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Humphreys, David

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ORIGINAL PAPER

Mining and might: reflections on the history of metals and power

David Humphreys[1,2,3]

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Abstract
Economic and military power have rested on the possession of metallic minerals for many centuries; far longer than has been the case with hydrocarbons. Since minerals are unevenly distributed around the world, there have been many instances in history where countries have sought to bolster or extend their power by the acquisition of minerals from others through trade or through territorial expansion (empire-building). This article explores the interplay of mining, metals and power, through case studies of Ancient Rome, Spain during its colonisation of South and Central America, Britain's maritime empire, and the Soviet Union's belated and rapid industrialisation during the twentieth century. These case studies serve to make the point that current concerns in the USA, Europe, Japan and China about the vulnerability of their economies and military capabilities to the disruption of mineral supplies from overseas are nothing new, although the range of minerals now used, the complexity of modern supply chains and prevailing geopolitical norms suggest that there may not be too much in the historical record to assist these countries and regions address their concerns.

Keywords Mineral supply · Power · Empire · Iron · Copper · Gold

JEL Classification F52 · F54 · L72 · N53 · N54 · Q34

The article is dedicated to Phillip Crowson, my predecessor as chief economist at Rio Tinto and long-time mentor. Phillip has contributed immeasurably to showing how the tools of economics can be used to improve our understanding of the mineral industry. His liberal style of management was matched by a conviction that facts need to be faced head on, a ready sense of humour and an intolerance of sloppy thinking and poor syntax.

Foundations of power

Much has been written in recent years about the reliance of modern lifestyles on dependable supplies of metallurgical minerals (Abraham 2015; Pitron 2020; McKinsey 2022). Numerous reports attest to the importance of lithium, cobalt and nickel in battery systems; to the critical role played by rare earth elements in permanent magnets used for wind turbines and electric vehicle motors; and to the need for gallium, tellurium and silver for solar panels. This, in addition, of course, to the traditional metals like steel and copper which are required to build the infrastructure to support new power systems and the cabling to connect them. Attention is also drawn to the many exotic metals required for modern defence systems: for night vision goggles, for missile control systems, for radar in fighter jets, for cyber warfare and many more. Discussion on these things is generally followed by a warning that many of the minerals which we need have long and precarious supply chains and originate in sometimes unstable or potentially hostile places. The implication of the analysis is clear; an inability to source these 'critical' minerals renders our economies vulnerable to disruption and our military capability subject to degradation.

Neither the manuscript, nor the content thereof, have been published, or submitted for publication, elsewhere.

✉ David Humphreys
dh@daiecon.net

[1] CEPMLP, University of Dundee, Dundee, UK

[2] Rio Tinto, London, UK

[3] Norilsk Nickel, Moscow, Russia

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These concerns capture an enduring truth. If mineral supplies are about utility, they are also about power. The maintenance and development of a county's industrial strength depends on its ability to source a vast array of mineral elements to assemble into consumer products like cars, household appliances and mobile phones. Its military capability similarly depends on being able to obtain supplies of metal to produce tanks, aircraft and warships. And its energy security depends on the metals that are used to build power stations, wind turbines, solar panels and battery systems. This last has become of growing significance as the world plots a transition from hydrocarbons to a more sustainable green energy future. For these reasons, metals lie right at the heart of a country's ability to acquire, sustain and project global economic, political and military power. As Otto von Bismarck succinctly put it in 1862, national power is about 'blood and iron'.

In the current era, the two global superpowers, the USA and China, have become increasingly sensitive about the extent to which their power rests on sources of mineral supplies which they do not control. In the USA, a flurry of reports in the late 2000s (NRC 2008; DOE 2010) drew attention to the dependence of advanced US technologies on metallic minerals sourced from abroad, many of them from China. The 2021 Infrastructure Investment and Jobs Act and the 2022 Inflation Reduction Act contained funding provisions for boosting the domestic and regional supply of a range of minerals deemed critical to the green energy transition, along with tax incentives to encourage US manufacturers to use locally sourced mineral supplies. In addition, the Cold War era Defense Production Act has been revived to bolster domestic supplies of minerals for the US military.

China has long been aware of the dependence of its industrialisation and political autonomy on securing plentiful supplies of mineral raw materials. It has pursued industrial policies to encourage the domestic production of minerals and, no less importantly, domestic mineral processing. And for those minerals which are not abundant in China, and which must be imported, such as iron ore, copper, nickel and cobalt, the Chinese Government has encouraged its companies to invest in mineral projects overseas and sought to cultivate close economic and diplomatic ties with suppliers of these minerals. (Humphreys 2015).

There is nothing new about any of this. Countries with power have always depended on a healthy supply of mineral resources. For the past 250 years, the most crucial of these resources have been hydrocarbons, first coal, then later, oil and gas. But, before that, going back literally thousands of years, economic and military power rested largely on metals. The re-emergence of metals as the key to economic and military security can therefore in some regards be viewed as a restoration of the traditional order and the period of dependence on hydrocarbons an historical aberration.

What exactly is meant by 'power' here? Clearly, there are different expressions of power. Economic power derives from the capacity of a country to enrich itself through the production of, and trade in, goods and services. Financial power comes from the possession of capital assets and monetary wealth. Political power derives from the capacity of a country to influence the behaviour of others. While military power represents the capacity of a country to impose its will on others through force. To this might be added technological power, which is a measure of a country's ability to gain advantage through the deployment of its technical knowledge and skills, and mystical power, power which derives from religious insights or sacred objects.

These expressions of power are, of course, interconnected. Economic and financial power are usually a prerequisite for the acquisition and exercise of military and political power. Armies are costly. At the same time, the possession of miliary power endows a country with the capacity to forcibly acquire territory and material resources to bolster its economic and financial power if it so chooses.

Pretty much all expressions of power are in some manner and to some degree dependent on the availability of mineral raw materials. In some cases, the local availability of mineral resources and a knowledge of how to extract and work them has helped elevate a country to a position of strength. The emergence of the Hittites as a dominant force in Asia Minor around 1400 BCE seems to have owed much to their discovery of how to work iron and thereby to produce superior weapons. In others, the required resources can be obtained by engaging in trade or overseas investment. In extremis, there is always the option for countries to seek to acquire resources through territorial annexation, in effect empire-building. Indeed, history shows that the possession of minerals has often provided both the basis of, and motivation for, empire-building. But whatever path is taken, it is self-evidently the case that mining and metals have had a long and intimate relationship with the acquisition and exercise of power.

This article examines the complex relationship between mining, metals and power over a period of more than 2000 years through a series of case studies. The focus is on some of history's great empires. In each case, the attempt is made to look at these empires through the prism of their particular mineral requirements and how they sought to meet them. It begins with Ancient Rome, then progresses through Spain in the sixteenth and seventeenth centuries, Britain in the eighteenth and nineteenth centuries and then Russia in the nineteenth and twentieth centuries. Each serves to illustrate a slightly different aspect of the relationship under examination. The concluding section considers if there are any learnings that can be derived from this history.

