

Mine 2024: 21st edition

Preparing for impact



As the industry innovates, it's also reinventing the role that it can play in the global economy—by mobilising the resources needed for sustainable growth.



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Executive summary

The world's top mining companies have an important story to tell. They are helping feed the world while lighting the way to a low-carbon future and providing materials for infrastructure development and consumer demand. They are a force for good, critical to life in the 21st century as we know it. Yet this tale remains largely obscured, hidden from the view of the public and even investors. The industry is often accused of lacking transparency, and it could certainly be more open about its impacts.

To tell their story, mining companies need to be innovative about the way they measure their impacts—good and bad. A more accurate and insightful reading on this front has many advantages. It provides investors with a useful gauge that goes beyond their returns. Capital allocation decisions can be directed where they will have maximum impact and viewed through the prism of a broader lens. And other stakeholders—communities, unions and the wider public—can be more informed about their views of the industry.

Powerful trends are underpinning the demand that miners will need to supply if they are to remain profitable and competitive in a world where the pace of change is accelerating. One vein that the Top 40 mining companies in our report need to tap is urban mining, or recycling. This approach often produces commodities with a significantly reduced environmental footprint, which can command a green premium.

Technology must also be harnessed to maintain and grow productivity throughout the mine life cycle. Mining needs to unlock AI to advance productivity and extend the vast health and safety improvements the industry has already made. And without mining, there would be neither AI nor the game-changing impact the technology will have on other industries and society more widely. The semiconductor chips that AI applications require contain metals such as copper, zinc and gold.

Amid a new and ever-changing landscape, mergers and acquisitions (M&A) remain a crucial strategy for miners that want to maintain their competitive advantage even while the industry grows in new terrain in response to emerging demand. The percentage of completed mining

deals involving the Top 40 that were focused on critical minerals rose to 40% in 2023 from 22% in 2019, underlining this seismic shift driving M&A activity. Copper and lithium dominated such deals, accounting for over 70% of them by volume, up marginally from 2022.

Sustainability factors and considerations are key to such transactions. Investors are not interested only in the current bottom line—they want insight into how a company will perform and what it will look like in the future. Recognising this, mining companies are increasingly forming alliances beyond traditional boundaries as they seek the technical skills they lack and collaborate with governments to create enabling environments.

While attempting to navigate this changing and challenging field, the Top 40's financial performance in 2023 was squeezed by falling commodity prices and rising costs. Revenues fell more than 7%, even as production of key commodities rose. But by using the emerging technical tools that are already available, the industry can achieve productivity gains that will contain costs, and, with an eye to an expected rebound in commodity prices, help position mining for the future.

A sustainable industry will be able to fulfil its vital role in providing critical minerals to sustain life. Earth's endowment of natural resources is finite. There is no better time than now for the Top 40 to maximise their positive long-term impact while sharing gains with all stakeholders.

内容摘要

Executive summary

世界顶级的矿业企业有一个需要讲述的重要故事。他们正在引领世界通往未来低碳的道路，并为基础设施的发展和消费者需求提供原材料。众所周知，他们是一股向善的力量，对于21世纪的生活至关重要。然而，这个故事并未被大众知晓，隐藏在公众甚至投资者的视野之外。矿业行业常被指责缺乏透明度，而且确实可以更加开放地展示其影响。

为了讲好这些故事，矿业企业需要在衡量其优劣势的影响方式上进行创新。对这方面更准确、更深刻的介绍会带来很多益处。这将为投资者提供了一个超越其回报的有用的衡量标准。通过更广泛的视角，资本配置决策可以被引导以实现最大影响，而其他利益相关者，包括社区、工会和更广泛的公众，可以更加了解矿业企业。在一个加速变革的世界中维持盈利和竞争力，矿业企业要为强劲的需求不断地提供原料。我们报告中的前40大矿业企业需要进一步开发的一个领域是城市采矿或金属回收利用。这种方式通常会生产出环境足迹显著减少的矿产商品，从而获得绿色溢价。

矿业企业在整个矿山生命周期过程中还必须利用技术以保持和提高生产效率。采矿业需要利用人工智能以提高生产效率，并延伸到该行业迄今为止已经所做出的巨大的在健康和安全方面的改善。但是，如果没有采矿业，就不会有人工智能，技术也不会对其他行业和社会产生更广泛的诸如改变游戏规则之类的影响。因为人工智能应用所使用的半导体芯片含有铜、锌和金等金属。

即使采矿业为了应对新兴需求而发展了新的领域，并购仍然是矿业公司在新的不断变化的新格局下希望保持竞争优势的重要策略。在前40大矿业企业完成的矿业交易中，关键矿产的交易占比从2019年的22%上升至2023年的40%，突显出这一重大转变正在推动并购活动。铜和锂主导了这些交易，按交易量计算占比超过70%，较2022年略有增长。

可持续性因素和收购价款方面的考量对并购交易至关重要。投资者不仅对矿业公司当前的经营利润感兴趣，他们还希望了解企业未来的运作和前景。鉴于此，矿业企业越来越多地超越传统界限，形成联盟，从而寻求各自匮乏的技术技能，并与政府合作以创造赋能的环境。

在试图应对这个不断变化和具有挑战性的领域时，前40大矿业企业2023年的财务表现受到了矿产品价格下跌和成本上升的双重挤压。尽管主要矿产品的产量增加，但收入下降仍超过6%。通过利用现有的新兴技术手段提高生产效率来控制成本，并关注矿产品价格的反弹，将有助于定位矿业行业的未来。

一个可持续的行业将能够在提供维持生命的关键矿产资源方面发挥其重要作用。地球的自然资源是有限的。对于前40大矿业企业来说，没有比现在更好的时机来最大限度地发挥其积极的长期影响，并与所有利益相关者分享收益。

Resumen ejecutivo

Executive summary

Las principales empresas mineras del mundo tienen una importante historia que contar. Están ayudando a alimentar al mundo, mientras iluminan el camino hacia un futuro con bajas emisiones de carbono y proveen los materiales requeridos tanto para desarrollar infraestructura como para satisfacer la demanda de los consumidores. Son una fuerza que contribuye positivamente a la sociedad, y son fundamentales para la vida en el siglo XXI tal y como la conocemos. Sin embargo, esta historia permanece en gran medida en la sombra, oculta de la vista del público e incluso de los inversionistas. Frecuentemente se acusa a la industria de falta de transparencia, y ciertamente, ésta podría ser más abierta al mostrar sus impactos.

Para contar su historia, las empresas mineras deben ser innovadoras en la forma en que miden sus impactos—buenos y malos. Una lectura más precisa y esclarecedora en esta dimensión tiene muchas ventajas. Entrega a los inversionistas un indicador útil que va más allá de su rentabilidad. Las decisiones de asignación de capital pueden ser dirigidas hacia donde tendrán un máximo impacto, y ser vistas a través de un prisma con óptica más amplia. Y otras partes interesadas—comunidades, sindicatos y el público en general—pueden estar mejor informadas sobre su visión de la industria.

Tendencias poderosas están sosteniendo la demanda que las mineras deberán satisfacer para mantenerse rentables y competitivas en un mundo donde el ritmo del cambio se acelera. Una de las vetas que las 40 principales empresas mineras deben explotar es la minería urbana, o el reciclaje. Este enfoque frecuentemente produce materias primas con una huella medioambiental significativamente reducida, lo que puede suponer una prima verde (*green premium*).

La tecnología también debe aprovecharse para mantener y hacer crecer la productividad a lo largo de todo el ciclo de vida de la mina. La minería necesita desbloquear la IA para mejorar su productividad y ampliar las enormes mejoras en salud y seguridad que el sector ha logrado hasta ahora. Y sin minería, no habrá IA ni el impacto revolucionario que ésta tendrá en otras industrias y en la sociedad en general. Los chips semiconductores que necesitan

las aplicaciones de IA contienen metales como cobre, zinc y oro.

En medio de un nuevo y cambiante panorama, las fusiones y adquisiciones (M&A's) tradicionales siguen siendo una estrategia crucial para mineras que quieren mantener su ventaja competitiva, incluso mientras la industria crece en nuevos ámbitos respondiendo a una demanda emergente. El porcentaje de operaciones mineras completadas enfocadas en minerales críticos y que involucran a las 40 Principales aumentó hasta 40% en 2023 desde un 22% en 2019. Esto subraya el cambio tectónico que está impulsando la actividad de M&A's. El cobre y el litio dominaron dichas operaciones, representando más del 70% del volumen total, un aumento marginal desde el año 2022.

Los factores y consideraciones de sostenibilidad son clave para tales transacciones. Los inversionistas no sólo están interesados en los resultados actuales—sino que quieren tener información sobre cómo se desempeñará y cómo será la empresa en el futuro. Conscientes de ello, las empresas mineras están formando cada vez más alianzas más allá de las fronteras tradicionales, a medida que buscan las competencias técnicas que carecen y colaboran con gobiernos para crear ambientes propicios.

