

Argus Rare Earths Monthly Outlook



Outlook

The month ahead

Rare earth buyers seem reluctant to commit to significant spot purchases after the recent hike in prices, while suppliers are withholding sales in the hope of further price rises.

The next 3-6 months

Further forward, the direction for rare earth prices will depend to a large extent on the success of the Chinese authorities in controlling output, as well as growth in demand for rare earths in NdFeB permanent magnets.

12 months forward

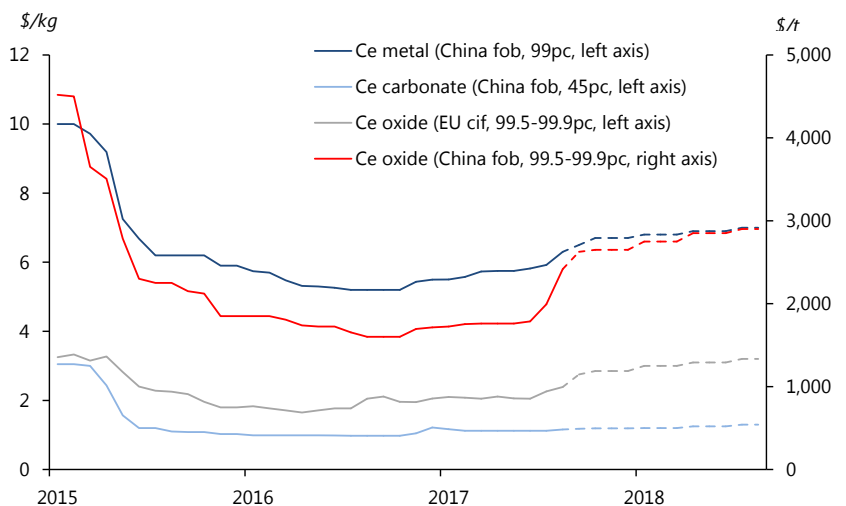
Prices for rare earths used in permanent magnets – neodymium, praseodymium, dysprosium and terbium – are forecast to rise further on increasing demand from electric and conventional vehicles, and wind power generation units. Other rare earths prices are expected to be flat at best as supply outweighs demand.

Cerium fob China

Average monthly cerium oxide and metal fob prices rose by 18pc and 6pc, respectively, in August because of continued supply disruptions. The average monthly fob price for 99.5-99.9pc cerium oxide was \$2,342-2,492/t, while fob prices for 99pc cerium metal were \$6.05-6.55/kg. Average monthly cif prices for 99.5-99.9pc cerium oxide in Europe increased to \$2.21-2.57/kg.

OUTLOOK: Steady/strengthening

Cerium fob China

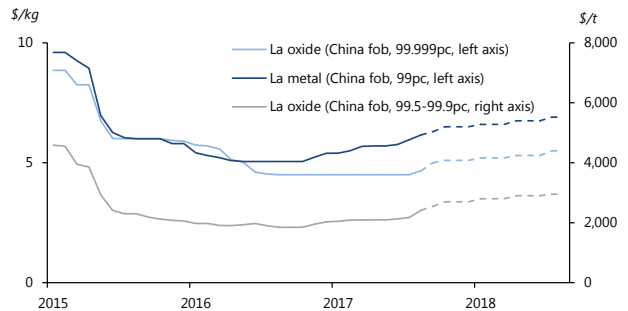


International pricing series

Lanthanum fob China

Average monthly lanthanum oxide and metal fob prices also increased during August. The average monthly fob price for 99.5-99.9pc lanthanum oxide increased by 10pc to \$2,291-2,541/t, while fob prices for 99pc lanthanum metal rose by 3pc to \$6.02-6.30/kg over the month. Average monthly fob prices for 99.999pc lanthanum oxide also rose to \$4.17-5.16/kg.

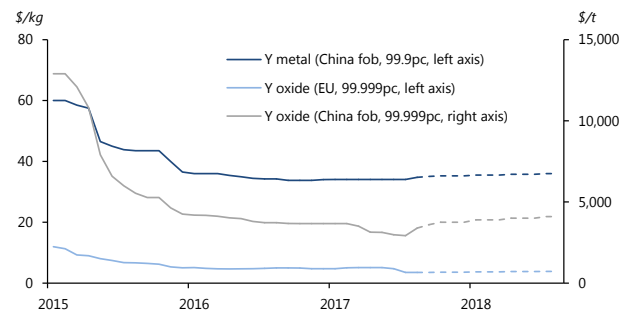
OUTLOOK: Steady/strengthening



Yttrium fob China

Average monthly yttrium oxide prices recovered strongly in August after dropping in June and July. The average monthly fob price for 99.999pc yttrium oxide was up by 14pc to \$3,092-3,694/t, while fob prices for 99.9pc yttrium metal were \$34.00-35.50/kg. Average monthly prices for 99.999pc yttrium oxide in Europe suffered a further small drop to \$3.00-4.00/kg.

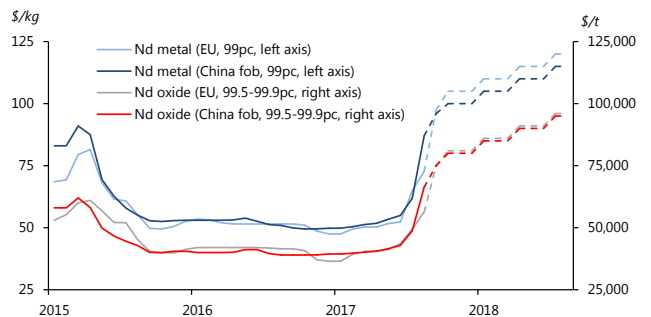
OUTLOOK: Steady



Neodymium fob China

Average monthly neodymium oxide and metal prices made further substantial gains in August. The average monthly fob price for 99.5-99.9pc neodymium oxide increased by 26pc to \$64,979-67,716/t, while fob prices for 99pc neodymium metal rose by 29pc to \$85.01-87.06/kg. In Europe, average monthly prices increased to \$53.59-59.23/kg for oxide and \$70.18-75.25/kg for metal.

