COBALT INSTITUTE

‘State of the Cobalt market’ report









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The Cobalt Institute (CI) commissioned Roskill Consulting Group (Roskill) to prepare this report in December 2020.This final version includes the Cobalt Institute's contributions. Data sources are identified with each of the data sets presented.

1. State of the market summary

The *state of the cobalt market is strong* despite the challenges brought about by the COVID-19 pandemic. In 2020, societies and economies around the world were confronted by the worst pandemic since the Spanish flu in 1918. The resultant fall in GDP, around 3.5%, represents the largest annual average decline in global output since the Second World War and the peak-to-trough decline recorded in Q2 last year exceeds the scale of all annual falls in global GDP seen since 1900. While broad-based movements in commodity markets mirrored these global economic changes, the impacts were not as pronounced as might have been expected based on previous relationships to movements in the global economy. Goods markets were less impacted than services. That largely reflects the resilience of the Chinese economy, which recovered swiftly from the impacts of its Q1 shutdowns, combined with the country's position as the world's largest consumer of most metals and minerals.

Cobalt demand was, on the whole, robust in 2020 despite the prevailing economic conditions. While the market contracted year-on-year it did so by less than 1%, buoyed by continued growth in demand for cobalt in lithium-ion batteries. The main end-use markets for lithium-ion batteries, electric vehicles and portable electronics weathered the economic storm brought about COVID-19. Electric vehicle demand increased sharply in 2020, with green recovery policies and other subsidies and incentives supporting strong sales, particularly in Europe. Meanwhile, the rollout of 5G helped to support demand for portable electronics. Robust growth in demand for cobalt in these applications helped offset declines in demand from other markets such as aerospace, where grounded fleets needed little or no maintenance, thus reducing demand for cobalt-bearing superalloys.

COVID-19 had a variety of impacts on cobalt supply. In the DRC, the world's main source of cobalt feedstock, production was largely unaffected by the pandemic, although there were temporary suspensions at some operations such as Chemaf's Mutoshi. Aside from Chemaf, all other DRC producers increased output year-on-year except for Glencore, the world's largest cobalt producer, whose output fell back as a result of its decision to place Mutanda (the biggest cobalt-producing mine in the world) on care and maintenance in late 2019. While DRC supply was not too affected by shutdowns, virus control measures nevertheless had a profound impact on African supply. Lockdown measures in South Africa, starting in Q2, led to a significant reduction in exports from Durban, from where most Congolese cobalt is shipped to China. The situation was compounded by a South Africa truckers' strike in July. Producers and traders were forced to look for alternative routes, for example re-routing shipments via countries such as Mozambique, Tanzania and Namibia. The result was significant delays in deliveries to Chinese refineries in Q2 and Q3, which in turn pushed up prices and payables.

While well below its historical peak, artisanal and small-scale mining (ASM) remained an important contributor to cobalt supply in 2020, accounting for around 9% of DRC mine production. There were also important developments related to ASM in the DRC in 2020. In late 2019, it was announced that a new state-owned company was being set up to regularise the ASM sector and would also buy and market all ASM cobalt. Entreprise Générale du Cobalt (EGC) is controlled by Gécamines and has been granted monopoly powers to purchase and market cobalt from the ASM sector. In November 2020, it was announced that Trafigura had signed a five-year deal with the EGC to finance the creation of controlled artisanal mining zones, buying centres and logistics in the DRC. It is unclear how the formation of EGC might impact the ASM landscape in the DRC, although any changes could have a considerable impact on the wider cobalt supply chain.

