



Perth USAsia Centre

STRATEGIES FOR SECURING CRITICAL MATERIAL VALUE CHAINS

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CONTENTS

EXECUTIVE SUMMARY	3
1. SECURITY RISKS IN CRITICAL MATERIAL VALUE CHAINS	4
2. BARRIERS TO PRIVATE SECTOR INVESTMENT	10
3. THE REFORM COALITION: AUSTRALIA, THE US, THE EU AND JAPAN	14
4. STRATEGIES TO ADVANCE CRITICAL MATERIALS SECURITY	19
ENDNOTES	21
ACKNOWLEDGEMENTS	22
ABOUT THE AUTHOR	22
ABOUT THE PERTH USASIA CENTRE	23

EXECUTIVE SUMMARY

The value chains for critical materials – such as rare earths, cobalt and lithium – are very insecure.

International monopolies, trade restrictions and state-owned enterprises distort markets and undermine supply security.

The US-China trade dispute has highlighted the need to develop new, secure and competitive value chains.

This will require bringing new suppliers into a market which is currently characterised by monopoly and a lack of competition.

Critical materials are geologically abundant. But high levels of risk inhibit private sector investment.

Technological, social, market and political risks beset the critical materials industry. As a result, few companies have entered the market in recent years, despite expectations of soaring demand.

Australia, Japan, the US and the EU have emerged as the reform coalition for improving critical materials markets.

In recent years, each government has announced policies to improve supply security, and they have collaborated to promote reform in international fora.

However, their reform efforts have yet to address the underlying risks that inhibit investment.

The next step for reform efforts is to adopt policies which will help de-risk investment by new market entrants.

There is a pressing need for reform-minded governments to augment their efforts to improve security in critical material value chains.

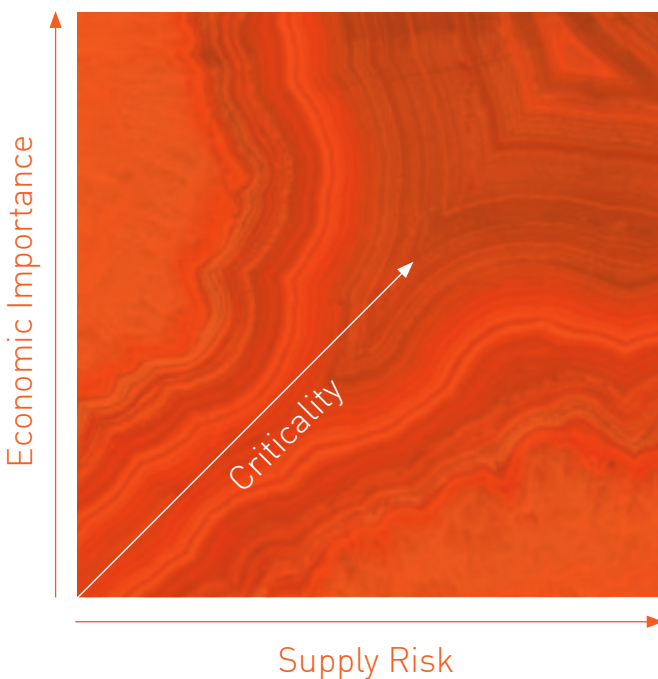
This should involve deploying financial support mechanisms to help de-risk private sector investment, and strengthen the international cooperation required for cross-border value chains.



1. SECURITY RISKS IN CRITICAL MATERIAL VALUE CHAINS

Critical materials are of existential importance for modern, technology-intensive societies. While all economies rely on natural resources, critical materials are a special category of outsized importance. This is because they pose unique risks to the security and sustainability of an economy. Critical materials are characterised by two distinct features: they are of considerable economic importance for the industries that consume them; yet are also subject to heightened levels of supply risk that can interrupt physical availability and/or affordability (see Figure 1)¹. This combination of economic importance and supply risk demarcates critical materials from other non-critical bulk commodities such as oil, gas or iron ore.

FIGURE 1 CRITICALITY MATRIX FOR DEFINING CRITICAL MATERIALS



There is no universal classification of critical materials. As each economy has its own geological endowments and industrial structure, which natural resources qualify as critical varies between countries. For example, energy is not critical for hydrocarbon-rich Russia in the way it is for hydrocarbon-poor Japan, though both require it for their transport and manufacturing industries. However, several governments have recently undertaken 'criticality studies', which identify the natural resources that should be considered critical given their particular endowments and industrial needs. Table 1 lists the thirty natural resources which have been classified as critical materials by the EU, US, Japanese and/or Australian governments.

While there is significant diversity amongst these thirty critical materials, they are united by their use in a range of specialised technologies. These include:

- Scientific applications, such as optics, medicine and nuclear technologies
- Digital technologies, including consumer and industrial electronics
- Industrial applications, particularly speciality alloys and composites
- Renewable energy, including batteries, electric motors and generators
- Defence equipment, such as guidance systems, electronic warfare and space technologies

Several features of critical material markets pose risks to the security of supply.