Rome's military might

Rome was not the first empire of the ancient world but, in terms of its ambition, its scale and longevity, it eclipsed all previous empires.[1] Through ferocious determination and ruthless organisation, the Romans institutionalised the exercise of power in a way that no one had done previously, creating an empire which encircled the Mediterranean. At the heart of this power was its military prowess. And at the heart of this military prowess was the availability of metallic weaponry.

To build and sustain its power, Rome required mineral raw materials on an unprecedented scale. By today's standards, the range of metallic minerals used was limited; it included iron, lead, copper and tin (for bronze), mercury and the precious metals, silver and gold.

A major application of these metals was for weaponry. A Roman legionary was armed with a short, two-sided sword called a *gladius* forged by blacksmiths from several mild steels around a softer iron core. Iron was also used in the heads of disposable weapons such as arrows and spears (*pila*) and in the protective edges and bosses of shields. To make a gladius required around 1.2 kg of iron; one pilum required around 0.25 kg.

A legion typically comprised 4000–6000 men, with at least as many auxiliaries in support, all of them needing to be armed. During the years of the republic, the number of legions varied from four in peacetime to twenty-five in time of war but, at the height of Rome's power, the number had grown to around thirty. This amounted to a lot of iron. Moreover, this was not a one-off requirement since weapons get used up in battle and corrode with time. (Mommersteeg 2010; Sim and Ridge 2002).

Body armour, in the form of mail or small metal sheets, and helmets during Rome's republican period were more usually made of bronze rather than iron although iron was increasingly used in the first century CE when plate body armour, the *lorica segmentata*, was introduced. Ring mail body armour, made from thousands of small, interlinked steel or bronze rings, was used by heavy Roman infantry and some auxiliary units.

In addition to weaponry, iron was important in making the tools that legionaries were required to carry in order to build camps and fortifications. Such tools included spades, pickaxes, trenching tools, and saws. Iron was also sometimes used in tethering pegs and tent pole attachments and in the carts and catapults which would have accompanied legions on the move and supported them in their military endeavours.

Not all metal uses were military. Metals were widely used in other important economic activities which characterised the power of Rome. Iron was used in construction for nails, tie rods and workers' tools, while lead was used for water channels and pipes. Lead, sometimes in combination with tin (to form pewter), was also commonly used in tableware and kitchenware. Bronze, as well as its uses in armour, was used in household goods and in ornamentation. Mercury was used for medical purposes, paints and cosmetics (often with unfortunate side effects resulting from its toxicity). Silver was particularly important as the basis for the coinage (*denarii*) used in trade and, crucially, for paying Rome's soldiers. Gold (*aureus* in Latin) was also used in coinage but was more generally important for ornamentation.

It is possible that the use of iron in agriculture was as great, or indeed greater, than its use in military applications. Use of the metal offered the possibility of big increases in productivity in food production, important to Rome's growing population. Contemporary sources refer to iron's use in land-clearing tools such as shovels, mattocks and saws, as well as tools used for cultivation such as ploughs, forks, hoes, scythes and pruning hooks. In his *Historia Naturalis*, Pliny the Elder gave pride of place to the agricultural uses of iron. 'With iron we plough the ground, plant trees, trim other trees that support our vines, and compel the vines to put out new shoots by cutting dead wood each year. With it we build houses, quarry rocks and achieve many other useful tasks' (Pliny the Elder 2004).

Exactly how much metal Rome used is hard to know. But based on a detailed assessment of the amount of weaponry and armour required by the Roman military and the metal tools required for agriculture production, it has been calculated that Rome's use of iron by the end of the third century BCE was of the order of 300–500 tons a year (Mommersteeg 2010).

As Rome's power and territorial reach grew, so its need for metals escalated rapidly. At the height of its power, it is estimated that maybe 80–85,000 tons of iron were being produced and used across the Roman Empire annually. A similar amount of lead was being produced and used and around 15,000 tons of copper. Again, very approximately, 200 tons a year of silver was being used and 9 tons of gold (Morris 1994, Healy 1978; Sim and Ridge 2002; Patterson 1972).

Obtaining supplies of these metals was no trivial matter. Rome was a city state and had no resources of its own. Moreover, geological knowledge and mining technologies were primitive. To grow and sustain its power, Rome needed minerals. Territorial expansion was both a means to enhance its power and to secure those minerals.

[1] Strictly, Rome did not become an empire until the installation of the first emperor, Augustus, in 27 BCE. Before this it was a republic. But in the broader, territorial, sense in which the term is used here, it had by then already been an empire for over two hundred years.

Following the overthrow of the monarchy in 509 BCE, the early Roman Republic largely sourced its mineral raw materials through trade with neighbours. One of these neighbours was Etruria (modern-day Tuscany) which had developed an advanced metal-working industry. Initially, this had been focused on copper and bronze using ores from a series of deposits on its coast, southwest of Siena. But by the seventh century BCE, the focus shifted to the harder and more versatile iron. The ores for this came mostly from deposits on the island of Elba, in the Tyrrhenian Sea off the west coast of Tuscany. The glow from the numerous small iron furnaces scattered across the island earned Elba the nickname *Aethalia* ('fire island') by passing Greek sailors.

All this on its doorstep was too tempting, and Rome duly occupied Etruria in the third century BCE. It then brought its formidable organisational talents to bear on raising output and productivity of the region's mines, as well, probably, as increasing the use of slaves.

Soon after Rome's subjugation of Etruria, the successful execution of the First Punic War with Carthage in 241 BCE provided a further boost to Rome's metal production, when, as part of the peace settlement, Carthage was obliged to cede control of the islands of Sicily and Sardinia to Rome. While Sicily was of more interest to Rome for its agriculture, southern Sardinia hosted significant mineral resources, notably of lead and silver.

Ultimately, however, the ability of Rome to supply its raw material needs locally was restricted by nature. The rocks of Italy are young in geological terms and metallic deposits are generally small and widely dispersed. Italy's miners often struggled to compete with producers working richer deposits elsewhere.

So, with time, Rome began to look further afield for its mineral supplies. To Rome's east, Greece and Macedonia, which were taken under the direct control of Rome in 146 BCE, brought with them significant production of silver, including the famous mines of Laurion, south of Athens, and some gold. To the north, Noricum (mostly modern-day Austria), initially an ally of Rome but from 16 BCE a province, was a source of special forms of iron ore (naturally enriched with manganese) from which were produced weapons highly prized by Rome's soldiers. To the south, Cyprus, seized from Egypt in 58 BCE, became an important source of the metal from which the island takes its name, copper. And way out to the northwest, the little island of Britain, which offered little of interest to the Romans other than its old rocks, was a useful source of several minerals, including lead, silver, copper, tin, iron and gold.