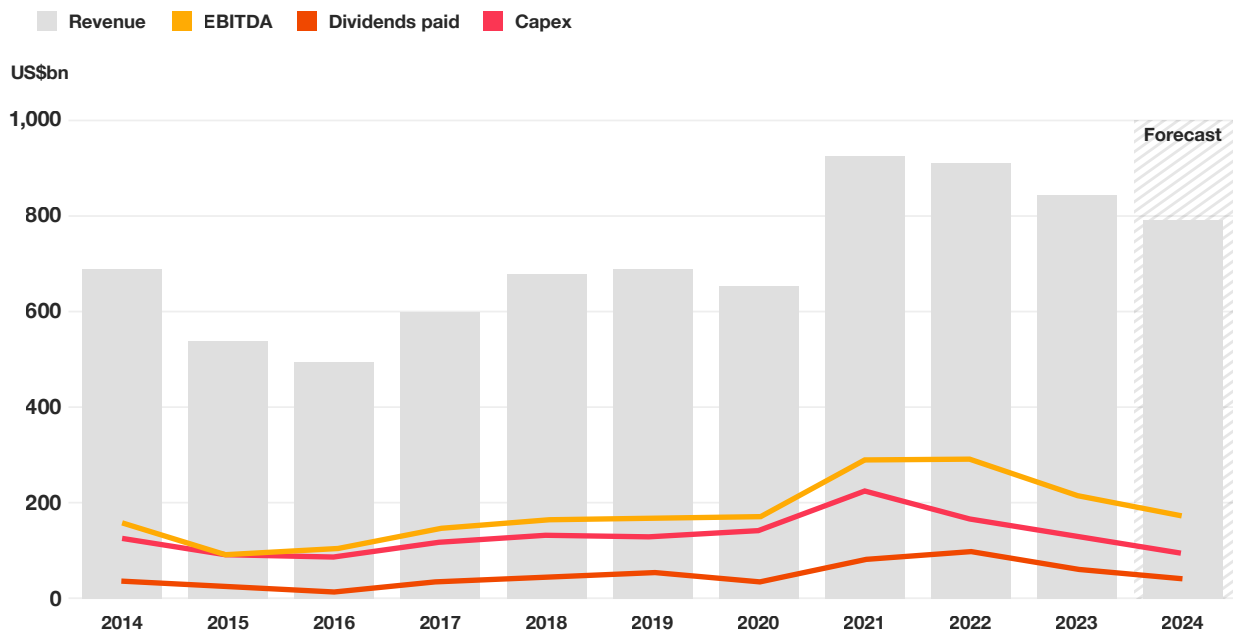
Mientras intentan navegar por este campo cambiante y desafiante, el desempeño financiero de las 40 Principales en 2023 fue presionado por la caída de los precios de las materias primas y el aumento de sus costos. Sus ingresos cayeron más de un 7%, a pesar del aumento en la producción de materias primas clave. Sin embargo, haciendo uso de las nuevas herramientas tecnológicas disponibles, la industria puede lograr aumentos en su productividad que contendrán los costos y, con la vista puesta en un rebote de los precios de las materias primas, ayudar a posicionar a la industria de cara al futuro.

Una industria sustentable será capaz de cumplir con su rol vital de proveer los minerales críticos necesarios para sostener la vida. La dotación de recursos naturales de la Tierra es finita. No hay un mejor momento que ahora para que las 40 Principales maximicen su impacto positivo de largo plazo, y al mismo tiempo compartan sus beneficios con todos sus grupos de interés.

Demanding times

The global mining industry faced a challenge in 2023 that was at once unprecedented and familiar. The financial performance of the world's Top 40 mining companies was squeezed by falling commodity prices and rising costs. Revenues fell more than 7%, despite increases in the production of key commodities, and profits shrunk, too; 2024 promises a continuation of these trends, marking the first time since 2016 that industry revenues will fall for a second consecutive year. And a mix of cyclical and structural issues compels leading miners to invest for growth and transformation even as revenues and profit margins come under pressure.

Financial metrics are under pressure



Source: PwC analysis

Mining occupies a unique role among global industries. The world's top mining companies are helping feed the world while lighting the path to a low-carbon future and providing materials for infrastructure development and consumer needs. These structural trends underpin the demand that miners will have to meet in a world where the pace of change and disruption is accelerating. As regulatory, economic and societal pressures increase, mining

companies are busily reinventing their business models so they can create value in new ways while working more effectively as important players in burgeoning ecosystems.

In this, PwC's 21st *Mine* report, we focus on how the industry is planning for impact—retooling and reimagining itself to be a key contributor to growth. That means throwing into relief the vital role mining plays in an adjacent domain: how the world feeds itself. It means delving into the potential and challenges of the complementary industry of urban mining (that is, recycling). And it means harnessing technology—including the revolutionary implications of AI—to advance productivity, sustainability and safety.

2023 financial snapshot

US\$845bn

in revenue

–7% from 2022

US\$217bn

EBITDA

–26% from 2022

US\$90bn

net profit

–44% from 2022

2024 forecast

US\$792bn

in revenue

–6% from 2023

US\$171bn

EBITDA

–21% from 2023

US\$55bn

net profit

–36% from 2023

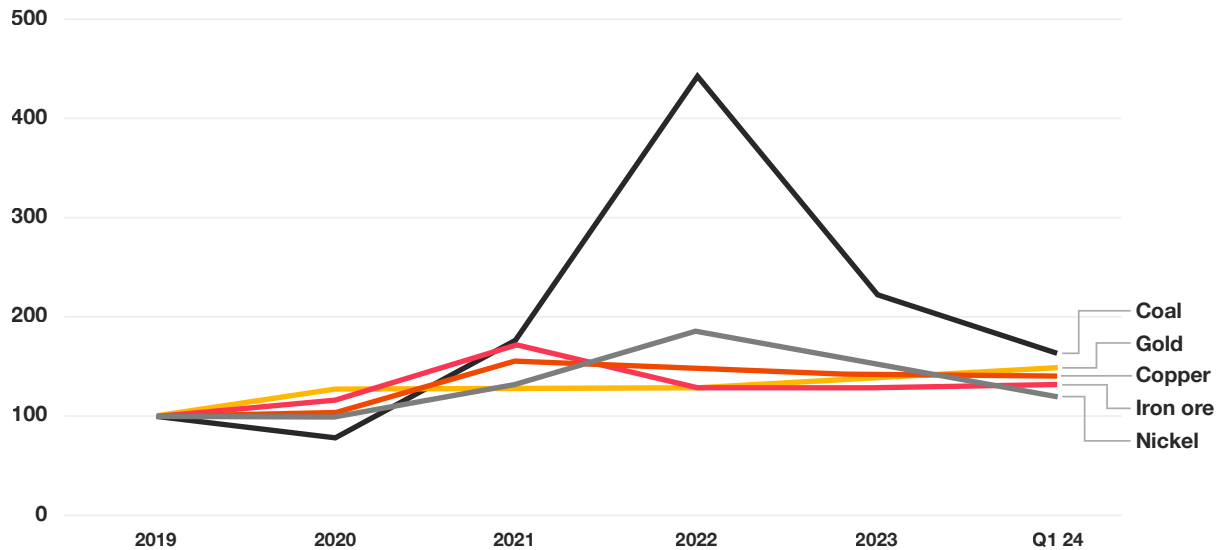
Amid the changing landscape, mergers and acquisitions (M&A) remain a crucial strategy for miners that want to create impact. Although the number of deals fell in 2023, their value increased, and so did the focus on critical minerals. But transactions today—and tomorrow—are not simply about gaining scale. They're about gaining the capabilities and assets that enable companies to collaborate with counterparts in broader industrial ecosystems. Mining companies are increasingly forming alliances beyond traditional boundaries as they seek to acquire vital technical skills and to collaborate with governments in order to create enabling environments.

When the cycle turns

In recent years, the industry has faced pressure to invest in sufficient mining capacity and production to meet the current and expected demand growth for metals supporting the energy transition. But markets aren't always completely efficient. In 2023, the prices of lithium, copper, nickel and cobalt fell sharply, as portions of the lumpy supply response came on stream while demand growth was temporarily stunted. At the same time, the price of uranium rose—with demand driven by growth in the nuclear industry after a decade of virtually no investment in supply. The spot price of uranium soared from below US\$50/lb in 2022 to more than US\$100/lb in early 2024. Although commodity prices remain well above pre-covid price levels, inflation adjustments show that only coal and gold significantly exceed 2019 levels in real terms. The drop in prices for coal, lithium, copper and platinum group metals (PGMs) resulted in six companies falling out of the Top 40, while the rally in gold and uranium prices propelled six replacements into it.

A moderating price trend

Average inflation-adjusted prices of five key commodities, indexed to 100 in 2019



Source: World Bank, PwC analysis

Beyond the energy transition—which can proceed in fits and starts—strong structural trends continue to buttress powerful long-term demand for commodities. Urbanisation and ongoing infrastructure development needs in India and other parts of Asia and the developing world will continue to absorb the output of miners of iron ore, copper and other commodities. Consumer-driven demand is likely to follow as per capita income levels rise.

One key arena for structural growth can be seen in food production—in which mining plays an important but often overlooked role.