TABLE 1 THIRTY CRITICAL MATERIALS

MATERIAL	PRINCIPAL USES	LIFE OF PROVEN GLOBAL RESERVES (YEARS)	VALUE OF INTERNATIONAL TRADE (USD MILLIONS)
Antimony	Flame retardants, specialty alloys, electronics	10	173
Baryte	Medicine, fluorescent lighting, electrodes, glass, ceramics	38	595
Beryllium	Semiconductors, aerospace and defence components, spectroscopy		21
Bismuth	Pharmaceuticals, non-toxic lead substitutes		
Chromium	Specialty steels, pigments	16	4043
Cobalt	Super alloys, speciality steel, magnets, lithium-ion batteries	65	553
Fluorspar	Chemicals, glass, enamels	45	500
Gallium	Electronics, lasers, photodetectors, thin layer photovoltaics		
Germanium	Fibre and infrared optics, electronic and solar applications		315
Helium	Cryogenics, controlled atmospheres	47	
Indium	Semiconductors, thin-film electroluminescent panels		
Lithium	Batteries, specialist ceramics, optics, nuclear fuel cycle	372	1741
Magnesium	Speciality alloys, batteries, electronics	289	1861
Manganese	Specialty steels, batteries, fertiliser	43	6956
Molybdenum	Specialty steels, super alloys, pigments	59	2872
Natural Graphite	Composites, electronics, superconductors, large-scale fuel cells	225	448
Nickel	Specialty steels, batteries, magnets	35	2967
Niobium	Micro capacitors, superconductors, super alloys	67	
Phosphate Rock	Fertiliser, industrial chemistry	266	2833
Platinum Group Metals	Catalytic converters, electronic components, fuel cells	168	27353
Rare Earth Minerals	Magnets, catalysts, metal alloys, phosphors, energy storage, superconductors	923	350
Selenium	Thin-film photovoltaics, alloys, glass, batteries	30	165
Silicon Metal	Aluminium production, chemicals, electronics, photovoltaics		2655
Tantalum	Microcapacitors, medical technology	85	912
Tin	Industrial and electronic solders, touch screen technologies	17	1356
Titanium	Pigments, carbides, specialty engineering, medical devices	131	2569
Tungsten	Electronic applications, lighting, carbides, speciality allows	34	186
Vanadium	Superalloys, chemical catalysts, batteries	250	399
Zinc	Anti-corrosion, polymers, semiconductors, hydrogen production	17	11775
Zirconium	Refractory products, nuclear fuel cycle	46	1350
TOTAL			74947

Source: Author's calculations, from USGS² and UN Comtrade Database³. Note: Comprises all critical materials identified for Europe, Japan, United States and Australia⁴. Some critical materials omitted as they geologically co-occur with other products on the list⁵.

First, critical materials have very complex value chains.

Chemically, the desired elements are usually a minor component of the minerals in which they are found, and several elements often co-occur together. This requires extensive chemical processing to initially separate ores into individual oxides. Figure 3 illustrates the mineral processing flow required to extract twelve distinct rare earth minerals from a single source material. These chemical intermediates then require further processing and manufacturing, often at specialised facilities, to create useable products such as permanent magnets, battery cells and electronics components. These products are then incorporated into the supply chains of final product manufacturers in the electronics, automotive and energy sectors. This is a considerably more complex value chain than for iron ore, which requires only simple crushing and screening before it is suitable for use in steel production.

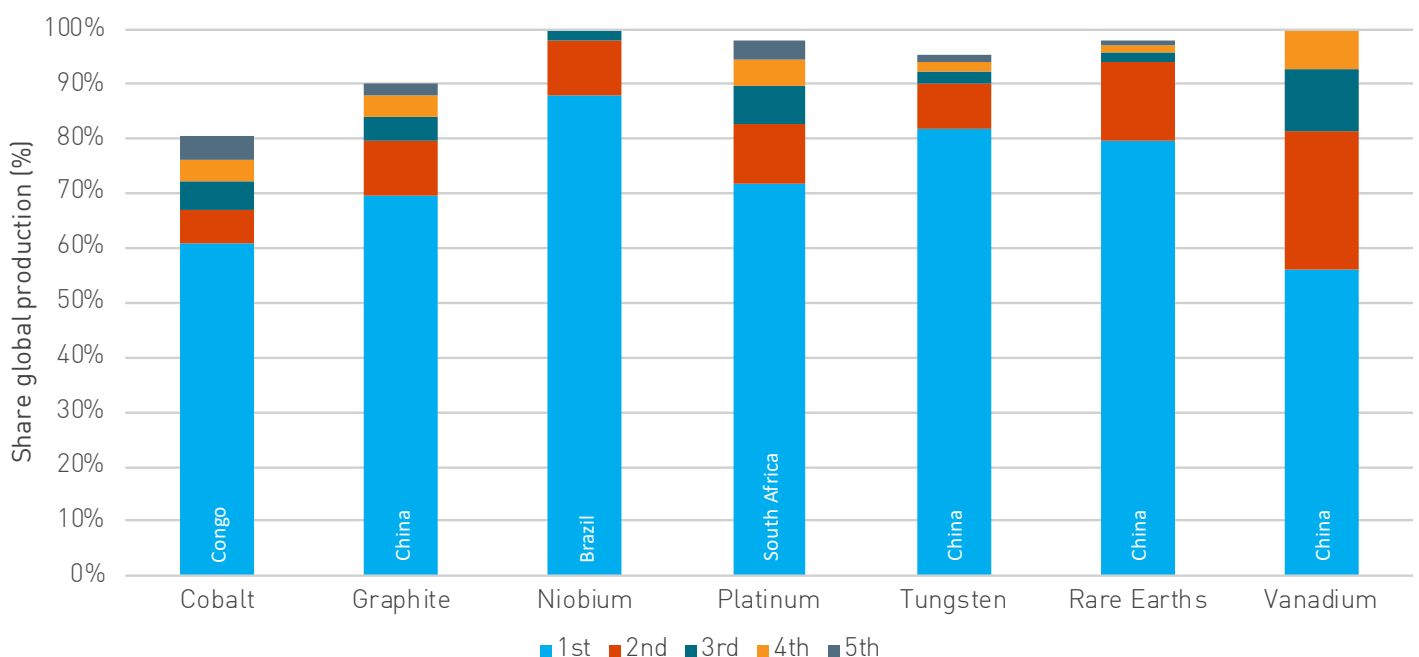
Second, many critical material markets are characterised by a high degree of monopoly.

The complexity of value chains, and high investment overheads for processing facilities, means only a small number of companies and countries participate in each critical material market. As a result, many of these markets are characterised by a high degree of producer concentration, with a single dominant supplier accounting for over half of world supply. Figure 2 outlines producer concentration in the most-heavily monopolised critical material markets. Of the thirty critical materials outlined in Table 1, in only one market – nickel – do the top-three suppliers account for less than half of world supply.

Importantly, China plays an outsized role in these markets. It is the world’s top supplier of eighteen critical materials⁶, and a near-monopolist (over 70 percent market share) in five.

Critical materials security presently depends on the reliability and affordability of Chinese supplies.