But the jewel in the crown for Rome's mineral supplies was Iberia (modern-day Spain and Portugal). This was a cornucopia of mineral riches. Seized by the Roman general Scipio Africanus from Carthage in 209–206 BCE, Iberia brought with it immense mineral wealth. As the Greek geographer, Strabo, informs his readers '…the whole country of the Iberians is full of metals… Up to the present moment, in fact, neither gold, not silver, nor yet copper, nor iron, has been found anywhere in the world, in a natural state, either in such quantity or of such good quality' (Strabo 2022). Access to these riches came at an opportune time for Rome in terms of its imperial ambitions, ensuring that a shortage of minerals would not hamper its growth. And the Romans at once put to work developing the mines, drafting in slaves and introducing new methods for mining and metals recovery.

Mining took place all over Iberia. Lead and silver were recovered from central Spain and from the far southeast between Almeira and Murcia. Mercury came from the mines of Almadén in the province of Ciudad Real some 200 km south of Madrid. Iron ore from around Toledo provided the basis for a metallurgical industry which produced swords of the very highest quality. Gold production was focused on the northwest of Spain and across the border in what is now Portugal. Pliny reported that gold production from Asturias, Galicia and Lusitania reached 200,000 oz a year at its peak (Pliny the Elder 2004, Coulson 2012).

Of special importance were the mineral deposits of the Pyrite Belt in Huelva Province in southwest Spain. Stretching from Aznalcollar near Seville in the east to Aljustrel in Portugal in the west, it included the fabulously rich deposits of Rio Tinto, near the town of Nerva. These comprised a complex mixture of minerals including copper, gold, silver, lead and iron and were, quite literally, the stuff of legend, having been exploited from the early Bronze Age (3300–2100 BCE). While the copper was prized by the Romans, the silver was arguably an even greater attraction given that silver formed the basis of Rome's currency. At the time of Iberia's occupation, Rome's need for money was escalating fast with the expansion of its territories and the growing scale of its military undertakings.

Mining in the Rio Tinto area was a large-scale and brutal affair. Initially, it seems to have been undertaken by the indigenous Tartessian people, who had been responsible for mining under Carthaginian rule. However, over time, the Romans brought in slaves and convicts to man the mines; this practice appearing to have peaked in the first and second centuries CE, at a time when the mines would have required several thousand workers. While the early activities had focused on surface mineralisation, as resources accessible from the surface were worked out, it became necessary to access the ore from tunnels dug into the sides of the open pits and shafts which reached deeper underground.

With the passing of the years, Rome's need for metals outran its ability to produce them given the technologies then available. The most abundant resources of copper at the Rio Tinto mines were in the form of sulphides, which the Romans were unable to process to metal. Declining

production of gold and silver led to the gradual debasement of Rome's currency (by 270 CE, the denarius contained no silver whatsoever) and, ultimately, to inflation and economic instability. Many bronze statues were melted down to recover the metal from which they were made.

The seizure of Dacia, a region which falls largely within the borders of modern-day Romania, and which possessed possibly the last known major source of gold in Europe, by Trajan in 106 CE, is often seen as motivated by Rome's increasingly desperate need for precious metals and was used to help launch an unsuccessful campaign to the east in Persia and Arabia, seemingly aimed at recovering by force the precious metals it had traded away (Bardi 2014; Coulson 2012). How far this shortage of metals contributed to the fall of the Roman Empire in the fifth century CE is hard to know. But what is known is that with Rome's collapse, mining technology slipped into the Dark Ages. Although European production of metals began to recover from the eleventh century onwards, it was not until the fifteenth century, a full thousand years later, that the industry began to advance beyond where the Romans had taken it (Coulson 2012).

Spanish gold

The next case shows a very different facet of minerals and power. It shows how Spain employed its technological superiority to subjugate the peoples of South and Central America and then enrich itself through the exploitation of the gold and silver it found there. More than in the case of Rome, minerals were in large part the purpose of Spain's imperial mission. Also, the minerals being sought were not sought as raw materials from which to make useful products or weapons but because they represented the purest form of wealth; they were in effect mined money.

In the centuries following the collapse of Rome, political fragmentation on the continent of Europe combined with a persistent challenge from the Islamic world resulted in a shift in the focus of power in Europe from the Mediterranean to the Atlantic. Here, in the late fifteenth century, Spain and Portugal were competing for supremacy. Aided by major advances in maritime technology, Portugal had asserted its dominance in the eastern Atlantic by establishing trading posts on the west coast of Africa and by rounding the Cape of Africa to reach the Malabar Coast of India.

So, when Christopher Columbus lobbied Queen Isabella and King Ferdinand of Spain to mount an expedition in the western Atlantic in 1492 to see if he could find a route to the Indies the other way around the world, they saw this as an opportunity to hit back. This being the fifteenth century, a claimed justification for these long voyages was to extend the reach of Christendom and in fact, The Treaty of Tordesillas in 1494 effectively gave papal sanction to the division of the Atlantic and the lands that bordered it to the east and west, to Portugal and Spain (Frankopan 2015). A more basic motive was provided by the conviction that over the horizon to the west lay lands brimming with gold and Columbus's journals reveal this as being a prime motive for his voyage. King Ferdinand, keen to elevate Spain into the first rank of European powers as well as to raise funds to retake Jerusalem for Christendom, had no illusions with regard to what this voyage was about either, commanding, 'Get gold, humanely if possible, but at all hazards – get gold' (Bernstein 2000).

Although Columbus succeeded in reaching the Caribbean (he did not reach the American mainland on this first voyage), his quest for mineral riches was less successful. Gold was discovered on the island he christened Hispaniola, the island comprising present-day Haiti and the Dominican Republic. This was subsequently developed at devastating cost to the local Taino people, but it was not the bonanza Columbus had promised Isabella and Ferdinand and their support for his voyages of exploration gradually ebbed away.

While Columbus may have fallen from favour, his voyages had inspired a new generation of adventurers who realised that if riches of gold existed, then they must lie on the American mainland. This new generation had absolutely no illusions that this was about anything other than enrichment. Foremost amongst the new adventurers—the Conquistadors as they came to be known—was Hernán Cortés who had made a name for himself in Hispaniola and Cuba. In 1519, he launched an expedition to explore Mexico and to find the Aztec people who it was rumoured possessed great wealth. The story of how Cortés found and conquered the Aztecs is well known as is the extreme brutality of his treatment of the local peoples. By August 1521, the Aztecs had been routed, the capital Tenochtitlán destroyed and Mexico claimed for the Spanish crown.

It turned out that Mexico did have gold and a developed gold-working tradition. When they first encountered the Spanish, the Aztecs had been generous with their gold. Unlike the Spanish who valued gold as a token of wealth, the Aztecs valued it primarily for its versatility in fabricating ornaments and items of personal adornment. They also believed it had spiritual properties. But this generosity, far from invoking gratitude, simply drove the Conquistadors on. As Cortés informed the Aztecs, 'I and my companions suffer from a disease that can be cured only by gold' (Frankopan 2015).