Mining's impact on food security

How the world feeds itself is one of the fundamental challenges society faces. According to the United Nations, of the world's 8 billion people, at least 700 million are estimated to have insufficient access to food. And according to the World Economic Forum, 16 countries have very high hunger levels. To ensure a well-fed future, agricultural production needs to grow more than 55% in the next two decades.

Mining plays a critical role in global food security and in reducing the impact of agricultural production on the environment, due to its direct link in supplying the raw materials necessary for a wide range of inputs and consumables required in agriculture. Improved crop yields support a reduction in deforestation — currently responsible for 20% of total global greenhouse gas emissions. Of the six core uses in which minerals and metals improve food security, fertiliser is the most important:

- 1. Fertilisers.** Phosphorus and potassium are mined minerals that are essential for the production of fertilisers.
- 2. Water treatment.** Gypsum and sulfuric acid are among the chemicals used in irrigation management to prevent water alkalinity and sodicity from affecting soil health.
- 3. Soil improvements.** Lime (from calcium carbonate) is used to adjust soil pH levels, improving nutrient availability and soil structure. Lime contains calcium and often magnesium, which are essential plant nutrients.
- 4. Micronutrient supplements.** Zinc, boron, manganese, iron, copper and molybdenum, which are essential for plant health, are often applied as foliar sprays or soil amendments.
- 5. Pesticides and herbicides.** Many pesticides and herbicides contain minerals as active ingredients or as carriers. For example, copper-based fungicides and herbicides have metallic salts.
- 6. Animal feed supplements.** Calcium, phosphorus, magnesium, and trace elements are crucial for animal health and are added to feed.

Commercial fertilisers are produced from three main ingredients: nitrogen, phosphorus and potassium. Whereas nitrogen is generally obtained from the oil and gas value chain, potassium and phosphorus are mined from phosphate rock and brine. These synthetic fertilisers have been pivotal to the successful decades-long effort to enhance crop growth, yield and quality. But to keep feeding a growing global population, crop yields on already utilised land need to improve further. More than 40% of soils are deficient in phosphate. It's no surprise, then, that phosphorus is classified as a critical mineral for China and the European Union, and potassium is a critical mineral for China and Canada.

To grow the agricultural products that feed the 1.9 billion additional people who will live on the planet by 2050, global annual production of phosphorus needs to increase by 55 million tonnes per year (25%) by 2050.

Recycling impact

Covid, restrictive trade policies, increased energy prices, and the Russian invasion of Ukraine have caused fertiliser prices to spike and supply to decline over the past several years.

(According to the International Food Policy Research Institute, Russia is responsible for 17% of phosphate exports and 20% of potash exports.) Given the disruptions, there is a greater need to source these minerals from elsewhere. At the same time, reasonably abundant new uses of phosphorus—for example, in lithium-iron-phosphate (LFP) batteries, which account for almost one-third of new electric vehicle (EV) supply—could increase competing demand for the available resources.

Phosphorus can be recovered from sewage sludge, animal manure and bonemeal. Technologies such as struvite precipitation can extract phosphorus from wastewater treatment processes. And potassium can be recovered from various organic wastes, including crop residues and certain industrial by-products. But scaling up these alternative sources to meet global agricultural demand presents significant challenges.

The impact of urban mining

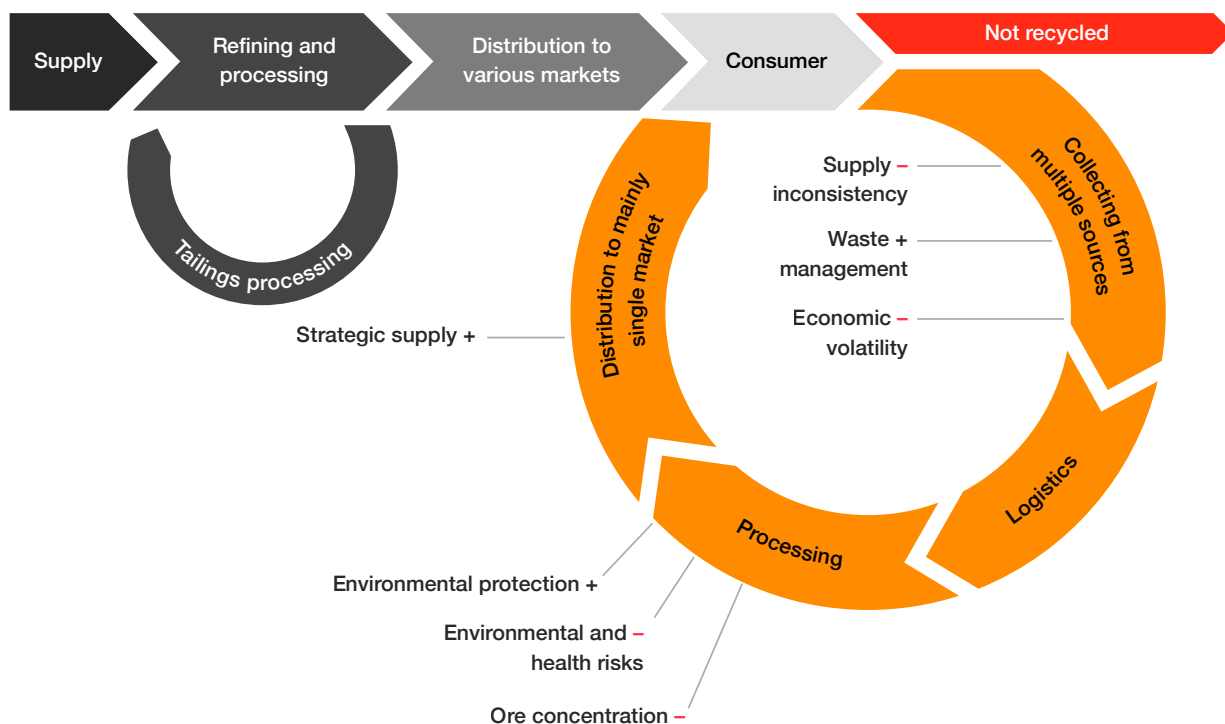
Alternative methods can provide only a modest supplement to the supply of phosphorus and potassium. But in other areas, the recycling of minerals at scale is already common, and it's a key adjunct to traditional mining. Urban mining, also known as recycling or secondary production, has evolved into a sophisticated, multibillion-dollar industry. In certain instances, recycled metals may command a 'green premium,' as they appeal to sustainability-minded consumers and industrial users who prioritise environmentally responsible production methods.

In theory, using more recycled materials could reduce the demand for mined materials. But given the rising populations and increasing industrial usage, demand is not a zero-sum game. Urban mining presents significant opportunities for traditional mining companies as

they reinvent their business models and find new methods of value creation in the broader ecosystem (see chart, below). As regulatory requirements tighten, investing in circular economies will be key in achieving success.

Recycling offers the prospect of a more circular—and sustainable—mining value chain

Advantages in the recycling loop are indicated by a + sign. Disadvantages are shown by a – sign.



Source: PwC analysis

Urban mining can be more resource-efficient and cost-effective than primary mining. It reduces the environmental impact associated with traditional mining, mitigating issues such as land degradation, rock waste, water pollution and greenhouse gas emissions. And it shortens supply chains and reduces the reliance on imports. However, urban mining also faces considerable challenges. In many areas, the economics of recycling don't make sense. The recycling process can generate hazardous waste by-products. And the supply of source material can be erratic.

These issues underscore the pressing need for technological advancements to further refine and optimise urban mining processes. Innovations such as improvements in hydro- and pyrometallurgical processes and new technologies such as artificial intelligence hold promise in enhancing the efficiency of recovering materials from complex scrap sources.

AI and mining: A mutually reinforcing relationship

AI systems depend on minerals and metals in several critical ways. Semiconductor chips are made from silicon, and they also contain such metals as copper, gold, tin, nickel, palladium and silver. Storage devices rely on metals such as platinum, palladium, and gold for their magnetic and conductive properties. Data centre facilities use vast amounts of metal in their construction.

The demand for AI is contributing to an increased need for these metals. At the same time, integrating AI into urban mining will allow the industry to achieve higher efficiency, better material recovery rates, reduced costs and a lower environmental impact. Current AI applications include:

Advanced sorting technologies. Using sensors, machine learning and computer vision, AI-driven systems can identify and separate different types of metals more accurately and efficiently than traditional methods.

Supply chain optimisation. AI helps in optimising the logistics and supply chain of metal recycling, ensuring that materials are collected, processed and delivered to manufacturers in the most efficient way. AI can also be used to better recognise early signs of materials' unavailability and predict shortages based on previous data patterns.

Quality control. AI algorithms can analyse the quality of recycled metals, ensuring they meet the necessary standards for reuse in manufacturing.

Depending on the source material, the metal recycling sector can be considered emerging, developing or mature in its market development. Although technological advancements, increased investments and an expanding regulatory framework that supports sustainable practices are major drivers of progress, the economic value obtained from recycling with higher commodity prices provides an important incentive.

26%

Proportion of platinum group metal (PGM) production that's recycled today. In 2000, it was less than 5%.