FIGURE 2 HIGHLY CONCENTRATED CRITICAL MATERIAL MARKETS, 2017



Source: Author’s calculations, from USGS⁷

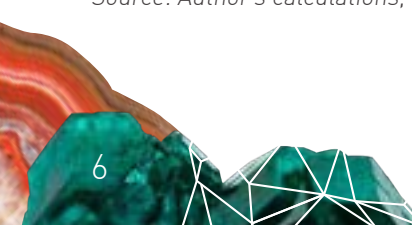
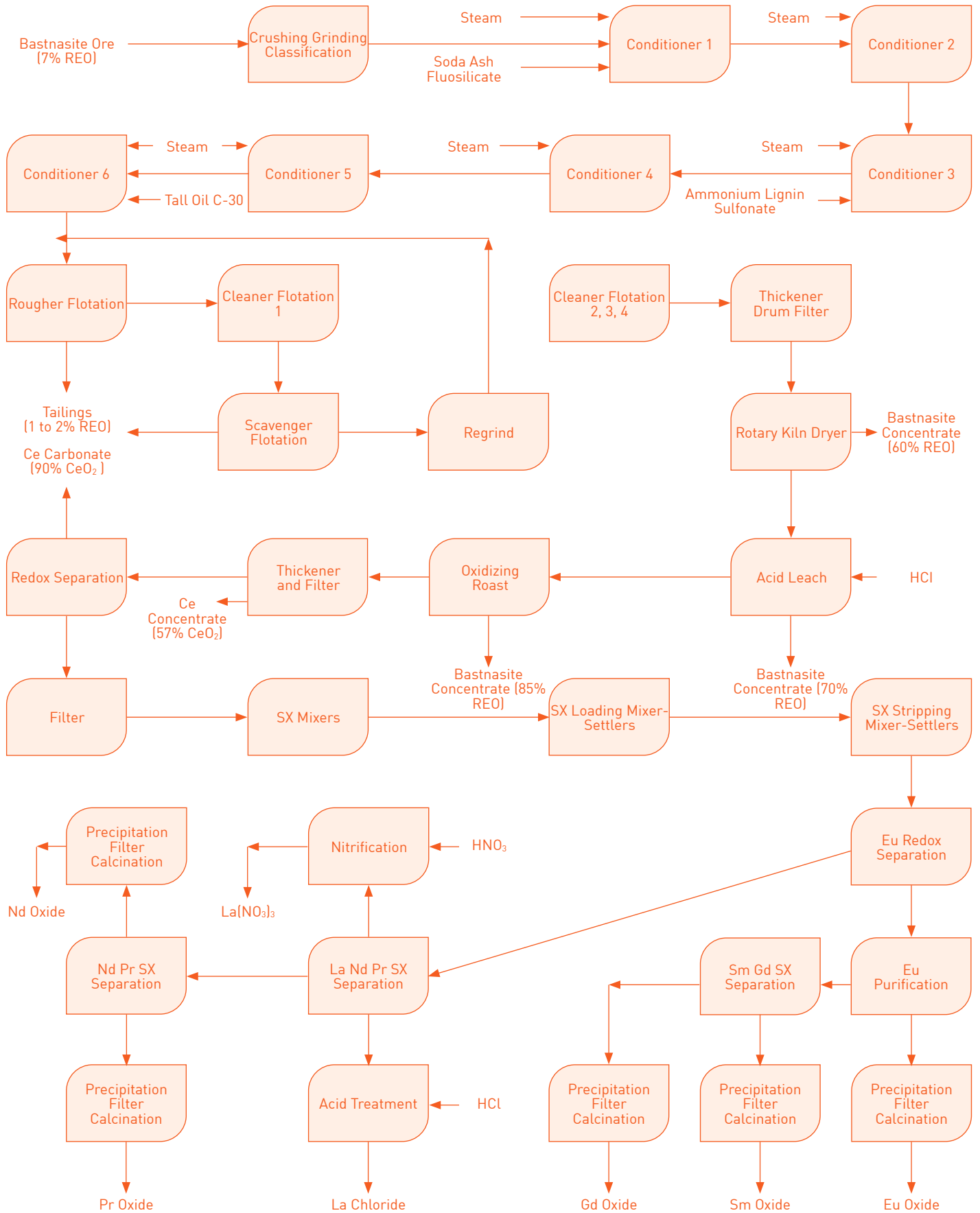


FIGURE 3 INDICATIVE MINERAL PROCESSING FLOW FOR RARE EARTH MINERALS



Source: USGS⁸. Note: Describes the mineral processing flow for the Mountain Pass mine, California, which extracts twelve different rare earth minerals from a single source of bastnasite ore.

Third, markets are frequently distorted by government policies. In complex critical material value chains, the majority of value-adding occurs in the mid-stream (processing) and down-stream (manufacturing) stages of production. Governments often attempt to capture a greater share of value through distortive policies that mandate a degree of local processing. These policies can take a variety of forms, include export prohibitions, special taxes, and other licensing and performance requirements. For some products, such as the Chinese rare earths sector, the majority of output is produced by state-owned enterprises⁹. While ostensibly designed as a developmental measure, these policies undermine the operation of markets by distorting price mechanisms and deterring investment. They are also extremely widespread¹⁰. According to OECD data, in 2017 governments imposed 3795 export restrictions on industrial raw materials¹¹.

