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Quarterly Journal Of Indian Refractory Makers Association





IRMA
PARTNERING HEATING SOLUTIONS
INDIAN REFRACTORY MAKERS ASSOCIATION

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National Award

National Award

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MESSAGE FROM THE CHAIRMAN

Dear Colleagues,

Reports by various research agencies suggest that the Indian economy will achieve a growth rate at or above 7% for FY24, and some predict it will achieve another year of 7% real growth in FY25 as well. If the prognosis for FY25 turns out to be right, then it augurs well for Indian economy.

Overall, the global economy is struggling to maintain its recovery post-Covid because successive shocks like energy and commodity prices hike in 2022, the ongoing war situation in Middle East etc. In this backdrop, when global economy at large and big names like China are struggling to maintain a growth rate of 2-3%, it is a commendable feat of Indian economy to display a consistent growth of 7%.

In the coming years, three important trends will continue to shape our industry. Firstly, the days of hyper globalization are over because it has the Achilles Heel of supply chain disruptions. While the main features of global supply chain will remain intact, companies will seek to invest in domestic capabilities to resist supply chain shocks. The main challenge for our industry is raw material security as good quality refractory raw materials are not found in India.

Secondly artificial intelligence is going to play a major role in ensuring product quality, increasing the effectiveness of supply chain and ensure much better product performance with least human intervention. It might appear to be a double-edged sword for cheap labour economies like India as processes are being automated at a swift rate thereby reducing the dependence on human resource.

Thirdly, the most important challenge is that of energy transition. Policy makers have given ample signals to the industry that a change in this regard is imminent and India is also duty bound to implement the resolutions of Paris Declaration. While the transition will be relatively smoother for large scale units, the difficulties will be felt by MSME units whose access to resource and technology are limited. Maybe the Government may consider providing some subsidy or tax holidays to help them absorb the cost of transition. As a responsible industry we must join hands with the Government to leave a cleaner and greener country for our progeny.

Ish Mohan Garg
Chairman

ASSOCIATION ACTIVITIES

IRMA Board of Directors Meeting

IRMA Board of Directors meeting was held on 16th February 2024 under the chairmanship of IRMA Chairman Mr Ish Gag at Hotel Pullman, New Delhi. The issues discussed were plans for IREFCON24, review of market conditions, future activities of IRMA, WRA activities etc.

IRMA Directory of Members 2023

IRMA Directory of members 2023 has been published, copy of which has been sent to all the member companies.

IREFCON 24

IREFCON 2024 will be organized from 13th-15th November 2024 at Taj Cidade de Goa , Horizon, Goa. Already the program has generated active interest amongst all the stake holders of the industry. All the exhibition stalls have been booked.

Vesuvius India has agreed to become the Title sponsor while RHI Magnesita will be the Cultural Night sponsor. Calderys will become Diamond sponsor while Maithan Ceramic Ltd to become Bar Sponsors for both the cocktail dinners. More companies are coming forward with sponsorship offers.

There will be a special session on "Women in Refractories" on 13th November 2024 coordinated by RHI Magnesita India Ltd.

The lectures of the following speakers have been confirmed:

Dr. Atul Narayan Vaidya, NEERI

Dr Helge Jansen, Refratechnik

Mr. Alexander Laugier-Werth, Vesuvius Plc

Dr Atanu Ranjan Pal, Tata Steel Ltd

IREFCON24 Organizing Committee meeting was held under the chairmanship of Mr. Sunanda Sengupta on 3rd February 2024 on online platform. Issues discussed were flow of events for IREFCON24, tentative budget, CEO meet, participation of customers, sponsorship, exhibition and registration charges.

IREFCON24 Technical Committee meeting was held under the chairmanship of Dr. Arup Samanta on 9th February 2024. Issues discussed were finalization of speakers for Keynote Speeches and Theme Lectures, drive to get abstracts for case studies and oral presentations etc.

Room booking at IREFCON24 venue is now open. Members may reserve the rooms available at a discounted rate directly from IREFCON website.

Further details are available at www.irefcon.com.

IN THE NEWS

Arcelor Mittal

As per the statement of its Chairman, Mr. Laxmi Mittal, when the second phase of ArcelorMittal's Hazira steel plant completes by 2029, it will become the world's largest steel plant with a production capacity of 24 million tonnes. The first phase of the plant is expected to be completed by 2026.

Indian coal and lignite production

For the first time, India has crossed the milestone of 1 billion tonnes of coal and lignite production in the financial year 2023-24. India's total coal and lignite output was at 937 million tonnes (MT) in the preceding 2022-23 fiscal, as per official figures.

Tata Steel

Tata Steel India has reported a 6 per cent growth in deliveries to 19.90 million tonnes in FY24, supported by higher demand from retail, automotive and railway segments. The company produced 18.85 million tonnes (MT) of steel during the preceding 2022-23 financial year.

Ultratech

UltraTech Cement has crossed 150 million tonne in production capacity with the commissioning of two greenfield units in Tamil Nadu and Chhattisgarh. The combined capacities of the plants in Chhattisgarh and Tamil Nadu will be 5.4 million tonne.

Shree Cement

Shree Cement Ltd has inaugurated its Rs 2500 crore new integrated plant at Dachepalli village in Guntur, Andhra Pradesh, six months ahead of schedule. The new plant which has a production capacity of three million tons per annum will propel Shree Cement's manufacturing capacity to 56.4 MTPA.

JSW Group

The JSW Group will set up an integrated steel plant, a power plant, a port facility and a cement plant at Jagatsinghpur, Odisha with an investment of Rs 65,000 crore. The steel plant will have the capacity to make 13.2 million tons of steel per annum while the cement plant will be able to produce 10 million tons per annum.

Vedanta Aluminium

Vedanta Aluminium has expanded its annual alumina refining capacity to 3.5 million tonnes at its Lanjigarh unit in Odisha. The alumina refining capacity earlier was 2 million tonnes per annum (MTPA).

NALCO

State-owned NALCO has made a record production of cast metal at 4,63,428 metric tonne during the financial year 2023-24. The excavation of bauxite reached a record high of 7,600,230 metric tonne during the financial year 2023-24.

Hindustan Zinc

Hindustan Zinc's refined metal (zinc and lead) production for the financial year 2023-24 increased 1 per cent to 273 KT as against 269 KT in the same period a year ago.

Appointment

Shri Naveen Jindal, the chairman of Jindal Steel and Power, has been appointed as the President of the Indian Steel Association. Shri Dilip Oommen, the CEO of AMNS India was previously the president for the industry body.

OVERSEAS NEWS

Shinagawa Refractories

Shinagawa Refractories has announced the establishment of a new joint venture company, PT. Shinagawa Refratech Perkasa, in Indonesia with PT. Refratech Mandala Perkasa, a respected local refractory manufacturer. In the Indonesian market, Shinagawa has been engaged in production and sales activities mainly for monolithic refractories, based on PT. Shinagawa Refractories Indonesia, its consolidated subsidiary.

RHI Magnesita

For the year 2023, RHI Magnesita's revenue was €3,572 million, increased by 8% mainly driven by contribution from acquisitions, offsetting a demand driven 5% decline in sales volumes in the base business. The company delivered a 7% increase in Adjusted EBITA to €409 million (2022: €384 million), as M&A, cost saving initiatives and resilient pricing offset the underlying weakness in customer demand. Adjusted operating cash flow increased by 166% to €413 million.

Vesuvius

The performance of Vesuvius Plc for the year 2023 is as follows:

- Revenue of £1,929.8m, 3.1% lower on an underlying basis vs. 2022, reflecting lower volumes in a weaker market, partially offset by good pricing performance and market share gains in Flow Control and Foundry
- Robust trading profit of £200.4m, 6.7% lower on an underlying basis vs. 2022. Return on sales of 10.4%, 40bps lower than 2022 on an underlying basis
- Increased R&D investment (£37.4m, up 3.7% vs. 2022 and now 1.9% of sales) leading to 21 new products launched in 2023 and a strong pipeline of new products for the coming years

Imerys

Imerys has published its Group consolidated financial statements for 2023 financial year, with highlights as below:

- Full year revenue at €3,794 million impacted by weak demand in most markets
- Current EBITDA in line with guidance1 at €633 million; current EBITDA margin resilient at 16.7% benefiting from cost reductions (€126 million)
- Substantial net current free operating cash flow generation of €191 million (2022: €20 million), and €288 million (2022: €105 million) before strategic capital expenditures, supported by working capital management actions
- Solid financial structure and strong liquidity position: net debt reduced by €548 million (-33%), improving the net financial debt to current EBITDA ratio to 1.8x compared to 2.3x in December 2022

Saint Gobain

The salient features of Saint Gobain's performance for the year 2023 are as follows:

- Sales were down by 6.4% to €47.9 billion, with a negative currency effect of 2.3% and a negative Group structure impact of 3.2%.
- Volumes were down by 5.5% over the year (down 4.5% in the fourth quarter).
- Group prices were up 4.6% over the year (up 0.8% in the fourth quarter), generating a positive price-cost spread.

Operating income was €5,251 million, a record-high at constant exchange rates (2022 rates). The operating margin reached a new record-high of 11.0% in 2023 (versus 10.4% in 2022), representing an increase of 330 basis points since the launch of the Group's transformation at the end of 2018.

MEMBERSCAN

TRL Krosaki Refractories

TRL Krosaki Refractories Limited, as part of its commitment towards conducting business in a sustainable way, has taken a massive step forward by introducing Natural Gas in place of Furnace Oil, High Speed Disel, Coal, etc. as a fuel in its thermal units. The use of Natural Gas, being a cleaner fuel, shall be maximized across all kilns and furnaces, thereby eliminating and minimizing use of other conventional fuels. The primary objective of this switchover is to reduce the carbon footprint and protect the environment. With this conversion the company would reduce CO2generation by around 50,000 MT per annum.

Calderys India Refractories

Calderys has launched its expanded insulation production line in Dharuhera, Haryana region, in India. The expansion includes substantial technological upgrades, with the installation of an advanced boiler system that shifts from traditional fossil fuels to Piped Natural Gas (PNG), a cleaner alternative.

IFGL Refractories

Reported Consolidated December 2023 quarterly numbers for IFGL Refractories are:

- Net Sales at Rs 366.18 crore in December 2023 up 15.89% from Rs. 315.97 crore in December 2022.
- Quarterly Net Profit at Rs. 1.52 crore in December 2023 down 90.37% from Rs. 15.79 crore in December 2022.
- EBITDA stands negative at Rs. 0.02 crore in December 2023 down 100.05% from Rs. 36.66 crore in December 2022.

Vesuvius India Ltd

Vesuvius India Ltd. has recently inaugurated a new mould flux manufacturing plant Vishakhapatnam. The said plant is the first of the three new manufacturing plants of the company expected to be operational in 2024.

OBITUARY

Mr. Amrik Singh, former IRMA Chairman (1998-2000) peacefully passed away on 5th January 2024. A ceramic graduate of IIT BHU (1958), he had helped the growth and development of many refractory companies in his professional career including SNCCI, CUMI, Associated Ceramic Ltd.. He developed a number of innovative refractory products which were well accepted by the customers. May His Soul Rest in Eternal Peace.

ECONOMY AT A GLANCE

- India's CAD has narrowed to 1.9% of GDP in fiscal 2023 (and is expected to go down further in the next fiscal), while foreign exchange reserves have nearly doubled to US$568 billion.
- Current inflation stands at 5%, and the fiscal deficit is targeted to be 5.9% of GDP in fiscal year 2024.
- The government prioritised capital spending in its recent budgets and supported the state governments for doing so. As a result, gross capital formation increased by over 11 per cent during the 2022–23 fiscal year and is expected to expand by over 10 per cent during the 2023–24 fiscal year.
- Private investment fell from over Rs 14 lakh crore (US$168.6 billion) in February 2023 to below Rs 2 lakh crore (US$24.1 billion) in October 2023 before recovering marginally to Rs 2.2 lakh crore (US$26.5 billion) in December 2023.
- According to research conducted by the State Bank of India, out of the estimated INR 5 trillion capex, government has received investment commitments for INR 3 trillion and 21% of committed capex, while 12% of planned capex has been spent in fiscal year 2023 with most capex activity likely to happen between fiscals 2024 and 2026.
- Foreign direct investors reduced their participation in India. Between April–November 2023, gross foreign direct investment inflows declined by about 4 per cent compared to the corresponding period in 2022. Despite this decline, India seems to have performed better, as foreign direct investment inflows in developing countries declined by 12 per cent in 2023, according to the UN Conference on Trade and Development.
- The government expects retail headline inflation to be marginally higher in 2024 at 5.4 per cent, increasing from about 4 per cent in 2023.
- The external sector has been impacted by the global economy's loss of momentum, with exports of goods and services declining during the first nine months of the current financial year. But with imports declining — notably merchandise goods — India's imbalance on the trade account has reduced by almost 36 per cent compared to the previous year.
- The expected decline of the growth of agriculture and allied sectors in 2023–24 is a worrying sign for the economy. These sectors must grow consistently and at a significantly higher rate, given the depressed state of farm incomes.
- India to grow between 6.9% and 7.2% through fiscals 2023 to 2024.

BUSINESS SECTION:

TESTING TIMES- NEW ERA OF MINERAL SUPPLY DAWNS GLOBAL REFRACTORY MINERAL SUPPLY TRENDS & OUTLOOK

Mike O' Driscoll, Director, IMFORMED

Outline

1. **Refractory mineral overview**

   Key raw materials & sources

2. **Supply situation**
   - Influencing Factors
   - China
   - India
   - Energy
   - Logistics
   - Corporate Strategy
   - Recycling
   - Spotlight: bauxite, magnesia, graphite, andalusite

3. **Outlook**

   FM ingots cooling at Haicheng Zhonghao Magnesite, Haicheng, Liaoning, China

Outlook for global mineral supply...for "Refractories for a Sustainable Future"

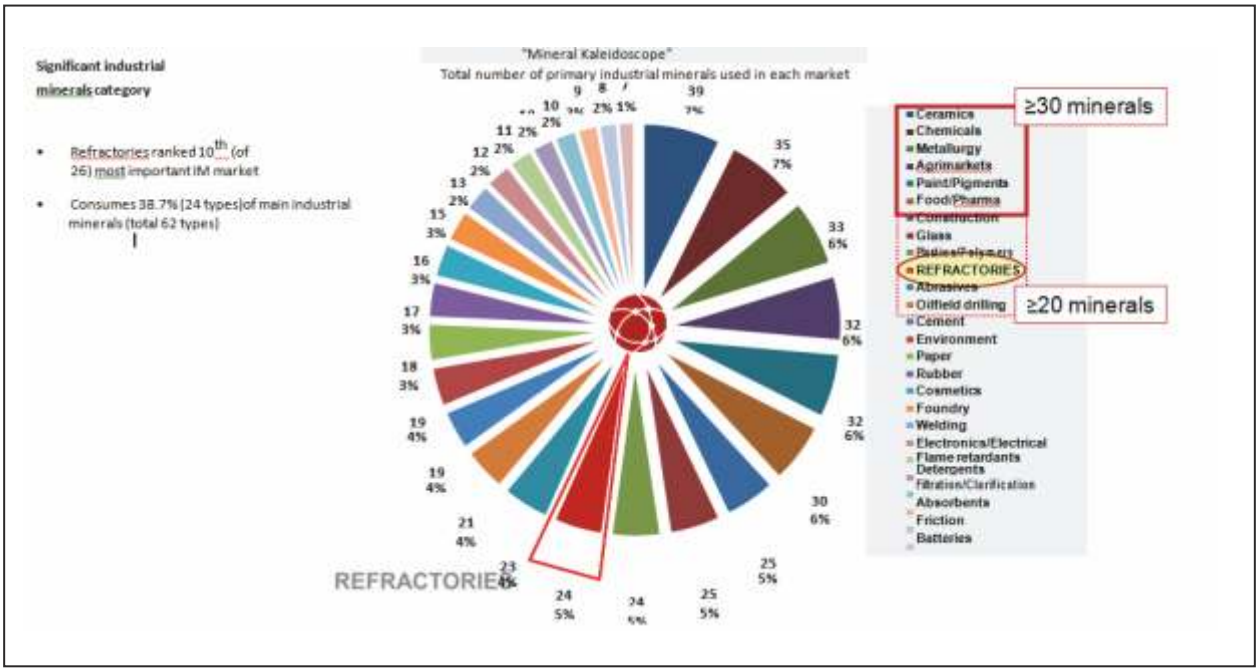
Ending of an era?

A change of course?