Source: [Johnson Matthey](#)

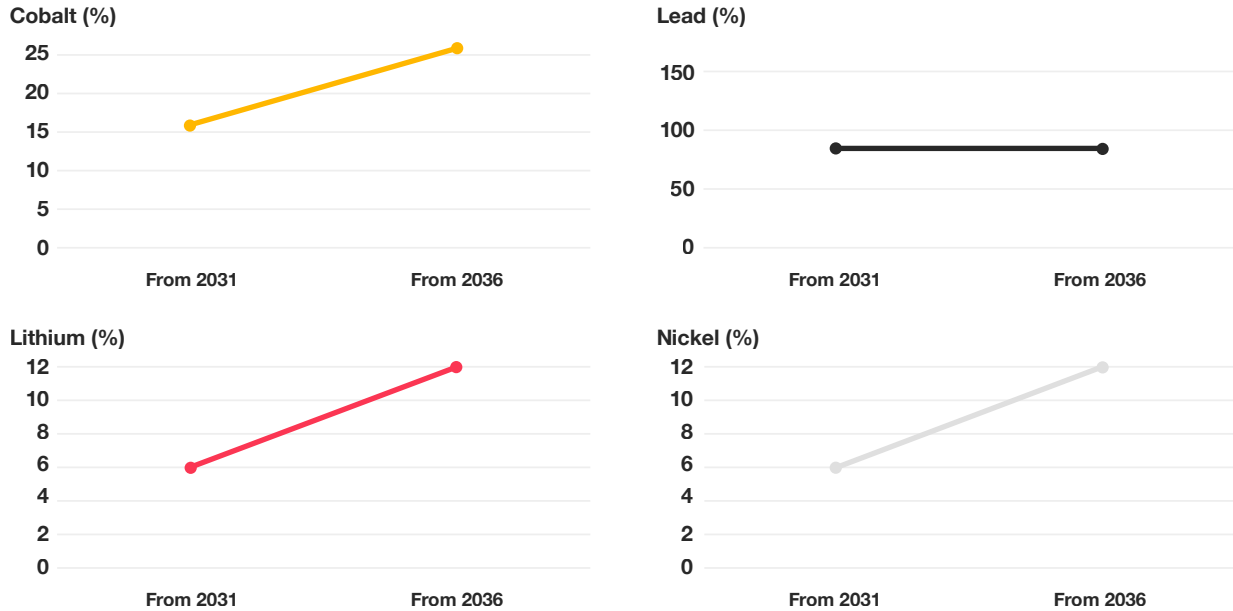
The mature metal recycling ecosystem includes copper and PGMs. Copper has been recycled for centuries, because high-grade copper can easily be remelted; about 30% of the copper supply today is generated from recycled material. PGMs are renowned for their exceptional catalytic qualities and are extensively utilised across a diverse number of industrial applications, including in the automotive sector. Given the relative scarcity of PGMs and the escalating demand for them from various industry sectors, the recycling of these metals is both economically advantageous and environmentally beneficial. Until around 2000, less than 5% of PGM production was recycled. Today, according to [Johnson Matthey](#), the proportion stands at 26%, with palladium recycling clocking in at an even higher 31%.

Recycling of critical metals, such as lithium and rare earth elements, is at an emerging state of maturity. Lithium's primary use is in the manufacture of rechargeable lithium-ion batteries, which are essential to the operation of a wide range of electronic devices, including EVs. We expect to see a significant increase in lithium recycling within the next ten to 12 years, in line with the average useful life of vehicles.

Regulatory requirements are a significant driver of the projected growth in metals recycling rates, particularly for lithium. The European Union's [Regulation \(EU\) 2023/1542](#) stipulates that active materials should contain certain minimum shares of materials that have 'been recovered from battery manufacturing waste or post-consumer waste' by 2031 and 2036, respectively (see chart, below).

Raising the bar on recycled content

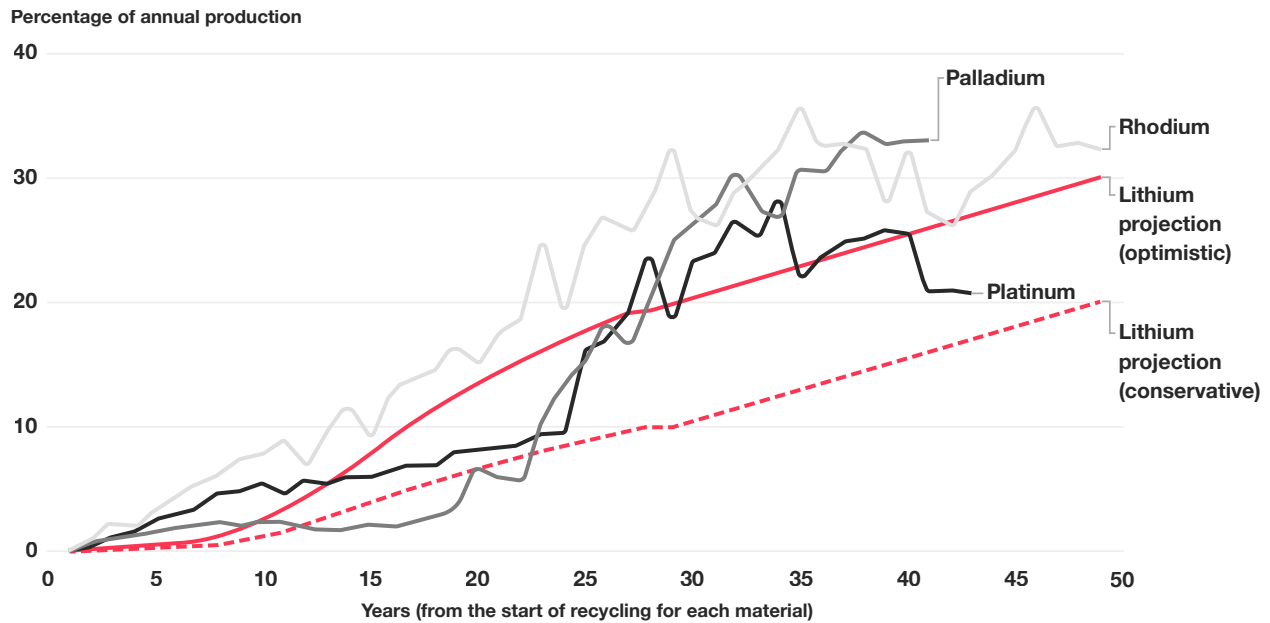
Minimum percentage of recycled battery metal required under the European Union's Regulation (EU) 2023/1542



Source: The European Union's Regulation (EU) 2023/1542

Fulfilling these goals will require a significant increase in recycling and sustained high annual compound growth rates. In an optimistic scenario, predicated on the assumption that global recycling efforts will align with the standards set forth by the European Union regulations and that all participating entities will achieve full compliance, recycling will account for nearly 30% of total lithium supply 50 years from now. In the more conservative scenario, taking into account practical challenges and limitations, we assume that global efforts will achieve approximately 50% of the recycling targets specified by the EU regulations—in which case nearly 20% of lithium will be recycled 50 years from now (see chart, below).

Recycled materials will gain market share



Note: Recycling projections for lithium begin in 2024.
Source: Johnson Matthey, PwC analysis

Lithium expansion

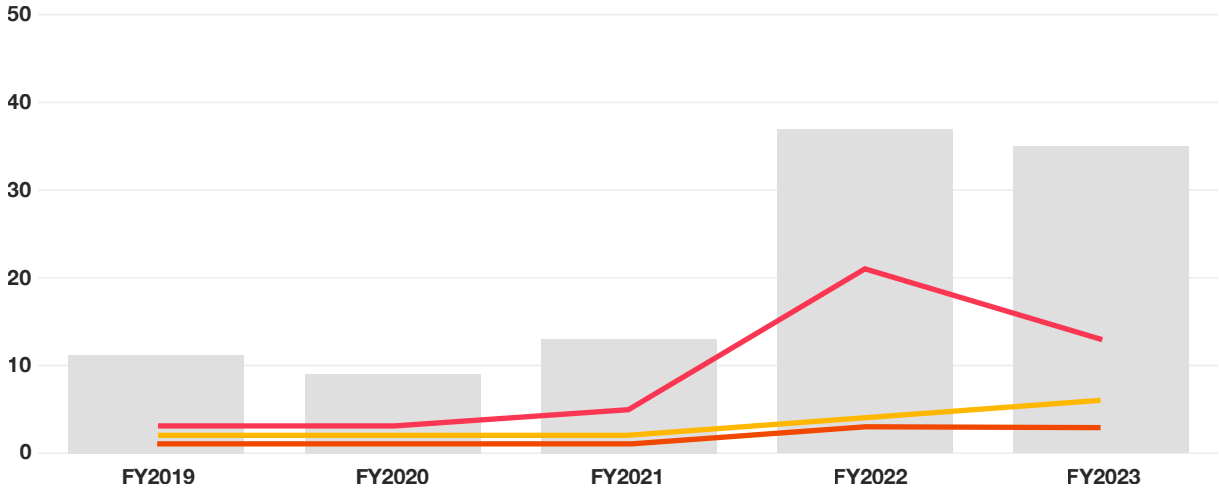
Lithium producers are underrepresented in the Top 40, because they are often classified as chemical companies as a result of the focus on processing in the value chain. Given lithium's critical role in the energy transition, we aggregated the publicly available financial statements from ten leading lithium miners. The steady production growth did not always translate into revenue growth, owing to volatile prices. Lithium investments are generally less capital intensive and have shorter repayment periods. The expected growth in lithium demand incentivises significant growth in investment.