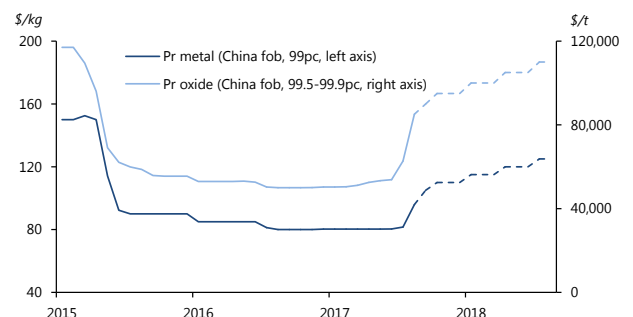
OUTLOOK: Strengthening



Praseodymium fob China

Average monthly praseodymium oxide and metal prices continued to follow neodymium up in August. The average monthly fob price for 99.5-99.9pc praseodymium oxide was \$83,587-86,578/t, up by over \$22,000/t compared with July. Fob prices for 99pc praseodymium metal were at \$92.76-99.00/kg, an increase of 15pc.

OUTLOOK: Strengthening



Price outlook

- Hastings Technology Metals signs second agreement regarding future offtake from its Yangibana rare earths project with China Rare Earth Holdings (CREH)
- Rare earth gadolinium demand is expected to fall as a result of increased concerns over its toxicity in magnetic resonance imaging (MRI) technology
- Indian government plans to triple renewables capacity to 175GW by 2022, including 60GW of wind capacity

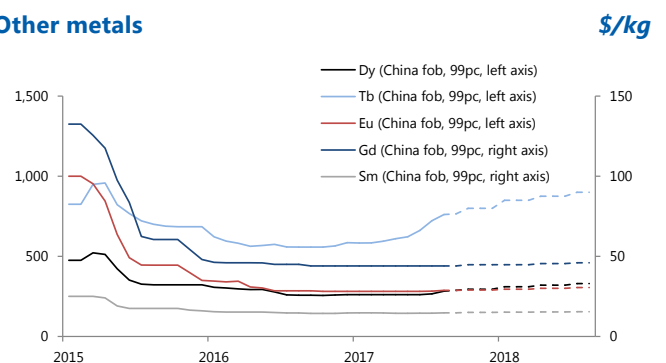
Prices for some rare earths have continued to rise at the beginning of September as supply remains relatively constrained. But buyers generally seem to be holding off making significant spot purchases at the higher price levels and are waiting to see if the near-term tight-supply situation eases. China's state-controlled Southern Rare Earth raised its price for the last week in August for terbium oxide, amid limited supply availability. Southern's listed price for 99.99pc terbium oxide was Yn4,150/kg (\$623/kg), up from Yn4,050/kg the previous week because of tightening supply. Spot prices fell as most downstream buyers postponed purchases and were waiting for a clearer market direction. But the company remains upbeat about the market outlook in response to scarce supply. Listed prices for other elements were flat on the week. Southern operates in Jiangxi province, China's largest medium and heavy rare earths-producing region. It started to issue weekly listed prices on 17 April. The company's size means that domestic buyers and sellers are starting to use its prices as a reference. Listed prices for the week beginning 21 August were as follows — Terbium oxide (99.99pc) at Yn4,150/kg; Dysprosium oxide (99.5pc) at Yn1,400/kg; Erbium oxide (99.5pc) at Yn190,000/t (\$28,520/t); Gadolinium oxide (99.5-99.9pc) at Yn180,000/t; Holmium oxide (99.5pc) at Yn500,000/t; Yttrium oxide (99.999pc) at Yn30,000/t; Lutetium oxide (99.99pc) at Yn4,900/kg; Samarium oxide (99.5pc) at Yn15,000/t; Scandium oxide (99.5pc) at Yn9,000/kg; Ytterbium oxide (99.99pc) at Yn150,000/t; Europium oxide (99.99pc) at Yn620/kg.

China's state-owned Northern Rare Earth has raised its September listed prices for many light rare earths as output falls as a result of continuing government measures to reduce pollution and tackle illegal production. The company

has raised its listed price for 99.99pc lanthanum oxide to Yn15,500/t (\$2,370/t) for September, up from Yn15,220/t in August. Prices for 99.95pc cerium oxide have risen to Yn15,500/t, up by Yn3,500/t compared with Yn12,000/t in August. Northern Rare Earth's decision to raise listed prices during the summer suggests it is confident that tight supply will overcome resistance to higher prices. The listed price for 99.5-99.9pc neodymium oxide has increased by Yn100,000/t to Yn500,000/t, up from Yn400,000/t. The price of 99pc neodymium metal has moved higher by Yn130,000/t to Yn640,000/t, up from Yn510,000/t. Unlike unseparated 99pc praseodymium-neodymium oxide, spot prices for both 99.5-99.9pc neodymium oxide and 99pc neodymium metal rose consistently over the previous month, largely in response to government-led environmental and illegal production inspections. The listed price for 99.5-99.9pc neodymium oxide is now slightly higher than domestic spot prices. It remains to be seen whether continued production cuts caused by government inspections will support prices further this month. The size and influence of Northern Rare Earth means that its listed prices are often used as a guide by buyers and sellers on the Chinese domestic market.