Calcined bauxite kiln, Jiexiu, Shanxi, China

Loading bags of DBM for export, Bayuquan, Liaoning, China

Refractory minerals overview

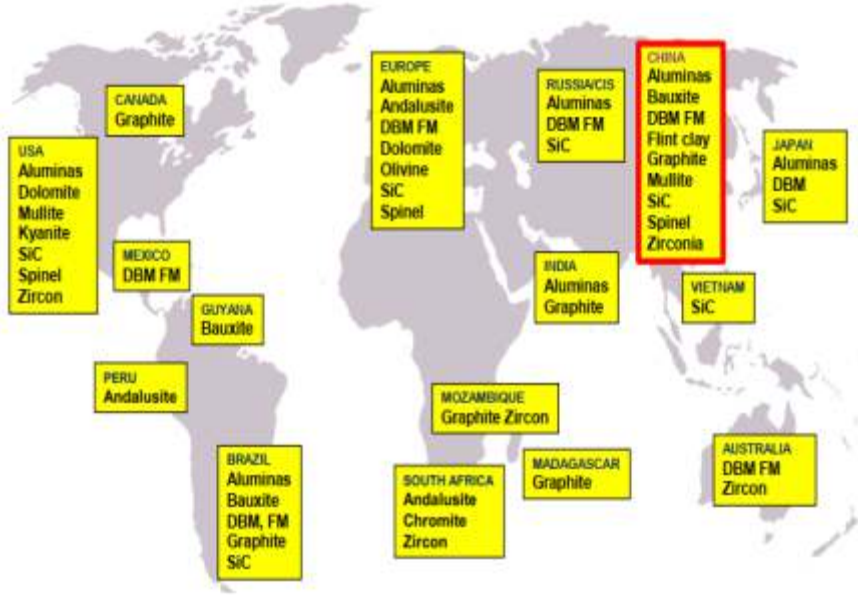


Refractory minerals overview **Categories | Chemistry | Source**

Refractory classification	Industrial mineral (incl. synthetic)	Main chemical component	Primary source country
BASIC	**Dead burned magnesia**	85-99.8% MgO	**China**
	Fused magnesia	97-99.8% MgO	**China**
	Dead burned dolomite	56-62% MgO, 36-40% CaO	USA
	Chromite	>46% Cr_2O_3	South Africa
	Sintered/fused spinel	66-80% Al_2O_3, 21-33% MgO	**China**
	Olivine	40-50% MgO, 35-45% SiO_2	Norway
ACIDIC High alumina	**Calcined alumina**	>99.5% Al_2O_3	**China**
	Fused alumina	94-99.5% Al_2O_3	**China**
	Calcined bauxite	85-88% Al_2O_3	**China**
	Sintered/fused mullite	40-75% Al_2O_3	USA
Low alumina	**Andalusite, sillimanite, kyanite**	60-65% Al_2O_3	South Africa
	Refractory clays	20-45% Al_2O_3	**China**
	Pyrophyllite	20-30% Al_2O_3	South Korea
Silica	**Quartzite, silica sand**	>97% SiO_2	Regional
	Fused silica	>99.8% SiO_2	USA
SPECIALISED	**Zircon**	66% ZrO_2+HfO_2	Australia
	Zirconia	>99% ZrO_2	**China**
	Silicon carbide	>93% SiC	**China**
	Graphite	75-99% C	**China**
INSULATING	**Diatomite**	>75% SiO_2	USA
	Perlite	65-80% SiO_2	**China**
	Vermiculite	45% SiO_2	South Africa

Refractory minerals overview

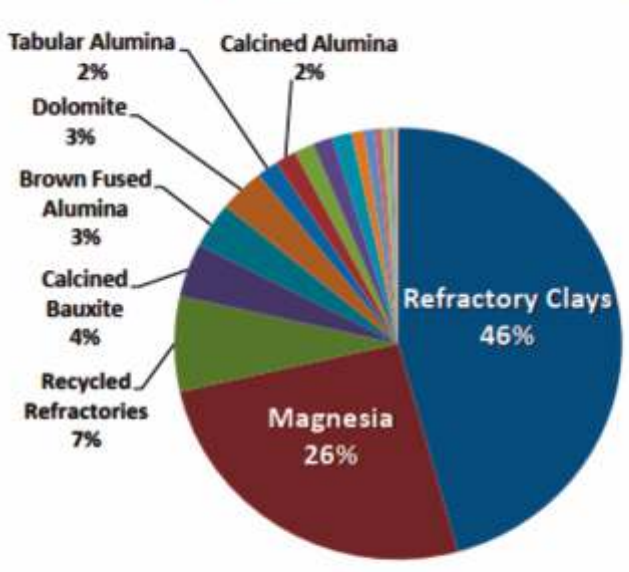
Summary of world distribution of primary established sources of main traded minerals



Mineral	Total no. country sources*
DBM	21
Silicon carbide	20
Fused alumina	14
Fused magnesia	12
Pyrophyllite	11
Dolomite	9
Graphite	9
Zircon	9
Aluminas	8
Kyanite	5
Andalusite	5
Bauxite	4
Chromite	4

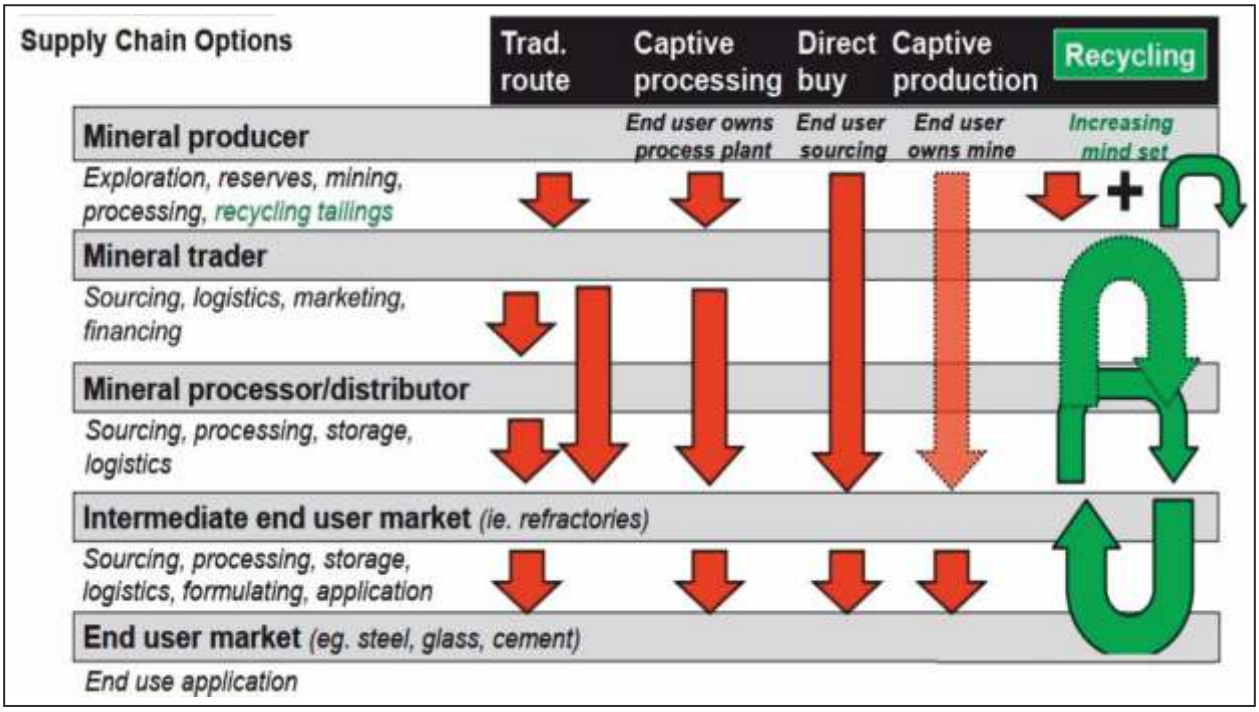
Note:
1. certain sources supply only regional/local markets
2. others are captive to consumers

Estimated world consumption of refractory minerals: total ~35-37m tonnes



- Refractory Clays
- Magnesia
- Recycled Refractories
- Calcined Bauxite
- Brown Fused Alumina
- Dolomite
- Tabular Alumina
- Calcined Alumina

≤1%
- Graphite
- Calcium Aluminate Cements
- Sillimanite Minerals (incl. Andalusite)
- Chromite
- White Fused Alumina
- Zircon
- Silicon Carbide
- Silica
- Spinel
- Olivine



World annual production capacity 2020/21 selected minerals

DBM	k. tonnes
Total	**10,500**
China	(48%) 5,000
Russia	2,500
Turkey	760

FM	k. tonnes
Total	**2,100**
China	(90%) 1,900
Russia	115
Turkey	40

Fused Alumina	k. tonnes
Total	**1,300**
China	(62%) 800
Germany	80
USA/Austria	60

Calcined Bauxite	k. tonnes
Total	**1,225**
China	(82%) 1,000
Guyana	180
Spain (Guyana)	45

Zircon	k. tonnes
Total	**1,200**
Australia	400
South Africa	270
China	(12%) 140

Graphite	k. tonnes
Total	**1,000**
China	(82%) 820
Brazil	68
Mozambique	30

Silicon Carbide	k. tonnes
Total	**1,000**
China	(45%) 450
Norway	80
Japan	60

Andalusite	k. tonnes
Total	**310**
South Africa	160
France	55
Peru	45

Supply situation

China: export dominance | 2021 exports

Refractory Mineral Export	Volume tonnes	World share avg 2016-20	Value US$m.
BFA	564,877	59%*	719.2
WFA	393,324		477.3
Bauxite	1,014,467	90%**	279.7
Graphite	121,719	52%	137.0
DBM	1,239,617	54%*	326.3
FM	615,473		366.5
Silicon Carbide	374,891	45%	349.2

Bauxite operations, Shanxi, China

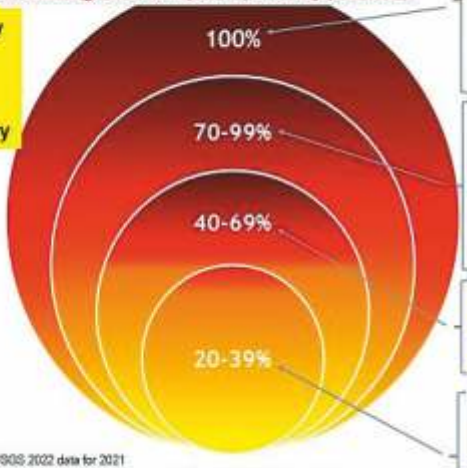
* world share combined; ** estimate Source: China Customs; ITC

Supply situation

China: export dominance | eg. US mineral import reliance

- in 2021 **24** industrial minerals @ ≥50% import dependency
- **10** @ 100% import dependency, of which **6** sourced from China
- **+8** sourced from China @ 50-91% import dependency (=14 total)

- **7 refractory minerals**
- **@ >50% import dependency**



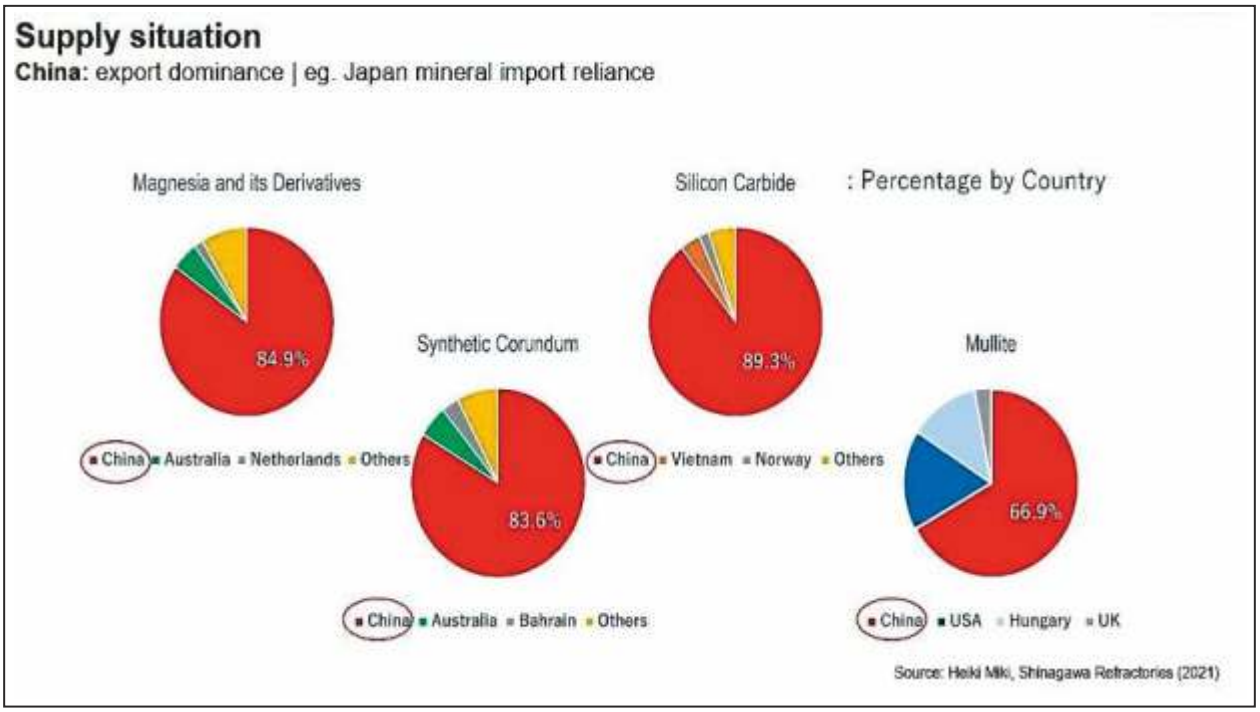
Asbestos		Brazil, Russia
Bauxite (non-met)		CHINA, Guyana, China
Fluorspar		Mexico, Vietnam, S. Africa, Canada
Graphite		CHINA, Mexico, Canada, India
Mica (sheet)		CHINA, Brazil, Belgium, India
Nepheline syenite		Canada
Manganese		Gabon, S. Africa, Australia, Georgia
Scandium		Europe, CHINA, Japan, Russia
Strontium		Mexico, Germany, CHINA
Yttrium		CHINA, S. Korea, Japan
Potash	93%	Canada, Russia, Belarus
Iron oxide pig.	91%	CHINA, Germany, Brazil
Rare earths	>90%	CHINA, Estonia, Malaysia, Japan
Titanium min.	90%	S.Africa,Australia, Madagascar, Mozambique
Antimony	84%	CHINA, Belgium, India
Chromium	80%	South Africa, Kazakhstan, Russia, Mexico
Diamonds	76%	S.Africa, India, Congo, Botswana
Barite	>75%	CHINA, India, Morocco, Mexico
Fused alumina	>75%	CHINA, France, Bahrain, Russia
Garnet	56%	S. Africa, CHINA, India, Australia
Alumina	58%	Brazil, Australia, Jamaica, Canada
Magnesia	55%	CHINA, Brazil, Israel, Canada
Iodine	>50%	Chile, Japan
Silicon carbide	>50%	CHINA, Netherlands, S. Africa
Feldspar	32%	Turkey
Salt	29%	Chile, Canada, Mexico, Egypt
Mica (scrap,flake)	28%	Canada, CHINA, India
Lithium	>25%	Argentina, Chile, CHINA, Russia
Bromine	<25%	Israel, Jordan, CHINA
Zircon	<25%	S.Africa, Senegal, Australia, Russia
Perlite	23%	Greece, CHINA, Mexico, Turkey
Vermiculite	20%	S.Africa, Brazil

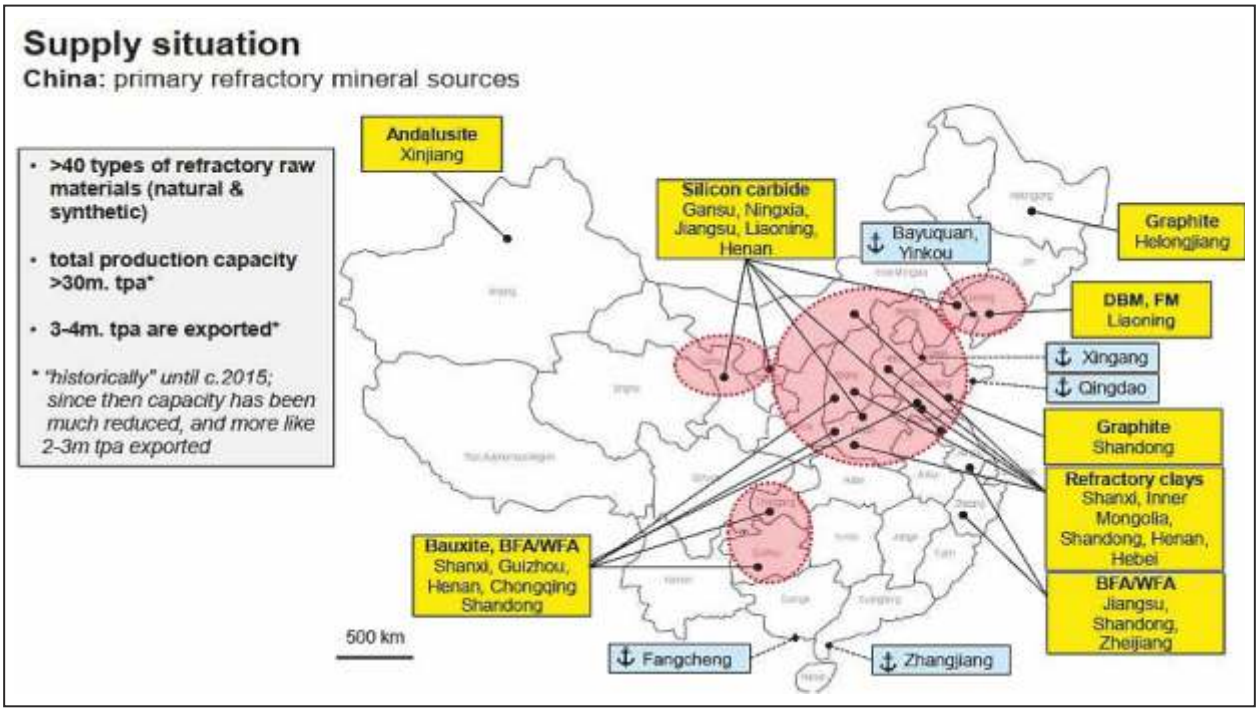
Fused alumina
China 91%
France 3%
Bahrain 2%
Russia 2%
Other 2%

DBM+FM
China 69%
Brazil 13%
Turkey 5%
Mexico 4%
Other 9%

Silicon carbide
China 88%
Netherlands 4%
South Africa 4%
Other 4%

Source: adapted from USGS 2022 data for 2021
Major import sources 2017-21; US net export minerals excluded, eg. boron, clays, diatomite


Supply situation
China: export dominance | eg. Japan mineral import reliance
Magnesia and its Derivatives
: Percentage by Country
84.9%
China
Australia
Netherlands
Others
Synthetic Corundum
83.6%
China
Australia
Bahrain
Others
Silicon Carbide
89.3%
China
Vietnam
Norway
Others
Mullite
66.9%
China
USA
Hungary
UK
Source: Heiki Miki, Shinagawa Refractories (2021)


Supply situation
China: primary refractory mineral sources
>40 types of refractory raw materials (natural & synthetic)
total production capacity >30m. tpa*
3-4m. tpa are exported*
* "historically" until c.2015; since then capacity has been much reduced, and more like 2-3m tpa exported
Andalusite
Xinjiang
Silicon carbide
Gansu, Ningxia, Jiangsu, Liaoning, Henan
Bayuquan, Yinkou
Graphite
Heilongjiang
DBM, FM
Liaoning
Xingang
Qingdao
Graphite
Shandong
Refractory clays
Shanxi, Inner Mongolia, Shandong, Henan, Hebei
BFA/WFA
Jiangsu, Shandong, Zhejiang
Bauxite, BFA/WFA
Shanxi, Guizhou, Henan, Chongqing Shandong
500 km
Fangcheng
Zhangjiang