The lithium economy

Financial results of ten leading mining producers

Revenue EBITDA Capex Dividends paid

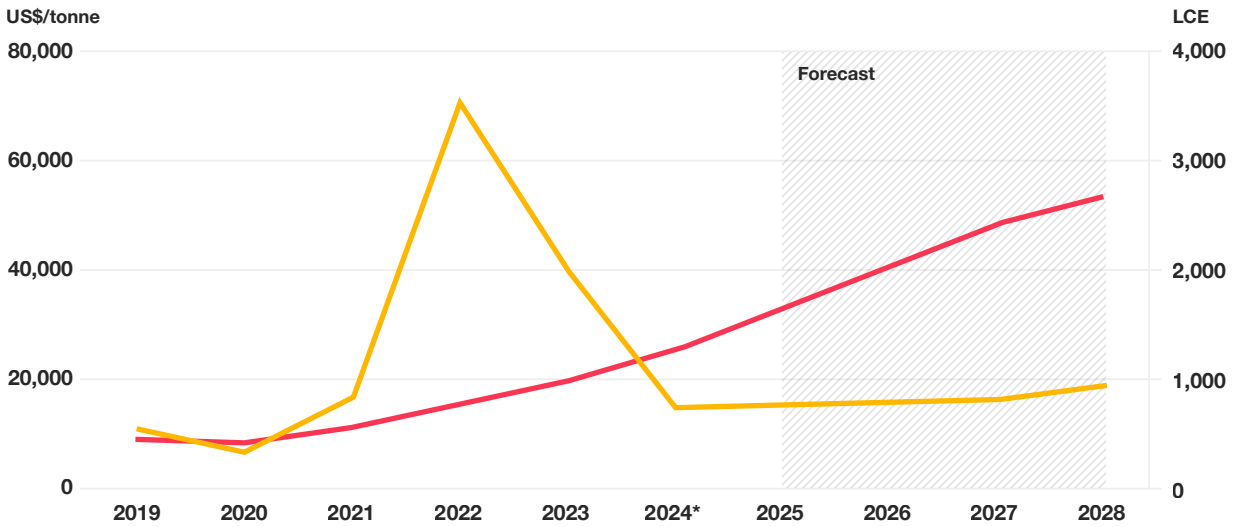
Revenue (US\$bn)



Source: Company annual reports, S&P Capital IQ, PwC analysis

The impact of rising lithium supplies

Lithium carbonate CIF Asia price Lithium raw material supply (thousands of tonnes)



*Estimate

Note: LCE stands for lithium carbonate equivalent.

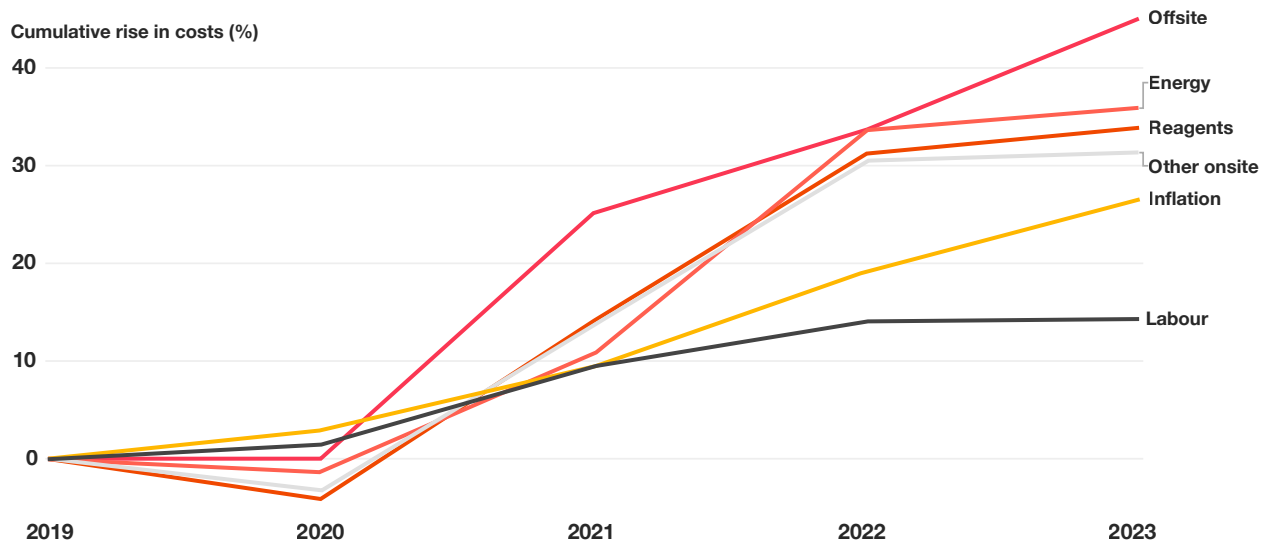
Source: S&P Capital IQ, PwC analysis

The productivity imperative

Urban mining is one of several key pillars in promoting productivity for the industry. But miners are caught between the pincers of two powerful trends. As noted, commodity prices have been falling. At the same time, in the last five years, mining production costs have increased by nearly 30%, making it urgent for companies to invest in cost-saving technology (see chart, below). In today's increasingly complex mining landscape, expanding commitments to sustainability, rising production costs, declining ore grades, more dispersed reserves and a shortage of technology-savvy talent are all contributing to the imperative for the Top 40 mining companies to focus on productivity.

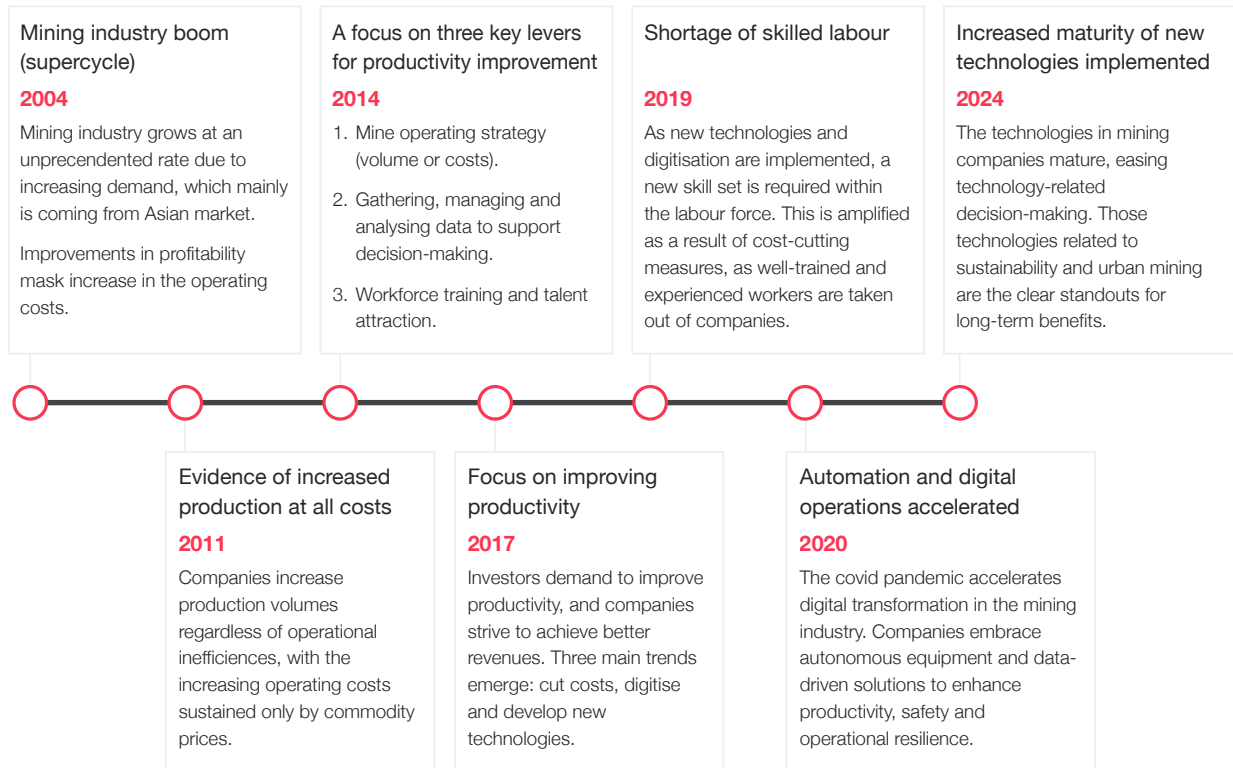
A rising tide

The increase in cash costs of production per unit in mining has been significant.