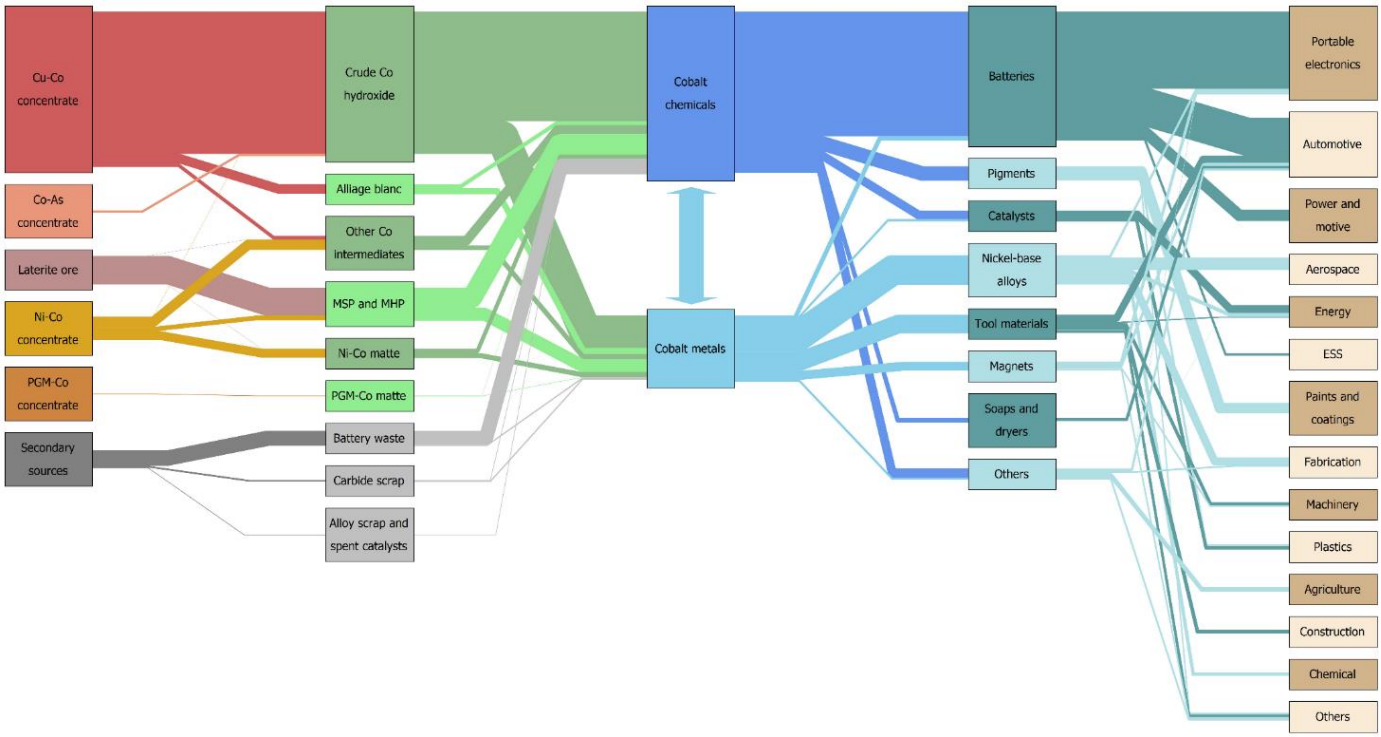
Outside the DRC, while most mine producers were unaffected, COVID-19 caused suspensions at several operations including Ambatovy in Madagascar, CTT in Morocco and Vale in Canada. Shutdowns at these operations, also key producers of cobalt metal, contributed to refined

production falling back 5% in 2020, totalling 132kt. This reduction reflected not only reduced metal output (which dropped by 8%) from these producers but also the aforementioned issue of reduced feedstock availability and a reaction to weaker demand in certain segments.

At the start of 2020, the cobalt market was in a state of oversupply regarding feedstock (principally cobalt hydroxide intermediates). The suspension of Mutanda, and the depletion of industry stocks through 2020, led to a more balanced market at the year's end. The refined market also finished the year broadly in balance, both in terms of cobalt metal and cobalt chemicals. Notably, the drop in metal demand caused by reduced consumption in aerospace and tool materials did not lead to oversupply, as metal production was temporarily suspended at various sites across the world. Overall, the blue metal showed its resilience in 2020 and with a market size of 135kt the cobalt market remained a >US$4Bn industry based on last year's average LME cash prices.

The schematic below provides an overview of the material flows in the cobalt market, from mine production, through intermediate and refined stages, into cobalt's main applications and, finally, the use of cobalt by industry, based on estimates for 2020. The most important flow of cobalt units in terms of volume is shown at the top. Cobalt mine production (mainly in the DRC) as a by-product of copper mining results in the production of a Cu-Co concentrate. This is processed into an intermediate, mostly crude cobalt hydroxide (and mostly in the DRC). Intermediates, in turn, are processed into refined cobalt (mainly chemicals and mostly in China), consumed in battery manufacturing (mostly in Asia) and then portable electronics and automotive applications.