The praseodymium-neodymium oxide and metal markets resumed their recent rally on tight spot supply amid continued government inspections targeted at reducing pollution. But demand for heavy elements remained low given sufficient supply. Prices for 99pc praseodymium-neodymium oxide rose by Yn10,000/t on the low end of the range to Yn490,000-500,000/t (\$74,285-75,800/t) ex-works on 31 August, after holding at Yn480,000-500,000/t the previous week. There was no sign of a supply shortage easing as a result of government inspections and unauthorised producers

Other metals



were expected to remain closed in the short term. Prices for 99pc praseodymium-neodymium metal rose to Yn650,000-680,000/t ex-works after falling to Yn640,000-670,000/t in the previous assessment, because of high raw material costs and a supply shortage caused by shutdowns for environmental inspections. Prices for praseodymium oxide were assessed unchanged at Yn590,000-600,000/t, while the range for 99.5-99.9pc neodymium oxide rose to Yn475,000-485,000/t from Yn460,000-480,000/t because of higher demand. Export prices for 99.5-99.9pc neodymium oxide increased to \$72,000-73,500/t fob from the previous assessment of \$68,950-71,950/t in response to the rise in domestic prices.

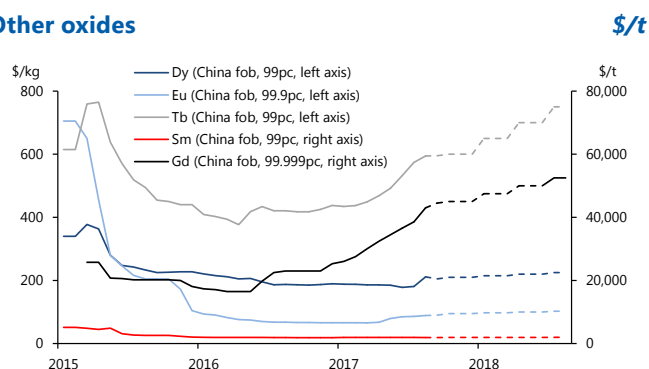
The range for 99.5-99.9pc cerium oxide remained at Yn16,500-18,000/t (\$2,500-2,730/t) ex-works, and prices for 99.5-99.9pc lanthanum oxide were assessed unchanged at Yn16,000-17,500/t ex-works. Some large buyers made enquiries to gauge the level of spot prices, but they held sufficient stocks and had no immediate need to enter the spot market. Prices for high-purity lanthanum oxide continued to rise as the enforcement of production quotas at major producers reduced output. The range for 99.999pc lanthanum oxide rose to Yn28,000-30,000/t ex-works on 31 August from the previous assessment of Yn27,000-30,000/t, while export prices were assessed higher at \$4.60-5.30/kg fob from the previous \$4.30-5.30/kg. Lanthanum-cerium (LaCe) mischmetal prices moved higher in response to the reduction in unauthorised output. Prices for 35pc lanthanum, 65pc cerium mischmetal were assessed at Yn36,000-39,000/t ex-works, up from Yn35,000-38,000/t. Price rises for secondary products such as LaCe mischmetal, commonly used in inoculants for the steel industry and flints for gas lighters, have also been attributed to a rise in prices for cerium and lanthanum oxides in recent months. Government-led environmental and illegal production inspections are also targeting mischmetal producers, placing additional upward pressure on prices.

Liquidity on the dysprosium market was limited with few deals concluded. Most suppliers cut their offer prices as a number of consumers observed the market in anticipation of lower prices next week. Prices for 99.5pc dysprosium oxide were assessed at Yn1,300-1,350/kg (\$197-205/kg) ex-works, down from Yn1,320-1,380/kg on 29 August. Export prices moved lower to \$196-205/kg fob, down from \$198-210/kg on 29 August. There was little demand on the terbium market as most buyers had no need to restock. Prices for 99.99pc terbium oxide were assessed unchanged at Yn3,900-3,950/kg

ex-works. Some deals were concluded towards the lower end of the range. Prices for 99.5-99.9pc gadolinium oxide and ferro-gadolinium were unchanged at Yn130,000-150,000/t and Yn150,000-170,000/t ex-works, respectively, amid stable demand and producer offer prices. A release of spot material by some suppliers increased availability, with prices poised to fall in the nearer term.

There was a sharp rise in European neodymium prices, with 99pc-grade metal assessed up at \$95-99/kg cif on 31 August, from \$69-74.40/kg in the previous assessment. Lower liquidity on the market in Europe resulted in a delayed response to price volatility in China. A similar pattern occurred on the neodymium oxide market, although liquidity was higher and some European traders sought to sell stock in Rotterdam to glass and ceramic producers, taking advantage of higher prices on the domestic Chinese market. The range for 99.5-99.9pc neodymium oxide was assessed up at \$66-73/kg cif, from \$53-59/kg the previous week. The cerium oxide market was more active, reflecting the larger number of catalyst and glass consumers in Europe. Several deals larger than 10t were done at \$2.50-2.90/kg. Prices for 99.5-99.9pc cerium oxide were assessed up at \$2.50-3.00/kg cif, from \$2.20-2.55/kg last week. Buyers of heavy elements erbium oxide and terbium oxide received offers for small tonnages from China at higher prices. The range for 99.5pc erbium oxide was assessed up by \$1/kg at the top end at \$27-30/kg cif, and prices for 99.99pc terbium oxide were assessed up at \$600-650/kg cif from \$595-625/kg the previous week.