Source: S&P Capital IQ, PwC analysis

Timeline: Twenty years of productivity gains



Source: PwC's *Mine* reports

Over the past 20 years, through cycles of growth and retrenchment, the mining industry has been on a journey to improve productivity (see timeline, above). Looking ahead, miners have identified clear opportunities to enhance productivity while mitigating risks and maximising the positive impact in their business by leveraging technology, fostering innovation and adopting new ways of working. The World Economic Forum reports forecasts from technology solutions providers and business intelligence suppliers that the total internet of things (IOT) market and potential incremental value of technological advances in mining will be worth billions in US dollars by 2030. Progress can be seen in a range of activities:

Value chain process optimisation. In processes ranging from exploration to extraction, as well as in transportation and in management of key resources (e.g., energy and water), miners are thoroughly reviewing and optimising production and operation. In Chile, at the world's largest copper mine, Escondida, BHP and Microsoft are collaborating. Using real-

time data from concentrator plants and recommendations based on Microsoft's Azure platform, concentrator operators at Escondida can adjust operating variables to improve ore processing and grade recovery. Freeport-McMoRan has made investments in artificial intelligence and data analytics to maximise copper extraction under the Americas' Concentrator initiative, starting in Bagdad, Arizona, and expanding to other operations in the region.

Increased reliability via investments in renewable energy. With operations in remote areas, companies often face the prospect of interruption in power supplies even as they strive to decarbonise. Anglo American entered into a partnership in 2022 with EDF Renewables to develop a regional renewable energy ecosystem in South Africa, a country stricken by electricity shortages. Envusa Energy, the jointly owned company they formed, plans to develop at least 500 megawatts of solar and wind capacity, and has ambitions to increase capacity to three to five gigawatts by 2030.

Extraction technologies designed to face more complex orebodies. Chalcopyrite and low-grade primary sulphates pose challenges to the efficiency of copper mining. And the presence of clays and impurities in main orebodies affects productivity, owing to operational constraints. In 2023, BHP's venture arm invested in Ceibo, a start-up that is developing a revolutionary process to leach low-grade primary copper sulphides.

Automation and advanced technology. Automation, robotics and advanced control systems can be fully integrated to enhance efficiency in mineral extraction and processing. Autonomous mining is on the rise, and such trucks and equipment are operating more safely with less human intervention. First Quantum Minerals utilises IOT technology for energy efficiency and process optimisation, and Barrick Gold is using predictive tools for gold production planning.

Safer and more sustainable operations. Health, safety and environment management systems enable proactive monitoring and managing of workplace safety. Ivanhoe Mines and Zijin Mining Group are using virtual reality and simulator training to provide accelerated opportunities for upskilling the local workforce at the Kamo-a-Kakula copper mine in the Democratic Republic of Congo. Digital twins allow for the creation of virtual models for process optimisation and failure prediction. BHP is using AI for early detection of equipment failures. Vale uses digital twins to optimise production and prevent equipment failures, and Glencore is implementing digital twins in its underground mining operations.

Double impact: reducing emissions and increasing profits. Efforts to minimise environmental impacts through water reutilisation and energy-efficient processes can help miners meet sustainability targets while creating cost savings and operational efficiencies. Fortescue (formerly Fortescue Metals Group) currently spends US\$560 million on diesel and gas annually. By 2030, decarbonisation will allow the company to save more than 700 million litres of diesel and 15 million gigajoules of gas, and avoid 3 million tonnes of carbon dioxide equivalent emissions each year. With its flagship sustainability programme Ecoterako, PT Vale Indonesia has reduced costs by US\$2.5 billion by using slag nickel as a substitute for natural stone in the production of road aggregates.

Technology risks

Reliance on productivity-enhancing technology can also bring risks, which means miners have to be vigilant about warding off potential negative impacts. Some areas to watch include the following:

Cybersecurity. Given companies' increasing reliance on digital technologies, robust cybersecurity protocols are critical to protecting essential operational and personnel data from potential breaches and threats.

Balancing technology dependence. Unexpected system failures or technological disruptions could lead to vulnerabilities. A balanced approach, combining cutting-edge technology with traditional mining expertise, is crucial for maintaining operational resilience.

Technology obsolescence. Rapid obsolescence of technology and continuous software upgrades pose a significant risk, affecting the financial viability of portfolios and capital investments.

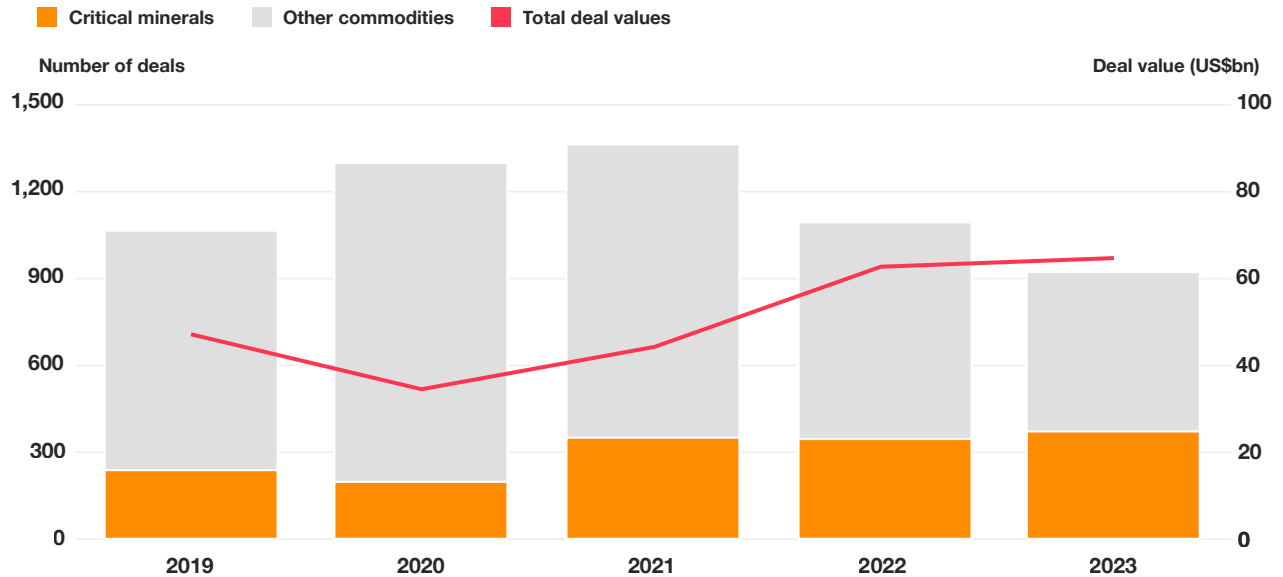
The impact of deals

M&A has remained a pivotal strategy for mining companies aiming to sustain their competitive advantage, expedite transformation and secure essential resources for future growth. And because the industry has garnered significant attention for its role in supplying the growing need for agricultural products, infrastructure and materials for the energy transition, outside investors are taking a greater interest. These factors are bringing more capital into the industry and setting the stage for high-impact deals. In 2023, the total number of deals among the Top 40 fell about 15% from 2022, while the total *value* rose more

than 3% to over US\$64 billion. Not surprisingly, the percentage of deals that involved critical minerals rose to 40% in 2023.

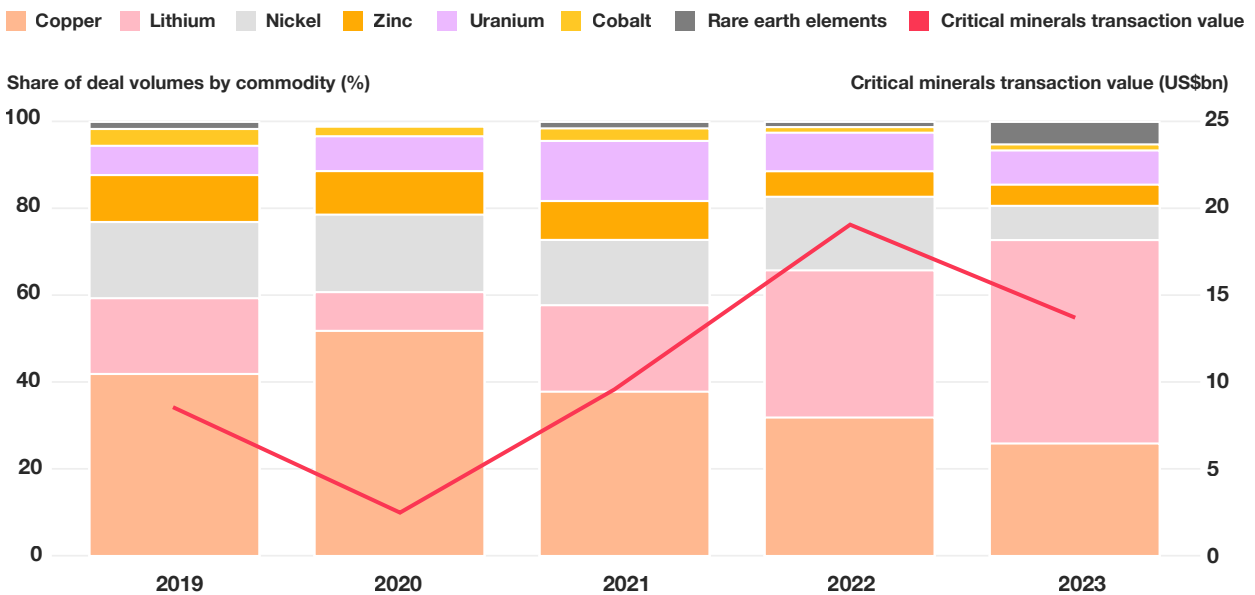
Transacting to transform

The number of mining deals has declined, but the aggregate value of those deals is growing.