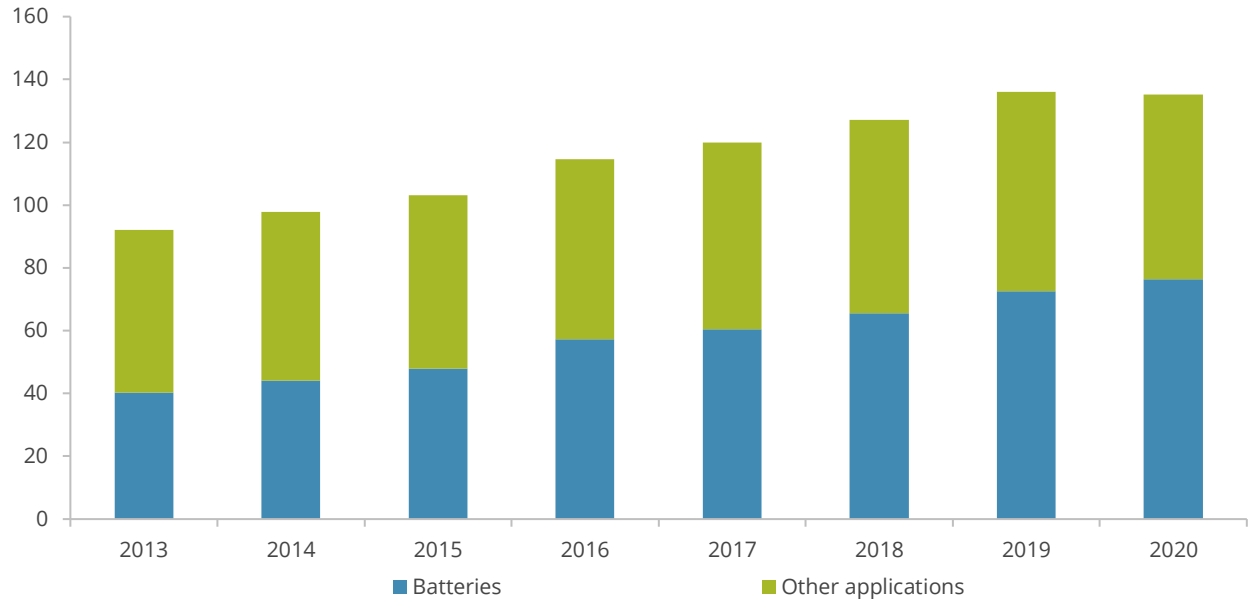
Figure 1: Flowchart of the cobalt supply chain, 2020



2. Demand and consumption trends

Global consumption of cobalt has increased markedly in recent years, with all major uses driving growth. Overall, the market has grown at an annual rate of more than 5% since 2013. Much of the increase in consumption is the result of demand for cobalt in one application in particular, the lithium-ion battery. Demand for cobalt in lithium-ion batteries, used chiefly in portable electronics and electric vehicles, increased at an annual rate of 10% between 2013 and 2020. As a result, batteries accounted for 57% of total cobalt consumption last year.

Figure 2: Consumption of cobalt, by application, 2013-2020 (kt)