Other oxides



Price table

Argus rare earths indexes (cumulative averages)					
Element	Units	Month index Aug 17	Moving quarterly average	Moving yearly average	Forecast Aug 18
Cerium					
carbonate min 45% REO fob China	\$/kg	1.16	1.13	1.10	1.30
metal min 99% fob China	\$/kg	6.30	6.01	5.64	7.00
oxide min 99.5-99.9% fob China	\$/t	2,416.74	2,065.16	1,796.92	2,900.00
oxide 99.5-99.9% cif Europe	\$/kg	2.39	2.23	2.10	3.20
Dysprosium					
metal min 99% fob China	\$/kg	282.47	269.82	262.30	330.00
oxide min 99.5% fob China	\$/kg	211.27	190.09	187.61	225.00
Europium					
oxide min 99.99% fob China	\$/kg	89.00	86.67	72.52	102.50
Ferro-dysprosium					
min 80% Dy fob China	\$/kg	215.42	197.08	207.55	235.00
Gadolinium					
metal min 99% fob China	\$/kg	44.00	44.00	44.00	46.00
oxide min 99.999% fob China	\$/t	43,006.52	39,376.78	28,691.49	52,500.00
Lanthanum					
metal min 99% fob China	\$/kg	6.16	5.96	5.55	6.90
oxide min 99.5-99.9% fob China	\$/t	2,416.00	2,238.70	2,068.55	2,950.00
oxide min 99.999% fob China	\$/kg	4.67	4.56	4.51	8.00
Mischmetal					
35% La 65% Ce fob China	\$/kg	5.91	5.41	5.19	6.50
low Zn and Mg fob China	\$/kg	21.35	20.10	19.30	23.25
Neodymium					
metal min 99% fob China	\$/kg	87.06	67.94	54.93	115.00
oxide min 99.5-99.9% fob China	\$/t	66,348.00	52,685.33	42,985.17	95,000.00
metal 99% cif Europe	\$/kg	72.72	63.30	53.19	120.00
oxide 99.5-99.9% cif Europe	\$/kg	56.41	49.78	41.93	96.00
Praseodymium					
metal min 99% fob China	\$/kg	95.88	85.96	81.67	125.00
oxide min 99.5-99.9% fob China	\$/t	85,083.11	67,205.37	54,984.16	110,000.00
Praseodymium-neodymium					
metal min 99% fob China	\$/kg	91.59	72.03	56.13	125.00
oxide min 99% fob China	\$/t	70,553.00	55,944.70	44,184.70	95,000.00
Samarium					
metal min 99% fob China	\$/kg	14.75	14.58	14.55	15.45
oxide min 99.5% fob China	\$/kg	1.92	1.94	1.92	1.97
Terbium					
metal min 99% fob China	\$/kg	760.97	714.80	616.81	900.00
oxide min 99.99% fob China	\$/kg	594.33	566.82	473.33	750.00
Yttrium					
metal min 99.9% fob China	\$/kg	34.75	34.28	34.03	36.00
oxide min 99.999% fob China	\$/t	3,392.83	3,099.28	3,422.71	4,100.00
oxide 99.999% cif Europe	\$/kg	3.50	3.92	4.70	3.85

Markets

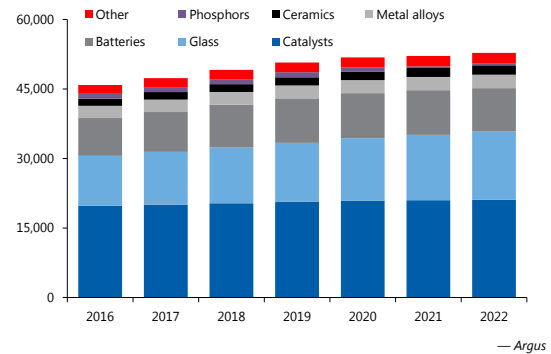
Demand for rare earths has been subdued in July/August, partly because of the summer break in Europe but also perhaps a result of the rise in rare earths prices, putting buyers off making significant spot purchases. Expectations of continued strong demand for praseodymium-neodymium in permanent magnets, driven by sharp growth in the electric vehicle and wind turbine industries, has led some analysts to forecast further price rises for rare earth magnetic materials. Forecast compound annual growth rates (CAGRs) for consumption of rare earths in permanent magnets range anywhere between 3pc and 8pc over the next 5-10 years, depending on predictions of electric vehicle uptake and overall growth in the automotive sector.

It should not be forgotten that in terms of volume, cerium and lanthanum dominate the rare earths market and, despite more traditional uses in industries such as glass, ceramics and catalysts, forecast growth rates are steady — in the region of 2-4 pc/yr. Argus forecasts lanthanum demand to grow at 2 pc/yr overall over the next five years, with robust growth of 5 pc/yr in the glass industry negated somewhat by sluggish 1 pc/yr growth in the catalyst sector — the main end-use application for lanthanum. Because of the preference for lithium-ion batteries over nickel-metal hydride equivalents in electric and hybrid vehicles, growth in demand for lanthanum in battery applications is forecast at less than 2 pc/yr to 2022. Changes to phosphor formulations and a switch away from rare earth-containing phosphors could see demand for lanthanum in that sector drop by more than half over the same forecast period. The combined growth rate for lanthanum use in metal alloys, ceramics and other uses is estimated at just under 3 pc/yr.

India and Mongolia will expand wind powered generation capacity, with new orders from Danish turbine manufacturer Vestas. The Danish Climate Investment Fund, German developer Ferrostaal, French energy company Engie and a Mongolian entrepreneur will collaborate on construction and operation of the 55MW wind park at Sainshand in Mongolia's Dornogobi province. The Sainshand wind park will be the third developed in Mongolia, and is expected to launch in the first half of next year. Vestas will also provide turbines with a combined 100MW of generation capacity to an Indian customer, in line with increased adoption of renewable generation across the subcontinent. India's government plans

Forecast lanthanum demand, 2016-22

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to increase renewables capacity to 175GW from the current 57GW by 2022, including 60GW of wind power capacity.

Vestas is also collaborating with US-based electric vehicle and battery manufacturer Tesla on the development of energy storage solutions for wind power projects. This is part of a wider programme aimed at marrying sustainable electricity generation with energy storage solutions. Wind turbine construction is a key consumer of the rare earth dysprosium, which is used in the production of permanent magnets. Rechargeable battery energy storage technologies use a range of minor metals, including lithium, vanadium, cobalt and manganese.

China plans to build a large permanent magnet production base in the Baotou Rare Earth Hi-Tech Industrial Development Zone in Inner Mongolia. Baotou is expected to complete construction of 30,000-50,000 t/yr of permanent magnet capacity by the end of 2020, director of the Hi-Tech zone An Sihui said at the 9th China Baotou International Rare Earth Industry Forum. Baotou is China's production hub for light rare earths because of the huge reserves in the Bayan Obo mine, which contains around 1.5bn t of iron ore, 43.5mn t of rare earth oxides and 3.2mn t of niobium pentoxide reserves. The rare earth ore grades at Bayan Obo are 27.2pc lanthanum oxide (La₂O₃), 48.7pc cerium oxide (CeO₂) and 5.1pc praseodymium oxide (Pr₆O₁₁).