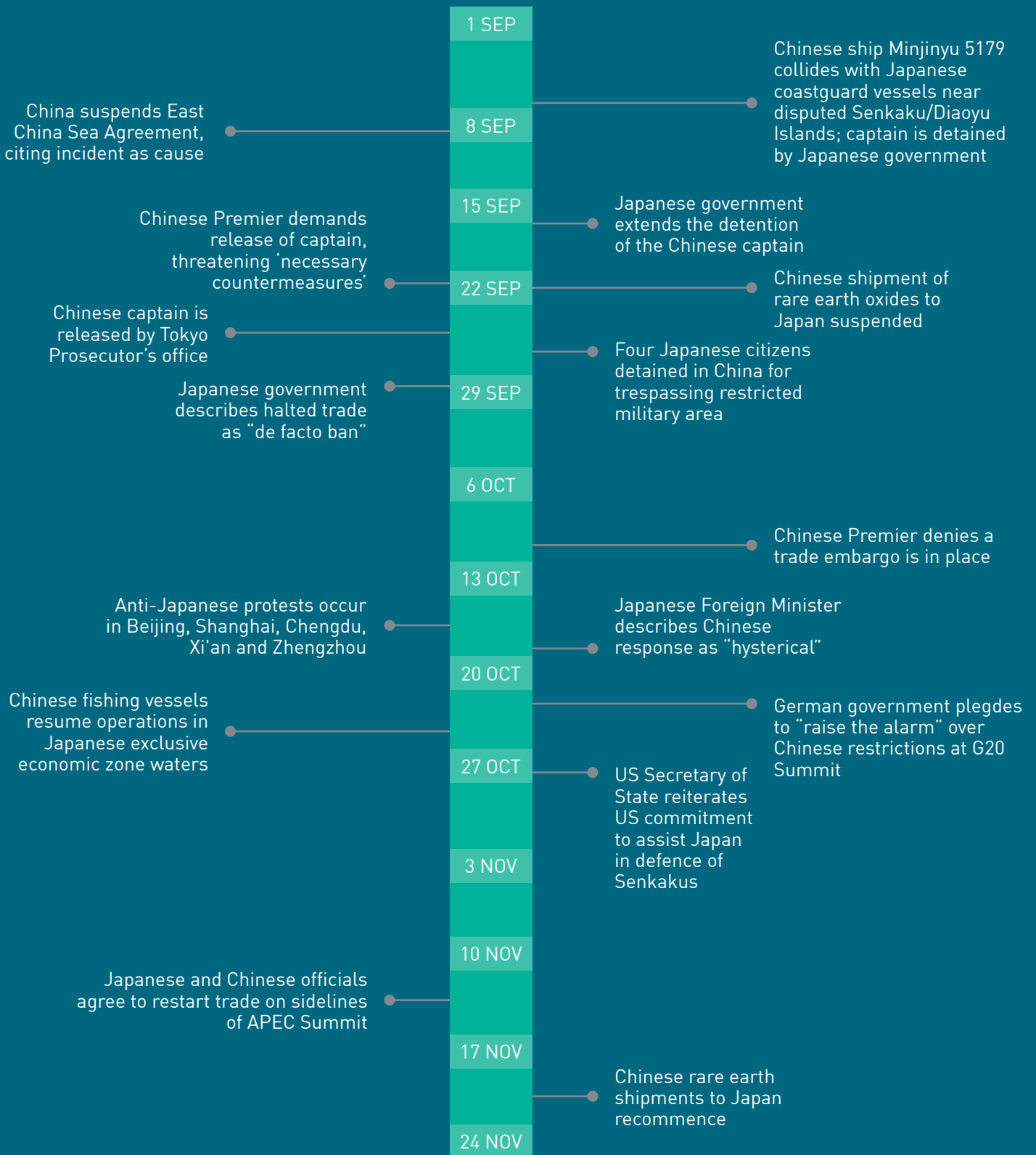
Fourth, critical materials can be diplomatically used as a 'resource weapon'. This is a form of economic sanction, where a government withholds (or threatens to withhold) supply of a natural resource to extract some kind of concession from a target. The resource weapon can be an effective tool for diplomatic sanctions in situations where a consumer is dependent on a particular supplier. There is also a long track record of its use in international diplomacy. Famous examples including the OPEC oil embargo of 1973¹², and Russian threatens to withhold gas to Eastern European neighbours on at least fifteen occasions during the last decade¹³. As critical material markets are highly monopolised, with few viable sources of alternate supply in the short-term, they make an ideal instrument for diplomatic sanctioning.

Indeed, China has recently deployed its rare earths monopoly as a diplomatic weapon.

In late 2010, rare earth minerals were the subject of a trade conflict between China and Japan, which had originally begun over a maritime incident near the disputed Senkaku/Diaoyu Islands (Figure 4). Chinese exports of rare earths to Japan were suspended for fifty-nine days, with dramatic effects on global markets. Prices for rare earth oxides immediately spiked four-fold, before taking over a year to return to pre-dispute levels (see Figure 6). In the more recent US-China trade dispute, Chinese authorities have made similar threats that the 'rare earths weapon' will be deployed if a negotiated settlement cannot be reached¹⁴. While this threat has yet to be executed, its effects on global markets would be of a similar or greater magnitude to the Japan-China dispute of 2010. Given the central role of US technology companies in the global industrial ecosystem, its effects would also be felt far beyond the US.

These distinctive features reveal that critical materials are not "just another commodity". Complex value chains, high levels of monopoly, distortive government interventions and the threat of the resource weapon pose serious challenges for supply security. Unlike mature commodity sectors – such as oil, gas or iron ore – open, transparent and competitive markets for critical materials do not presently exist. Industrial consumers cannot be confident that international markets will provide either reliable or cost-effective access to these essential inputs. Importing governments are also dangerously exposed to diplomatic coercion by monopoly suppliers.

FIGURE 4 TIMELINE OF CHINA-JAPAN RARE EARTHS DISPUTE, 2010



Source: Smith 2014¹⁵ and Wilson 2017¹⁶

2. BARRIERS TO PRIVATE SECTOR INVESTMENT

Existing critical material value chains are not fit-for-purpose for 21st century needs. Monopoly, opaque markets and political manipulation undermine supply security to end-users across the industrial ecosystem. Technological change means these security challenges will only become more pressing in future decades. As digital communications further penetrate into developing economies, global demand for critical materials will steadily increase. Many new technologies associated with the energy transition – including electric vehicles, renewables generation, energy storage systems and new chemical products – also depend on a reliable and affordable supply of these inputs. To provide a secure foundation for the technological future, there is a pressing need to diversify critical material markets.