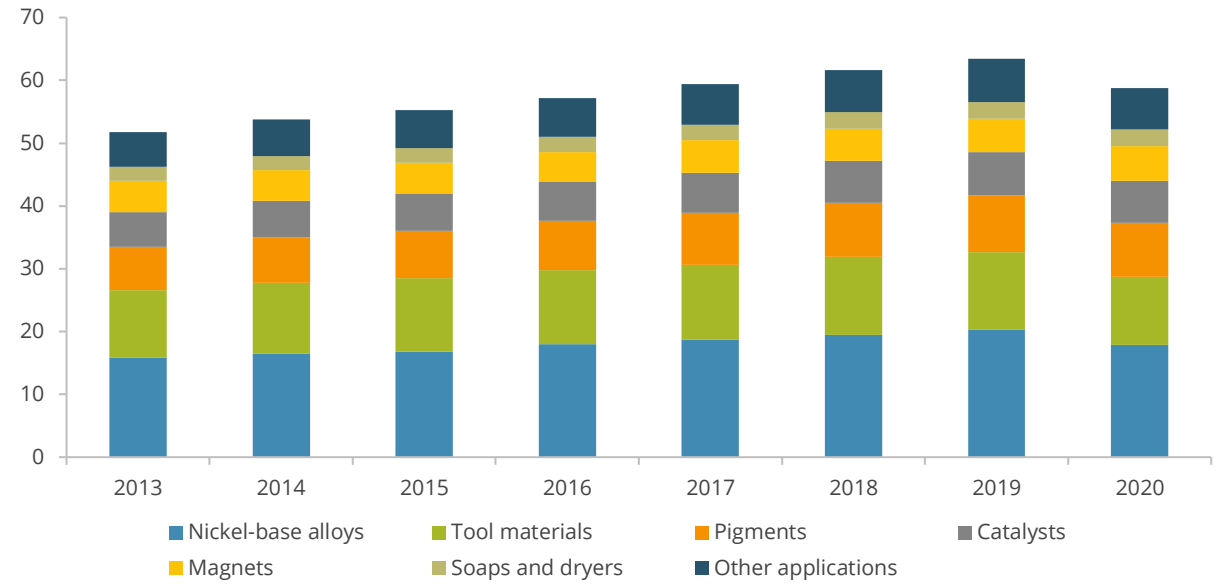


Source: Roskill

Despite the impacts of COVID-19, global cobalt consumption only fell back marginally (by 0.6%) between 2019 and 2020. Importantly, demand from the battery sector continued unabated, increasing by 5% year on year. This was underpinned by sustained demand for cobalt in electric vehicle batteries. Electric vehicles continued their exponential growth trajectory in 2020, supported by government subsidies and incentives. Sales of new electric vehicles (NEVs) increased 42% year on year, with particularly strong sales in Europe aided by incentives. Strong growth is expected in electric vehicle demand and NEV sales are forecast to increase by nearly 30% year on year to 2025.

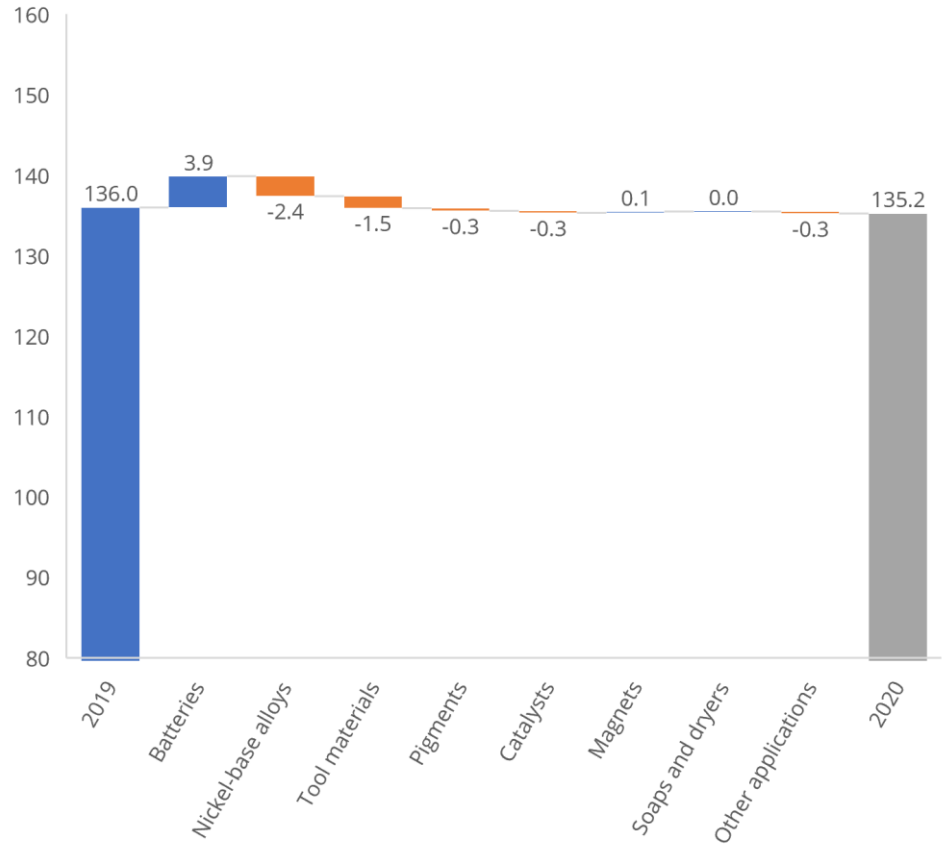
Growth in demand for cobalt in batteries helped to offset a sharp decline in demand for cobalt in several other end uses in 2020, shown in the charts below. Overall, consumption of cobalt in non-battery applications fell back 7% year on year. The biggest declines were in nickel-base alloys, used mainly in aerospace, and tool materials, used mainly in industrial applications.