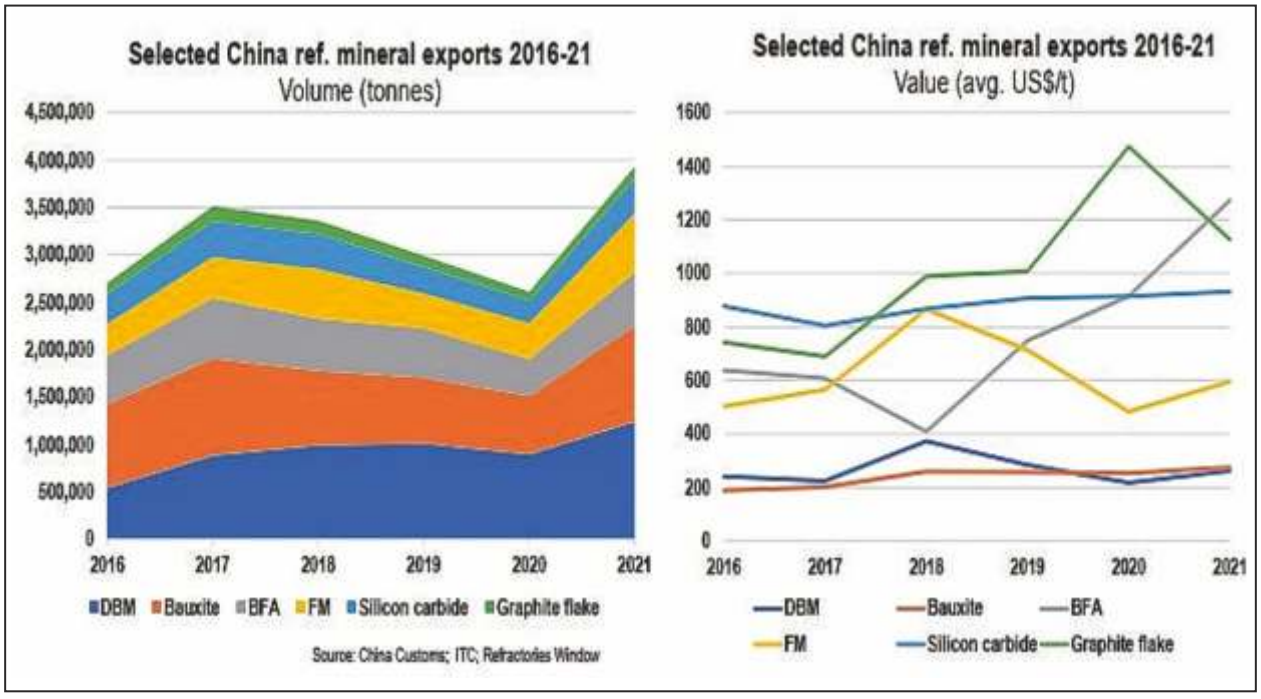
Supply situation China: since 2017 "perfect storms" of ongoing disruption & uncertainty

- **Pollution control:** 2022: 2nd year of China's 14th Five-Year Plan (2021-2025), ongoing resource conservation, environmental controls to meet government goals = mine / plant inspections, disruptions, shutdowns
- **Annual Winter Shutdown Oct-March:** major disruption to all energy- intensive operations, ie. ref. mineral processing, calcination, fusion (FM, BFA, SiC). eg. "2022 Liaoning Province Orderly Electricity Consumption Plan" October implementation.
- **Energy crisis:** Increased fuel/power costs, shortages, conservation, rationing (summer heatwave, winter slowdown) – ditto above.
- **Internal logistics:** rising transportation charges
- **Events impact:** National holidays; Winter Olympics; CCP meetings
- **Supply sector reforms:** restrictions and changes in mining/processing, quota controls, capacity reduction
- **Domestic market:** sluggish demand now, but exports not first priority; prices declining, profit margins squeezed = closures
- **Covid-19 lockdowns**: disrupted production & port / logistics activity

Supply situation China: primary refractory mineral exports

Overall

- China ref. mineral exports sharply increased in 2021 over 2020; largely consistent supply from Feb. 2021
- prices steady to increasing from 2016, fluctuations from 2018, and fused minerals rising
- availability outlook unsettled (esp. bauxite), some operations still to resume, others may never.

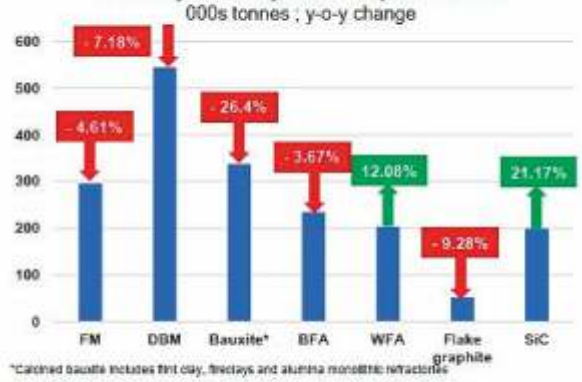


Supply situation

China: refractory mineral exports

Total China refractory mineral exports H1 2022: 2.5m tonnes, -3.77%

China key refractory mineral exports H1 2022
000s tonnes ; y-o-y change



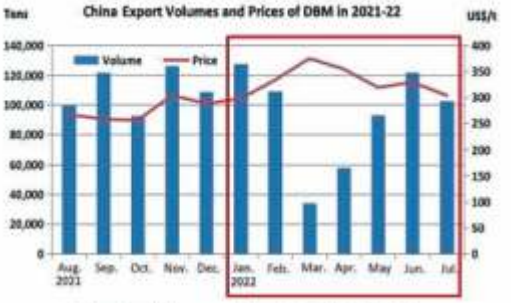
*Calcined bauxite includes flint clay, fireclays and alumina monolithic refractories

Rising domestic cost of minerals H1 2021-H122

Calcined bauxite	5-7%
BFA	12.5%
WFA	15%
Tabular alumina	12%
Flake graphite	45%
SiC98	32%
FM97	26%

Total export value increased 28.87% from H1 2021

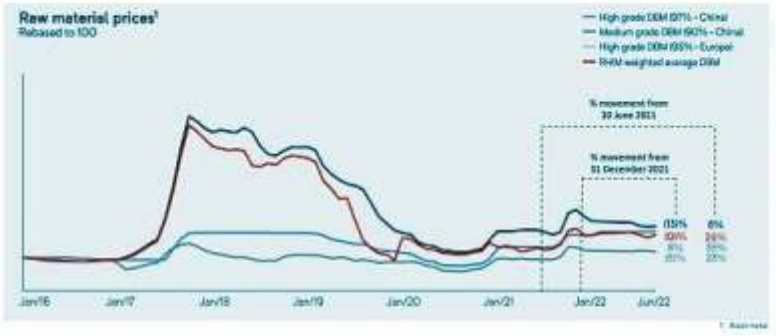
Average export price increased 33.92% from H1 2021

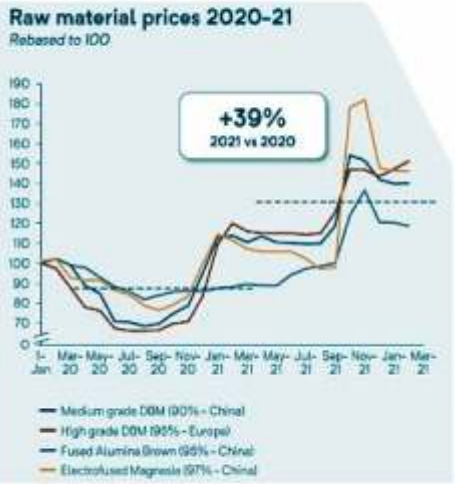


Supply situation

China: consumer fatigue in mineral price increases & volatility

RHI MAGNESITA





RHIM reported 2021 purchased raw material costs rose by €69m (39%) over 2020

- 70% self-sufficient in magnesia
- 100% reliant on external sources for other eg. aluminas, graphite, zircon

(2021 freight costs rose by €92m (209%) over 2020, sea freight €80m of which 85% inflation)

Source: RHI Magnesita (2022)

Supply situation

China: refractory mineral trends

Overall: depressed domestic demand, stable/declining prices, rising energy costs, output reduced Magnesia

DBM95 US$415-435/t FOB DBM97.5 US$420-445/t ; FM95.5-96 US$445-560/t FOB FM96.5-97 US$485-585/t FM97.5LC US$870-930/t FOB

- Low domestic demand, oversupply, nat. gas cost up 50% on 2021, prices stable/declining = low profit margins = closures?
- Covid controls in Haicheng, Anshan influencing output; Jan.-May 2022 magnesite industry output decreased by 10.6%.
- Liaoning consolidation/reform progressing (slowly): no mines <100k tpa; mining limit of 9.6m tpa; mining permits cut 114 to 57;

>80% by top 5 groups by 2025, 2-3 by 2030; eg. Haicheng, mines cut 40 to 23 (8 large, 6 medium, 9 small scale).

Bauxite RK85 US$415/t FOB RK88 US$500/t FOB

- raw ore shortages persist, fuel price rises, low domestic demand, impacting ref. bauxite output

Supply situation

China: 20th National Congress of China's ruling Communist Party

- President Xi Jinping secured for historic 3r 3rd term

16 Oct. 2022 Xi speech take-aways:

> **Zero-covid policy**

- Shanxi: few producers operating, some to close; 20% operating rate in Yangquan; high quality ore and coke shortages
- Guizhou: power cuts, covid controls, low op. rates

BFA 95% US$765/t FOB

- Shanxi/Guizhou: prices softening, low operating rates, declining demand, Covid lockdown impacting Guizhou plants.

SiC 90-98% US$1,118-1,320/t FOB

- Using Shanxi coal = higher costs; Gansu: op. rate 60-70%; Ningxia stable; some producers closed due to environment rules
- US ban on green SiC imports from Xinjiang Uyghur Autonomous Region = shortage for US abrasives market.

Graphite Flake -194# to -196# US$750-900/t FOB Luobei ; +890# to +895# US$1,025-1,170/t FOB Qingdao

- Onset of winter = lower production; stocks v. low (2 months) owing to earlier environmental controls; narrow profit margin = temp. closure some ops.
- Price rises expected

Source: Market contacts; Refractories Window no sign of change; rising frustration, maybe 2023 might see some "relaxation"?

Otherwise expect continued disruption.

> **Achieving economic growth**

"We must intensify efforts to advance reform and explore new ground, and we must remain steadfast in expanding opening up" & "High-quality development. Achieve greater self-reliance" key to China's future.

Ongoing reforms, new developments, Green future, going "west"

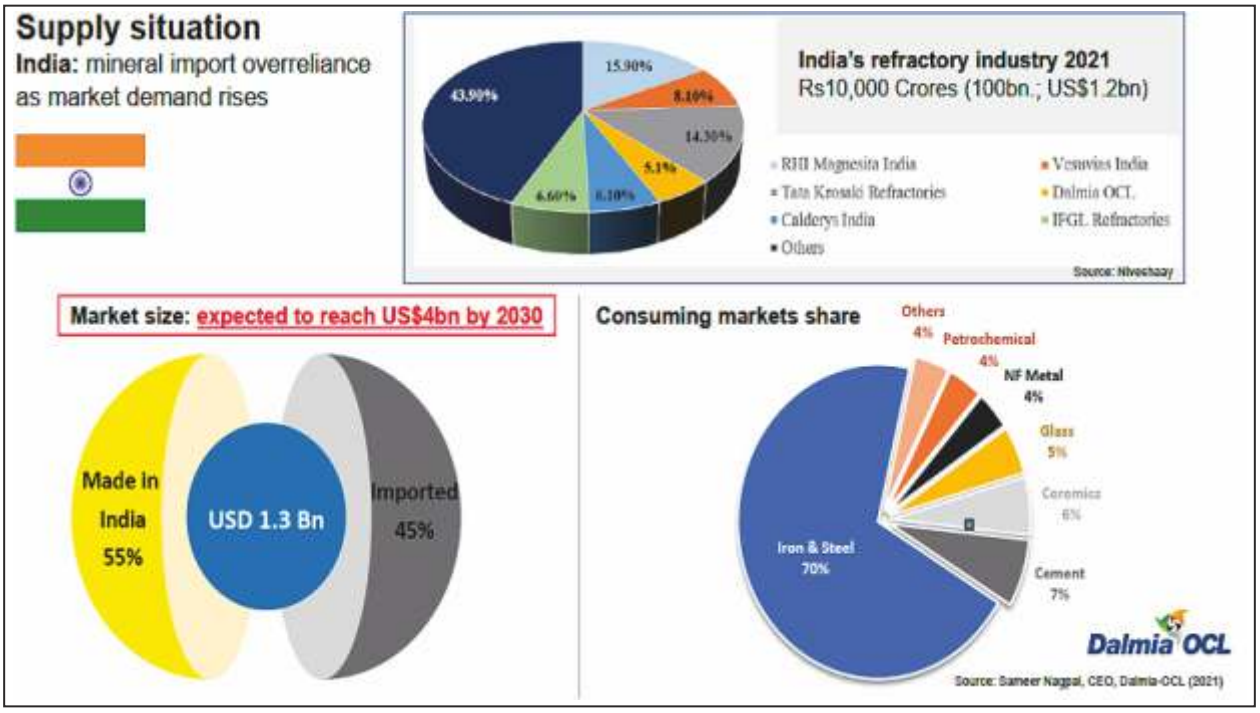
> **Taiwan "reunification"**

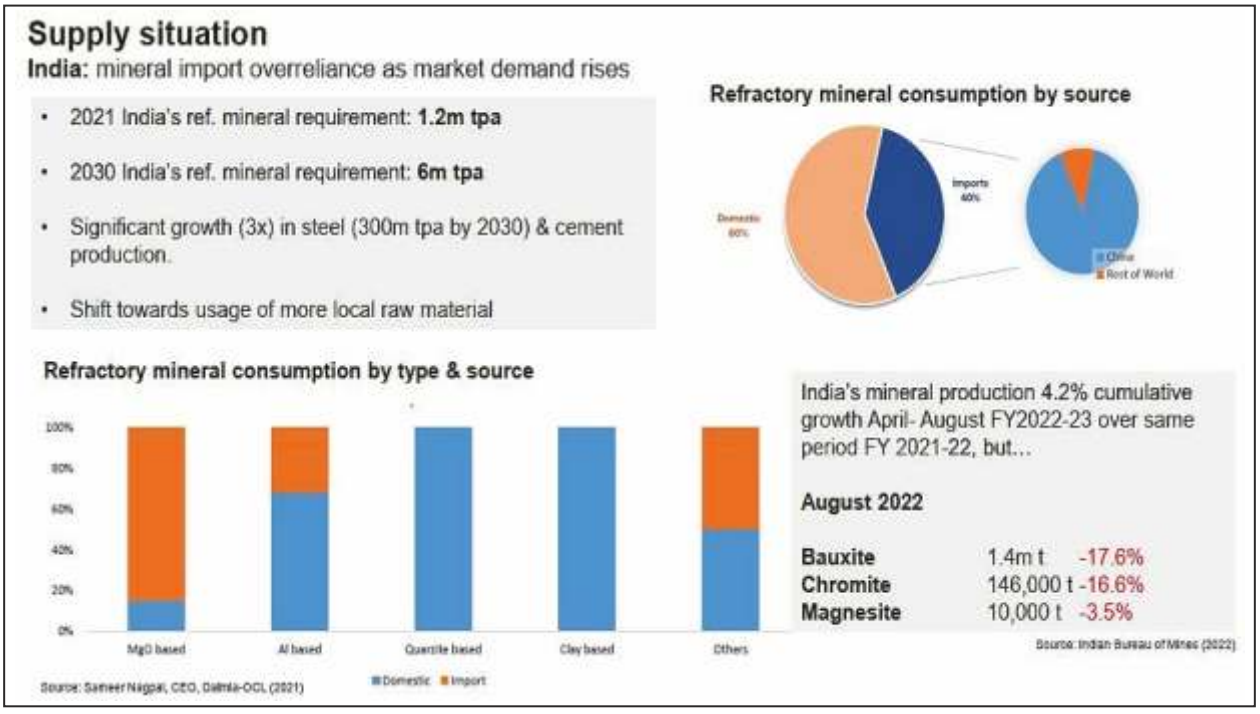
not going away; to remain a goal "by all means" Potential future friction/conflict; threat to world trade

> **Global ambitions**

"A new round of scientific and technological revolution and industrial transformation is well underway, and a significant shift is taking place in the international balance of power, presenting China with strategic opportunities in pursuing development."

China's dominant role in new global tech era reinforced; expect domestic and overseas activity





Supply situation

Energy: rising costs, decarbonisation, energy transition

Consuming market impact: steel sector already reacting with capacity reductions and closures

EU idled steel plants 6 Sept. 2022

Jan.-July 2022
EU steel production dropped 5.2m t, or 5.7% y-on-y, decline set to increase in H2.

Sept. 2022
German steel production reduced by 15.4% y-on-y to 2.84m t

Supply situation

Energy: rising costs, decarbonisation, energy transition

Mineral sector to follow?