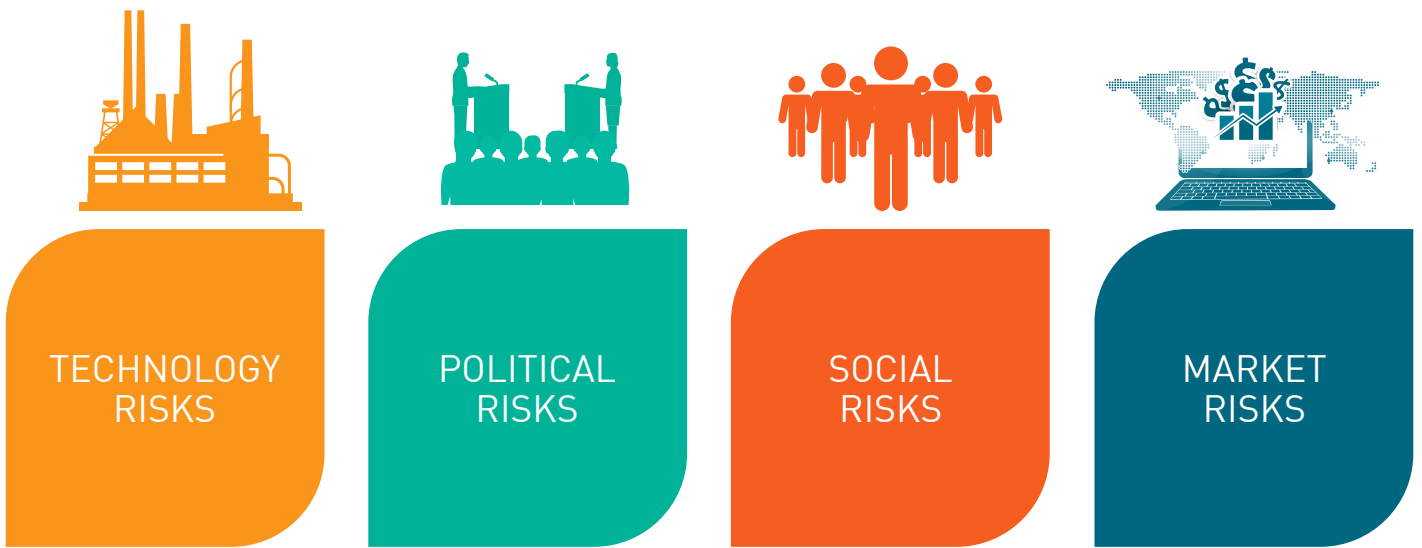
Unfortunately, the record shows that it is very difficult for new players to successfully enter the marketplace.

Rare earths provide an instructive example. Since the China-Japan dispute of 2010, many companies have attempted to launch new rare earth projects outside of China. Yet in the subsequent decade, only one company – Australia's Lynas Corporation – has successfully achieved commercial scale. Lynas now supplies just under one-sixth of the global market for rare earth oxides, and is an important supplier of neodymium and praseodymium (Nd-Pr) to manufacturers of permanent magnets. However, China's rare earth monopoly largely remains in place, particularly for the 'heavy' rare earths such as dysprosium and samarium. The only other major non-Chinese supplier – the Mountain Pass mine in California – was shuttered in 2015 when its owner Molycorp filed for bankruptcy. Four other rare earth projects sponsored by Japan in the wake of the 2010 dispute have failed to proceed commercial-scale production¹⁷.

The problem facing new market entrants is not a lack of suitable geology. As Table 1 shows, critical materials are relative abundant in geological terms, and are certainly no scarcer than other mineral commodities such as iron ore or base metals. Ironically, proven reserves of rare earths are sufficient to meet current needs for the next 923 years! Indeed, Australia alone could potentially supply a significant portion of global demand. Australia is currently an established supplier of five critical materials (lithium, rare earths, tantalum, titanium and zirconium), and has geologic endowments with potential for commercial development in a further seventeen products¹⁸. The US, Canada, and several other established resource producers also have significant critical materials deposits.

Rather, the problem is a unique set of investment barriers, which limit the capacity of private sector resource companies to develop new projects. These barriers arise from a set of four risks that make critical materials a more challenging investment environment than other natural resource sectors (Figure 6).

FIGURE 6 INVESTMENT RISKS IN CRITICAL MINERAL INDUSTRIES



TECHNOLOGY RISKS:

The economics of critical materials are very different to other bulk commodities. Mining projects are rarely viable as standalone enterprises, and either require dedicated processing facilities close to mine sites, or vertical integration within the value chains of mid- and down-stream manufacturers. This requires additional investment in geochemical technologies to process raw materials. Several critical materials also have very specific technical features that require bespoke processing technologies. In the case of rare earths, small differences in geology mean that every mine must have a processing facility calibrated to the unique geochemistry of its particular mineral resource. This imposes significant technological risks on critical materials suppliers beyond what is seen in other resource sectors that do not require integrated processing facilities.

POLITICAL RISKS:

As essential and monopolised resources, critical materials have considerable value in international politics. The risk that producing governments deploy them as a resource weapon – and the fact that consuming governments must take counter-measures to protect against this risk – inherently politicises international markets. Private sector investors must price these political risks into their business plans, which are considerably harder to estimate than normal commercial risks. For example, rare earth prices rapidly trended upwards during 2019 as markets priced-in risks associated with the US-China trade dispute. But if this political dispute is resolved, prices will likely fall back towards pre-dispute levels. The politicisation of markets amplifies the pattern of extreme volatility seen in these industries, and exacerbate the difficulties of making informed risk assessments on potential investments.

BOX 1 SOCIAL CHALLENGES IN THE DRC MINING SECTOR

Critical materials are the largest source of export income for the Democratic Republic of the Congo (DRC), which is a major global producer of cobalt, copper, tantalum, tin and gold. In its 150,000 artisanal mines, labourers work for as little as 65 cents a day with only hand tools, a lack of safety equipment, and minimal oversight. The sector is also rife with corruption, which has contributed to cycles of fragility and civil war for many decades. There are minimal regulatory provisions governing the country's mining sector, resulting in many cobalt mines falling under the control of illegal armed groups in the past. These mines have been a major cause of ecological degradation, poor labour standards and other human rights abuses. Child labour is widespread, with 40,000 children estimated to currently be working in DRC artisanal mines.



