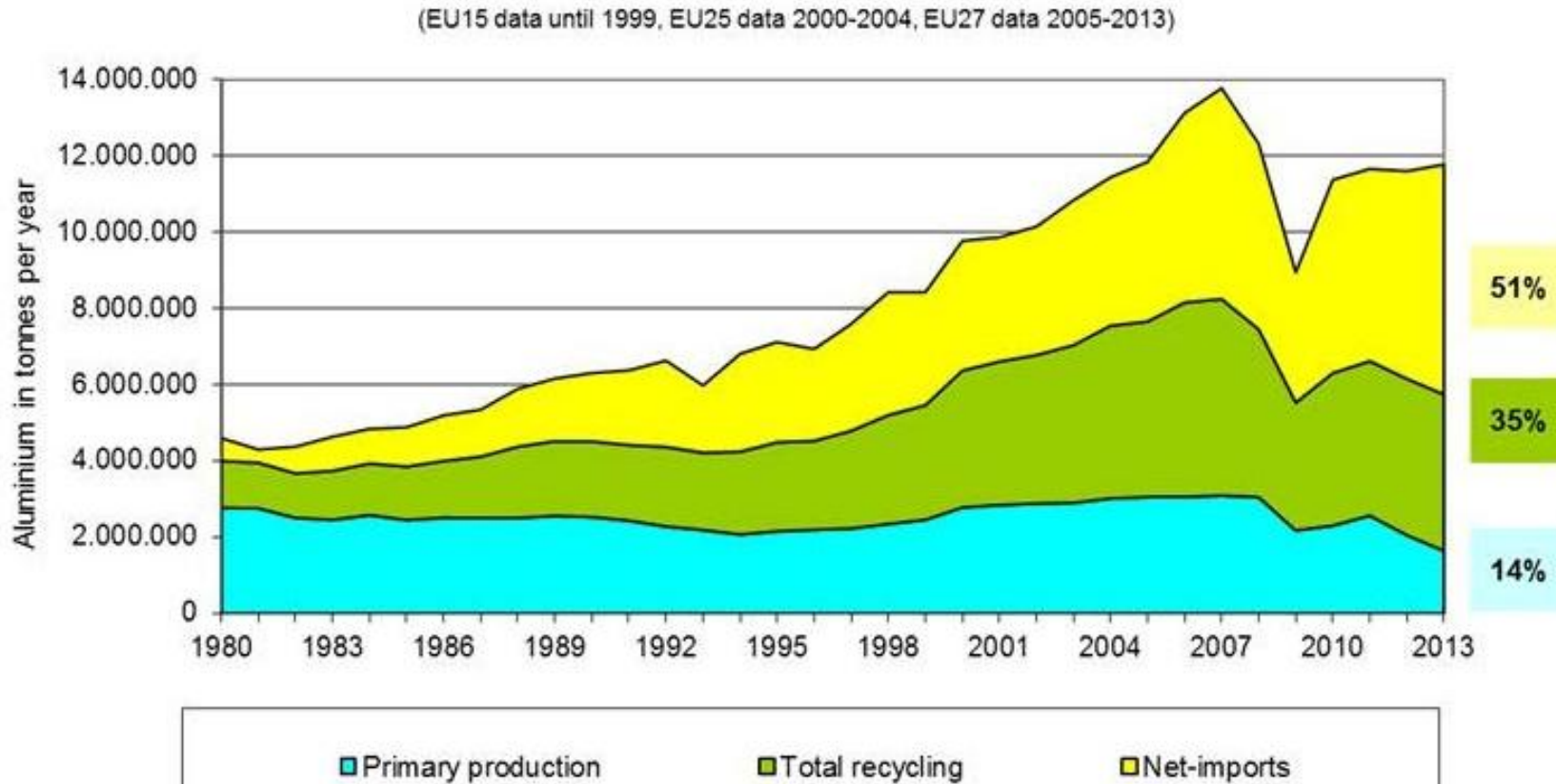


Source: EAA for Europe, CRU for other regions

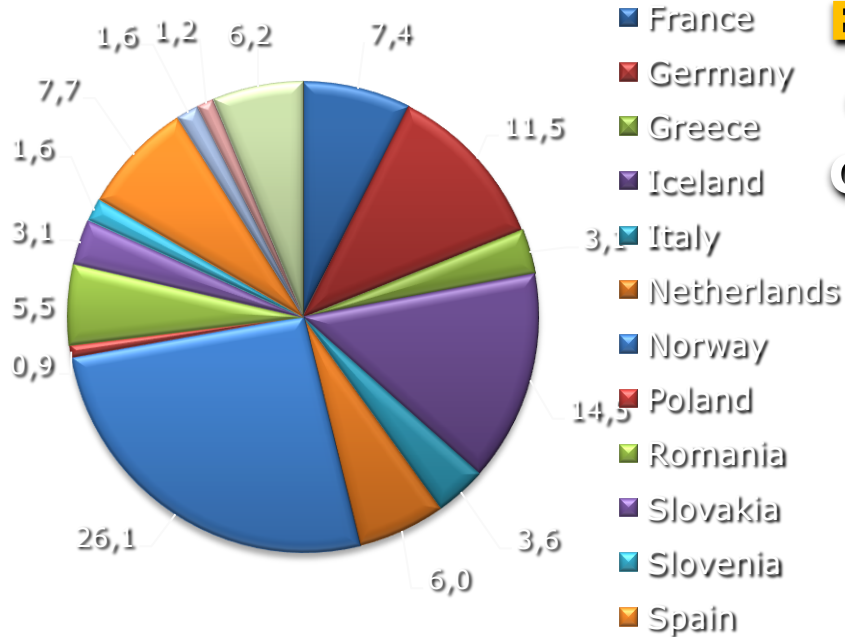
13.

China is the main user of primary aluminum worldwide, with 23.2 mil tons in 2013. Europe (7.2 mil tons) and North America (5.5 mil tons) continue to be key regions for the consumption of primary aluminum.

Aluminum EU27 Production and Trends (source: EAA)