- Refractory mineral producers are high energy consumers
- Drying, calcination, fusion, transport
- Need to evaluate/diversify energy sources

Carbon footprints of refractory raw materials

(Tonnes CO_2-eq / tonne)	Chemical emissions	Process emissions	Total
Silicon carbide	2.2	5.3	7.5
Fused magnesia	1.1	4.5	5.6
Brown fused alumina	0.1	3.8	3.9
Dead burned magnesia	1.1	2.4	3.5
White fused alumina	0	2.8	2.8
Tabular alumina	0	2.2	2.2
Calcined bauxite	0	1.9	1.9
Alumina cements	0.2	1.7	1.9
Calcined fireclays	0	1.7	1.7
Calcined alumina	0	1.0	1.0
Andalusite	0	0.4	0.4
Graphite	0	0.4	0.4

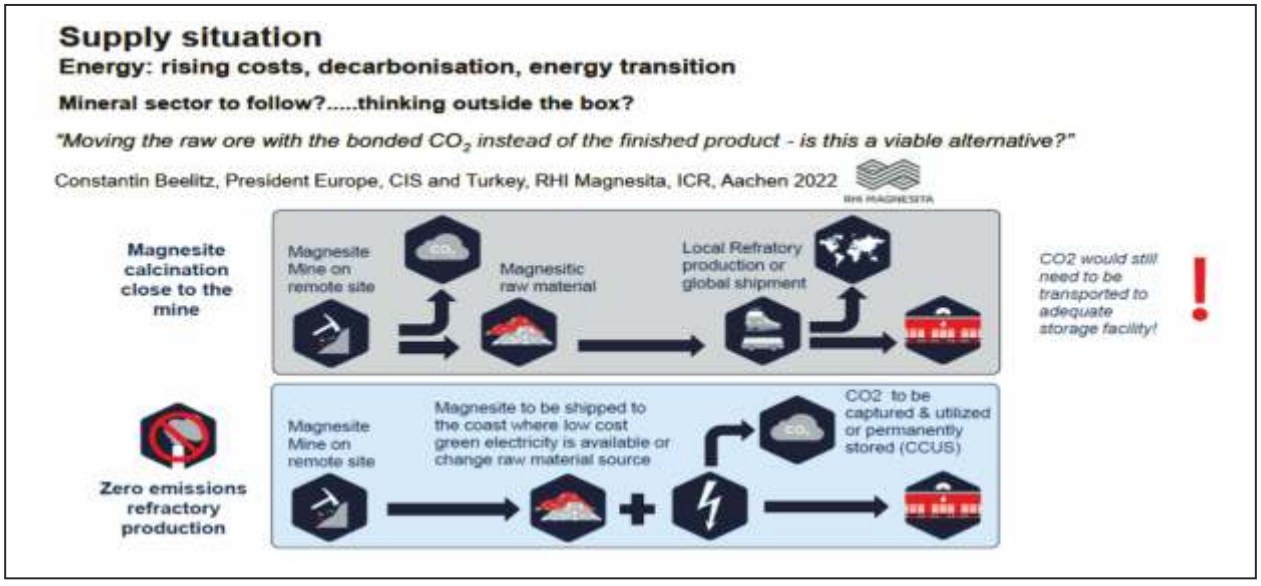
Source: Dr Richard Flook presentation (2022) based on work by Flook & Phil Edwards estimates 2009

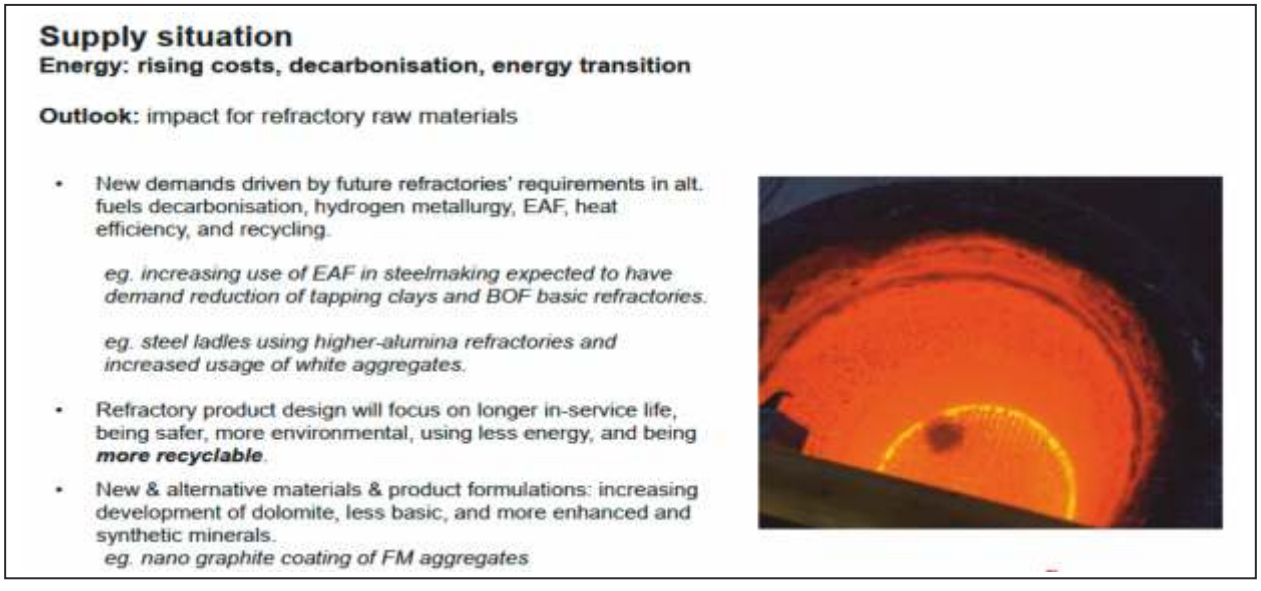
Supply situation

Energy: rising costs, decarbonisation, energy Mineral sector to follow?

- Some producers already reducing output and/or seeking alt. energy solutions:

eg. **SMZ Jelsava, Slovakia**: 390,000 tpa DBM/CCM (& refractories) 3 rotary kilns, 6 shaft kilns **20% reduction in output** – energy costs, Russia-Ukraine war eg. **RHIM, Austria**: DBM "normal", but no EU CCM output Q422 (resume Q123); investing in alternative energies & own gas reserves to replace 50% "normal" gas consumption; secured LPG supply at fixed prices & investing €15m to secure natural gas in physical storage in Austria.

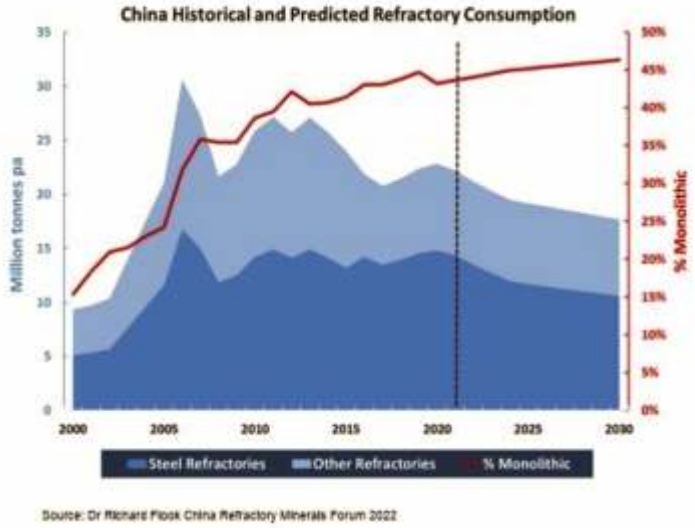




Supply situation

Energy: rising costs, decarbonisation, energy transition

Outlook: impact for China's refractory industry



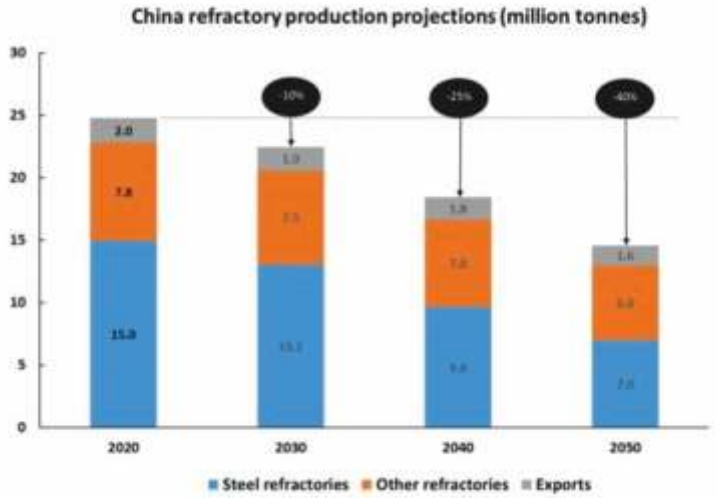
Source: Dr Richard Flook China Refractory Minerals Forum 2022

- Predictions based on "business as usual"
- Refractory production and consumption could change significantly after 2030 with new low carbon technologies

Supply situation

Energy: rising costs, decarbonisation, energy transition

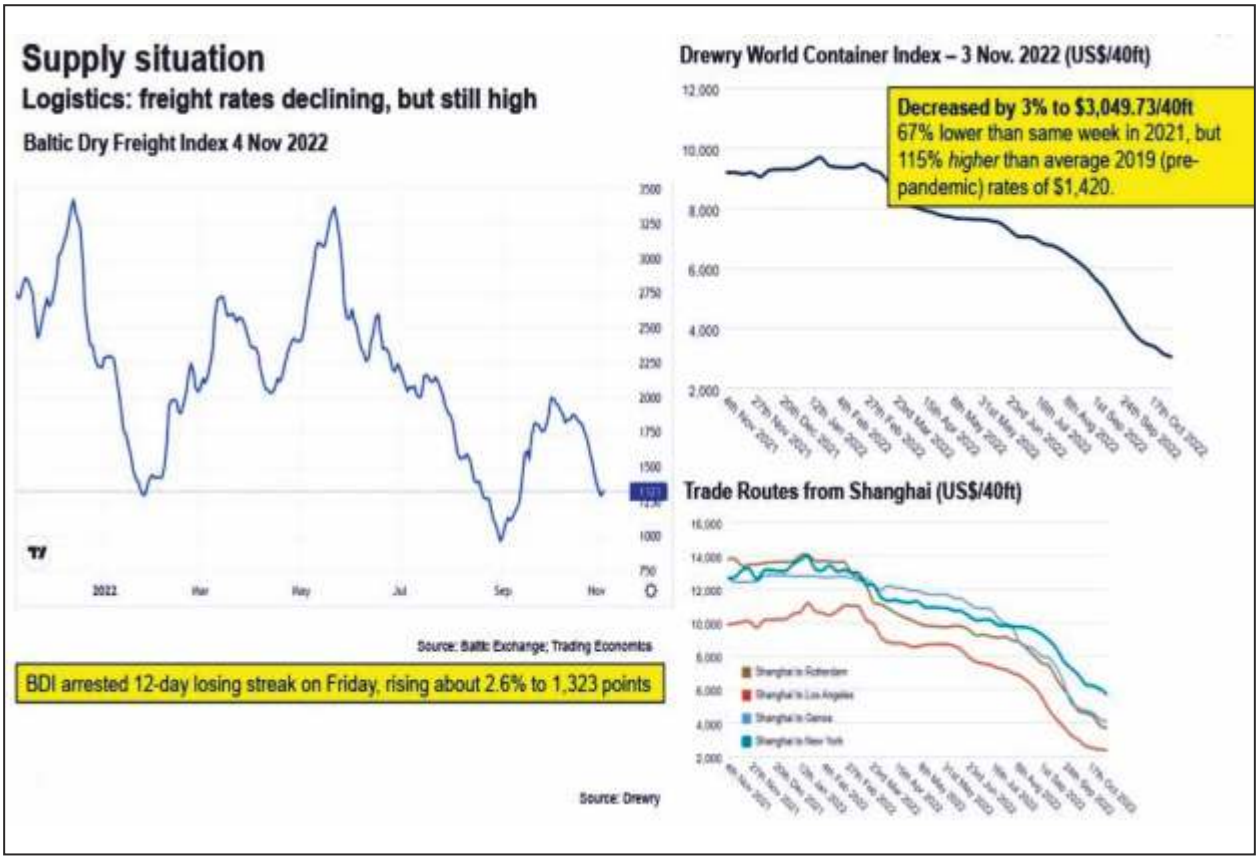
Outlook: impact for China's refractory industry



To achieve 1.5⁰ pathway by 2050 **refractory production is also projected to decrease**

- 10% reduction by 2030
- 25% reduction by 2040
- 40% reduction by 2050
- Many competing assumptions!

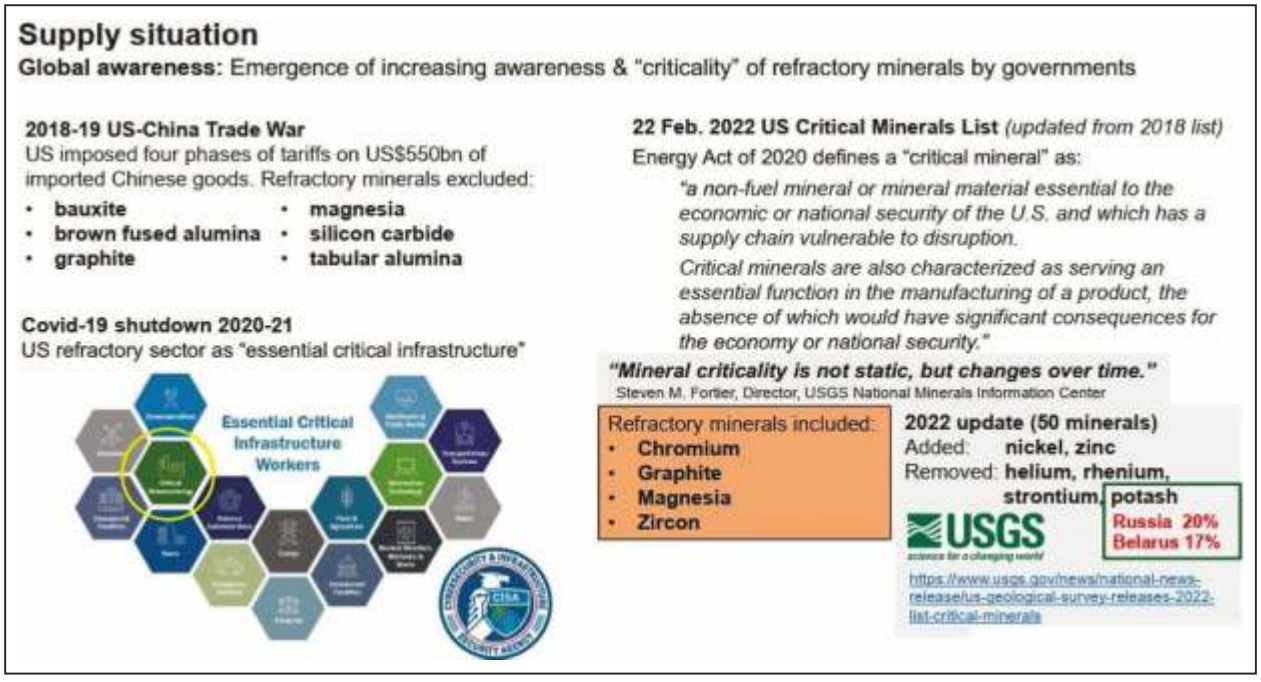
Source: Dr Richard Flook China Refractory Minerals Forum 2022



Supply situation

Logistics: overall improvement, but still issues

- Improving, global supply chain crisis could start to unwind end- 2022
- Hardest hit markets may await until 2023 to "normalise" but recovery interrupted by:
  - > Ukraine conflict: fuel cost rise bunker surcharges already enacted US$10-20/t; congested ports?
  - > Moving from "just in time" to "just in case"; precautionary stocking by consumers
  - > "Avalanche" of empty containers causing congestion problems H2 2022-2023; result of additional containers utilised during pandemic
  - > Warehouse space shortage US and Europe
  - > China:
    - o Ongoing China covid-19 lockdowns
    - o Port congestion easing but still higher than pre-Covid
    - o Domestic transportation slower because of truck driver Covid testing requirements.
    - o Disruptions to overland rail transportation from China to Europe



Supply situation

Global awareness: Emergence of increasing awareness & "criticality" of refractory minerals by governments.

Future expectations?

- Increased awareness
- Govt. support + Protection
- Domestic investment
- Fast tracking

Supply situation

Corporate strategy: strategic alignment & investment with new sources / offtakes

Supply situation

Corporate strategy: M & A, restructuring, new strategies – influence on raw material sourcing

Refractory Sector 2020-22

- **Imerys HTS (Calderys)** acquired by Platinum Investments
  - > **Calderys** (Imerys) / Haznedar /

Examples:

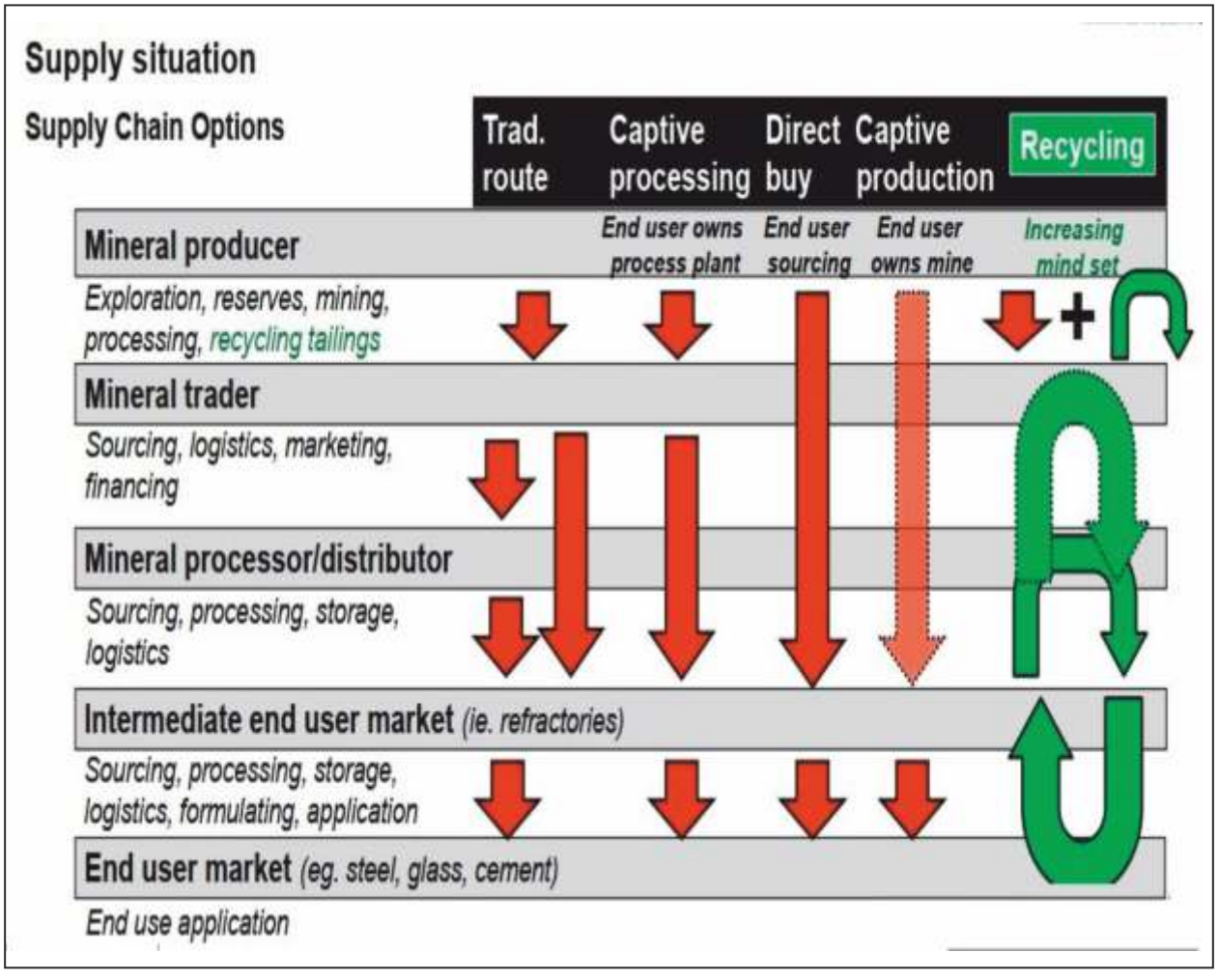
2020

- RHI Magnesita / Black Earth Minerals **graphite**, Madagascar
- Possehl / Arciresa, **calcined bauxite**, Guyana 2021
- POSCO / Black Rock Mining, **graphite**, Tanzania
- Refmin China / Etablissements Gallois, **graphite**, Madagascar 2022
- Mario Pilato Blat / Hyperion Metals, zircon, USA Sunward Refractories
  - **Saint-Gobain**/Monofrax
  - **Intocast**/Slovmag
  - **Resco** acquired by Balmoral Funds LLC
  - **Cementos Molins**/Calucem
    - > **Calucem** to develop $35m CAC plant in eastern New Orleans

- **RHIM** / Sörmaş / HiTech Chemicals
- **Vesuvius** / Universal
- **PRCO** / Serbia MALBEX WBI DOO
- **Seven Refractories** / Euroref / HB Refractories
- **Sisecam** / Refel
- **HWI** new $22m. US refractory centre "Alabama One"
- **Alfran/NRL** j-v India