The gold of Mexico, while welcome to the invaders was not on the scale they had hoped for. A bigger prize lay in the discovery that Mexico hosted much more substantial resources of silver. Silver was harder to extract than gold. It seldom occurred on the surface or in a native state so had to be chipped out of hard rock, often underground. Moreover, the mined ore had to be crushed and the silver separated out

from associated metals like lead by smelting multiple times in small furnaces (Lynch 2002). Producing silver was therefore an altogether lengthier and more complex process than producing gold. On the other hand, the resources were large. Cortés had by 1540 personally acquired a clutch of mines in the *Provincia de la Plata* to the south-east of Mexico City.

It was rumoured that a richer source of gold lay to the south of Mexico, in the land of the Inca, in what is now Peru. Francisco Pizarro, a hard-bitten adventurer with significant experience of exploring in Mexico (and, incidentally, a second cousin of Cortes), decided that he needed to take a look and in 1530 raised funds in Spain to mount an expedition.

The Inca were a complex and powerful civilisation. The empire was vast, covering much of what we know today as Peru, Chile, Bolivia and Ecuador, plus parts of Colombia and Argentina, and having a population of maybe 10 million. It boasted fine cities and a highly productive agricultural system, using terraces for food production on the steep slopes of the Andes. The whole was connected using an extensive system of roads and relays of messengers. Gold for the Inca, as for the Aztecs, was valued for its decorative and spiritual qualities rather than as a medium of exchange. And they had a lot of it.

Pizarro arrived in their midst at a time when the Inca were experiencing severe problems. Diseases like measles and smallpox, brought to the continent by Europeans, were already killing large numbers of people. In addition, the Inca empire was in the throes of a civil war. The death of the Inca emperor, Huayna Capac, in 1528 had led to a war of succession between two of his sons, Atahualpa and Huáscar. By late 1532, Atahualpa had effectively won but the conflict had divided the empire and there were still significant pockets of resistance to his rule, including in the capital Cuzco.

Atahualpa did not see Pizarro and his small handful of men as a major threat, but Pizarro had steel and he had horses, and he compensated for his lack of numbers by taking advantage of Atahualpa's innocent hospitality and kidnapping him. As the price for his release, in what would become one of the iconic founding legends of Spanish colonialism, the Inca undertook to fill a room in the town of Cajamarca measuring 6.8 m by 5.2 m, as high as a man could reach (2.75 m), with gold once and silver twice over. (Bernstein 2000) During the next two months, the palaces, temples and public buildings of the Inca Empire were stripped of their precious metal artefacts to make good on this commitment. When the room had been filled, Pizarro ordered that the metal objects from the room be melted down into ingots for transport back to Spain. It is estimated that the total haul amounted to around six tonnes of gold and over twelve tonnes of silver (Lynch 2002; Bernstein 2000).

Adding insult to injury, Atahualpa was not released. Instead, he was charged with seeking to instigate an insurrection again the Spanish, adultery and idolatry, and put to death. The Spanish then set about sacking the Inca Empire and stripping it of its gold artefacts. When the easy pickings had been had, they sought to boost local production using local Indian labour and, because this was in short supply, importing slaves from Africa. This effort did not, however, produce the amounts of gold the invaders wanted.

Two developments were to help boost the production of precious metals in the region. The first was the discovery in 1546 of vast silver resources high in the Andes at Potosi, in what is now Bolivia. The development of mines in the area led to Potosi becoming for a while a city of over 100,000 persons, one of the largest in the world at that time. The second development was the introduction of mercury amalgamation by the Sevillian merchant Bartholomé Medina in 1556. The technique, developed initially in Europe, significantly increased the recoveries and productivity of the mines. Mercury for the process was initially sourced from the Almadén mines in central Spain before a more local source was discovered at Huancavelica in 1563 (Lynch 2002).

Exactly how much gold and silver was shipped from South and Central America is a matter of much debate. The most authoritative sources suggest that, in the course of the sixteenth century, some 154 tons of gold and 7440 tons of silver were shipped back to Spain. Initially dominated by gold, the balance of shipments shifted over time towards silver. Silver shipments then peaked around 1600 before going into a steep decline from 1630 (Vilar 1984). To put some sort of perspective on this, it is estimated that, as a result of this influx of gold and silver, the total European stock of precious metals at the end of the sixteenth century was around five times what it had been at the start (Bernstein 2000).

What is not in dispute is that the riches of South and Central America transformed the place of Spain in Europe. Charles V, the grandson of Ferdinand and Isabella, came to the throne in 1516 with many territorial claims around Europe, in Italy, in France and in the Low Countries. The wealth flowing from the Americas enabled him to assert these claims militarily and also to secure for himself the title of Holy Roman Empire in the teeth of opposition from Francis I of France with whom he was pretty much permanently at war during his reign. He also fought with the Ottomans in the east of Europe and in North Africa. His belligerence was inherited by his son Philip II who came to the throne in 1556. Neither king appears to have had much interest in their colonies except in so far as they could provide finance for pursuing their European ambitions.

Although this era is often characterised as Spain's Golden Age, and unquestionably produced some great architecture and art, it was built on very shaky foundations. Little effort was made to reform Spain's deeply conservative institutions and little investment went into developing its domestic economy. Thus, despite the wealth flowing from its colonies, Spain was incurring huge debts, these precipitating a series

of sovereign debt crises from 1576 onwards. The use of the wealth extracted from the Americas was akin to squandering an inheritance.

During the seventeenth century, Spain's power began to ebb away. In addition to the slowing flow of wealth from the Americas, the country experienced devastating plagues in Castile and Seville and high levels of inflation which raised food prices and created hardship for the poor. Gradually, Spain's territorial possessions in Europe began to slip away. It was forced to cede control of the Netherlands at the end of the Spanish-Dutch War in 1648 at the Treaty of Westphalia and was expelled from France at the end of the 1650s. Portugal, which had been brought under the Spanish crown in 1580, broke with Spain in 1640, re-establishing its own monarchy.

As for its colonies in South and Central America, despite efforts under the Bourbon monarchy in the eighteenth century to improve the governance of its colonies, Spain's ability to manage such far-away territories was diminishing, a situation not helped by the destruction of the Spanish fleet at the Battle of Trafalgar in 1805. Inspired by the revolutions recently taken place in France and America, and with Spain weakened by the overthrow of its monarchy by Napoleon Bonaparte, Spain's colonies experienced a series of local uprisings aimed at shaking off European control, starting in Hispaniola in 1801. In 1810, a series of rebellions against Spanish rule broke out across South and Central America. Although Spain retaliated militarily, gradually the forces of independence prevailed, and one by one the revolutionaries won for their states the right to self-government: Argentina in 1816, Chile in 1818, Peru, Venezuela and Mexico in 1821 and Bolivia in 1826. The Spanish empire had come to an end.