The municipal authorities will provide tax incentives to local producers of magnets, hydrogen storage and polishing materials. Electricity prices will be cut to 0.26 yuan/kWh, compared with over Yn0.70/kWh in other regions of Inner Mongolia. The Baotou hi-tech zone now has nearly 100 firms and is China's only high-technology zone focusing on rare

earths. Baotou’s production of rare earth functional materials rose by 266pc year on year to 331,342t in January-June. Combined output of permanent magnets, hydrogen storage, polishing and catalytic additives rose by 58pc compared with the same period a year earlier to 25,270t.

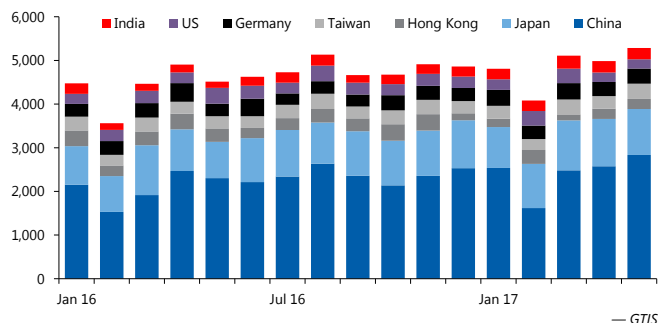
The magnet industry will be the main driver of rare earths consumption in the future, Chinese rare earth industry association ACREI’s secretary-general, Ma Rongzhang, said at the 9th China Baotou International Rare Earth Industry Forum. Rare earth oxides, metals and carbonates are used to produce a range of advanced materials. China’s production of bulk magnets reached 141,000t in 2016, compared with 5,250t in 2000. Revenues in the magnet industry reached Yn28bn (\$4.3bn) in 2016, accounting for 69.5pc of the country’s total revenues from rare earth materials, Rongzhang said.

Revenues for four other major downstream products — catalysts, hydrogen storage alloys, phosphors, and polishing powders — reached Yn10bn, Yn800mn, Yn1bn and Yn490mn, respectively, in 2016, accounting for 24.8pc, 2pc, 2.5pc and 1.2pc of the total, respectively. China’s output of hydrogen storage alloys reached 8,300t in 2016, up by 2.5pc from 2015 in line with rising demand for alternative fuel sources and power storage to reduce carbon emissions. Output of polishing powder rose by 10pc year on year to 22,000t in 2016 on strong demand for speciality glass, Rongzhang said. China produced 200,000t of fluid catalytic cracking catalysts in 2016, the same level as in 2015. Production of phosphor powders for use in coloured lighting fell by 9pc year on year to 2,000t in 2016 because of the development of the LED lighting industry, which is less reliant on rare earth-bearing phosphors for colouration.

Rare earth gadolinium demand is expected to fall because of increased concerns over its toxicity in magnetic resonance imaging (MRI) technology. The metal helps increase contrast in high resolution three-dimensional (3D) imaging and is injected into the body as a dye. But there are concerns that gadolinium accumulates in the brain after repeated use, perhaps as few as four doses. The side-effects of gadolinium in patients with severe kidney failure are known, but new research raises concerns over possible future health risks.

There is no evidence of harmful effects of the brain’s retention of gadolinium but use should be limited to absolute necessity and used sparingly, regulator the US Food and

Monthly rare earth magnet exports, 2016-17 '000kg



Drug Administration said. The influential California-based International Society for Magnetic Resonance in Medicine (ISMRM) echoed this advice in a review on guidelines. More than 300mn doses of the gadolinium drug have been administered globally since it was introduced in 1987. In the UK, the National Health Service performs more than 2.4mn MRI scans a year with a growth rate of almost 7 pc/yr. A millilitre dose of a usual gadolinium dye costs \$2. The dye is typically used in one in three MRI scans.

The value of the MRI global industry is growing rapidly, particularly in emerging markets where healthcare provision is rising sharply. Growth in the use of gadolinium is aligned to the growth in demand for MRI scans. Analyst estimates expect the industry to be worth \$9.2bn by 2020, up from \$4.1bn in 2013. Greater use of the technology is expected in the future as MRI machines become less expensive and more widespread. This would mean the rate of growth of gadolinium MRI drugs would be more than the rate of growth in the value of the MRI machine market. Pharmaceutical companies are considering substitution to other metals for the gadolinium dye, including iron oxide, platinum and manganese. But these technologies are not well-developed.

Gadolinium is used in a variety of technologies, including compact discs (CDs), magnetic materials, superconductors, fluorescent lighting, nuclear reactor control rods and shielding, communications and refrigeration. In healthcare, it is used in cross-sectional X-ray imaging of the body and anti-cancer drugs. But its use as an MRI contrast agent is expanding around the world.

Supply

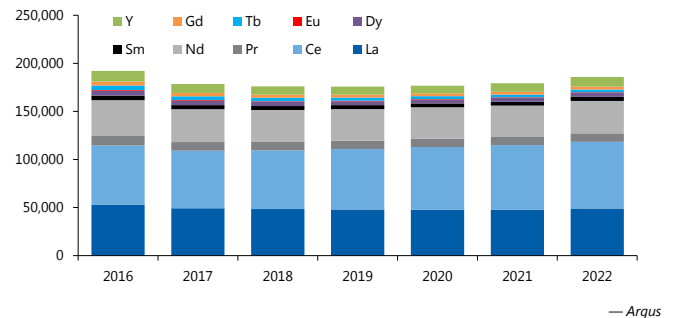
Rare earths supply has been somewhat constrained this year as a result of continuing Chinese government measures to reduce pollution and tackle illegal mining, leading to a sharp increase in prices for a number of elements. In addition, the authorities have set a target to reduce total rare earths output to 140,000t rare earth oxide by 2020-21, which would be a drop of around 20-25pc from current production levels. Significant overcapacity remains through the rare earths production chain in China, but if the government were able to meet its target then there would be an opportunity for new rare earth projects to enter the market to fill the potential supply gap. Which projects might go ahead will depend to a large extent on project economics, the rare earths mix — a higher proportion of rare earths used in magnets would be advantageous — and the ability to attract sufficient financing to get to the commissioning stage. The risk that Chinese producers could raise production rates to take advantage of higher prices and maintain market share is ever present.