Mineral supply sector 2019-2022

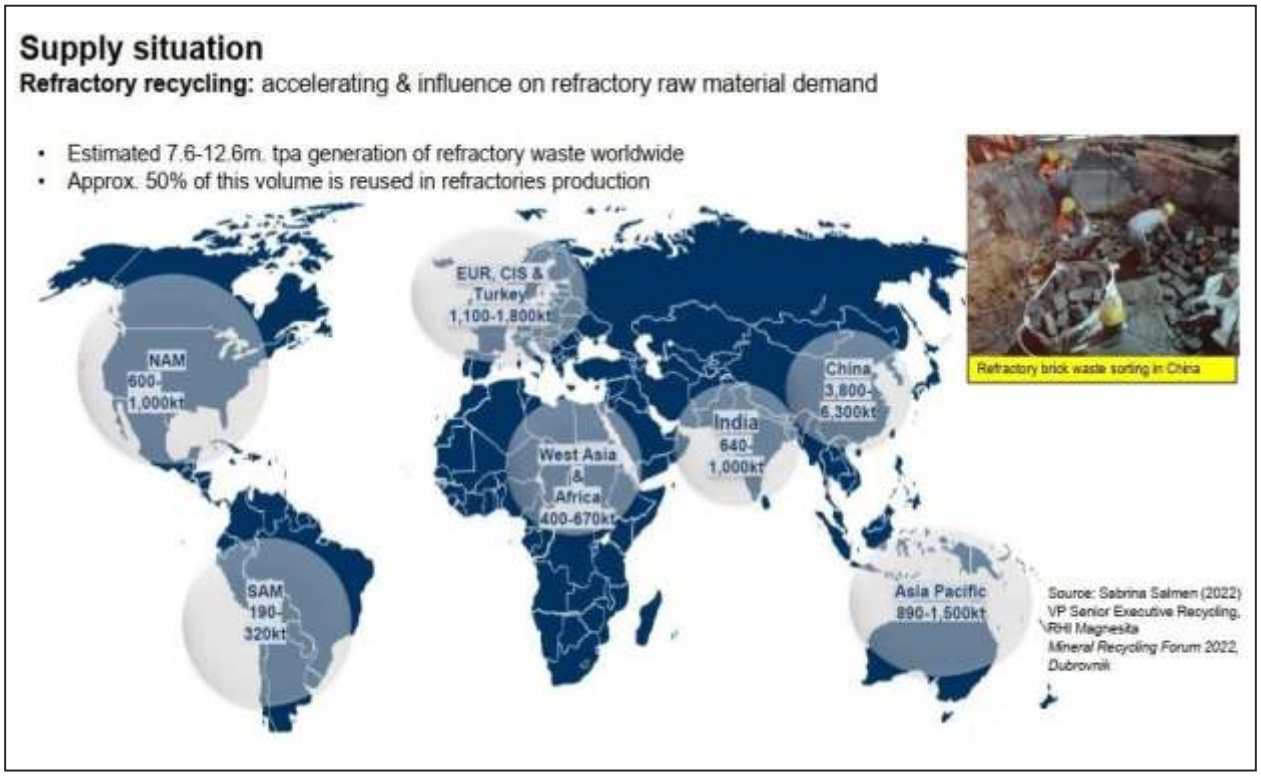
- **Fiven ASA** acquires **S-G SiC**
- **NICHE Chemical** acquires **Imerys FM, Alteo WFA**
- **Refra** acquisition of **QMAG, Australia magnesia**
- **Andalusite Resources** new owner **ARM Andalusite**
- **UMS** acquires **Alteo, aluminas**
- **Kümaş magnesia** acquired by Turkish no.1 steel leader **Erdemir** (part of the Mining Metallurgy Group of OYAK) **Northern Graphite** acquires **Imerys graphite** assets



Supply Situation

Refractory Recycling: accelerating & Influence on refractory raw material demand

- **Mineral/Refractory Recycling**: Inevitable And Evolving Development.
- **Drivers:** environment, Circular Economy, alt. sources of raw material, Govt. Initiatives
- **More mainstream:** processing lines; opportunities sensed and sought after.
- **"New normal":** recycled raw materials becoming regular supply chain option for mineral buyers
- **Economic & strategic alliances**: between waste sources (eg. steel, glass makers) and recyclers, new logistic chains
- **Supply chain co-operation:** in modifying refractory formulations to ease end-of-life recyclability, costs, and enhance market application – challenging combination!
- **Emerging sector:** Europe, Brazil, Asia, eg. S. Korea's refractory recycling rate increased from 33% 2013 to 65% 2019



Supply situation

Refractory recycling: accelerating & influence on refractory raw material demand.

Refra/Horn refractory recycling JV

- Sept. 2021: Refratechnik Horn Produktions GmbH (Refratechnik Steel / Horn & Co. Minerals JV)
- revival of Horn's Hünsborn plant, ramp up to 20,000 tpa MgO-C brick in 2022, 40,000 tpa in 2026.
- 2nd hydraulic 2000t press operational Q2 2022
- 25% raw material recycled refractories from Horn, remainder DBM / FM from QMAG, Australia.

Sidenor LIFE 5RefrAct Project

- Evolved refractory waste recycling management with LIFE 5RefrAct Project since 2018.
- Co-operation with Magna = 9 MgO products @ 70% recycled, with Refralia, 12 Al2O3 products @ 65%

Supply situation

Spotlight: Bauxite

- Refractory grade supply limited to China and Guyana (Bosai Group)
- Intense interest in alternative sources and/or materials, eg. andalusite, aluminas

Emerging newcomers: **First Bauxite LLC, Guyana**

> subsidiary Guyana Mining Co. (GINMIN) producing 340,000 tpa cap. high purity (63% Al2O3) raw gibbsitic bauxite at Bonasika.

> July 2020 started bulk ocean shipments raw ore.

> trialling sintered and calcined grades; planning own calcination plant eventually.

> calcination (92-93% Al2O3) by US toll processors & **Arciresa, Spain.**

- 2022: 60,000 t BauxSTAR 90
- 2023/24: 80,000 t BauxSTAR 90 + FBA

FIRST BAUXITE LLC

- May 2022: FBX acquires US Ceramics LLC
- Rotary kilns at plants in Wrens & Andersonville, GA
- adds processing & logistics capabilities for refractory, proppant, & flame retardant markets BAUTEK

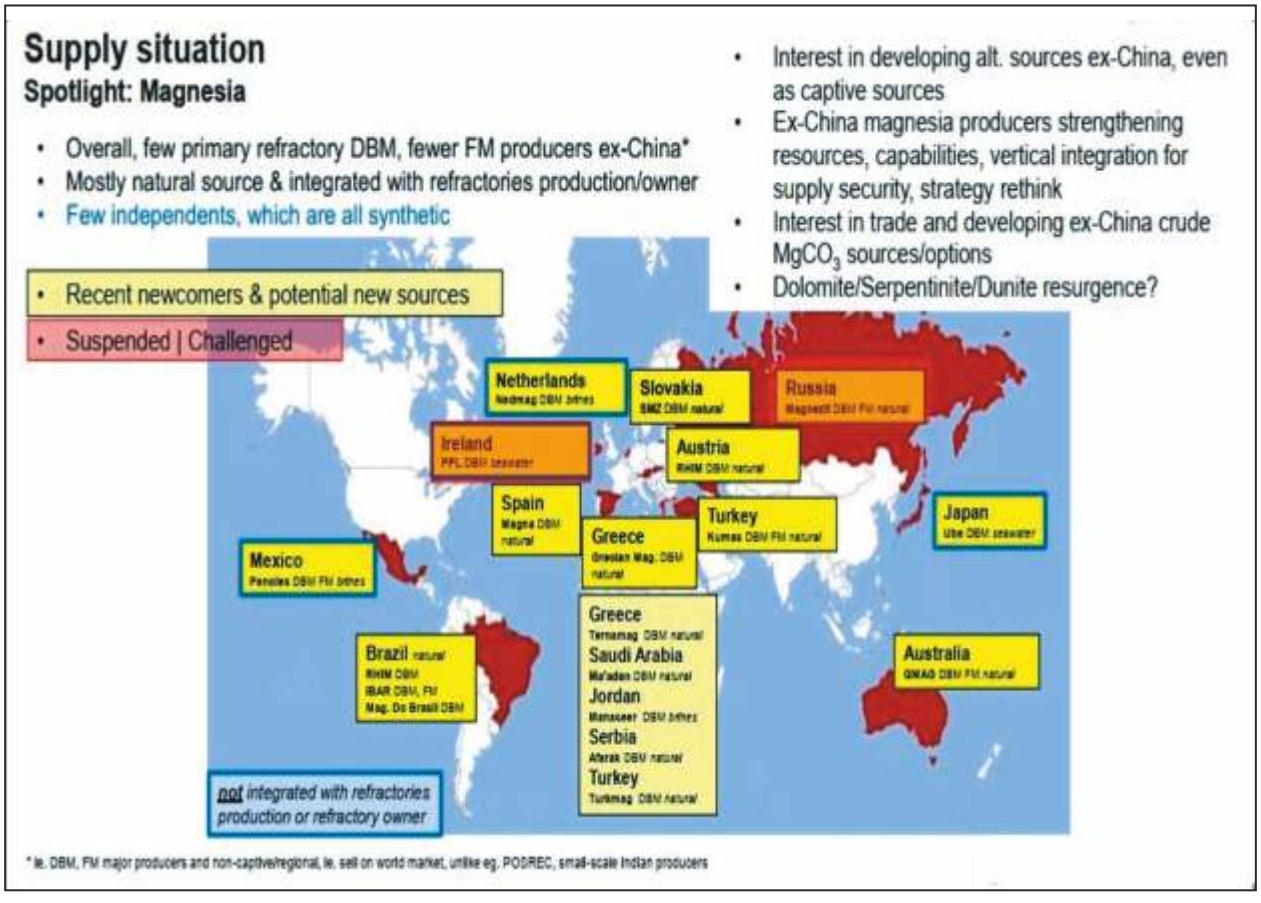
Emerging newcomers: **Bautek Minerais Industriais Ltda, Brazil**

> US$30m. investment/development of chamotte & bauxite since 2016:
  - fleet of 25 trucks to transport to ports
  - drying/milling plant at Barro Alto (chemical grade bauxite for water and wastewater treatment)
  - new laboratory in Goiás, for quality control/new products
  - 3 new rotary kilns at Barro Alto for abrasive, refractory, and welding grades
  - 1st 36,000 tpa rotary kiln to double Bautek kiln capacity started early March 2022; 2 further kilns 2023/2024, with combined capacity of 140,000 tpa.
  - new ball mill and briquetting plant at Barro Alto for 2022

> non-met. bauxite production by TGM, Barro Alto expected to increase 450,000 tonnes in 2022 to 600,000 tonnes in 2023

> calcined bauxite production Bautek expected to increase 120,000 tonnes in 2022 to 180,000 tonnes in 2023.

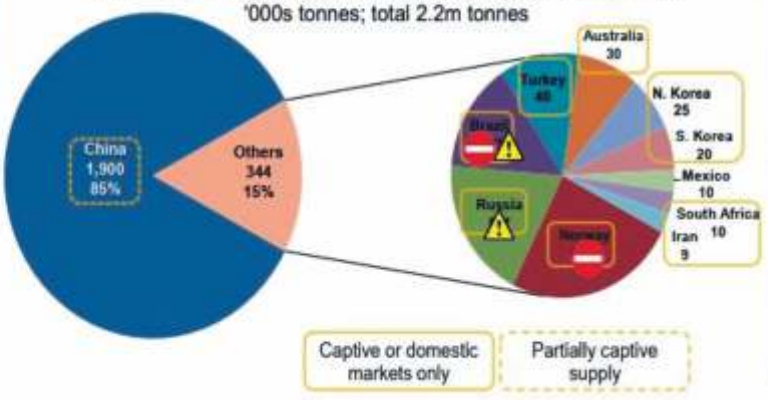
> Products: calcined sintered bauxites for BFA, CAC, refractory, welding; milled bauxite for water treatment, flame retardants; high alumina chamottes (50, 70 alumina)



Supply situation
Spotlight: Magnesia

FM supply: China dominates; even fewer ex-China sources, mostly captive
Magnezit to significantly increase capacity – captive only? Russia-Ukraine war + external sales uncertain?

World fused magnesia production capacity by country 2018
'000s tonnes; total 2.2m tonnes



UPDATE

Russia
Magnezit to increase FM cap. to 115k 2021, eventually 175k 2025

Norway
Capacity withdrawn with RHI Magnesita restructure 2020-21

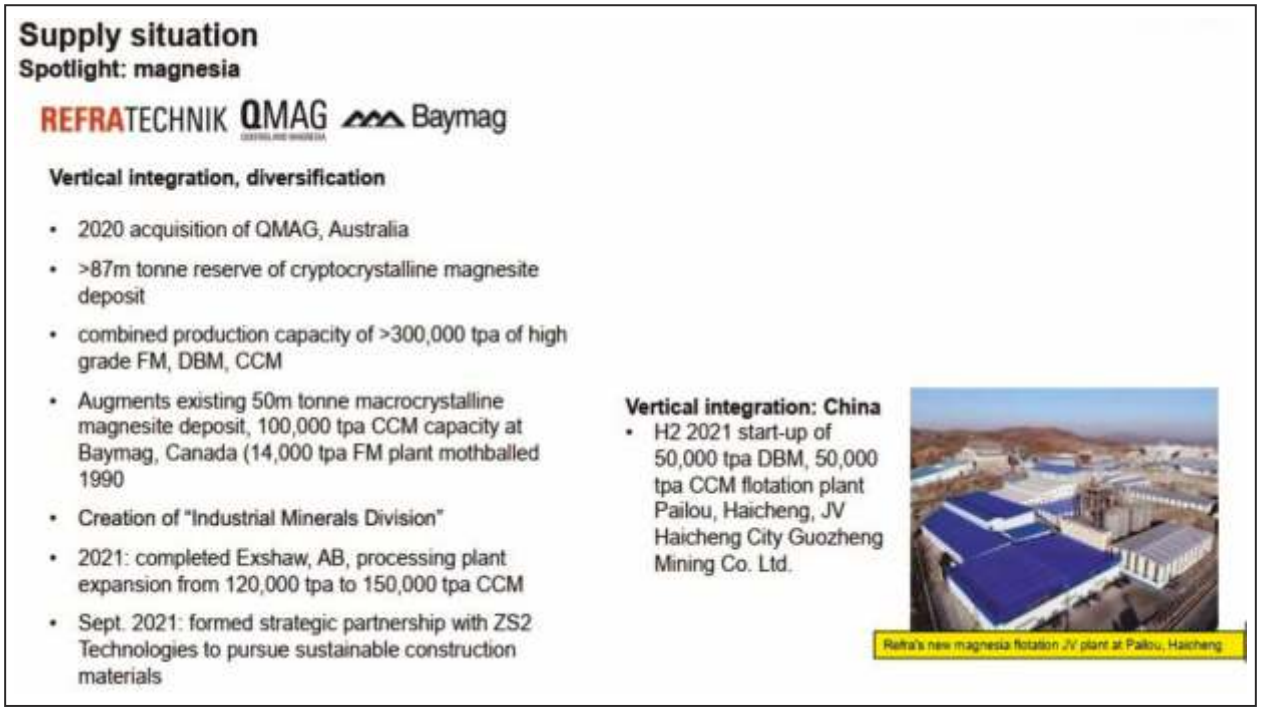
Brazil
- RHIIM Brazil stopped then restarted
- IBAR starts FM

Source: data USGS

Supply situation
Spotlight: magnesia

- Existing CCM/DBM/refractories producer

- Magnesite mine in Bahia
- 2020 started developing fusion capacity Poa, Sao Paulo
- 2022: 4x Higgins EAF installed & in operation
- Total capacity about 1,800 tpm FM
- Space & infrastructure for further 4x EAF to double capacity



Supply situation

Spotlight: magnaesia

RHI MAGNESITA

Vertical integration | FM strategy rethink

H1 2020: suspend FM production facilities Normag, Porsgrunn, Norway and Contagem, Brazil (latter restarted 2021 using renewable energy);

"internal costs to produce grades of fused magnesia are too high relative to Chinese sourced equivalent materials…to enter into long term alternative supply arrangements."

Brumado, Brazil investment

"Magnesite hub for the Americas"

- Brumado, Bahia: H2 2020 €30m investment in new 140,000 tpa rotary kiln plant (to replace 8 vertical shaft kilns);
- On line H1 2023, after delays with cost control, contractors;
- expected to increase production 30% and lifetime of Pedra Preta mine to 120 years.
- Contagem: postponed commissioning new grinding lines for DBM/FM;

PPL + Normag sale

- Feb. 2021: sold Normag CCM/MDH facilities (FM dismantled) and PPL (DBM, CCM, MDH) to Callista (PE, Munich);
- Normag rebranded Magnor Minerals, then closed later in 2021; PPL suspended operations 2022.

Supply situation

Spotlight: magnesia

Dolomite focus China

- 2018 €20m investment to restart dolomite plant at Chizhou, Anhui (2015 prod. cap. 65,000 tpa DBD)
- new mine started end-2019: 1m. tpa crude dolomite, 100,000 tpa DBD

Austria

- Q4 2021 completed 2019 >€40m investment in "Dolomite Resource Center Europe" at Hochfilzen – biggest investment made in Austria in 30 years.
- New mine, 200,000 tpa; new rotary kiln 100,000 tpa completed Feb. 2022; transported by rail to EU markets.
- Sinterco JV, Belgium, est. 180,000 tpa capacity, closed 2020/21

France

- Oct. 2021: €3.8m. upgrade to Valenciennes fired dolomite brick plant

USA

- May 2021: new $8.6m primary crushing system at York, PA
- "5 years in the making"
- "unlocks new supply of dolomite resources"

Dolomite sector note

RHIM dolomite assets (Italy, Spain) divested to Intocast 2017
Imerys' 60% stake in Haznedar, Turkey (Aug. 2020) leaves independent Vardar Dolomit, Skopje, North Macedonia (60,000 tpa).

Supply situation

Spotlight: magnesia

KÜMAŞ ERDEMİR

Vertical integration

- Jan. 2021: Kümaş acquired by Turkish no.1 steel leader Erdemir (part of the Mining Metallurgy Group of OYAK); approved Dec 2021.
- Erdemir: *"...will achieve cost control and efficiency by ensuring vertical integration in its activities in iron, steel, and cement."*
- Major consumer of steel and cement refractories:
  2021 crude steel: 9.2m tonnes (22% Turkey total output)
  2020 cement: 32.6m tonnes
- OYAK acquired world leading speciality aluminas producer Almatis in 2015
- potential non-refractory MgO end user synergies in group.