Focus on: Critical minerals deals

Total deal volume and value trends



Source: S&P Capital IQ, PwC analysis

Recent deals have been driven by four principal motivations:

Consolidation

Consolidation has continued to be a dominant M&A trend as companies reconfigure their asset portfolios and refine their future business direction. This approach often involves divesting non-core assets and reallocating capital towards strategic growth opportunities.

In November 2023, for example, in the largest deal in the history of the gold sector, Newmont acquired Newcrest for US\$14.5 billion. Newmont, whose annual production was anticipated to remain flat over the next decade, expanded its portfolio by adding five operating mines and two advanced-stage projects, while also enhancing its copper exposure. Following this acquisition, Newmont announced plans to divest eight non-core assets.

Critical minerals

A forecasted supply deficit for a variety of critical minerals has catalysed a competitive race to secure resources. The considerable price volatility that has accompanied the rapid expansion presents opportunities for investors with a high risk tolerance, attracting new players to the investment landscape—and placing a premium on the most stable of these minerals for others.

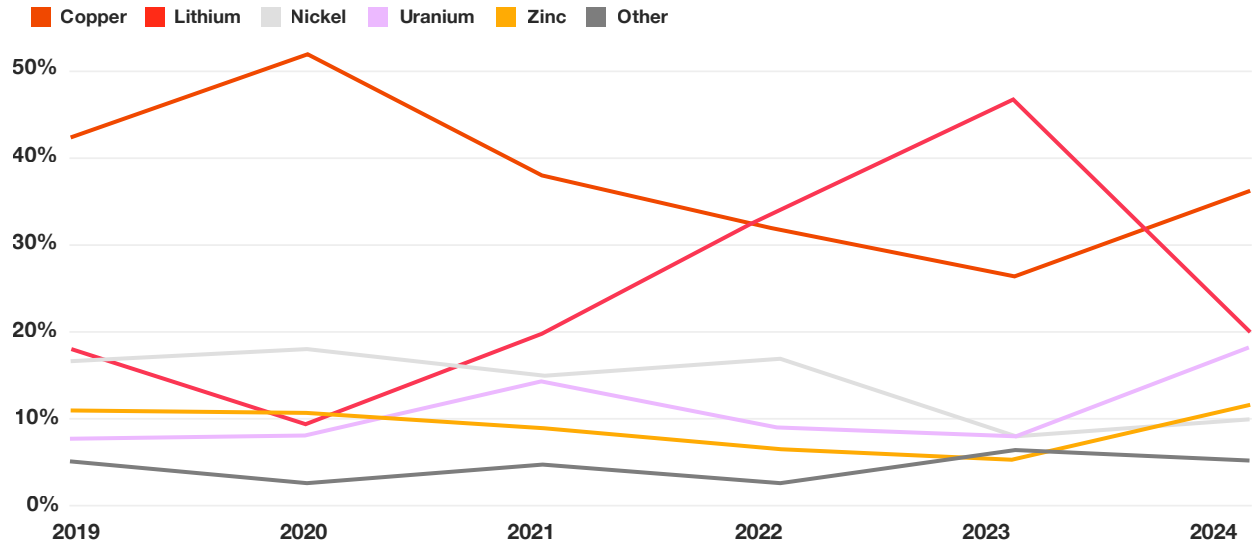
In 2023, copper and lithium dominated critical mineral deals, representing over 70% by volume—up marginally from the year before. But copper accounted for more than 80% of the total value of critical mineral transactions.

In early 2024, Chinese miner MMG acquired Cuprous Capital, the parent company of the Khoemacau Copper Mine in Botswana, for US\$3.6 billion. The transaction aligns with MMG's strategy of building a portfolio of high-quality mines that can supply the minerals most important to a decarbonised world.

Copper and lithium lead the pack

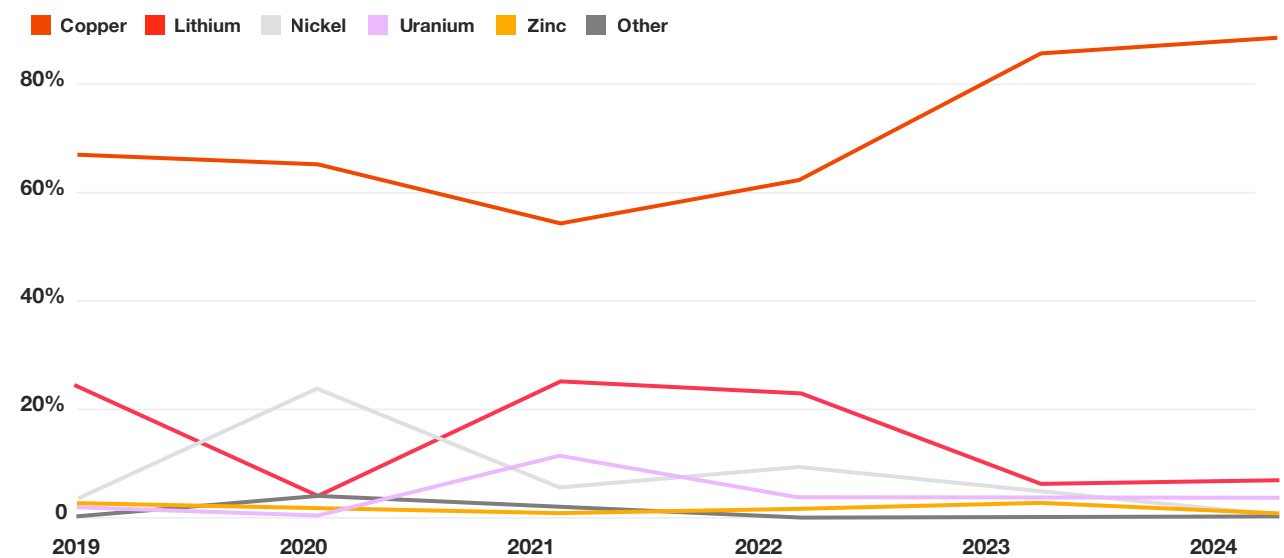
Volume of deals

Critical deals weighting by commodity



Value of deals

Critical deals weighting by commodity



Sustainability

Sustainability considerations have been a pivotal element in transaction decisions. In their quest to decarbonise, mining companies are investing in renewable energy projects. Such projects bolster their sustainability profiles and help them gain greater control over one of their most significant operational costs.

Rio Tinto recently finalised the US\$700 million acquisition of a 50% stake in the Giampaolo Group's Matalco recycled aluminium business, with an aim of meeting increasing demand for low-carbon aluminium, a key material in the energy transition.

In March 2024, Vale moved to acquire the 45% of Aliança Energia shares that it didn't already own, for approximately US\$540 million. The deal brings hydroelectric and wind generation assets into Vale's portfolio, strategically aligning the company's investments with its environmental, social and governance (ESG) objectives.

Partnerships

The mining sector has long recognised the value of partnerships and joint ventures. Historically, these collaborative efforts have been instrumental in helping companies comply with local regulations, enhancing cooperation, pooling expertise and distributing risks associated with mineral extraction. Mining companies are increasingly seeking alliances beyond traditional sector boundaries, as their view of the ecosystem broadens. These strategic moves are driven by the need to access capital; integrate new skills in highly specialised areas, such as technology and sustainability; and work more closely with government (see table, below).

Mining partnership objectives

Deal objectives	Recent examples
<p>Accessing capital</p> <ul style="list-style-type: none"> ■ Sovereign wealth and pension funds ■ Acquisition of secure commodity supplies by industries 	<p>Ma'aden's joint venture with the Saudi Arabia Public Investment Fund into Manara Minerals to diversify away from oil and gas and expand local investment in mining</p> <p>General Motors's investment in Lithium Americas to accelerate development of the Thacker Pass Lithium Mine, while securing an offtake agreement from the miner</p>
<p>Harnessing technology</p> <ul style="list-style-type: none"> ■ Artificial intelligence ■ Efficiency improvement ■ Commodity recycling 	<p>Ivanhoe Electric's partnership with Ma'aden, leveraging Ivanhoe's Typhoon (AI) technology for mineral exploration in Saudi Arabia</p>
<p>Improving sustainability</p> <ul style="list-style-type: none"> ■ Diversification of carbon-intensive assets ■ Decarbonisation of supply chains and mining operations 	<p>Rio Tinto's partnership with Sumitomo and the Australian Renewable Energy Agency to explore the use of green hydrogen to refine aluminium</p>
<p>Collaborating with government</p> <ul style="list-style-type: none"> ■ Access to resources through alliances ■ Laws and regulations ■ Infrastructure and development 	<p>The joint venture between Chile's National Copper Corporation (CODELCO) and SQM for lithium extraction in the Salar de Atacama salt flat through 2060</p>