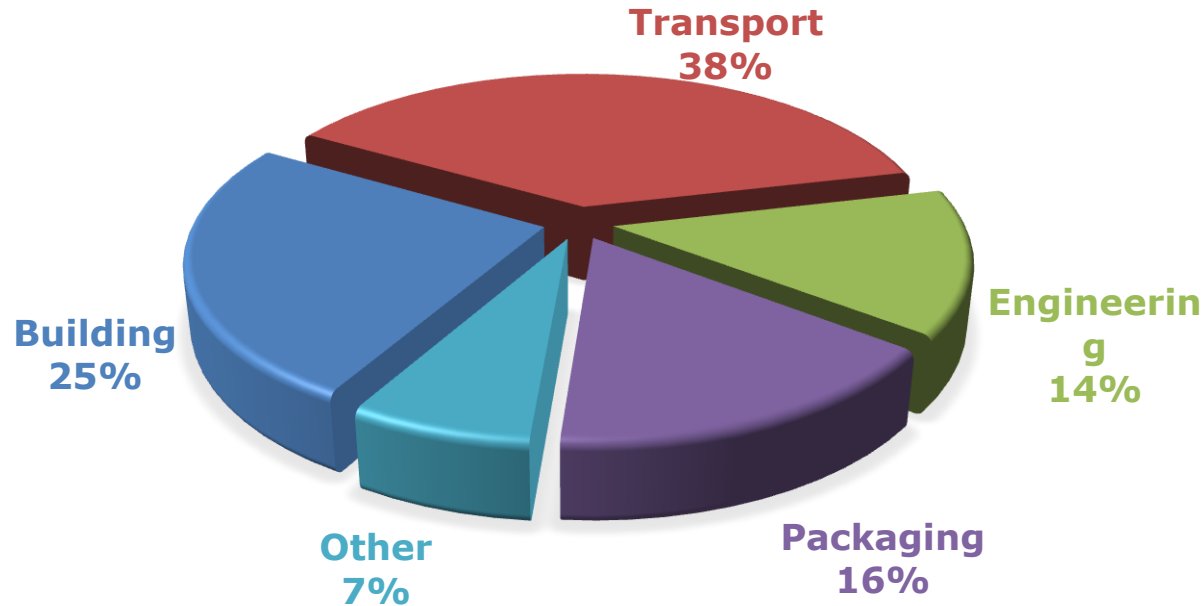
European Aluminum production



**EU33 produces 13%
of world Aluminum**

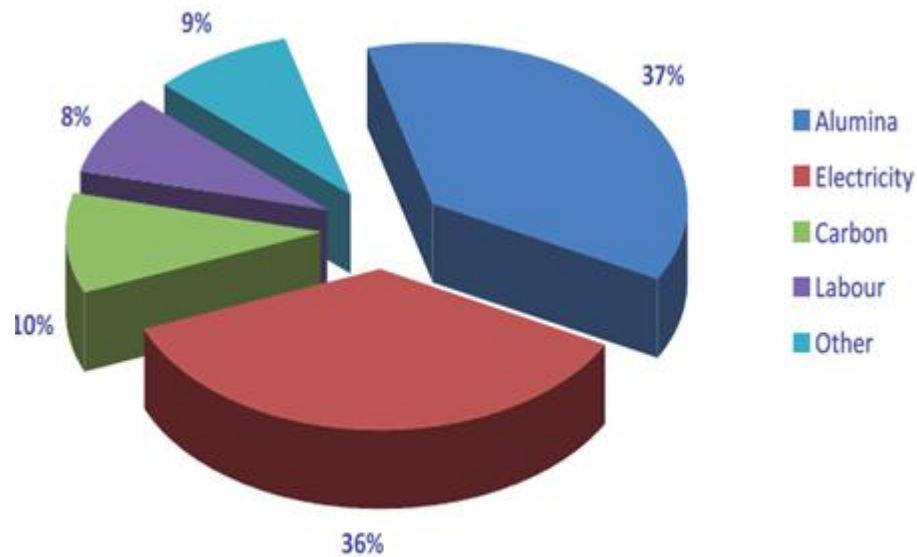
**Greece is ranked
12th in EE33
30th in the world**

Aluminum Uses in EU27 (source: EAA for 2011)



Building and transport are main end-use market for the aluminum products in Europe, each with around 1/3 of the total. The remaining part goes into applications such as electrical and mechanical engineering, office equipment, domestic appliances, lighting, chemistry and pharmaceuticals.