Source: Church and Crawford¹⁹

Source: Rob Lavinsky, <https://www.mindat.org/photo-112819.html>

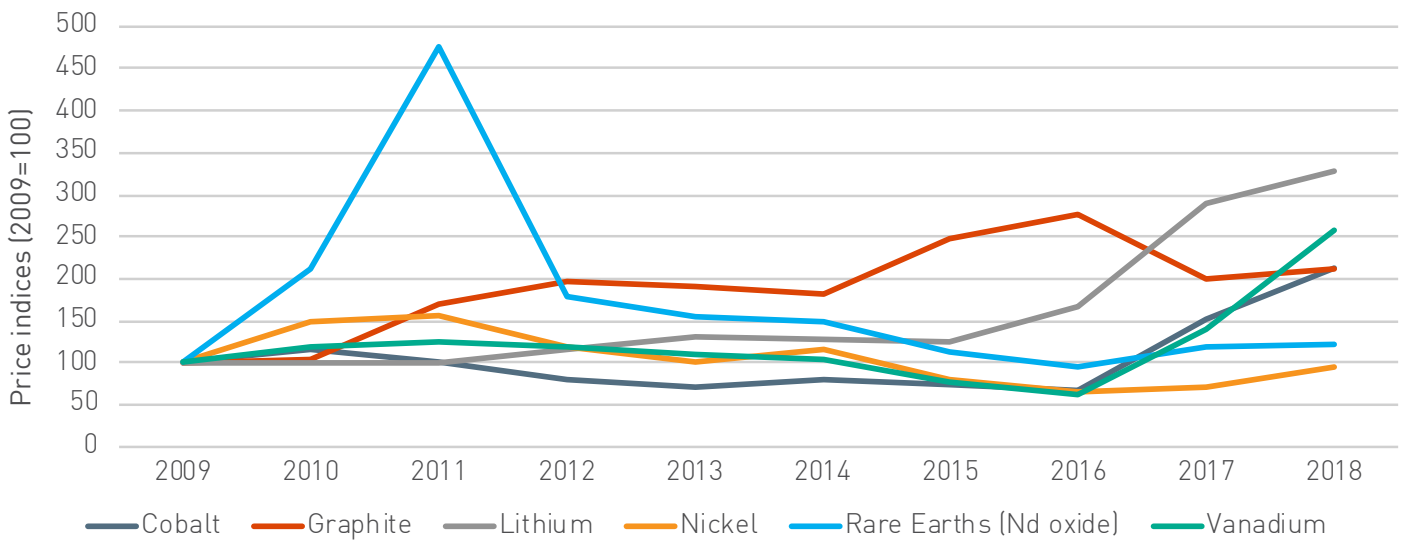
SOCIAL RISKS:

Most critical materials presently come from countries with poorly-developed political and governance institutions. As a result, their regulatory regimes often fail to protect against the adverse social and environmental consequences of mining. Poor labour standards, public health safeguards, sustainable water management, and in some cases forced and child labour, are unfortunately common in these industries (see Box 1). New critical material projects in countries with stronger regulatory institutions, such as Australia and the US, are required to comply with much higher environmental and social standards. However, these standards impose higher production costs, which make it difficult to compete with incumbent suppliers. Without the ability to command a 'social premium' in international markets, new critical materials projects often struggle to achieve price competitiveness.

MARKET RISKS:

Critical material markets are highly volatile. With only a small number of players in any one market, adverse events affecting a single producer can easily throw supply and demand out of balance. The China-Japan rare earths dispute of 2010 provides an instructive example. Despite lasting only 59 days, world prices immediately spiked four-fold, before taking over a year to return to pre-dispute levels. But as Figure 7 reveals, price volatility is a common feature across many critical material markets, and occurs even in the absence of political disputes. It is only in nickel – the sole critical materials sector where there is a diversity of suppliers – that there has been a degree of price stability in recent years. These volatile price cycles are harmful to both producers and consumers, as they make it difficult to the long-term investments required for technically complex mining and processing projects.

FIGURE 7 PRICE VOLATILITY IN SELECT CRITICAL MATERIALS, 2009-2018



Source: Author's calculations, from USGS²⁰

Critical materials are some of the highest-risk subsectors of the global mining industry.

Companies developing critical material projects need to manage levels of technology, sustainability, market and political risk significant higher than that of other resource sectors. This acts as a major barrier to private sector investment, as risk frequently exceeds what is comfortable given expected rates of return. It also explains why, despite the pressing need for new critical materials suppliers, that very few new projects have successfully entered the global market during the last decade.

Without some external change that reduces risk levels faced by private sector investors, it is extremely unlikely any new projects will enter the market in coming years.

3. THE REFORM COALITION: AUSTRALIA, THE US, THE EU AND JAPAN

Fortunately, the security risks facing critical materials are now receiving attention from policymakers. The Australian, EU, Japanese and US government have each launched critical materials security strategies in the last decade. These strategies recognise that the unique features of these markets, and the heightened risks they pose, mean that government support will be required to reform value chain governance.

Their strategies include:

- **The European Union's** *Raw Materials Initiative*²¹. Launched in 2008, this was the first government policy to recognise the need to develop new and more secure critical materials value chains. It comprised three strategies, including improving supply sustainability, better developing mining and processing industries within Europe, and promoting efficiency and recycling within value chains.
- **Japan's** *Strategy for Ensuring Stable Supplies of Rare Metals*²². To reduce the risks of over-dependence on monopoly producers, the strategy aimed to diversify import sources, promote recycling and the use of substitutes, and build international partnerships with new suppliers. Initially launched in 2009, efforts under the strategy accelerated rapidly following the 2010 rare earths dispute between Japan and China.
- **The US** Department of Energy launched a *Critical Materials Strategy*²³ in 2010, focused on minerals required for the energy sector. This emphasised R&D and international partnership efforts. In 2019, it was complemented by the US Department of Commerce's *Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*²⁴ that added efforts to develop both up- and mid-stream domestic capabilities, as well as international cooperation with new suppliers. A series of Executive Orders issued in July 2019 also enables financial support for specified rare earths projects through the Department of Defense²⁵.

- **Australia's** *Critical Minerals Strategy* (2019)²⁶. Principally a producing rather than consuming economy, Australia's efforts have focused on identifying the critical materials in which it could contribute to value chains, and developing policy frameworks to attract investment, spur innovation and develop supporting infrastructure. In November 2019, the Australian government also pledged financial support to new critical materials projects through Export Finance Australia (EFA) and/or the Northern Australia Infrastructure Facility (NAIF)²⁷.

The US, Japan, EU and Australia have now emerged as an international coalition for reform of critical material value chains.

These initiatives promise a much-needed change in the way which critical material markets are organised. They not only reflect a growing awareness to the security challenges affecting these minerals, but also commit governmental resources to building more sustainable and secure alternatives. Yet, given differences between these countries' endowments, needs and institutions, there is considerable variation amongst the approaches they have adopted. There are five distinct strategies that governments have employed to improve the security of value chains (Figure 8).