Rare earths producer Arafura Resources, which is developing the Nolans project in Australia's Northern Territory, has just extended its agreement with South Korea's OCI to develop a separation plant to process material from the project. An initial agreement was signed in December 2015 to consider toll processing rare earth chloride feedstock. This has now been extended until December 2018. Arafura and OCI will consider a joint venture to pilot a separation processing plant adjacent to OCI's Gunsan operation in South Korea. The two parties will consider a feasibility study on the project and talk with potential neodymium-praseodymium offtake partners and consumers. The Nolans project's mineral resource is 56mn t grading 2.6pc total rare earth oxide for 1,462t of total rare earth oxide.

At the end of August, Australian rare earths developer Hastings Technology Metals signed a second agreement regarding future offtake from its Yangibana rare earths project in Western Australia state. The Sydney-based company signed an initial agreement with Hong Kong-listed China Rare Earth Holdings (CRE) to supply mixed rare earth carbonate. Hastings is in discussions to formalise commercial offtake of 2,000 t/yr over three years with a two year extension option. CRE is an established rare earths and refractory products manufacturer based in Jiangsu province. In early August, Hastings started offtake discussions with Inner Mongolia-

Rare earths supply forecast, 2016-22

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based magnet producer Baotou Sky Rock Earth New Material regarding the supply of 2,500 t/yr of mixed rare earth carbonate. Yangibana expects to produce 15,000 t/yr mixed rare earth carbonate from early 2019. Its estimated mineral resource is 17mn t grading 1.27pc total rare earth oxide with a high content of neodymium and praseodymium.

Peak Resources, a rare earths project developer also based in Australia, has increased the amount of neodymium-praseodymium that it expects to produce from its Ngualla project in Tanzania. A process optimisation exercise carried out since the completion of a bankable feasibility study in April has shown that the project could produce roughly 2,800 t/yr of neodymium-praseodymium oxide. This is 16pc higher than in the feasibility study. The Ngualla project's estimated mine life has been reduced to 26 years from 31 years. But the operating margin has increased by 20pc to \$174mn/yr, while unit production costs have been reduced by 5.7pc to \$34.24/kg of neodymium-praseodymium.

The project's capital cost estimate has been raised to \$365mn from \$356mn, the payback period has been reduced to four years from five years. In addition to neodymium-praseodymium, it is forecast that the project will produce around 4,200 t/yr lanthanum carbonate, 1,900 t/yr cerium carbonate, as well as some mixed heavy rare earth oxides. The company is aiming to progress its mining licence application to fast-track Ngualla production in time for the projected increase in demand for neodymium and praseodymium from the electric vehicle market.

Towards the end of July it was reported that Australia-based Northern Minerals had started construction of a pilot plant at its Browns Range project in Western Australia and expected first output in the first half of 2018. The plant is expected to produce 180,000t of ore by the end of this year,

which will be stockpiled for processing before the end of the first half of 2018. Components for the processing plant are being assembled in China. The pilot plant is scheduled to operate for three years to provide proof of concept. During this period it will process 72,000 t/yr of ore to produce around 573t of heavy rare earths. If the pilot project proves successful, an A\$329mn (\$260mn) heavy rare earths facility will be developed to process around 585,000 t/yr of ore over an 11-year period. Browns Range aims to become the first major dysprosium producer outside of China and will produce other heavy rare earths.

Another Australian resource developer, Alkane Resources, secured a downstream processing agreement in July and produced separated rare earth oxides in the second quarter. Alkane secured 80t of concentrate for processing by Vietnam Rare Earth. This resulted in the production of 31t of separated rare earth oxides, including lanthanum, cerium, praseodymium and neodymium oxides. The firm did not conclude

sales, but further processing is expected to be completed by the end of this month, resulting in saleable rare earth oxides and metals. This is Alkane's first production of rare earth oxides after a 12-month toll treatment agreement with Vietnam Rare Earth was finalised in the second quarter. The concentrate was from an unspecified external source, rather than from the firm's own Dubbo Zirconia project, in New South Wales, Australia. Alkane is targeting production of zirconium, hafnium, niobium, tantalum, and rare earth elements including yttrium and light magnetic elements at Dubbo Zirconia, which it has owned since 1999. Construction of infrastructure at the site is not expected to get under way before the end of the year, with commercial output now expected in the first half of 2019, according to the company. Commercial output was originally expected to begin in late 2018. Construction is dependent on further financing, and discussions about this continue, the company said. As with other rare earth mining projects, Alkane expects permanent magnet demand from the electric vehicle and renewable energy sectors to be key