Salıdere Ana Damar magnesite mine of Kümaş, Kütahya

Kümaş Plants	Production capacity (tpa)
Kütahya	
3 rotary kilns	300,000 DBM,CCM,DBD
4 electric arc furnaces	40,000 FM
1 multiple hearth furnace	60,000 CCM
1 tunnel kiln	100,000 refractory bricks
	45,000 refractory monolithics
Tavşanlı	
1 rotary kiln	20,000 CCM
1 shaft kiln	10,000 CCM
1 shaft kiln	25,000 CCM, DBD

Supply situation

Spotlight: magnesia

MAGNEZIT
cooperation in creation

Vertical integration: Russia

- 2010+: approx. US$394m. investment in new magnesia & refractory plants, & renovation of existing plants at Satka, Chelyabinsk + Razdolinsk, Krasnoyarsk, Siberia
- 2016-20+ "a period of important investment projects…aimed at mobilising internal reserves, modernising and building new capacities."
- 120th Anniversary 2021

Satka

- **Magnesite:** development of Yelnichnoye >2m tonne deposit in progress, 220,000t 2021; & developing new +100 horizon in underground Magnesitovaya mine to add 1.6-2m tpa magnesite, completion 2024.
- **FM** US$88.7m new "Avangard" plant 1st phase online Aug. 2020, completed end-2021, 50,000 tpa FM, 5x 8.8 MVA 10 ktpa EAF; adds to existing 65,000 tpa FM cap.
- **DBM** MHF no.2, 100,000 tpa commissioned 2 June 2021; max. feed 25 tph of Razdolinsk, Krasnoyarsk ore

Razdolinsk

- **CCM** annular shaft kiln, 50,000 tpa under construction 2019/2020
- **FM** plant: new 60,000 tpa FM, planned 2025.

GRECIAN MAGNESITE

AKDENİZ
MINERAL KAYNAKLARI A.Ş.

New "green" mine | Capacity expansion | Product diversification

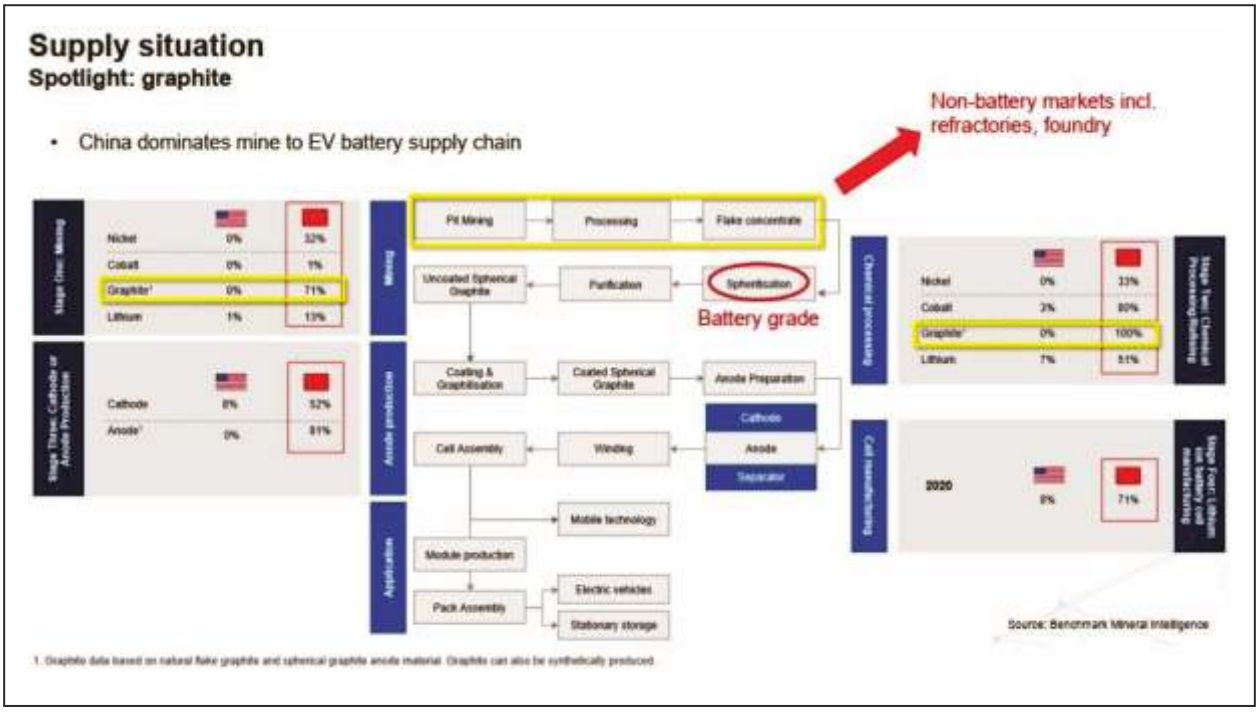
- **Process plant expansion:** March 2021: Akdeniz Mineral Kaynaklari A.Ş. (AMK), Turkey completed construction of new €1.5m 30tph automated mineral processing line
- production started Q4 2020 with approx. 20,000 tpa

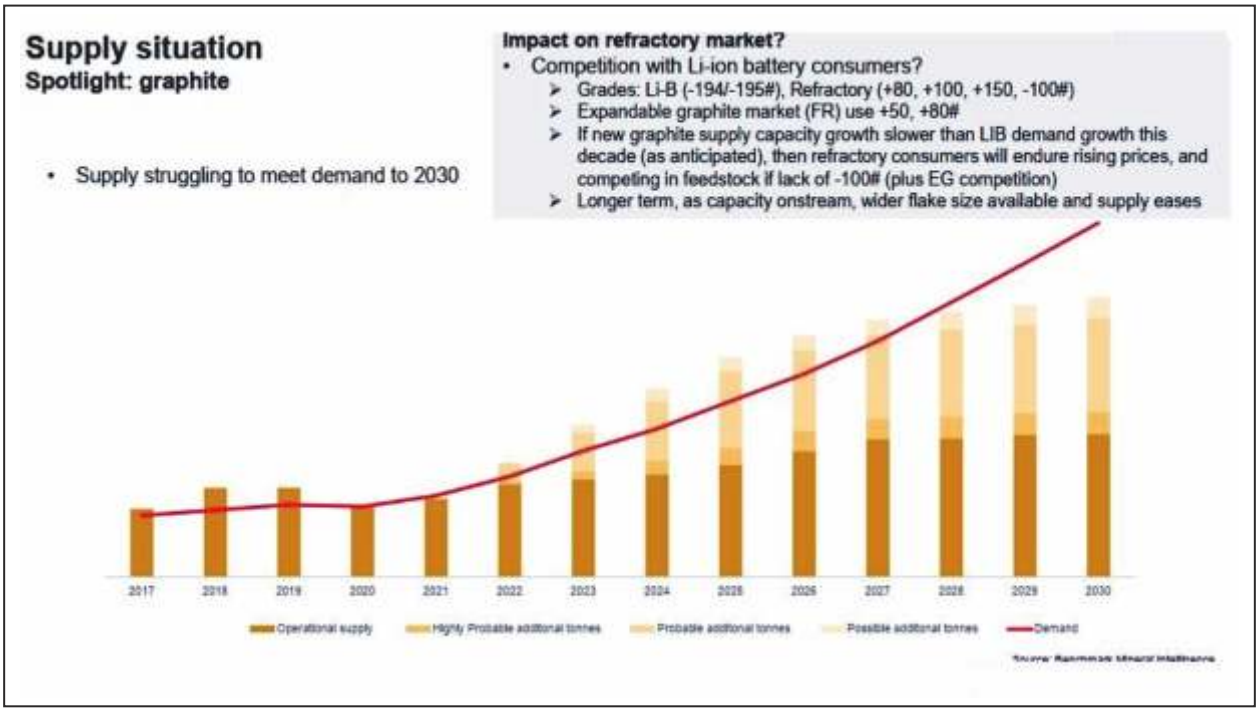
Supply situation

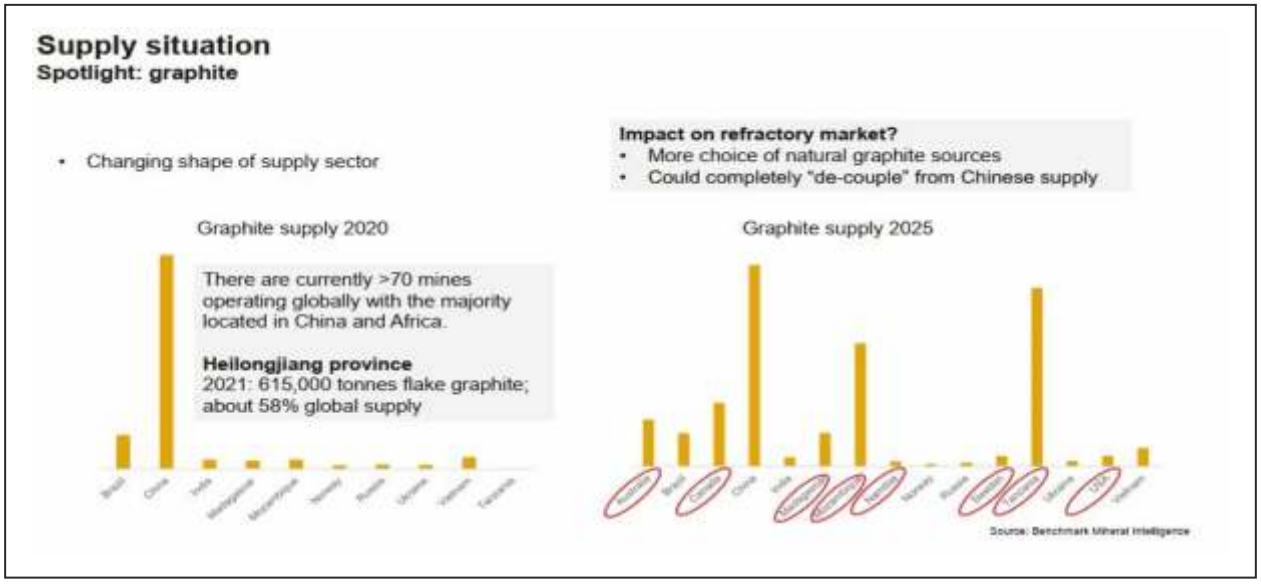
Spotlight: magnesia

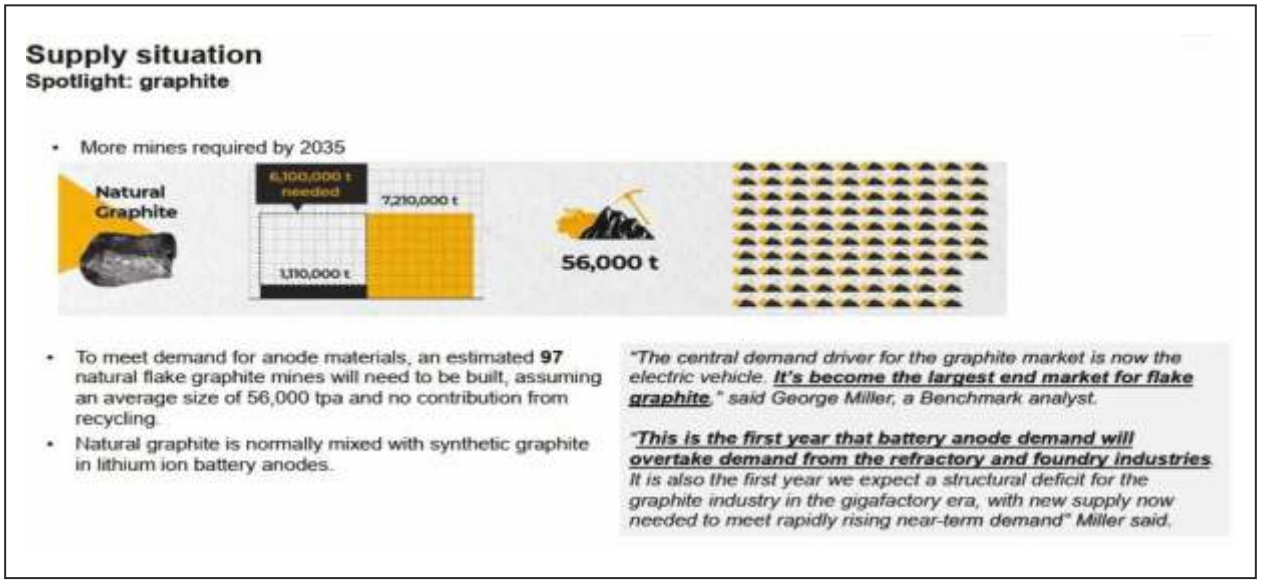
New source

- Askale, Erzurum
- 100,000 tpa cap. DBM
- **New mine:** May 2021: start of Koutzi UG mine, Evia, Greece; "a small scale, surgical, underground mine" with narrow vein mining techniques for the extraction of high quality magnesite
- 50,000 tpa RoM, out of an estimated 11m tonnes of reserves
- **New product:** recently launched new dunite-based product OLIDUN-REFRA for refractories and other markets; 1m. tpa cap.
- 6 mines; can only be operated 6 months/year
- 2020: new mining licence & plant investments in magnetic separation & optical sorters.
- 2021: new Deve Korusu mine on stream with high grade magnesite; 75,000 t total DBM output (grades ranging 86-96%MgO), 70% exported
- Aim to reach full capacity by 2024 with R&D projects + XRT sorters on order to enhance quality control


Supply situation
Spotlight: graphite
China dominates mine to EV battery supply chain
Non-battery markets incl. refractories, foundry
Battery grade
Source: Benchmark Mineral Intelligence


Supply situation
Spotlight: graphite
Supply struggling to meet demand to 2030
Impact on refractory market?
Competition with Li-ion battery consumers?
Grades: Li-B (-194/-195#), Refractory (+80, +100, +150, -100#)
Expandable graphite market (FR) use +50, +80#
If new graphite supply capacity growth slower than LIB demand growth this decade (as anticipated), then refractory consumers will endure rising prices, and competing in feedstock if lack of -100# (plus EG competition)
Longer term, as capacity onstream, wider flake size available and supply eases
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Operational supply
Highly Probable additional tonnes
Probable additional tonnes
Possible additional tonnes
Demand





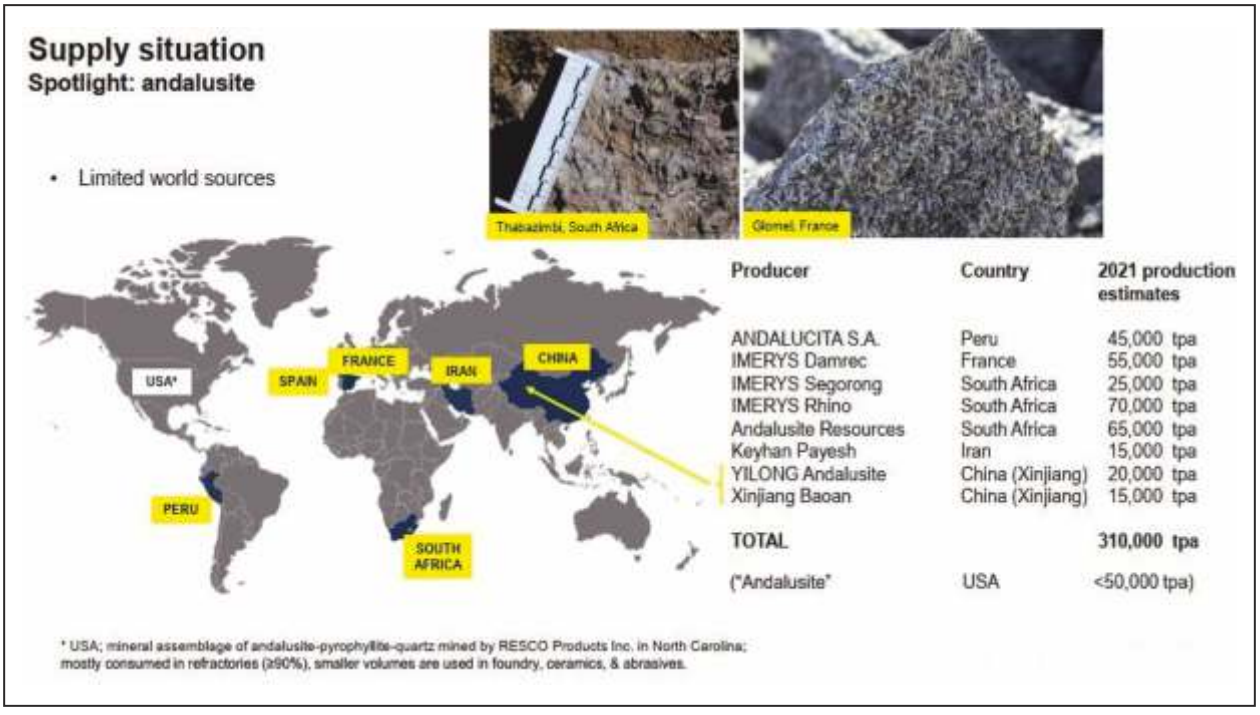
Supply situation

Spotlight: graphite

- Jan. 2022: Northern Graphite invests US$55m on Bissett Creek, ON, & acquires Imerys graphite ops. Lac des Iles, Quebec & Okanjande, Namibia (closed May 2022).
- Okorusu, Namibia processing plant undergoing capital improvements and expected to be back in operation in 2023 at 30,000 tpa
- August 2022: Northern Graphite to acquire Mousseau West graphite project located approx. 80 kms from, and within economic trucking distance of Lac-des-Iles graphite mine in Quebec; 4.1m tonnes grading 6.2% graphitic carbon

- Mousseau West will extend mine life at LDI and return its production to 25,000 tpa

- = potential world no.3 ex-China, N. Amer. no.1 natural graphite producer



Supply situation

ARM ANDALUSITE

Spotlight: andalusite

- 2021: **Andalusite Resources** emerges from Business Rescue with new ownership of ARM Andalusite (Pty) Ltd
  - > July 2022: back to capacity, 70,000 t projected 2023
  - > Diesel power option if no electricity
  - > 2023 12-14% price rise owing to energy costs
  - > €540-600/t CIF Europe
- **Chinese andalusite** supply impacted by Xinjiang covid controls
  - > Production costs increased prices; US$600-615/t EXW
  - > Tight supply encouraging smaller players to emerge (again!):
- **Picobello Andalucita SL**, 65,000 tpa andalusite project, Galicia, Spain
  - > Feb 2021 prospectus: permits in place; "…entered into advanced discussions with a number of customers for the offtake of andalusite."
  - > Mar. 2022: seeking partners for "initial €9m. Investment" (€32.8m total cost).
- **Malapane Mineral Resources & Energy Pty Ltd**, license to sell stockpile former Imerys Hoogeneog, Limpopo, SA mine

Outlook for global refractory mineral supply China

- Are we witnessing a transformation in mineral supply expectations and trends from China?
  - > Yes, traders and consumers actively seeking alternatives
  - > But China to remain an important source of ref. minerals
  - > Supply sector reforms will reduce capacity but increase efficiency with modern plants
- And should we expect this to continue?
  - > Yes; future stability in China may possibly ease supply, but…
  - > rising energy costs will challenge mineral (esp. fused) output/exports.
  - > China refractory output may decline with CO_2 emission targeting, easing export availability or closing down capacity?
- What alternative sourcing strategies can be pursued by consumers?
  - > Diversify supply sources; secure ex-China mineral supply byofftakes, investment in new mineral projects, vertical integration
  - > Future should see a balance of China and ex-China supply sources to ensure consistent supply in volumes and quality

Overall

- **Global supply impacts:** COVID-19, logistics, Russia-Ukraine war, energy crisis, geopolitics – Taiwan? – industry must learn from these.
- **Existing mineral producers ex-China corporate readjustment:** rationalisation / consolidation; select investments / strategies; vertical integration & diversification; "reshoring"; increased M&A as companies restructure to survive
- **Refractory sector:** revision of mineral sourcing: security, supply chain strategies; "decoupling" from China; select innovation & investment to "be ready"; M&A
- **Boost to new/alternative sources worldwide**: eg. magnesia, graphite, bauxite, fused minerals; assisted by wider awareness; to serve market hotspots eg. India
- **New / alt mineral products:** eg. consideration of increasing use of alternative minerals, synthetic minerals, recycled refractory minerals
- **Emerging EV LiB market:** demand impact on graphite availability? Likely to have some impact, short term shortage, but longer term stability with new sources?
- **Environment:** greater & significant influence on mineral & market development; climate protection drive, CO_2 footprint reduction, energy transition, "green" mining/manufacturing; more recycling eg. from refractory/mine waste
  - > possible reduction of refractory volume use with new fuel tech. by end users
  - > modification of refractory formulation = impact on ref. mineral selection
  - > increased recycling & emergence of new recycled material supply chain.