Figure 3: Consumption of cobalt in non-battery applications, 2013-2020 (kt)



Source: Roskill

Figure 4: Year-on-year changes in cobalt consumption, 2019-2020 (kt)



Source: Roskill

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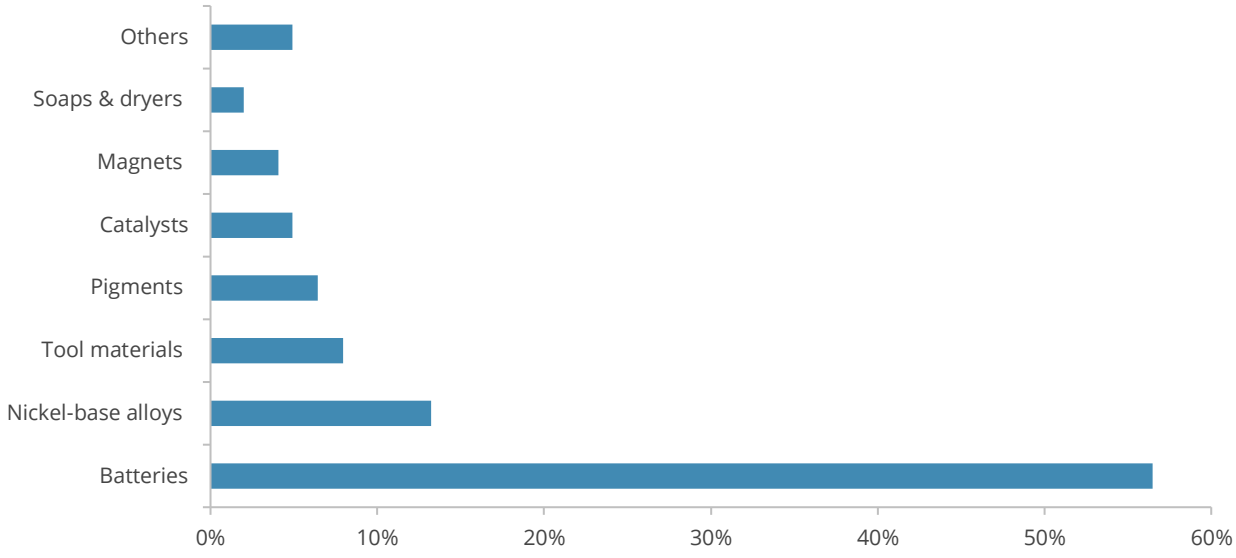
Nickel-base alloys accounted for 13% of total cobalt demand in 2020. Last year was a tough year for aerospace which was enjoying an extended bull run before the impacts of COVID-19 led to the biggest contraction in its history. After a near total shutdown in air travel, most airlines around the world scaled back or cancelled orders. The suspension of flights significantly diminished the need for aircraft maintenance and thus demand for cobalt in turbine blades. As a result, demand for cobalt in this application fell by 12% year on year in 2020. While a recovery is now underway, the commercial aerospace sector is expected to recover slowly, as travel demand is not expected to return to pre–COVID-19 levels before 2024. This, coupled with the scaling back of orders, could have longer term impacts on cobalt demand.

The third-largest end use market for cobalt is tool materials. Demand for cobalt from this segment also fell 12% year on year, owing to a slump in cemented carbide demand caused by the sharp drop-off in global industrial production.