British iron

The case of Britain reveals a third aspect of the interplay between mining, metals and power, specifically the role of mining and metals in promoting industrial power and the use of that power to sustain and grow a global empire.

Britain's industrial revolution and its rise to global power are, rightly, associated primarily with coal, the coal that raised steam to power textile mills, locomotives and ships. But, prior to any of this, coal revolutionised the production of metals, the metals used to make the machinery of the steam age, cheap manufactures for the consumer and the weaponry that was required to maintain Britain's military might.

Since well before its invasion by the Romans, it had been known that Britain's ancient rocks harboured rich deposits of metals. But, as the demand for metals grew in the lead-up to the industrial revolution, metal production in Britain was hampered by two important constraints. One was that, as mines went deeper, they faced an increased problem with water ingress. The second was that the smelting of metals relied on heat generated by the burning of charcoal. Given the extent to which it had already been deforested, and the fact that there were many other demands on Britain's remaining forests, including a strategic requirement for timber for shipbuilding, this was becoming a major constraint on production. Coal helped overcome both these limitations and was thus an important enabler of metal production.

In the early 1700s, a Devonshire iron worker, Thomas Newcomen, developed a method to dewater mines using a vacuum pump powered by steam. These pumps, with their distinctive beams, remained in widespread use through much of the rest of the century before being supplanted by a significantly improved pump developed by the Scotsman, James Watt. In addition to their use in coal mines, these pumps were quickly adopted by the tin and copper mines of Devon and Cornwall in southwest England, leading to increased productivity and greater worker safety.

The second means by which coal helped the development of metal production was the discovery in the late seventeenth century that burning coal could generate the temperatures needed to smelt many metals. Having been demonstrated in the 1670 s that coal could be used to smelt lead, it was subsequently shown that it could also be used to smelt copper and tin ores and, by the end of the century, a thriving metal-producing industry based on the use of coal to smelt metals had been established in Britain.

The bigger prize though was iron, but it was not until 1707 that Abraham Darby, a successful Bristol-based producer of brass, was granted a patent for producing cast iron based on the use of coal. Needing a larger furnace than was available to him in Bristol, he raised money to establish the first full-scale iron works at Coalbrookdale, a town to the west of Birmingham. Conveniently, the region, along the England-Wales border, had significant local occurrences of coal. This area was to become the crucible of the industrial revolution.

The local availability of coal was also critical to the development of a large copper smelting industry around Swansea in South Wales. Given that it took more coal, by weight, than it did copper ore, to produce copper, and given also that Swansea had a good harbour which was easily accessible from Devon and Cornwall, it made more sense to ship the copper ore to Wales than to smelt it near the mines. By 1823, there were nine copper works in the Swansea area, and up to the middle of the nineteenth-century, Swansea (dubbed Copperopolis) dominated Britain's, and indeed the world's, copper production. Copper was finding increasing uses, in saucepans, trays and coins, and in the brass industry where it could be turned into pipes, valves, decorative fittings and buttons. From the 1830s, there was a growing market for

copper for telegraph wires. There was also a growing export market for copper; copper cauldrons for sugar plantations in the Caribbean and copper bars to be turned into ornaments and coins in India.

These and other technological developments resulted in a rapid growth in the production of metals in Britain during the first half of the nineteenth century. Britain's iron production in 1780 is believed to have been no more than 100 thousand tons. By 1830, it had risen to 600 thousand tons and by 1870 to 6.7 million tons (Hobsbawn 1969). Tin, the metal that had first made Britain a target for metal seekers for its use in bronze and pewter, was finding new uses, notably in anti-rust coatings for iron and steel products, and production grew rapidly. By the middle of the nineteenth century, Britain accounted for around 40% of global production of the metal (Umhau 1932), so too with copper. Copper from the mines of Devon and Cornwall, supplemented by that from Cumbria, Staffordshire and North Wales, meant that Britain accounted at its peak for over 40% of global copper mine production and over 50% of its copper metal production (Julihn 1928).

These metals did much to promote Britain's industrial strength and to sustain its role as the world's leading trading nation. The growth in Britain's GDP, which through the previous three centuries is estimated to have averaged around 0.75% a year, surged to almost 2% a year in the first half of the nineteenth century, a rate which it sustained through the balance of the century to 1900 (Maddison 2006). Trade surged with it as Britain exported the products of its factories and imported the raw materials, such as cotton, to feed them.

Metals also made a significant contribution to underpinning Britain's role as the leading maritime power. The copper sheathing of ships' wooden hulls to prevent fouling by marine life encrustation gave Britain's ships a significant advantage in manoeuvrability and was said to be a factor in winning the battle of Trafalgar. More abundant iron led to improvements in the quality and number of cannons carried by the navy's ships (Bardi 2014). The middle of the nineteenth century began to see the introduction of iron-hulled, screw-propeller-driven ships powered by steam. This massively increased their range and carrying capacity. In 1874, Britain accounted for almost half the total international ocean-going fleet and between 1880 and 1900 it built 60% of the world's ships by tonnage (Ojala and Tenold 2016).

The rapid growth in metals use on which the economics and defence of the empire had come to depend could no longer be supported by Britain's mines. Britain's ore deposits were small and, although initially rich, ore grades were declining. Moreover, there was growing competition from countries elsewhere with bigger, richer deposits, the USA, Chile, Spain, the Malay States and, later, the colonies of Australia and Canada. During the second half of the nineteenth-century output from Britain's mines began to decline sharply.

As advocates of free trade, a system which favoured the notion that goods should be produced in countries where costs were lowest and exported to those that wanted them, this was not a situation that seemed greatly to worry Britain strategically. The assumption was that if the market was allowed to operate it would furnish an abundant supply of minerals to the global market and thereby satisfy Britain's growing need for such raw materials at competitive prices. Then again, given the scale of Britain's economy and the ability of its navy forcibly to keep trade routes open, it was able to trade from a position of strength. Moreover, the increasing ability to invest globally meant that this growing trade was seen by Britain as a commercial opportunity from which it could profit. In short, this was not a situation like that of Rome where a shortage of minerals pointed to a need for direct annexation of resource-rich territories.

The newly liberated countries of Latin America saw a flurry of activity from British investors in the 1820s, this directed primarily at silver mining in Mexico and gold in Brazil. However, this proved unprofitable and was short-lived. The following decade, British investors were back, this time in pursuit of Chile's copper. A change in government in Chile in 1830 had led to increased activity in Chile's copper mining and Chilean ores were becoming of increasing importance to the copper smelters in Swansea. British investors helped fund the Caldera to Copiapó railway line, which opened in 1851. This connected the principal copper mining region to the coast and was the first railway of any scale to be built in Latin America. Exports of copper ores began to flow out in volume and the Swansea smelters entered their golden age. In the late 1880s, the British would increase their involvement in the Chilean copper mining industry, helping to finance a railway to the port of Antofagasta in the far north of Chile, a railway originally intended to ship mineral nitrates, but which also provided access to what was to become Chile's largest copper-producing region (Lynch 2002).