TECHNICAL SECTION

PERFORMANCE IMPROVEMENT OF SLIDE GATE REFRACTORIES- "A STEP TOWARDS REDUCED CARBON EMISSION"

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Abstract

Slide gate refractories plays a vital role during transfer of molten metal from ladle to tundish or tundish to mold. Slide gate refractories are one of the major component of steel ladle which controls the flow of molten metal from ladle to tundish. Now-a-days, secondary steel making demands reduction of plate brick consumption by improving the life of slide plate so that down time will be reduced with minimum energy consumption. In this context, IFGL attempts to minimize carbon emissions during manufacturing of slide plate although keeping the required properties. Hence, lowering the environmental impacts and emphasizes on reducing carbon emissions in the long term. Optimized carbon content and selection of optimized concentration of antioxidants are the key concept to improve thermomechanical properties of slide plate. Material properties have substantially improved in this material selection process and characterization techniques. Field trial showed improved performance of the plate during teeming of liquid steel from ladle to tundish.

Key words: Ladle, Tundish, mould, slide plate, Thermo-mechanical

Spinel or Alumina-zirconia quality slide plate have been considered to improve thermal properties with carbon being used in different form[1]

As desired, slide plates have been fired at higher temperature (above 1200^{0}C)to achieve volume stability and desired thermal properties. As a result of which energy (fuel) consumption became higher during manufacturing process followed by undesirable carbon emission.

Constituents	Standard	Developed
Alumina	90%	92%
Fixed Carbon	5%	<5%
Antioxidants	5%	>5%
Phenolic Resin	5parts	3 parts
VM%	1.85	1.41
Cylinder BD(gm/cc)	3.04	3.23
Product Green BD	3.16	3.27

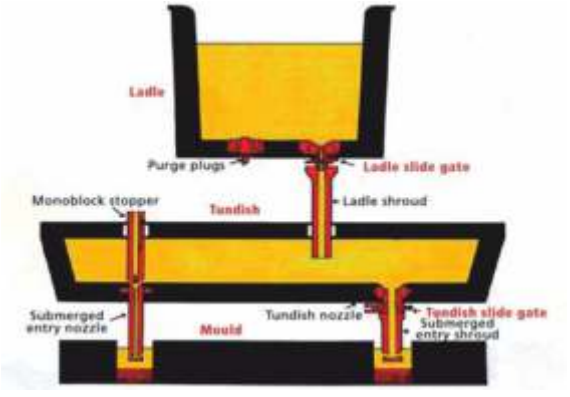


Fig.1. Schematic diagram of flow control refractories

As a green binder, phenolic resin have been used since a long period. This has adverse effect on the working environment and also health hazardous. Some literature pointed out that firing has a vital influence on the weight loss, heat release behaviour and structure evolution of the resin binder in carbon-containing refractory [2,3]

Hence, therefore the objective of the present work in this paper is to optimize the carbon content in the material so as to require

optimum amount of phenolic binder for the manufacturing. Also selection of proper antioxidants will help further optimization in firing temperature of material resulting green environment. Thermal properties are enhanced drastically which in turn resulted better performance followed by minimum down time during application.

Experimental Technique

Different raw materials like alumina, carbon and antioxidants with different fraction ranging from 3mm to 20 microns (or lesser) have been selected for the batch formulation as per table 1 Both the standard recipe and the developed one are processed in similar fashion upto drying.

Table-1.Batch formulations and Green properties

Constituents	Standard	Developed
Alumina	90%	92%
Fixed Carbon	5%	< 5%
Antioxidants	5%	> 5%
Phenolic Resin	5 parts	3 parts
VM%	1.85	1.4
Cylinder BD (gm/cc)	3.04	3.23
Product Green BD	3.16	3.27

Table-1. Batch formulations and Green properties.

The above mentioned raw materials were mixed with phenolic formaldehyde resin in high intensive mixer machine. After screening, the green mix was then cured properly in controlled AC chamber and then the aged mix was molded in desired shape in a hydraulic press with specific pressure of >1800 Kg/Cm2. Green BD of the standard product was found to be 3.16gm/cc and that for developed product, it was 3.27gm/cc

The products are cured at above 200°C prior to further processing. Then the product was tempered under reducing atmosphere at a temperature below 1000^{0}C. The physical, thermal and thermomechanical properties are evaluated with the help of different instruments. Morphology of the tempered product has been correlated with that of standard product (those fired at above 1000^{o}C) by means of Scanning Electron Microscope (SEM). Pore size analysis of standard product sample and with that developed product sample were compared through Mercury porosimeter.

Evaluations and discussions

Comparative study has been made for standard and developed product. The binder content has been reduced drastically in case of developed sample due to optimization in carbon content in the developed recipe.The physical & thermal properties were correlated in the Table-2.

Table-2: Physical and thermal properties

In the evaluation process, the apparent porosity and bulk density of the developed sample arefound to be better as compared with that of standard one. This might be attributed due to the effect of granulometry adjustments followed by optimized resin additions. Also by lowering the firing temperature, it has the impact to reduce pore size and its distribution density. Binder burn out during pyrolysis stage was attributed to be minimum as compared to that with firing in excess of 1000^{0}C. Hence porosity was getting reduced followed by higher BD in the developed sample. Hot strength was found to be much higher for the developed material than that of standard sample. This might be due to use of antioxidant which enhances the grain-matrix bond of the developed sample. The oxidation resistance of the developed sample was found to have nominal difference in both the cases (Fig.2) This is attributed to the pyrolysis of phenolic resin at lower temperature which is more prone to oxidation in air in case of developed case and in turn, the standard material has already initiated the ceramic bond while firing at the temperature around 1000^{0}C.

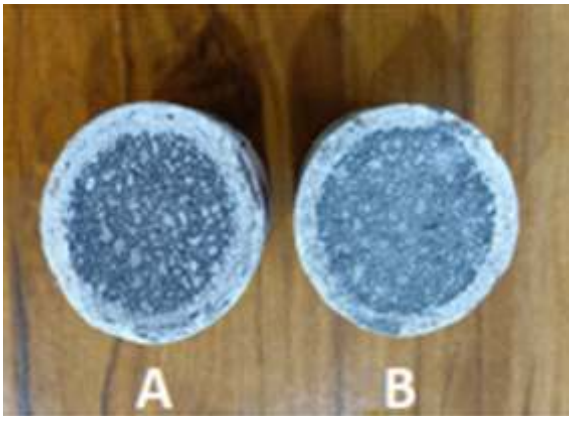
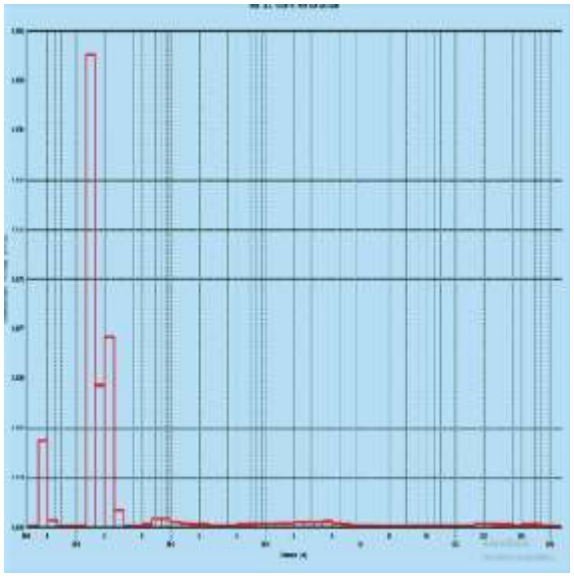


Fig.2. A-Standard sample, B- Developed sample after oxidation test at 1400°C/2hrs in air Both standard and developed sample have been simulated in rotary corrosion test at 1550°C having steel ball and acidic slag as media. Developed sample showed corrosion resistance higher than that of standard sample(Fig.3). This

Parameters	Standard	Developed
AP (%)	13.2	5.3
BD (gm/cc)	3.07	3.22
HMOR at 1400°C/30min (Kg/Cm2)	134	262
Oxidation index (at 1400°C/2hrs)	100	84
Corrosion index (at 1550°C/1hr)	100	71

might be attributed to the higher density and higher hot strength of the material followed by lower pore volume in case of developed sample. Comparative pore volume in both the cases are given in the Fig.4.

This phenomenon leads to lower molten metal/slag infiltration at the interface.



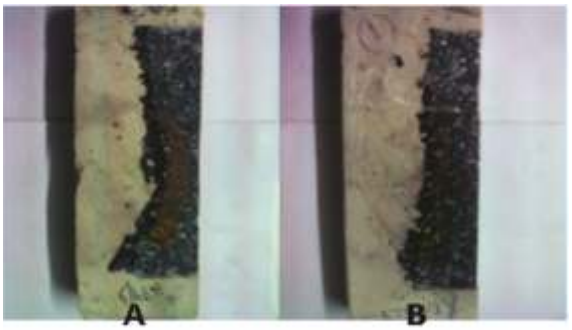


Fig.3. A-Standard sample, B- developed sample after rotary corrosion test at 1550°C/1hr

Fig.4. Pore Size Analysis (Top-Standard sample, Bottom- developed sample)

The Scanning Electron Micrograph (SEM) of standard and developed sample are picturized in the Fig.5. It shows the compact structure of developed sample against the standard sample.

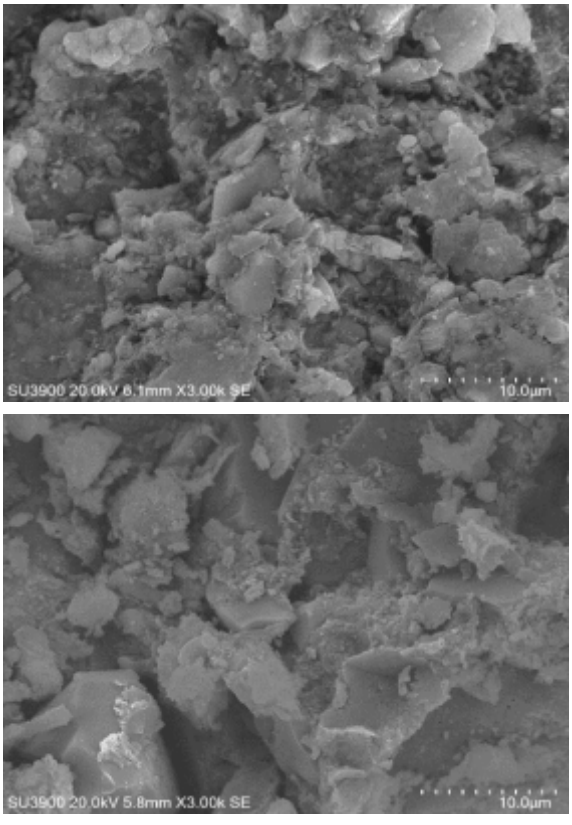


Fig.5. SEM Micrograph (Top-Standard sample, Bottom- developed sample)

Simulation through field trial:

After small scale field trials followed by extensive trials done at different steel plants with ladle capacity(varying from 60T to 120T) of few plants, plate performance is summarized in tabulated form. Operating condition of respective plants are given in the table 3.

Plant	X	Y
Caster type	Billet	Billet/Bloom/slab
Steel grade	MS/Alloy	MS/Alloy
Ladle capacity (T)	60	120
Casting temperature (°C)	1550-1580	1560-1580
Casting duration(min)/ht	50-65	55-70
Bore dia of plate (mm)	40	55

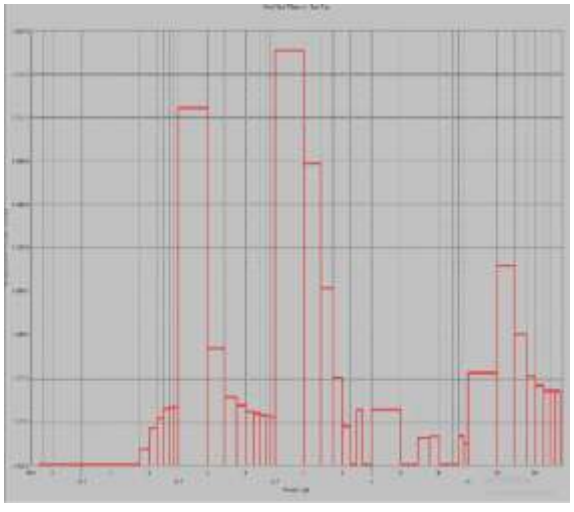


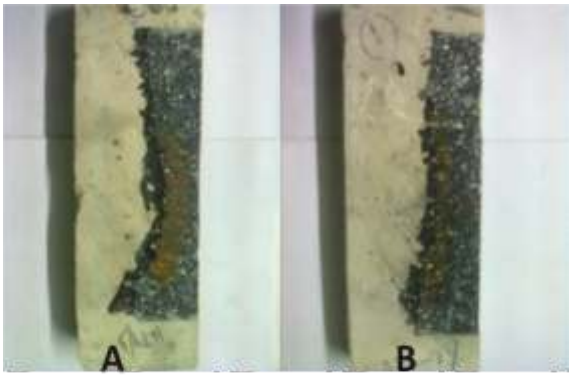
Table-3: Operating conditions at steel plants

In the above operating condition, slide plates have been tried as per the standard practice in respective steel plants. Performance summary of regular plate and developed plate are tabulated in table.4.

	Standard		Developed	
Plant	X	Y	X	Y
Life of plate (hts)	4	5	5	6
Bore erosion(mm/ht)	1.8	2.0	1.2	1.5
Extent of throttling erosion(mm)	56	38	24	15
Total Casting duration (minutes)	220	255	280	332

Table-4: Performance summary of plate Plant-X:

In this case, both the standard and developed sample have been tried. It seems that bore erosion was found to be reduced as compared with that of standard product and also performance enhanced upto 25%. Used plate conditions Can be compared as per the fig.6.



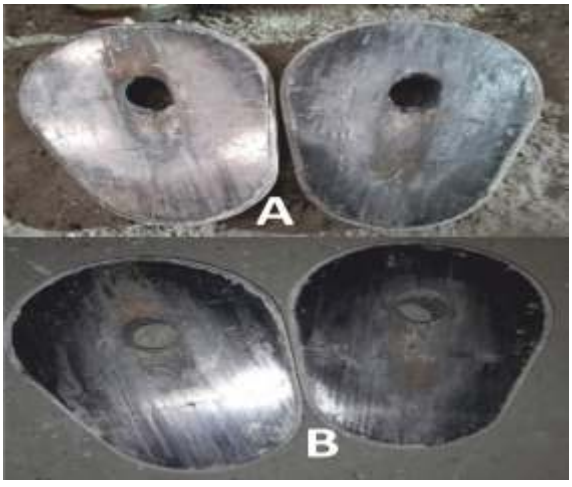


Fig.6 Used plate condition at Plant-X
(A-Standard B- Developed)

Throttling path of developed product indicates that there is no abnormal oxidation or erosion phenomenon even after 5hts.

Plant-Y: Similar comparison has been made both with the standard and developed sample after field trial at plant-Y. It is confirmed that bore erosion is found to be reduced as compared with that of standard product. Extent of throttling in this case although lower but bore erosion rate quiet higher in comparison to plant-X due to the high ferro static head of liquid stream.

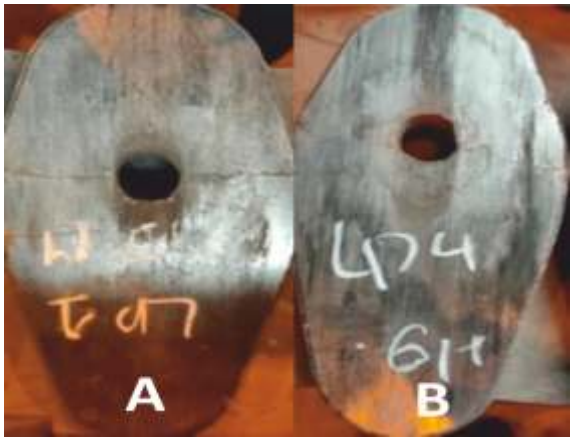


Fig.7 Used plate condition at Plant-Y
(A-Standard B- Developed)

By comparing the surface of both standard and developed plate, although the throttling erosion pattern seems nominal however bore erosion of developed plate found to be lesser than that for standard plate.