Rare Earth Project Tracker					
Company	Mine	Country	Stage of Development	TREO (mn t)	Production (tREO/yr)
Alkane Resources Ltd.	Dubbo Zirconia	Australia	DFS (April 2013); Mining permit secured (December 2015); Modular production proposed & detailed engineering assessment ongoing	73.20	1
Arafura Resources Ltd.	Nolans Bore	Australia	JORC Resource Estimate (December 2014); Finalising feasibility study	56.00	1
Avalon Advanced Materials	Nechalacho	Canada	Definitive feasibility study completed (October 2013)	269.40	4
Commerce Resources	Ashram	Canada	Preliminary economic assessment completed (July 2012); Pre-feasibility study ongoing	249.60	5
Galileo Resources PLC	Glenover (JV)	South Africa	Preliminary economic assessment completed (March 2013)	28.90	0
Geomega Resources Inc.	Montviel	Canada	NI 43-101 resource estimate completed (June 2015)	250.60	4
Greenland Minerals and Energy Ltd.	Kvanefjeld	Greenland	Definitive feasibility study completed (May 2015)	956.00	10
Hastings Technology Metals Ltd.	Yangibana	Australia	Independent scoping study completed (November 2014); JORC resources update June 2017	17.02	0
Matamec Exploration Inc.	Kipawa	Canada	Definitive feasibility study completed (October 2013)	19.70	0
Mkango Resources Ltd.	Songwe	Malawi	Pre-feasibility study completed (December 2015); Licence renewed October 2016	31.80	0
Namibia Rare Earths Inc.	Lofdal	Namibia	Preliminary economic assessment completed (October 2014); Mining licence application filed November 2016	6.20	0
Northern Minerals Ltd.	Browns Range	Australia	Definitive feasibility study completed (February 2015)	9.00	0
Peak Resources Ltd.	Ngualla	Tanzania	Pre-feasibility study completed (March 2014)	214.40	5
Pele Mountain Resources Inc.	Eco Ridge	Canada	NI 43-101 resource estimate completed (June 2013)	59.30	0
Quest Rare Minerals Ltd.	Strange Lake	Canada	Preliminary economic assessment completed (April 2014)	492.50	4
Rainbow Rare Earths Ltd.	Gakara	Burundi	Funding secured (April 2015); Internal production studies & MSA completed 2016; IPO & construction financing completed 2017	10.00	0
Rare Element Resources Ltd.	Bear Lodge	US	Pre-feasibility study completed (August 2015)	18.00	0
Ucore Rare Metals Inc.	Bokan Mountain	US	Completes construction of RE pilot plant in Utah (March 2016)	5.20	0
Montero Mining & Exploration Ltd.	Wigu Hill Twiga	Tanzania	NI 43-101 resource estimate completed (August 2011)	-	0
Hudson Resources Inc.	Sarfartoq	Greenland	Preliminary economic assessment completed (November 2011)	343.00	0
Pacific Wildcat Resources Corp.	Mrima Hill	Kenya	NI 43-101 resource estimate completed (September 2013)	-	-
Tanbreez Mining Greenland A/S	Tanbreez	Greenland	Definitive feasibility study completed (March 2012)	186.00	-
Texas Mineral Resources Corp.	Round Top	US	Preliminary economic assessment completed (April 2014)	300	-

Trade

China's rare earth oxide exports were almost level in July compared with the previous month, dropping by less than 0.5pc, while exports of rare earths metals fell by nearly 8.7pc month on month. Data for the first seven months of the year show a rise of 26pc in Chinese exports of rare earth oxides compared with a year earlier, and a 13pc rise in rare earth metal exports over the same period. According to GTIS data, China exported 30,564t of rare earths in January-July, an increase of 12pc compared with the same period in 2016, while export revenues reached \$230.5mn, a rise of 14pc. The unit value of rare earth exports from China only increased slightly to \$7.47/kg from \$7.46/kg, as the rise in assessed domestic rare earths prices has yet to impact export prices — which are on a contract basis.

China's exports of rare earth permanent magnets also fell slightly month on month in July, but increased by 3.6pc compared with the same month a year earlier and by 15pc for the year to date, official customs data show. The country exported 2,424t of rare earth permanent magnets in July, with an export revenue of \$113.9mn, which was slightly down on 2016, and a unit value of \$46.97/kg — a drop of 3.1pc. Exports in January-July reached 17,090t, up by 15pc on a year earlier, with a total revenue of \$794.9mn, which was up by 7pc, and an average price of \$46.51 — down by 6.6pc. China imported 1,319t of rare earth permanent magnets in the first seven months of the year, down by 0.3pc on the year, with import costs down by 3.7pc to \$115.2mn and average import prices easing by 3.5pc to \$87.32/kg.

China exported 7,393t of lanthanum oxide in January-July 2017, down by 8pc on the year, as a result of lower exports in February and April, when buyers in the ceramics and fluid

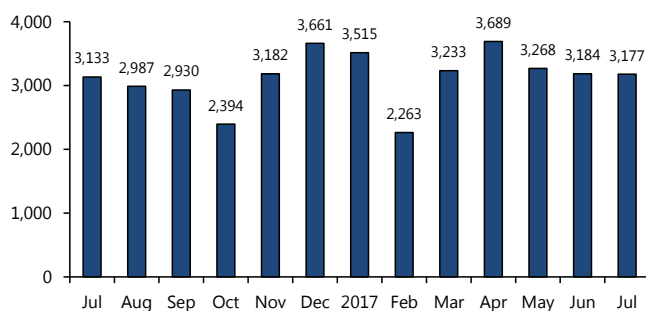
catalytic sectors were reluctant to make purchases because of plentiful stocks and higher prices. Export revenues totalled \$15.7mn in the same period, a rise of 4pc, while the average export price was 13pc higher at \$2.16/kg, reflecting tightened supply as a result of environmental inspections. Exports to the US hit 4,582t, down by 8pc. Japan was the second-largest importer of Chinese lanthanum oxide, receiving 1,129t in January-July.

Cerium oxide exports totalled 2,185t in January-July, a drop of 2pc compared to the same period in 2016, with a significant increase in demand from the UK offset by lower shipments to the Netherlands, Japan, Italy and South Korea. Export revenues of \$18.9mn were down by 17pc, while the average export price was \$8.66/kg, down by 15pc — reflecting the oversupply situation in the market for cerium compounds. The Netherlands has been the largest importer of Chinese cerium oxide so far this year, accounting for 34pc of exports, followed by the UK with 21pc, Spain's 8pc, South Korea's 8pc, Italy's 6pc and Japan's 5pc.