FIGURE 8 SUPPLY SECURITY STRATEGIES FOR CRITICAL MATERIALS



■ **Criticality studies** are the simplest and lowest-cost strategy. These involve undertaking economy-wide surveys to ascertain the specific raw materials used by industry, and then investigate and measure the supply risks posed in their value chains. All four governments have undertaken these in recent years²⁸. Criticality studies serve important informational functions: raising awareness of critical materials risks, and enabling the design of targeted policy interventions. Their role is purely informational, however, and findings must be translated into concrete policies if they are to improve value chain security.

■ **Emergency stockpiles** are somewhat less common. These are government-held stocks that can be released in situations where foreign supply is interrupted for political or economic reasons. At present, only the United States²⁹ and Japan³⁰ maintain critical materials stockpiles. Emergency stockpiles are of most relevance for strategic users in the defence sector, as they ensure that supply will continue to be available during a time of crisis. However, the cost of maintaining these stockpiles is high – the US National Defense Stockpile presently holds \$1.2 billion of critical materials – and are not a cost-effective solution for economy-wide needs beyond the defence sector. Moreover, while they provide temporary protection against supply interruptions, they do nothing to address the underlying monopoly problems that lead to interruptions in the first place.

■ **Research and development (R&D)** efforts address the demand side of the problem. These seek to improve the technical efficiency of industry, through government-funded science programs targeting processing efficiency, recycling and development of substitutes. They also reduce economies' external exposure by lowering the volume of raw critical materials needed. All four governments have included R&D measures in their policy package, typically delivered through national research agencies and/or industry and university partnerships. However, the inherent limitation of R&D measures is that they lessen, but cannot eliminate, demand for primary raw minerals.



■ **Financial support measures** target the supply side. These support the emergence of new projects through equity, loans and loan guarantees from government financial institutions. They have the advantage of addressing the root barrier to investment – high investment risk – by sharing these risks between the private investors and the government. However, it also exposes governments to commercial risks, and many have therefore been hesitant to take this step. While the Japanese government adopted financial support policies in the wake of the rare earths dispute of 2010, few others initially joined it. It was not until mid-2019 that the US and Australia added financial support mechanisms to their policy suite, though neither government have deployed it yet.

Only the Japanese government has thus far offered financial support to new critical materials projects.

■ **Diplomatic strategies** have also been deployed. In the wake of the 2010 rare earths dispute, Japan began bilateral efforts with key suppliers. It quickly negotiated agreements to cooperate for the development of new rare earths projects with Australia, India, Kazakhstan, Vietnam and the US³¹. In 2019, Australia and the US also established a bilateral critical minerals dialogue³², which has delivered an information sharing mechanism between the US Geological Survey and Geosciences Australia³³. The US, EU and Japan have also deployed multilateral diplomacy, working together to challenge Chinese export restrictions via the World Trade Organisation (WTO). In the last decade, three WTO disputes have been raised against Chinese trade policies for twenty-one critical materials, of which two were resolved in the complainants' favour (with the third ongoing). Following the conclusion of these WTO cases, China has agreed to reform certain aspects of its export licensing and taxation policies for critical materials (see Box 2).

BOX 2 EVOLVING INTERNATIONAL TRADE RULES FOR CRITICAL MATERIALS

Given the importance of trade for the security of critical material value chains, there have been several recent efforts to reform international trade rules for raw materials. These have principally made use of the Dispute Settlement Body (DSB) of the World Trade Organisation (WTO).

Three recent WTO disputes have concerned raw materials, all of which target Chinese policies on critical materials exports:

DS394/395/398:

Initiated by the US, EU and Mexico in 2009.

Concerns Chinese export duties, quotas, price regulations, licensing requirements and customs administration for bauxite, coke, fluorspar, magnesium, manganese, silicon carbide, silicon metal, yellow phosphorous, and zinc.

DS431/432/433:

Initiated by the US, EU and Japan in 2012.

Concerns Chinese export duties, quotas and licensing requirements for rare earth minerals, tungsten and molybdenum.

DS508/509:

Initiated by the US and EU in 2016.

Concerns Chinese export duties on antimony, cobalt, copper, graphite, lead, magnesia, talc, tantalum, and tin.

In all three cases, the complainants argued Chinese export restrictions constituted a restraint on trade prohibited under the *General Agreement on Tariffs and Trade* (GATT); and were designed to advantage Chinese critical materials processing firms over foreign competitors. They also argued the policies were in breach of product-specific commitments made by China in its Protocol of Accession to the WTO (2001).

China defended its policies as an allowable environmental protection measure. It cited a GATT provision – Article XX(g) – which allows governments to restrict natural resources exports if it is done for conservation purposes. China also argued the conservation rights implied by Article XX(g) overrode its product-specific commitments in the Protocol.

DS394 was resolved in 2012, and DS431 in 2014. In both cases, the WTO DSB ruled in favour of the complainants. It found that Chinese export restrictions functioned principally as an industrial rather than environmental protection measure, and were therefore not protected by Article XX(g). It also found product-specific commitments in China's Protocol overrode the general provisions of the GATT.

Following the completion of the cases, China undertook reforms to its trade policies for these critical materials to bring them into compliance with DSB rulings.

At time of writing, DS508 remains within the WTO dispute settlement process.

Source: Author's summary, from WTO³⁴.

These strategies are an important first step in developing more resilient critical material value chains. They recognise that existing arrangements fail to provide security for either producers or consumers, and commit governmental resources to improving the integrity of value chains.

However, these strategies alone are not sufficient to ensure more diverse and secure critical materials supply. This is because of:

- **An emphasis on information sharing, with less attention to addressing barriers to investment.** Governments have been very active in undertaking research to better understand critical materials supply risks. But fewer efforts have been dedicated to addressing the risks which have inhibited private sector investment in the first place. This in part reflects the appropriate role for the state in market-based economies, where governments regulate but do not undertake economic activity. However, it has also meant that the pervasive investment risks afflicting the sector remain unaddressed.
- **A focus on raw materials supply, rather than an integrated value chain approach.** Most strategies aim to either secure raw critical materials at their source, or reduce consumers' exposure to raw material supply risks. Yet given the complexity of value chains, intermediate processing stages are equally important. Establishing new upstream suppliers does little to improve security if monopolies remain at the mid-stream processing stage. Integrated approaches, which adopt a whole-of-value-chain perspective and promote the development of both upstream extraction and mid-stream processing, will be needed to properly secure supply.