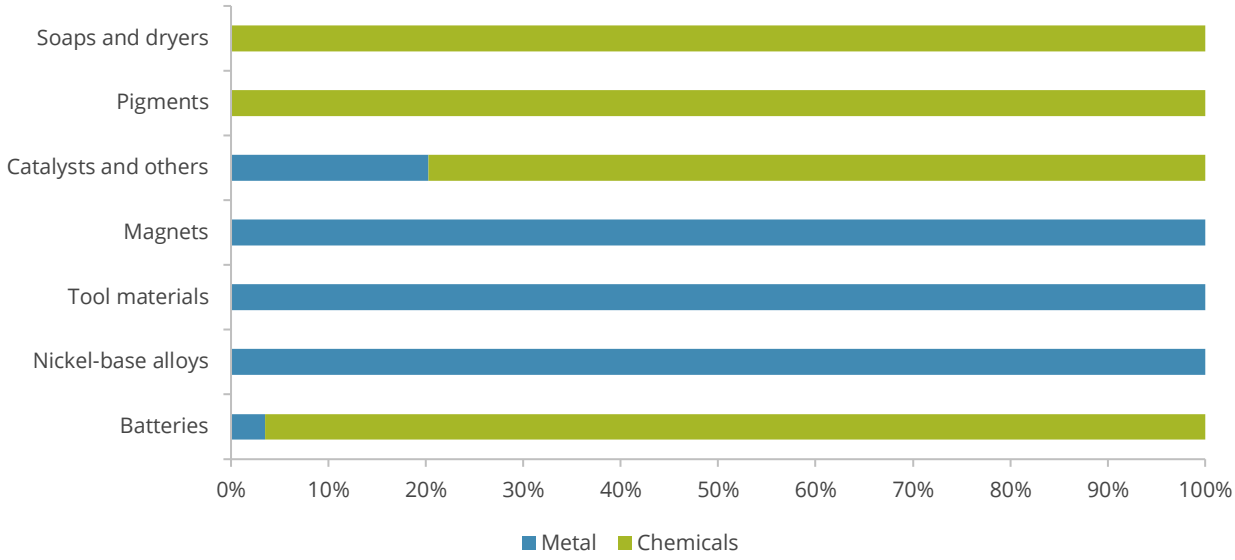
Figure 5: Consumption of cobalt, by application, 2020



Source: Roskill

Different industries use different forms of cobalt. Nickel-base alloys, magnets and tool materials are exclusively reliant on the metallic forms of cobalt such as cathodes and powders. 2020 therefore saw a sharp drop in demand for cobalt metal as a result of the challenging conditions in the aerospace and industrial sectors. Lithium-ion batteries meanwhile, together with catalysts, pigments and soaps and dryers, consume mainly cobalt chemicals. Demand for chemicals was therefore comparatively more robust.

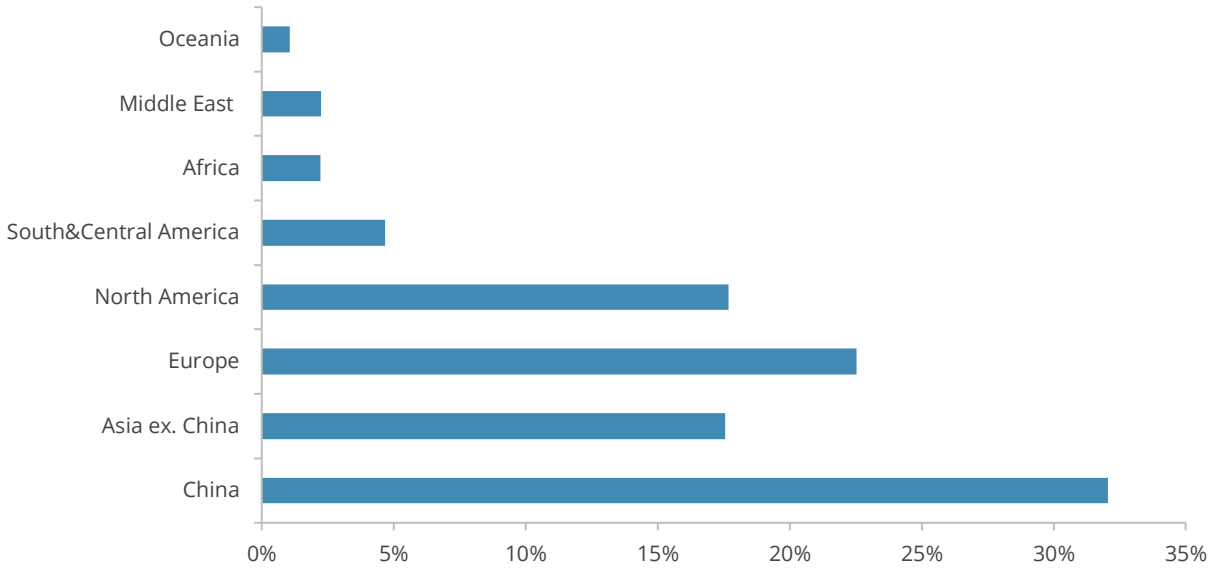
Figure 6: Consumption of cobalt, by raw material form, 2020