Appendix I: Top 40 global mining companies

2024 rank	2023 rank	Change from 2023	Company	Country/region of incorporation	Commodity focus
1	1	0	BHP Group Ltd.	Australia	Diversified
2	2	0	Rio Tinto Group	Australia/UK	Diversified
3	5	-2	China Shenhua Energy Company Limited	China	Coal
4	3	1	Glencore plc	Switzerland	Diversified
5	4	1	Vale S.A.	Brazil	Diversified
6	6	0	Freeport-McMoRan Inc.	United States	Diversified
7	9	-2	Fortescue Ltd.	Australia	Iron ore
8	10	-2	Saudi Arabian Mining Company (Ma'aden)	Saudi Arabia	Diversified
9	12	-3	Newmont Corporation	United States	Gold
10	11	-1	Zijin Mining Group Company Ltd.	China	Diversified
11	14	-3	Grupo México, S.A.B. de C.V.	Mexico	Diversified
12	8	4	PT Bayan Resources Tbk	Indonesia	Coal
13	13	0	Barrick Gold Corporation	Canada	Gold
14	New	-	PT Amman Mineral Internasional Tbk	Indonesia	Gold/copper
15	7	8	Anglo American plc	UK/SA	Diversified
16	21	-5	Coal India Ltd.	India	Coal
17	16	1	Agnico Eagle Mines Ltd.	Canada	Gold
18	18	0	Teck Resources Ltd.	Canada	Diversified
19	19	0	Antofagasta plc	United Kingdom	Copper
20	32	-12	Cameco Corporation	Canada	Uranium
21	17	4	Yankuang Energy Group Company Ltd.	China	Coal

Top 40 global mining companies (continued)

2024 rank	2023 rank	Change from 2023	Company	Country/region of incorporation	Commodity focus
22	24	-2	China Coal Energy Company Ltd.	China	Coal
23	22	1	Hindustan Zinc Ltd.	India	Diversified
24	26	-2	CMOC Group Ltd.	China	Diversified
25	34	-9	Gold Fields Ltd.	South Africa	Gold
26	29	-3	Shandong Gold Mining Co., Ltd.	China	Gold
27	20	7	Tianqi Lithium Corporation	China	Lithium
28	33	-5	Ivanhoe Mines Ltd.	Canada	Diversified
29	23	6	The Mosaic Company	United States	Potash
30	35	-5	Northern Star Resources Ltd.	Australia	Gold
31	New	-	JSC National Atomic Company Kazatomprom	Kazakhstan	Uranium
32	28	4	South32 Ltd.	Australia	Diversified
33	31	2	Mineral Resources Ltd.	Australia	Diversified
34	New	-	CSN Mineração S.A.	Brazil	Iron ore
35	38	-3	Pilbara Minerals Ltd.	Australia	Lithium
36	36	0	AngloGold Ashanti plc	South Africa	Gold
37	New	0	Kinross Gold Corporation	Canada	Gold
38	New	0	NMDC Ltd.	India	Iron ore
39	40		Jiangxi Copper Company Ltd.	Poland	Metals and mining (primary)
40	New		Lundin Mining Corporation	Canada	Metals and mining (primary)

Appendix II: Leading lithium companies

Company
Albemarle Corp.
Sociedad Química y Minera de Chile S.A.
Pilbara Minerals Ltd.
Tianqi Lithium Corp.
IGO Ltd.
Mineral Resources Ltd.
Ganfeng Lithium Group
Qinghai Salt Lake Industry Co.
Allkem Ltd. (before inclusion in Arcadium Lithium plc)
Arcadium Lithium plc

Appendix III: Extracts of financial statements

Top 40 mining companies: Income statement extract (US\$bn)

	2024 forecast	2023	2022	2023–24 forecasted change	2022–23 change
Revenues (excluding trading revenues)	662	667	713	-1%	-6%
Trading revenues	130	178	198	-27%	-10%
Total revenues	792	845	911	-6%	-7%
Operating expenses	-621	-628	-619	-1%	2%
EBITDA	171	217	292	-21%	-26%
Impairment charge	-18	-18	-13	0%	37%
Depreciation charge	-60	-59	-59	2%	-1%
Net finance costs	-12	-10	-8	16%	25%
Profit/(loss) before tax	81	130	212	-36%	-39%
Tax expense	-26	-40	-53	-36%	-23%
Net profit	55	90	159	-36%	-44%
Profitability measures					
EBITDA margin	22%	26%	32%		
Net profits margin	7%	11%	17%		
Effective tax rate	31%	31%	25%		
Return on capital employed		13%	22%		
Return on equity		13%	24%		

Statement of cash flows (US\$bn)

	% Change				
	2024 forecast	2023	2022	2023–24 forecasted change	2022–23
Net operating cash flows	98	132	168	-26%	-22%
Purchase of property, plant and equipment	-75	-80	-73	-6%	10%
Free cash flow	23	52	96	-56%	-45%
Other investing cash flows	-3	-4	-5	-14%	-33%
Dividends paid	-43	-55	-79	-22%	-30%
Share buybacks	-4	-7	-12	-43%	-39%
Total shareholder returns	-47	-62	-92	-24%	-31%
Other financing cash flows	0	-2	-7	-100%	-68%
Net drawdowns/(repayment) of debt	12	7	-4	80%	-254%
Net cash flow	-15	-9	-13	62%	-23%

Top 40 mining companies: Balance sheet extract (US\$bn)

	2023	2022	% Change
Current assets			
Cash and cash equivalents	142	151	-6%
Inventories	104	104	1%
Receivables and other current assets	72	76	-6%
Other current assets	46	38	21%
Total current assets	364	369	-1%
Non-current assets			
Mining and production assets	702	647	9%
Goodwill and intangible assets	70	65	8%
Investments and loans granted	77	71	10%
Other non-current assets	75	70	7%
Total non-current assets	924	853	8%
Total assets	1,288	1,221	6%
Current liabilities			
Accounts payable and other liabilities	127	126	1%
Borrowings, current	48	41	15%
Short-term lease liabilities	2	1	42%
Unearned revenue current liabilities	1	1	1%
Other current liabilities	54	59	-9%
Total current liabilities	232	228	1%

Top 40 mining companies: Balance sheet extract (US\$bn) (continued)

Non-current liabilities			
Borrowings, non-current	199	181	10%
Long-term lease liabilities	6	5	34%
Environmental provisions	92	82	13%
Unearned revenue, non-current	6	7	-11%
Other non-current liabilities	91	85	7%
Total non-current liabilities	394	360	10%
Total liabilities	626	588	6%
Total shareholders' equity	662	631	10%
Ratios			
Gearing	16%	11%	
Market-to-book ratio	2.0	1.9	
Current ratio	1.6	1.6	

Constructing the report

Our analysis includes major companies whose primary business is assessed to be mining. The results aggregated in this report have been sourced from the latest publicly available information, primarily annual reports, and financial disclosures available to shareholders. Our report also expresses PwC's point of view on topics affecting the industry, developed through interactions with clients and other industry leaders and analysis.

Companies have different fiscal year ends and report under various accounting regimes, including International Financial Reporting Standards (IFRS), United States Generally Accepted Accounting Principles (US GAAP) and others. Information has been aggregated for the individual companies, and no adjustments have been made on the basis of different reporting requirements. As far as possible, we have aligned company financial results to be as at, and for, the year ended 31 December 2023. For companies that do not have December year ends, we added and deducted reviewed results to reflect the comparable 12-month period.

All figures in this publication are reported in US dollars (US\$), except where specifically stated. The balance sheets of companies that report in currencies other than US dollars have been converted at the closing US dollar exchange rate, and the cash flow and financial performance have been converted using average foreign exchange rates for the respective years.

Some diversified miners undertake part of their activities outside mining, such as parts of Rio Tinto's aluminium business and Glencore's marketing and trading arms. We have not excluded these activities from the aggregated financial information, except where noted. Companies whose primary business is not mining have been excluded from the Top 40 listing.

All royalty companies and metal streamers are excluded. Entities that are controlled by others in the Top 40 and consolidated within their results have been excluded, even where minority stakes are listed.

Mine 2024 methodology

Income statement

We have forecast revenues from the sale of commodities based on critical inputs of commodity price and production volumes. Foreign exchange has been considered for expenses. A wide variety of functional and operating currencies are used by the Top 40, so estimates are subject to judgment.

For commodity prices, we have utilised the latest consensus economic data available for each of the major commodities mined by the Top 40, coupled with the latest production estimates for the 2023 financial year from annual reporting. More recent public information releases made prior to the finalisation of this publication have also been used.

Taxes are forecast with reference to the average effective tax rate over the last eight years, with the exception of notable anomalies.

Cash flow statement

Cash flow from operations was forecast with reference to movement in EBITDA. The drivers of working capital balances are expected to move in line with their historical tendencies, and no material movement in working capital adjustment is expected.

Investing cash flows include capital expenditure forecasts based on guidance issued by the Top 40 at the date of the report.

Dividends are forecast with reference to amounts declared at the date of the report. Net debt repayments are expected to remain consistent with historical trends.

Share buybacks are based on history and announcements made at the date of the report.

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Mine 2024: 21st edition

Preparing for impact



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