- **Limited willingness of governments to incur financial costs.** The more impactful security strategies – particularly financial support measures – impose financial costs and exposes government to commercial risks. While all governments have proven willing to undertake low-cost criticality studies, only the Japanese government has gone on to extend financial support to new market entrants. That the only successful entrant to the rare earths markets – Lynas Corporation – was a recipient of Japanese financial support indicates the importance of these policies. A broader commitment to value chain reform, and the financial costs it entails, will be required to de-risk private sector investment.
- **Low ambition in, and results from, international diplomacy.** Bilateral diplomatic strategies have largely focused on information sharing, particularly between national geoscientific agencies. While this is an important first step, it is also a comparatively low-ambition form of cooperation, and does not address the underlying investment risks facing the industry. Multilateral diplomacy through the WTO has proven more successful, resulting in concrete policy changes by the Chinese government to some of its trade practices. However, the recent dispute over the WTO's Dispute Settlement Mechanism – whose Appellate Body became inquorate in December 2019 due to appointment vetoes by the US – has since undermined the reliability of WTO mechanisms in policing critical material markets.

4. STRATEGIES TO ADVANCE CRITICAL MATERIALS SECURITY

It is clear that more needs to be done to secure critical material value chains. At present, monopolised supply creates shallow and volatile markets, and exposes consumers to political, economic and defence supply risks. Critical materials have also been the subject of diplomatic disputes, politicising trade and undermining the reliability of international markets. Indeed, these security challenges are likely to intensify in coming years. As digital communications further penetrate into social life, and the renewable energy transition gathers pace, the demand for critical materials will only increase in coming years.

More secure critical material value chains are essential to provide a foundation for the technologies which will define the 21st century.

This will require a rapid diversification within value chains. There is an immediate need to expand supply networks by bringing in new up-stream mineral producers. These will reduce the prevalence of monopoly, and allow properly-functioning and competitive markets (rather than political machinations) to determine patterns of trade and investment. There is also a need to broaden the number of players in the mid-stream processing stage, so that the monopoly problem is not simply moved along the value chain. Importantly, new players must have robust governance and institutional frameworks at home, and trustworthy diplomatic relationships abroad, if they are to provide a reliable and secure source of supply.

However, this diversification is unlikely to happen without government intervention. Critical materials are subject to very high levels of technological, social, market and political risks, which greatly exceed those seen in other natural-resource based sectors. These heightened risks pose a major barrier to private sector investment, and explain why few companies have successfully entered the industry in the last decade. Unless regulatory action by governments to de-risk investment and improve the functioning of market mechanisms is taken, it is very unlikely that any new producers will enter the sector in the next decade.

Fortunately, the nature of the problem – and the need for regulatory action – has already been recognised. The US, EU, Japan and Australia have now emerged as an important coalition for critical materials reform, and have each launched initiatives to improve value chain governance. However, their initiatives are yet to directly address the underlying problem – high investment risk – facing the industry. Government policies have been most successful in improving information and supporting technology through R&D measures. But financial support, which can help de-risk new investments, has only been offered by Japan. And diplomatic efforts have largely been limited to information sharing activities which do not address the root causes of investment risk. Alone, these existing strategies will not induce the required changes in global critical material markets.

There is now a pressing need for reform-minded governments to upgrade their strategies.

There already exists a solid foundation for this agenda. Domestically, all four governments now have critical materials policy frameworks in place, and initial efforts have greatly improved the availability of information on the industry. Internationally, there is also an established track-record of cooperation between these likeminded partners, on both a bilateral (Japan-Australia and US-Australia) and multilateral (Japan-US-EU) basis. Governments should now build upon these established foundations to develop new and more ambitious policies that will expand and diversify critical material value chains.

To realise this agenda, there are several steps that the US, Australia, Japan and the EU should now take:

1. Recognise that critical materials are not 'just another commodity'. Unlike other bulk materials, these critical material markets have special and distinctive challenges. Technically complex value chains, monopolised supply, social challenges and the politicisation of markets are structural features. They also pose significantly higher levels of investment risk than seen in other resource-based industries. Applying the standard regulatory frameworks for resource development will not be enough to support the growth and diversification of critical materials industries. Policy interventions must address this broader and more complex range of challenges.

2. Adopt an integrated value-chain perspective, which supports both mining and processing projects. The technological complexity of critical material value chains means their economics more closely resembles that of a manufacturing than mining industry. The development model commonly employed for large-scale resource projects – which focuses on producing raw materials at cost-competitive scale – is simply not calibrated to the economics of critical materials. Building partnerships between companies at the up-, mid- and down-stream stages of production will be an essential component for successful market entry.

3. Deploy financial support mechanisms. Existing market dynamics mean that barriers to investment are simply too high for new market entrants. Without some form of government financial support to de-risk investment, private sector resource companies are unlikely to launch new projects, particularly in the highest-risk markets. The success of Japanese efforts in 2010 to diversify its rare earths supplies illustrates the utility of financial support mechanisms. As Japan, the US and Australia all now have financial support mechanisms established, it is imperative these are quickly deployed to sponsor new companies into the sector.

4. Activate and upgrade existing collaborative platforms. Mechanisms for international cooperation between the four likeminded governments have been established, but remain at an early stage of development. Information sharing activities are a natural first step for international collaboration, but it should not be the last. There are now opportunities for the governments to collaborate on supporting investment-ready projects to enter the market, via commercial diplomacy to facilitate the negotiation of trade and investment ties. As three of the four governments now have financial support mechanisms in place, there are also opportunities for joint-venture-style support for key projects.

5. Multilateralise cooperation amongst the reform coalition. Australia, Japan, the EU and US all share an interest in supporting more diverse and secure critical material value chains. Their ability to realise this interest will be amplified by working together. This might take the form of joint project development, which would bring together commercial partners from each country into shared cross-border value chains. It may also be realised via diplomacy, such as collectively promoting critical materials reform initiatives in international fora such as the WTO, OECD and/or G20.

ENDNOTES

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