Involvement in the mining industry of the Malay States, which were major producers of tin, was more problematic. This was partly because of political instability in the region arising from the rivalry between Malay nationals and Chinese immigrants, but was also because the tin operations were small-scale, dispersed, low-tech and difficult to mechanise. With the political situation worsening and with tin production badly disrupted, Britain intervened in 1874 to protect its commercial interests in the region, making the Malay States a British Protectorate. The early years of the twentieth century finally saw the mechanisation of the industry with the introduction of large capital-intensive dredges and, with it, the rise of the incorporated British tin companies, such as Pahang Consolidated, Kamunting Tin Dredging

and Petaling Tin, sealing the Malay States' place as the world's largest producer (Coulson 2012). Back in Britain, production in Cornwall fell away steeply as a result of competition from lower-cost producers, which also included the Dutch East Indies (now Indonesia), Bolivia and Australia. Tin metal continued to be produced at a smelter in Bristol from imported ores.

However, the best known, and most 'imperial', foray by Britain into the minerals industry of another country took place in southern Africa albeit that this was not primarily about the sourcing of industrial raw materials. The Cape colony at the tip of southern Africa had been acquired by Britain from the Netherlands during the Napoleonic Wars but most of the local population remained Dutch, or Boers as they were called. The discovery of diamonds along the fringes of the Cape Province in the 1860s led to a large influx of miners and investors. Then, 20 years later, large gold deposits were discovered at the foot of the Witwatersrand range of hills some 55 km south of the Transvaal capital of Pretoria.

These deposits posed two challenges. First, unlike the diamond mines, the gold was locked underground in tough quartz reefs and required large amounts of capital to liberate it from the surrounding rocks (Lynch 2002). This largely came from investors, like Cecil Rhodes, who had made their fortunes in the diamond mines. To assist with channelling money from Britain and elsewhere into South Africa, they created the mining finance houses, Gold Fields of South Africa, Rand Mines, General Mining and Central Mining. The second problem was less tractable. The newly discovered gold deposits occurred on territory claimed by the Boers who resented the incursions of the miners. In time, this was to lead to the Anglo-Boer War of 1899–1902 and thereafter to the incorporation of the Boer states into the Union of South Africa within the British Empire.

More usually, the influence of Britain on shaping of the global mining industry was exercised through harnessing the power of the market rather than by force of arms, although it would be wrong to underestimate the importance of the British navy's role in protecting British shipping interests and policing the supply chains of competitors. London's banks and stock exchange helped funnel money to mining projects in its dominions, Australia, Canada and South Africa in particular, but also in Latin America, Spain and Russia. Britain's smelters bought in ores from overseas to convert into metals for manufacturers and export. British manufacturers, in turn, enjoyed a healthy trade in the export of mining equipment. Miners who had learned their skills in Britain's mines, headed abroad to deploy those skills when jobs in Britain dried up. British mining schools, notably the Royal School of Mines in London (founded 1851) and the Camborne School of Mines in Cornwall (1888), trained up engineers to work in mining companies operating overseas. And in 1876, the London Metal Exchange (LME) was established to provide a forum in which global prices for non-ferrous metals could be set and where metal producers and consumers could hedge their price risk, a role which it continues to perform to this day (Lynch 2002). The LME's standard 3-month forward contract still reflects the approximate time taken to ship copper from Valparaiso in Chile to London and to ship tin from Malaya at the time the exchange was founded.

Soviet autarky

The industrialisation of Western Europe together with military conflicts in the latter part of the nineteenth century demonstrated an emerging truth. Military strength would henceforth go hand in hand with industrial strength. And a good supply of mineral raw materials would be critical to both.

Russia had been slow to industrialise and its acquisition of an empire under the Tsars during the eighteenth and nineteenth centuries had little to do with minerals. The driving force was essentially geopolitical. Russia sought territory to better protect its borders and to enable it to engage in global affairs through trade and big power politics. In contrast to the empires of the Western European powers, whose empires were widely dispersed and linked by sea routes, Russia was a land-based empire and contiguous. Its defeat at the hands of the British, French and Ottomans in the Crimean War of 1853–56 brought home to it the need to industrialise and during the latter years of the Tsarist regime, efforts were made to accelerate the process of industrial development. In particular, a major effort was made to connect together Russia's extensive territories through the construction of railways, notably the Trans-Caucasus Railway, the Trans-Caspian Railway and the Trans-Siberian Railway. But most of the technology and steel for this had to be imported. And in 1913, on the eve of World War I (WWI), steel production in the Russian empire was only 5 million tons, less than a half of Britain's and only a quarter that of Germany's.

WWI thus found Russia ill-prepared for conflict. Not only did it lag other European powers industrially but its attempt to catch up and to draw population into the cities from the countryside was creating significant social dislocation and food shortages. In February 1917, there was a revolution which forced the Tsar to abdicate. A further revolution in October 1917 brought the Bolsheviks to power under the leadership of Vladimir Lenin. The incoming Bolshevik government sued for peace with Germany, as part of the price of which it was forced to cede control of Ukraine, Belarus and the Baltic States, Latvia, Estonia and Lithuania.

The ending of the war in 1918 and the defeat of Germany provided an opportunity for Russia to re-instate its lost territories and, despite an avowed opposition to the

notion of empire, the Bolsheviks decided that they needed to restore the boundaries of Tzarist Russia, albeit that the new arrangement was initially presented as a federation of independent Soviet republics. The temporary divorce from its former imperial possessions had revealed just how much Russia needed them. Effectively, half the grain, coal, iron and human population of the former Russian Empire had been lost (Service 2003). Also, the civil war that the Bolsheviks had had to fight against a rear-guard action of the old regime, the so-called White Russians, during 1918–21, reminded Russia about the animosity that many foreigners felt towards it and the importance of securing its borders from outside threat. Accordingly, Russia quickly sought to re-assert its control over Ukraine and Belarus while Georgia was reconquered in 1921. In 1922, the Union of Soviet Socialist Republics (USSR) formally came into being. The Baltic States remained independent until 1939 when they too were taken back under Russian control (Service 2003).