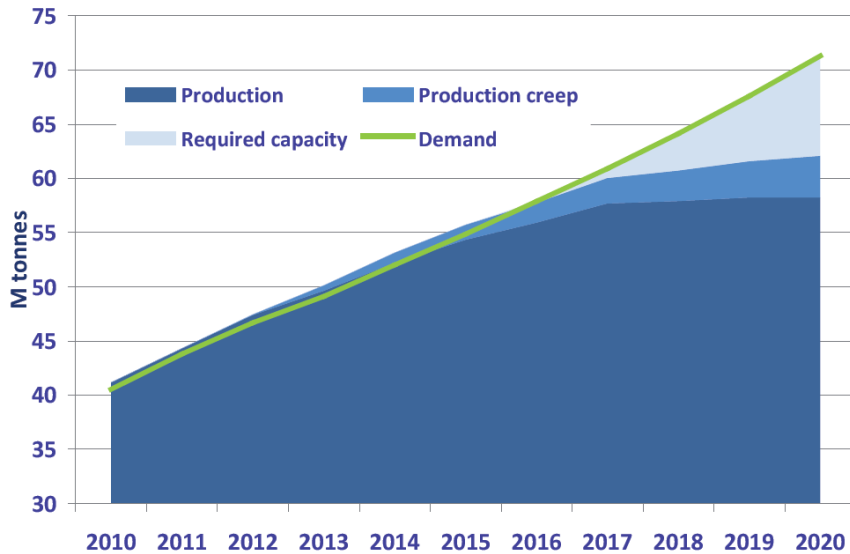
Aluminum production



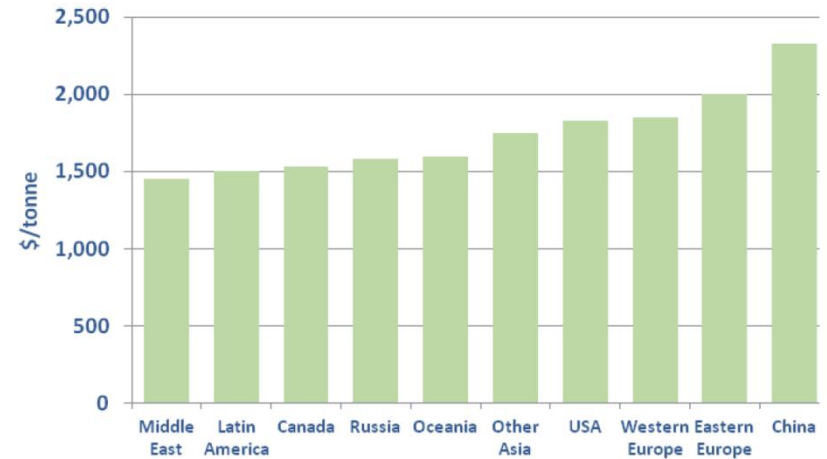
Energy and alumina are the most important cost factors in the production of aluminum.

Aluminum production and Trends

- Up to 2020 additional need for 10 Mt → New plants ?
- The combination of cheap energy with a large increase in demand will determine the location of new plants



Source: MBR



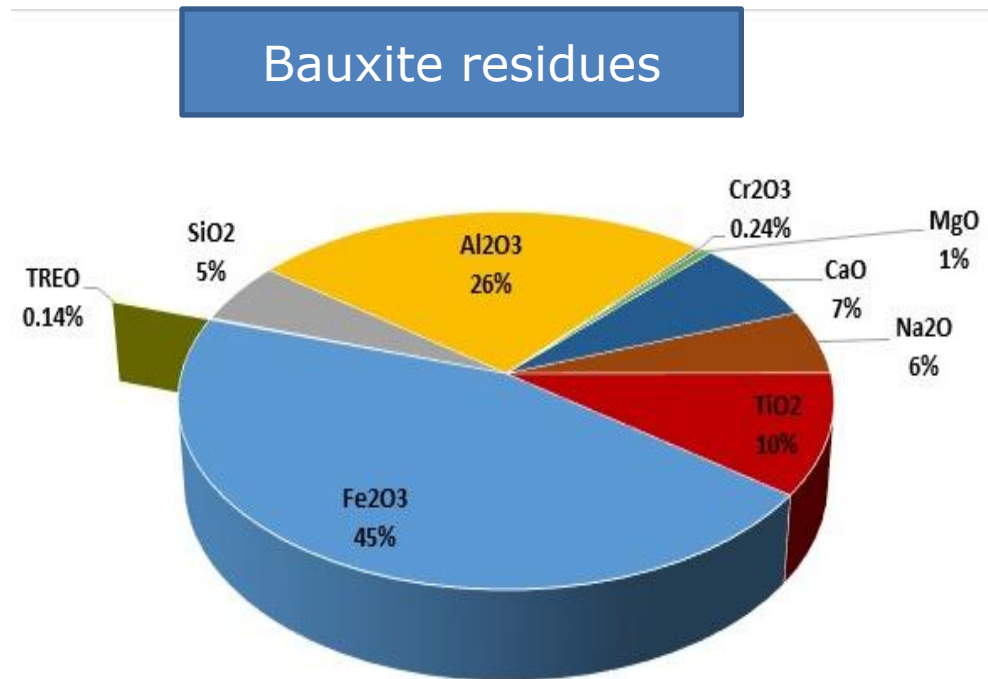
Source: MBR, Company info

BAUXITE RESIDUES

BAUXITE RESIDUES

Bauxite residue is mainly composed of iron oxides, titanium oxide, silicon oxide and un-dissolved alumina together with a wide range of other oxides which will vary according to the country of origin of the bauxite.

The actual composition of BR depends on the type of bauxite, the mining location and the process parameters of the Bayer process.