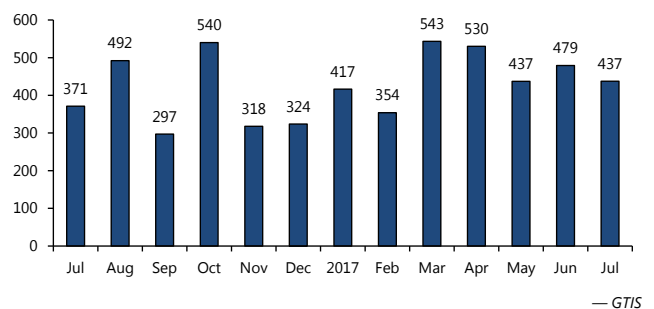
China exported 4,274t of cerium carbonate in the first seven months of this year, an increase of 55pc, as Japanese and US importers placed more orders to meet higher downstream demand. Export revenues totalled \$5.5mn, up by 54pc, while the average export price of \$1.28/kg was down by 11pc. Japan remained the largest buyer of Chinese cerium carbonate, importing 2,742t — a 26pc rise and 64pc of Chinese shipments. The US was the other major importer, receiving 1,169t — 178pc higher and 27pc of Chinese shipments.

Neodymium oxide and metal, core materials for the manufacture of permanent magnets, saw a significant fall in year

China's monthly RE oxide exports



China's monthly RE metal exports



— GTIS

to date exports this year compared with 2016, as consumers in Asia-Pacific struggled to compete with cheaper downstream products from China. Exports of neodymium oxide totalled 42.8t in July and 227.2t in January-July 2017, a drop of 22pc compared with the same period a year ago. Total export revenues were \$1.9mn in July and \$9.7mn for the year to date, down by 19pc, while average export prices were \$44.94/kg and \$42.81/kg, respectively. Japan is the main destination for Chinese neodymium oxide exports, representing 38pc of shipments in the first seven months of this year, followed by the France with 12pc and the Netherlands with 9pc.

Neodymium metal saw a decline in exports year on year of 40pc for January-July because of declining demand among Japanese consumers unable to compete with cheaper permanent magnets and alloys from China. Japan imported almost all of the 5t of Chinese exports in July 2017 and 137.3t out of a total of 167t for the year so far. Total export revenues were \$8.4mn in the first seven months of the year and \$0.3mn for July, while average export prices were \$50.4/kg and \$51.4/kg respectively.

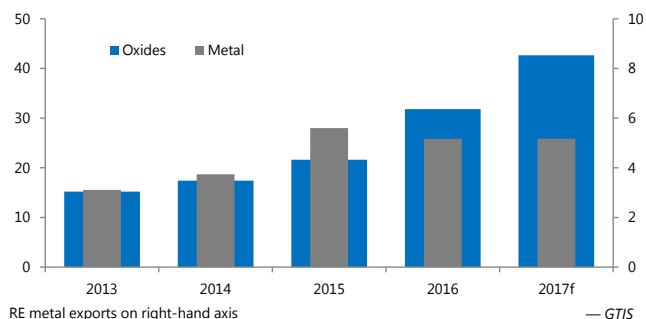
Praseodymium oxide and metal are also key materials for the manufacture of permanent magnets, and year to date exports of oxide were down by 20pc while shipments of metal were up by 21pc over the same period. Exports of praseodymium oxide were 25.7t in July and 114.2t for January to July, while exports revenues totalled \$1.47mn and \$6.0mn, respectively. Average export prices were \$52.23/kg for 2017 so far and \$54.8/kg for the month of July. Japan is also the main destination for Chinese praseodymium oxide exports, although it represents a lower share of shipments than for neodymium — 34pc in the first seven months of 2017 — followed again by the Netherlands' 19pc and France's 16pc.

Praseodymium metal has seen a sharp increase in exports year on year, reaching 29.8t for January-July 2017, while shipments were 2t in the month of July. Japan is the sole importer of China's praseodymium metal so far in 2017. Total export revenues for June were \$145,800, while revenues for the year to date were \$2mn. Average export prices were \$72.90/kg for June and \$68.29/kg for 2017 so far.

Dysprosium oxide exports totalled 67,619kg in the first seven months of 2017, up by 74pc on the year, driven by demand from Japan and South Korea, with export revenues of \$16.3mn and an average price of \$240.80/kg. China exported

Chinese annual rare earth exports, 2013-17

t



10,165kg of dysprosium metal over the same period — an increase of 97pc compared to 2016 — while export revenues were \$2.6mn with an average value of \$251.39/kg

Exports of terbium oxide reached 40,360kg in January-July, increasing by 111pc, as a result of stronger demand from Japan — the major importer. Export revenues totalled \$18.5mn and the average value was \$459.44/kg for 2017 so far. Terbium metal exports have increased even more strongly, rising by 312pc to 2,470kg in the first seven months of this year, with export revenues of \$1.5mn and an average export price of \$609.99/kg.

Scandium tends to be exported in its metallic form, rather than as a compound, and exports from China have increased by 80pc in the year so far, reaching 309.5t. Japan is the main export destination, accounting for 57pc of Chinese exports in January-July 2017, followed by the US with 12pc and Italy with 10pc. Export revenues reached \$8.2mn over the same period, while the average export value was \$26.54/kg.

China's yttrium oxide exports were recorded at 1,277t in the first seven months of this year, up by 31pc, reflecting lower prices and increased consumption from Italy, Japan and the US. Export revenues reached \$5.3mn, down by 8.4pc, while the average export price of \$4.18/kg was down by almost 30pc. Yttrium oxide supplies in China have not become restricted, unlike the light and heavy magnetic elements. Japan was the largest importer of Chinese yttrium oxide in January to July 2017, accounting for 52pc of shipments and up by 23pc compared to 2016. The other major importers so far this year were Italy with 17pc and the US with 13pc.

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