Although firmly in charge of Russia and its dominions by the early 1920s, the Bolsheviks had no clear plan about how to reform or manage the economy. Initial moves to bring agriculture and industry into state ownership had been unsuccessful and resulted in food shortages and social unrest. An attempt to address the problem by allowing greater market freedoms to small businesses and farmers under Lenin's New Economic Policy (NEP) had some success but was regarded by the harder-line elements in the Communist Party, including its General Secretary, Joseph Stalin, as a betrayal of the revolution. With Lenin's death in 1924, to counter any further liberalisation, Stalin advanced a doctrine of 'Socialism in One Country'. In many respects, this was no more than an acknowledgement of what was already becoming a reality. Hopes amongst some in the leadership group, most notably Leon Trotsky, that revolution in Russia would be followed by revolutions elsewhere, creating a socialist international, were fading fast. Moreover, foreign investment into Russia had effectively ceased. Russia was going to have to go it alone.

The Soviet leadership, which was growing impatient with the slow speed of industrialisation, was moving back towards the idea that what was needed was central economic planning backed by a firm political hand (Service 2003). This view was reinforced by a growing nervousness about Russia's military weakness and the fear that at some point Russia would find itself at war with capitalist nations. As Stalin was later to remark, 'We are fifty or a hundred years behind the advanced countries. We must make good this distance in ten years. Either we do it, or we shall be crushed' (Stalin 1931). By 1927, Stalin had successfully marginalised all his potential competitors and manoeuvred his way to an unassailable position at the apex of the Soviet system. The instrument to bring about the change he believed was needed was a comprehensive state-managed economic plan.

The two Five-Year Plans launched under Stalin, the first from 1928–1932, the second 1933–37, were aimed at nothing less than transforming the Soviet Union from an agrarian to an industrial economy. In the absence of foreign support, funding for this had to be forcibly extracted from the agricultural sector and, to this end, a massive programme of nationalisation, collectivisation and mechanisation for the sector was launched. The human cost was horrific. With farmers dispossessed of their land and driven into the cities, there was widespread starvation amongst the rural population and millions died. During the Second Five-Year Plan, increasing use was made of prison camps, or *gulags*, to forcibly provide the army of labour that industrialisation demanded. Numbers in the prison camps doubled from 950,000 to 1.8 million between the start of 1935 and 1938 (Applebaum 2004).

Despite the extreme human suffering that it brought with it, in terms of the narrow objectives set, Stalin's two five-year plans did what they were intended to. The Soviet Union industrialised. No less crucially, it had put itself in a position to defend itself against military attack, something which it was required to do when Hitler invaded in June 1941. During the ten years of the plans (1928–1937), Soviet industrial production increased around three times, implying an annual growth rate of 12% a year. Steel production rose over 400% to 17.7 million tons. Electrical generating capacity rose over 700% to 36.2 GWh. Some 700,000 tractors were produced under the two plans, this representing 40% of the total global production (Wikipedia 2022).

To support this breakneck rate of industrialisation, large quantities of mineral raw materials were required. Because of the 'one country' policy, these could not be supplied from abroad. Then again, the Soviet Union covered an immense area and, as such, was host to substantial mineral wealth. But this immensity was also a problem. The minerals were not necessarily where they were wanted, which is to say close to centres of population. Many of them were in the vast empty reaches of eastern Russia. This did not matter so much for high-value minerals like gold and diamonds, but for bulkier industrial raw materials like iron, copper and lead, it mattered a lot. Unless the deposits lay close to a railway line or a port, they might as well not have been there. Russia's resources were hostage to what has been termed the 'tyranny of geography'.

There was another agenda. This was the opening-up of Siberia, the great expanse of Russia in Asia. Its remoteness from European Russia and its severe climate meant it was not a place many people would go voluntarily. Stalin saw the emptiness of Siberia as both a wasted opportunity as well as a strategic liability. He wanted it settled and developed. The raw material requirements of the Soviet Union's industrialisation provided both a motive and a lever to achieve this. People might not have been prepared to head east to settle in Siberia voluntarily but the ideologically driven might be

persuaded to go there in the interests of the Soviet cause, and prisoners, both criminal and political, could be forced to go there. Two of the natural resources which were the target of these developments were oil and timber, two staples of Soviet production and exports. The other was metals.

The availability of metallic mineral deposits within Russia was generally rather mixed. Iron ore was not too much of a problem. The Urals, the heartland of the USSR's military-industrial complex, had substantial reserves of iron ore. It also had coal as well as good access to the coalfields of the Kuznetsk Coal Basin to the southwest. It thus became the focus of steel industry development. In the far west of Russia was the Kursk Magnetic Anomaly, the largest known occurrence of iron ore of earth, which started to be developed in the 1930s, and, further west still, the iron and coal resources of the Donbass and Kryvbas regions of Ukraine. Conveniently, Ukraine was also host to one of the world's largest deposits of the important steel-hardening alloy, manganese, around Marhanets in the Nikopol Basin.

Copper, crucial for the Soviet Union's push for electrification was not so widespread in Russia. The Urals were, once again, the primary source of Russia's copper. But the Urals copper deposits, although numerous, were generally small. Nonetheless, several smelters were built in the region during the 1930s to take feed from the mines around the towns of Ekaterinburg and Chelyabinsk. Better deposits of copper were found in Kazakhstan, directly south of Russia's industrial heartland. Copper production started up in 1930, with production from the mines being smelted at Balkhash. In the late 1930s, mining began at a large rich deposit at Zhezkazgan to the west of Balkhash. Kazakhstan also had resources of lead and zinc, metals with which Russia was not particularly well blessed and it became the Soviet Union's largest supplier of these metals, mainly from eastern Kazakhstan around Ust-Kamenogorsk and in southern Kazakhstan around Shymkent.

If the basic metals like iron copper, lead and zinc were still the core elements of Soviet industrialisation, as they had been for Britain's a hundred years earlier, the range of metals of interest to industrial countries was beginning to expand. Corrosion-resistant stainless steels began to be produced in the 1920s. The first of these involved the use of chromium only but they were quickly followed by higher-performing variants which also included nickel.

The Soviet Union was fortunate in having good domestic resources of both these metals. Kazakhstan possessed the second largest deposit of chromium in the world (after South Africa) in the Aktobe region of northwest Kazakhstan and a start was made on developing this towards the end of the second plan. Nickel, as well as a soup of other metals including copper, cobalt and the platinum group metals, had been discovered in the Russian Far North on the Taimyr Peninsula. The deposit was in an extremely inhospitable place, within the Arctic Circle, and far from any centres of population or infrastructure. Nonetheless, the prize was a large one and a settlement, called Norilsk, was established there in the late 1920s with the aid of Komsomol (Communist Youth) volunteers. However, the main work to build the town, the mines and the smelter, began in 1935 using labour from the Norillag labour camps. Amongst the most notorious of such camps, the number of prisoners incarcerated here rose from 1200 prisoners in 1935, to 19,500 in 1940 and to 68,850 at its height in 1952 (Applebaum 2004).