BAUXITE RESIDUES –Treatment & Disposal Technologies

- ✓ Wet disposal
- ✓ Disposal after neutralization
- ✓ Dry stacking
- ✓ Dry disposal (Filter presses)

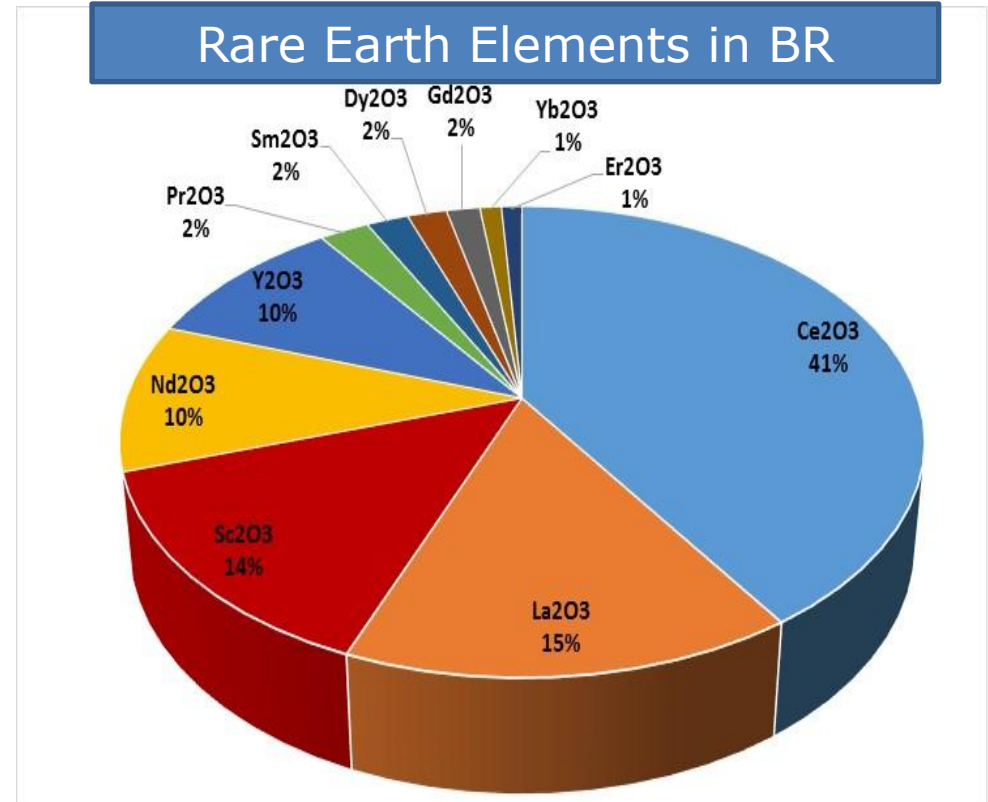
BAUXITE RESIDUES -APPLICATIONS

| Product | BR in use | Application | Comment |
|------------------------------------|--------------|--|---|
| Stabilized blocks | up to 50% | Road, sea/river shores, house floors, railways | Feasible, tested in Jamaica, Germany, India |
| Glass Ceramics | 15 – 25% | Decorative tiles for household and buildings | Feasible, small market |
| Light Weight Aggregates | 10 – 45% | Building construction, security walls | Feasible, tested in Germany |
| Ordinary Portland Cement (OPC) | 5% | Common applications for cement | Feasible, tested in Greece |
| Geopolymer | to be tested | Fire resistant concrete, building material | R&D, for example TU Freiberg |
| Soil Amendments | 10 – 20% | Converting arid lands to fertile lands | Feasible |
| Recovery of metals | n.a. | Iron, titanium, aluminium, sodium recovery | Feasible, but not competitive with traditional recovery from ores |
| Waste Water and Effluent treatment | n.a. | Neutralisation of for acid sulphate and acid mine tailings | Significant market for acid mine drainage neutralisation technology |

BAUXITE RESIDUES -REE

The average concentration of REEs in greek bauxite is 506 ppm, whereas the average concentration of the resulting BR is 1200 ppm. BR is rich in scandium.