Conclusion

By the addition of optimum amount of carbon content followed by lower amount of liquid resin addition shows to have the significant impact on the properties and performance of slide plate. Improvement in performance will lead to minimise the down time and also results in greener environment due to reduction in consumption input materials coupled with improvement in specific refractory consumption of Slide plate having higher absolute performance. Following conclusions can be drawn:

- Lowering the carbon content demands lower amount of phenolic binder for uniform mixing in the developed sample mix
- Hot MOR of the developed sample showed much better value than that of standard recipe
- Oxidation resistance in air have nominal variation in both the cases
- In case of developed sample, corrosion resistance was found to be higher upto certain extent
- In the field trial of both the product, the field performance of the plate have been enhanced upto 25% (or more) after the development

Higher the carbon content in the mix requires higher liquid resin for uniform mixing and also to achieve required green strength. Hence higher will be the total CO_2emission. This research work was carried out for a long period to optimize the CO_2 emission further considering manufacturing point of view. The developed Slide plates are performing better leading to lower specific consumption at user industry and also reduced CO_2 foot print due to recipe optimisation.

References

[1] E. Mohamed et al.Carbon based refractories, Journal of ceramic Society (2004)

[2] Jiu Zhang etal. Effect of firing temperature on mechanical properties of Al_2O_3–C sensor for continuous measurement of molten steel temperature, ISIJ International, Vol. 54 (2014), No. 3, pp. 553–558

[3] Hyiyun Jiang etal. The pyrolysis mechanism of phenol formaldehyde resin, Polymer degradation and stability, August 2012

GLIMPSES FROM THE PAST:

THE VALUE IN USE OF STEEL LADLE REFRACTORIES MANAGEMENT

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1) Corus Strip Products IJmuiden - Basic Oxygen Steel Plant 2
2) Corus Strip Products IJmuiden - Refractory Plant

From the end of the last century into the first decade of the 21st century the liquid steel capacity of BOS plant no.2 at Corus IJmuiden has increased drastically and process conditions have changed. Due to these changes and ambitious output targets, not only the life and availability of the steel ladles, but also monitoring of ladle use needed to be improved. Corus IJmuiden has developed a ladle management system which allows us to track, manage and plan the ladle fleet.

For optimization of refractory linings and developing new lining concepts a very good understanding of the interaction between process, ladle management and refractory lining is very important. From an economical point of view we are evaluating refractories on a "Value in use" basis in which not only the refractory cost but also availability and capability of the installations are taken into account.

Besides choosing the right refractory concept which fits the process, handling these new concepts properly is crucial. Ladle management is one of the big enablers of a stable and reliable production and improves refractory performance. The Corus IJmuiden ladle management secures ladle availability to production and minimum heat losses for the liquid steel, combined with optimal refractory performance. It results in a positive impact on the cost per ton of steel.

Key words: steel ladle, refractory, management, refractory performance

1. Introduction

The planning and control of steelmaking and casting operations is fundamental in achieving high quality steels and on time delivery of customer orders. It is often seen that integrated steel plants have a sophisticated and well maintained system to plan and control steel production and casting, but a system to efficiently manage the ladle fleet is often lacking. Inaccurate handling of steel ladles will result in a limited temperature control over the steel route. This can cause increased wear of the refractory lining which limits the availability of the ladles. Therefore, Corus IJmuiden has developed a ladle management system which allows us to track, manage and plan the ladle fleet. This resulted in a positive impact on the ladle lifetime and cost per ton of steel. The increased ladle availability was essential for the increased production output and will be further improved for the future output targets. With the coming of a second ladle furnace in the near future the refractory lining of the IJmuiden steel ladles are put to the test.

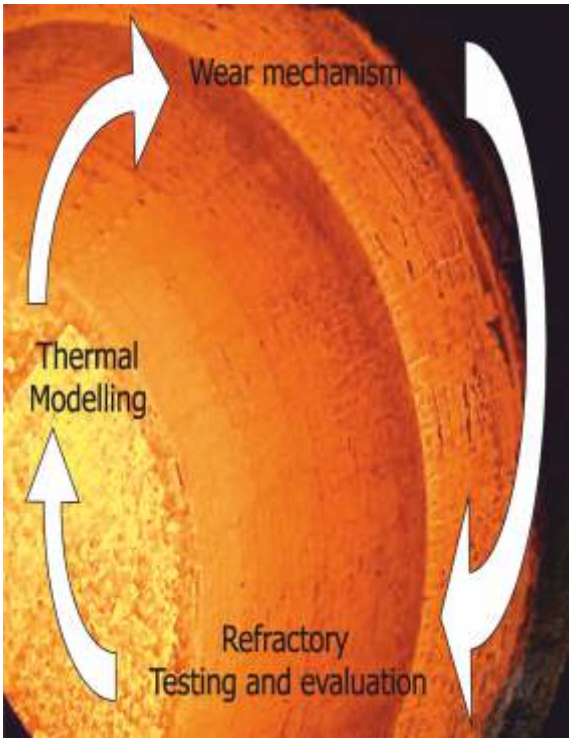

Figure 1. Understanding the interaction between process and refractory lining is important

2. Refractory philosophies

Without reliable refractories there is no reliable steel production. Therefore the philosophy of Corus IJmuiden is that refractory knowledge and expertise is a core competence and has to be kept in house. For optimization of refractory linings and developing new lining concepts a very good understanding of the interaction between process and refractory lining is crucial (figure 1). Corus IJmuiden has a well equipped refractories laboratory (Ceramics Research Centre, CRC) and production facilities in its own refractory brick plant (REP). This gives the opportunity to react quickly in case of failing refractory materials and also helps with fast implementation of new developments. From an economical point of view we are evaluating refractories on a “value in use” basis in which not only the refractory cost but also availability and capability of the installations are taken into account.

3. Steel ladle concept

At Corus IJmuiden 20 steel ladle shells are used of which normally 11 are in operation, 2 are standby and 7 are in maintenance/repair. Until the year 2000 an Andalusite brick lining was applied in the steel ladles, it was a relative simple lining with a reliable lifetime of 75 heats. With the introduction of the first ladle furnace the lifetime decreased drastically and together with the planned increase of steel output there was an availability problem of the ladle fleet. Based on research and trials a new wear lining concept was designed. This wear lining design consists of alumina spinel in the side wall with a thickness of 140 mm, the slagline and bottom are MgO-C qualities with a thickness of 178 and 250 mm respectively. The impact pad is 300 mm and is an AMC quality. Two purging plugs are used in the bottom for mixing during secondary ladle treatment.

At first there was no significant improvement, but with the new lining design there was also need for a new operating practice in the plant. The described spinel lining needs a careful handling of the ladles to receive its full benefits. Monitoring of the steel ladle logistics gives the opportunity to create optimum temperature control and equal distribution of ladle lifetime for the highest availability. With the significantly improved sidewall lifetime a split campaign was introduced for the steel ladles with an intermediate repair for slag line and bottom.

3.1. Steel ladle life

Over the years, developments in refractory lining of steel ladles has made significant progress in the service life of the ladles (figure 2). The improvements in ladle life are not only positive regarding refractory cost, but also on ladle availability. The change to a new refractory concept for the steel ladle (alumina spinel) shows a step increase of the life to 130 heats, but is still away from the optimal conditions. The former andalusite lining is more 'forgiving' with respect to temperature variations. Optimisation in the concept and improvements in handling of the ladles results in a gradual increase of the service life of the ladles.

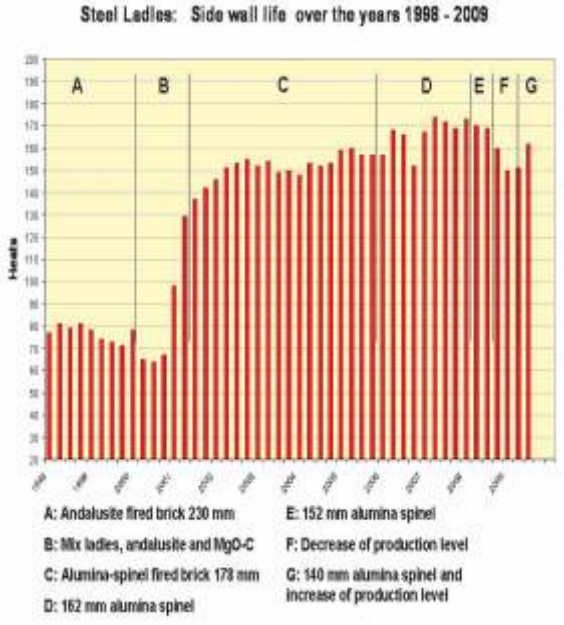

Figure 2. Service life of steel ladle side wall

4. Ladle management

The increase in steel output capacity at the steel plant in IJmuiden requires a stable and reliable production. Ladle management is one of the big enablers to achieve this and improves refractory performance. Corus IJmuiden has developed a ladle management system which allows us to track, manage and plan the ladle fleet in every stage, during relining and production. The ladle management system is also used to optimize output by linking the steel ladle output with the life of the ladle and by that means always transport the maximum amount of steel. This secures ladle availability to production, process control (stable casting and maximum output), combined with optimal refractory performance, resulting in a positive impact on the refractory cost per ton steel.

4.1. Planning and Monitoring

For the steel plant in IJmuiden two systems have been developed, a production controlling system (SPIN) and a production monitoring system (STANLEY). During daily operation, the lifetime distribution of individual ladles is controlled by the operators in order to keep a balanced ladle fleet. The distribution of ladles in A (first) and B (second) campaign is kept constant as much as possible. This provides a controlled workload for the brick layers during reline, resulting in a secured availability of the ladles. The number of heats per ladle per 24 hours is also controlled to minimize heat loss (thermal shock) and wear rate. This is visualized in the screen shot given in figure 3. The programs give direct access to steel ladle details such as volume (based on wear), lifetime and position in the plant (figure 4).

Figure 3. Screen shot which displays an overview of the real-time sidewall lifetime (top), bottom/slagline lifetime (middle) and heats per day (bottom) for each separate

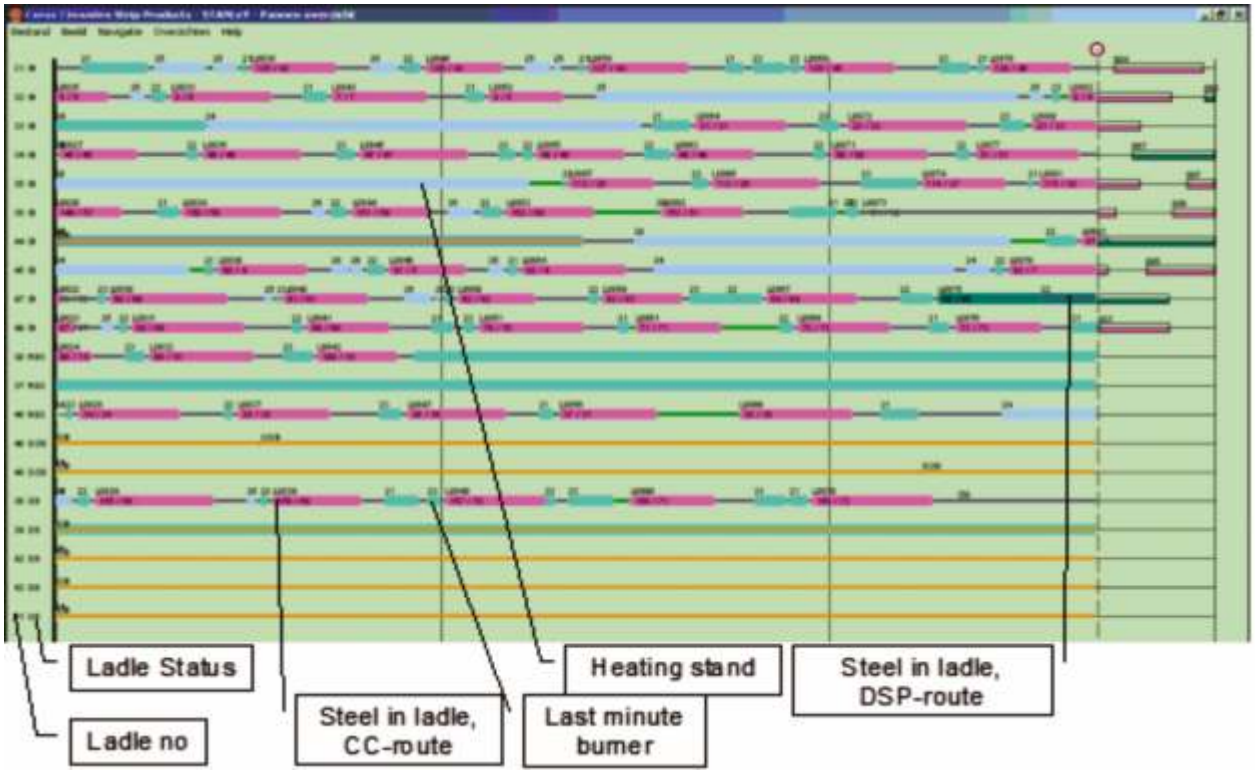

Figure 4. Screenshot which displays the route of each ladle in the plant

4.2. Temperature along the route

Temperature measurements that are done along the production route are automatically imported in the program. This gives a direct overview of the temperature history for each separate ladle at any time during the production. Visualisation of the process data makes it much more easy for the operators to react on deviations. Temperature control is not only a very important parameter for steelmaking but also has a big influence on the refractory performance of the steel ladle. In order to minimize the cycle time and reduce thermal shock in the ladle the amount of heats per day per ladle is well controlled and monitored. The best performance is reached with more than 5 heats per day per ladle.

4.3. Ladle history

Process data of the history of the ladle can be obtained from the program, which can be very useful when variations appear in the refractory lifetime of the ladles. It gives the opportunity to evaluate the refractory performance and to correlate this with possible process variations.

5. Conclusions

Ladle management is one of the big enablers of a stable and reliable production and improves refractory performance. Corus IJmuiden has developed a ladle management system which allows us to track, manage and plan the ladle fleet in every stage, during relining and production. Information on the ladle history can easily be obtained, which is a useful tool for evaluating refractory performances. From an economical point of view refractories are evaluated on a “value in use” basis in which not only the refractory cost but also the availability and capability of the installations are taken into account.

STATISTICS

		2023-24(Apr- Feb)	2023-24(Apr- Feb)
HSN code	**IMPORT OF REFRACTORY RAW MATERIALS**	**Qty(mt)**	**(Rs.Lakhs)**
25199010	Fused Magnesia (Natural)	58268.04	28229.99
25199020	Dead-Burnt (Sintered) Magnesia	180968.14	49041.17

(Source: Ministry of Commerce, Government of India)

ISR 2024

The 9th International Symposium on Refractories

Oct. 15–18, 2024 Chengdu, China

The Ninth International Symposium on Refractories (ISR2024), organized by The Chinese Society for Metals, The Chinese Ceramic Society, and Sinosteel Luoyang Institute of Refractories Research Co., Ltd. will be held in Chengdu, China on October 15–18, 2024.

International Symposium on Refractories (ISR) is a serial international symposium and has been held successfully for eight sessions. ISR2024 will provide a good opportunity for researchers, manufacturers, suppliers and users around the world to review the progress and achievements made in recent years.

Manuscripts, Proceedings and Presentation

Abstract shall be submitted before July 31st, 2024 while manuscripts shall be submitted before Sept. 15th, 2024 through the conference website (www.isr2024.com). During submission, please select the field of the manuscript (topics of the conference) and presentation preference (oral or poster). The presentation type (oral or poster) will be finalized after the manuscripts are reviewed. After assessment, all the accepted manuscripts will be published in the conference proceedings in the form of U disks.

Conference Schedule

Date	Morning	Afternoon	Evening
October 15th	——	Registration	Registration
October 16th	Opening ceremony Plenary Session	Plenary Sessions	Banquet
October 17th	Parallel Sessions	Parallel Sessions	——
October 18th	Parallel Sessions	——	——

Registration

Registration Fee	Before July 20th, 2024	From July 20th to October 14th, 2024	Pay On-site
Regular Participants	USD 650	USD 750	USD 850
Students	USD 450	USD 550	USD 650
Accompanying People	USD 100		

**Note: Students are requested to submit the copy of their student ID before payment.*
The registration fee for accompanying people only covers banquet.

Conference Venue and Hotel Reservation

The conference will be held in Chengdu, the capital of Sichuan Province. The city is renowned for its relaxing lifestyle and delicious food. It has many historical sites and cultural landmarks. Meanwhile, Chengdu remains one of the key economic, cultural, and transportation center in southwest China, with remarkable progress in technology and innovation in recent years. Chengdu is also famous for Panda Breeding and Research, attracting people from all over the world. Howard Johnson Agile Plaza Chengdu is the conference site. It locates in the Tianfu New district adjoining to the Luxehills International Community and Western China International Expo City. It is 30 minute-drive from Chengdu Airport, and 20-minute drive from the Chengdu South Railway Station.

Sponsorship and Exhibition

Sponsorship and exhibition opportunities are available. The exhibition will be organized during the conference. Refractory raw materials and products, production and testing equipment, as well as technologies and methods related to the latest developments in the field of refractories are welcome to exhibit at the conference site. Please contact the conference secretariat for booth reservation and sponsorship.

Contact Information

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SCABAL

"SCABAL" is a trusted brand and market leader in the processing and exporting of Raw Bauxite and Calcined Bauxite, for decades. Our unwavering commitment to maintaining consistency in product quality and service has earned us reliability in the market.

- Winner of CAPEXIL Export Award for consecutive Years since 1998-1999
- Renowned exporter of Raw Bauxite from own Mines having wealthy reserves of Bauxite.
- Leading manufacturer of Calcined Bauxite
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- SCABAL is dedicated to consistently progressing towards optimal utilization of bauxite and contributing to the production of its allied products.
- A project for producing downstream products like Mullite, High Alumina Refractory Products is in the pipeline.
- In addition to Bauxite and Calcined Bauxite, we maintain an active presence in the market with Castable, Mortar etc. through our sister concern Raghuvanshi Refractories, Porbandar.
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For further details, please visit our website www.scabalindia.com.

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SADASHIVA REFRACTORIES LLP

Raw Material Elucidation

A FEW WORDS

ABOUT US

SadaShiva Refractories LLP is an emerging company in the business of Mining and Processing of Refractory Raw materials in Jamnagar, Gujarat in India. We are engaged in producing Refractory raw materials like Calcined Bauxite, Calcined Clay and Chamotte. We have been registered with GMDC and we have been allotted more than 3500mts of Raw bauxite per month under the quota system. Our company headquarters is located in Mumbai and plant operations with advanced captive Rotary – Kiln Calcination is located at Meghpar in Jamnagar.

OUR MISSION

SRL core business mission hinges on its' commitment to quality and service and offering raw material products consistent in size, chemistry and physicality. Our Laboratory is equipped with latest equipment for testing as per the industry standard.

CALCINED BAUXITE

Refractory bauxite, also known as Calcined Bauxite is produced by sintering high-alumina bauxite in rotary kilns at high temperatures.

CHAMOTTE

Chamotte is sourced from best quality captive mines having pure grade of china clay by the process of levigation.

CALCINED CLAY

Calcined clay is obtained by calcining (heating) superior grade clay at high temperature in Rotary Kiln.

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