Another metal with which Russia was well endowed was gold. Indeed, in the first half of the nineteenth century, before the gold rushes of the USA, Australia and South Africa, it was the world's largest producer. Conscious of the role that gold could play in funding the purchase of precious imports, Stalin determined that increased gold production should be a priority of the First Five-Year Plan (CIA 1955; Applebaum 2004). Investment was thus ploughed into gold mines in the Urals, Kazakhstan and Transbaikal in the early 1930s and production from these mines rose from around 0.9 million ounces in 1928 to 4.8 million ounces in 1938 (CIA 1955).

However, a bigger prize lay further to the north and east. In the 1920s, gold had been discovered along the Kolyma River and its tributaries in Siberia's Far East, to the northwest of the small town of Magadan on the Pacific Coast. The problem was that this was an extremely remote and climatically hostile region located in permafrost. It was decided therefore to develop it using forced labour, and so in 1931 a new organisation, Dalstroy, was formed with the mission to bring this about (Applebaum 2004). The prison camps of the Kolyma were to become the largest and deadliest of all the prison camps. In total, there are believed to have been 80 camps across the region. Sevvostlag, the largest of the Dalstroy camps, contained 200,000 prisoners in 1940 (Applebaum 2004). There was very little mechanisation. Pretty much everything had to be done manually, including cutting down the region's forests to build huge fires on the mineral deposits to melt the permafrost in order that mining could take place. Gold production from the region rose from nothing in 1931 to an estimated 5 million ounces a year in the late 1930s. But, once again, the human cost was terrible. Nobody knows for sure, but it is believed that as many as 3 million people lost their lives here between the mid-1930s and the mid-1950s (Rubin 1991).

The biggest problem of resource availability that Russia faced was aluminium, a metal that was becoming increasing important for aircraft manufacture. The problem lay not with the large amounts of energy which the production of aluminium requires but with the mineral ore from which the aluminium is made, bauxite. Although bauxite is widespread in nature, the best bauxites for producing alumina, the intermediate product from which aluminium is made,

are the result of tropical weathering and the Soviet Union had nowhere in its extensive territories that was tropical.

After much experimentation, it was found that bauxites occurring around Tikhvin, some 200 km east of St Petersburg, although of poor quality, could, at a cost, be converted into alumina suitable for use in the production of aluminium. Based on these ores, a small (5000 ton a year) aluminium smelter was built at Volkhov near St Petersburg in 1932 and in 1933 another, rather larger, smelter (15,000 tons a year) was started up on the Dnieper River at Zaporozhye in Ukraine. The discovery of bauxite near Nadejdinsk in the Northern Urals in 1931–32 resulted in the construction of a further two smelters in that region so that by 1941 there were four aluminium plants operating in the USSR. Although this was production which would not have been regarded as economic elsewhere in the world, in the Soviet Union, strategic necessity would always trump economics.

World War II added to the pressure for Soviet industrialisation as well as forcing a relocation of industrial and mineral production away from its western territories which had been invaded or which were threatened with invasion. The political settlements of Yalta and Potsdam in 1945 brought the countries in Eastern Europe into the sphere of Soviet influence but these were not major sources of minerals. Stalin's death in 1953 led to an easing of the extreme repression that had characterised his regime, but it brought little change in the Soviet Union's commitment to autarky. More than ever, the USSR did not want to have to turn to the capitalist West for goods, technology or raw materials. For many minerals, this was not a problem. Nor was it a problem for manufacturing aluminium given the vast amounts of cheap hydroelectric power available in Siberia.

But for some minerals, it undoubtedly was a problem. During the 1970s, the Soviet Union had some limited success is developing resources overseas, notably the Erdenet copper mine in Mongolia and the Kindia bauxite mines in Guinea, but for the most part, it had to rely on domestic resources. This led to a reliance on some mines which were of too poor quality to be considered resources in the West or too remote to bear the cost of transport to market. An extreme example of this was the production of alumina from an aluminosilicate mineral, nepheline, in 1950s as an alternative to bauxite. This production of otherwise uneconomic minerals was, however, deemed a cost that needed to be met in order to preserve its capacity for political self-determination. This continued right through up to the collapse of the Soviet Union in 1991 (Humphreys 1995). In the end, the way in which Russia sourced its mineral resources typified the many inefficiencies which characterised the Soviet economy as a whole and which eventually helped bring it down.

Concluding thoughts

The question of how countries, or groups of countries, acquire supplies of the minerals required to support their economic and military strength is a pressing contemporary issue. The attempt has been made here to provide some historical context for contemporary debate on this topic.

The cases presented above show that power, whether military, financial, commercial or industrial, has long depended on the supply of minerals and that an increase in power has generally brought with it the need to expand that supply. Two of the cases, those of Rome and Spain, showed, conversely, how an ebbing of mineral supplies can contribute to a loss of power. This is a story as old as civilisation. While discussion of these matters has in more recent times been dominated by a focus on energy minerals, the dependence on metallic minerals is of longer standing.

A variety of strategies exist for the acquisition of minerals to bolster a country's power, ranging from local development of minerals (whether market-driven or state directed), through the acquisition of minerals by trade and the cultivation of alliances with potential suppliers, to the outright annexation of territories hosting the sought-after minerals. It is clear from the history of this matter that strategies for minerals acquisition have often been characterised by ruthlessness and brutality. Even in cases where trade has been the preferred mechanism for securing supplies, this trade has often been conducted under conditions of duress.

What has changed over the last century is that increased technological sophistication has massively increased the range of minerals required and has commensurately complicated and lengthened processing and supply chains. What has also changed is that a greater international regard for national sovereignty has meant that the option of obtaining minerals through territorial acquisition is no longer a legally or morally acceptable option, giving greater leverage to the countries possessing minerals. Resource nationalism is an expression of this leverage and one which, unsurprisingly, sometimes makes mineral-using countries feel vulnerable. With an era of globalisation giving way to one with a more national focus, many mineral-consuming countries are naturally looking to devise policies which give them greater control over their supplies of critical raw materials in order to protect their core interests.

There are many policies that mineral-consuming countries can adopt to meet the challenge this poses and a number of these are currently either being pursued or explored, as noted in the introduction. They can encourage investment in domestic mining and mineral processing by the provision of incentives, subsidies or trade restrictions, they can enact

policies which encourage the thrifting of mineral use and recycling, and they can fund research into mineral materials and their applications to create options for substitution.

The bigger challenge perhaps is how to construct robust and trusting relationships between mineral-consuming and mineral-producing countries based on a mutual appreciation of their respective economic, security and developmental needs. This will involve mineral-consuming countries and their companies building lasting partnerships with the countries rich in the minerals they seek. At the same time, it presents an opportunity for mineral-rich countries to benefit economically by positioning themselves as reliable long-term suppliers of both minerals and value-added components to countries requiring them for their programmes of energy transition and security. It is acknowledged, however, that achieving all this will require a degree of sensitivity, wisdom and diplomacy which, as this article shows, has rarely been in evidence in the long history of these matters.

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