BR from Greece contains about 135 ppm and the recovery of scandium from BR is considered to be of high economic interest.





The company

1960-
Establishment of
Aluminium of
Greece S.A.

1963-1966
Construction of
the industrial
facilities

1966
Inauguration and
launch of
operation

1970-2000
Expansion of
facilities,
production
doubled,
automatization

2003
Acquisition
from Alcan

2005
Acquisition
from
MYTILINEOS
Group

2006-2014
Investments
(CHP, Filter
presses,
Casthouse)

OVER HALF A CENTURY OF HISTORY



The company



The leading industrial producer of alumina and aluminium in S.E. Europe and the only vertically integrated bauxite, alumina and aluminium production plant in Europe.



The second largest bauxite producer in Greece (via its subsidiary company, Delfi-Distomon), with annual output of more than 650,000 tons.

Vertically integrated industrial plant



Bauxite deposits



Alumina production plant



Aluminium production plant (Electrolysis, Casthouse, Anodes Line)



Cogeneration plant



Port facilities

Bauxite

ALUMINIUM S.A. exploits annually:

- **1,4 mil. tons of diasporic bauxite** (Delphi-Distomon, S&B, Turkey)
- **0,3 mil. tons of tropical bauxite** (Africa, Brazil, etc)



Production capacity

Today its annual production is:

810,000 tn alumina

- 490,000 tn exported
- 320,000 tn used to produce aluminium

165,000 tn aluminium

- 100,000 tn exported
- 65,000 tn sold in the Greek market

Main clients

Main aluminium clients are aluminium manufacturers:

- Extrusion (construction, industrial applications)
- Rolling (metal sheets, foil, cans, packaging)

Alumina is sold as:

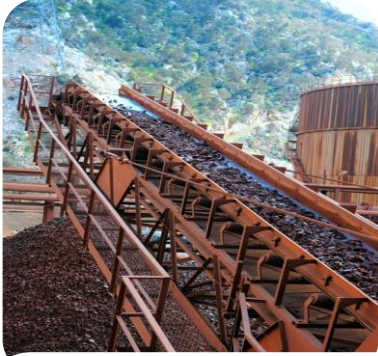
Calcined (dehydrated):

- Ten-years contract with Glencore for the sale of more than 350,000 tn nationally

Hydrated:

- Pharmaceuticals, detergents, water treatment
- Abrasives and insulating materials, refractory materials

Bauxite residues



Installation of 4 filter presses for the management of bauxite residues as a disposal resulting from the dissolution of alumina.

Innovative investment – €9.5 million



The bauxite residues are being filtered, dehydrated and placed in dry form.

The residues can be utilized in other industrial applications:

- cement production
- brick production
- road construction
- sanitary landfills

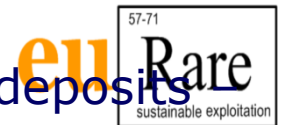


Discharge of the full quantity of bauxite residues ashore since 2012.

Innovative resolution of one of the greatest environmental challenges alumina production plants face worldwide.

Mud2Metal: Recovery of Critical Metals from the Bauxite Residues

- **Goal: Develop both the fundamental knowledge and the applied technology for recovery of metals from the Bauxite Residues (BR)**
- Commitment approved by the EIP Raw materials for 01/01/2014 to 31/12/2020
- On-going projects:
 - **ENEXAL**: Energy and Exergy Efficiency in the Aluminium industry – Recovery of Iron from BR
 - **EURARE**: Sustainable exploitation of Europe's Rare deposits Earth ore Recovery of REEs from BR
- Applied for the Marie Currie International Training Network Zero-Waste Valorisation of Bauxite Residue (Red Mud) - to fund 14 PhDs in 5 European Universities



RWTHAACHEN
UNIVERSITY

KU LEUVEN

BAUXITE RESIDUE VALORISATION
AND BEST PRACTICES CONFERENCE
Leuven 5-7 October 2015



ALUMINIUM S.A.

Woman engineers in mining & metallurgical industry

Difficulties ?

How to overcome them ?

Recommendations?

Education and Industry

Is education provided from university sufficient to meet the needs of working environment ?



Thank you !!