Source: Roskill

Geographically speaking, Asia is by far the largest cobalt-consuming region. The Cobalt Institute believes this region alone accounted for around half of total cobalt consumption in 2020. This reflects the high concentration of battery materials production in Asia, particularly China, Japan, and South Korea. China is by far the largest consuming country, with demand put at an estimated 44kt Co in 2020, or 32% of the world total. Apart from being a hub for battery manufacturing, China is also a major producer of tool materials, magnets, and pigments. Europe and North America also consumed considerable amounts of cobalt, together accounting for 40% of global consumption in 2020. In these regions, cobalt is mostly used in batteries, nickel-based alloys, and tool materials.

Figure 7: Consumption of cobalt, by region, 2020



Source: Roskill

3. Geology and reserves

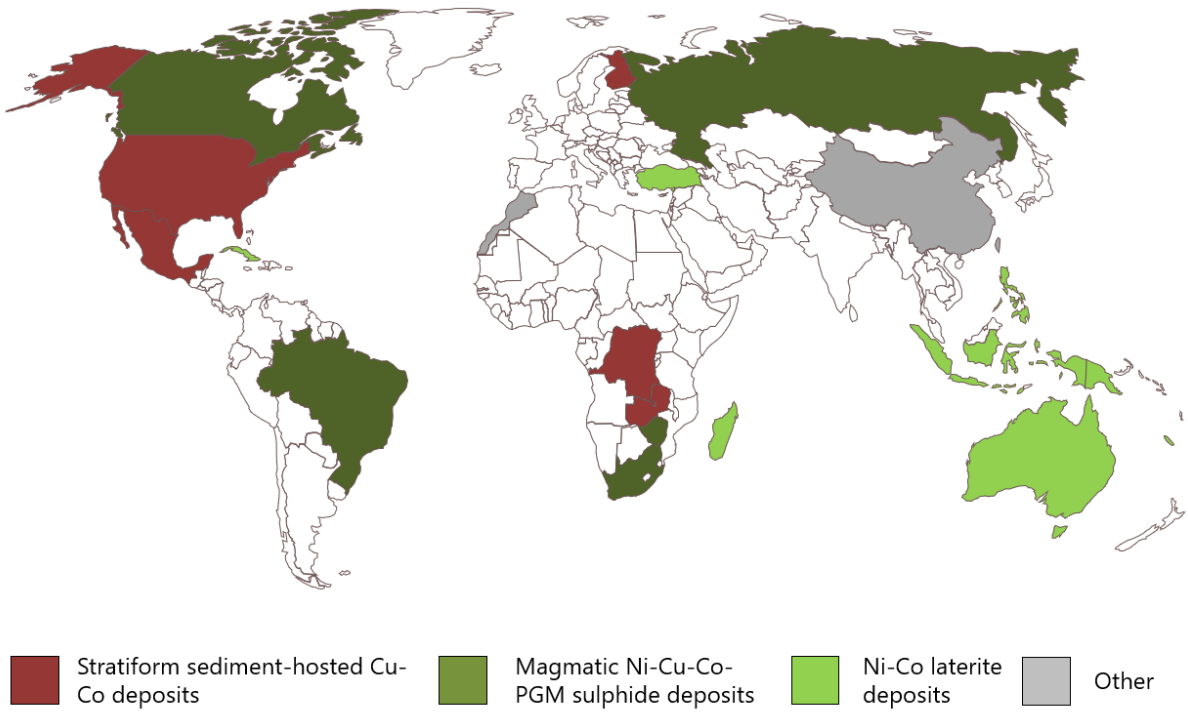
Cobalt can be found in economic concentrations in three principal deposit types:

Stratiform sediment-hosted copper-cobalt deposits are typically worked for copper with cobalt as a by-product. These deposits represent the world's second largest source of copper (after porphyry deposits) and the largest source of cobalt. The most significant deposits of this type are found in the Central African Copperbelt which spans the south of the DRC and the north-west of Zambia.

Magmatic nickel-copper-cobalt-PGM deposits account for about 30% of global nickel supply with copper, cobalt and PGMs being important by-products. Countries exploiting these deposits to produce cobalt include Canada, Russia, and South Africa. Generally speaking, the number of economic nickel sulphide deposits has dwindled in recent years.

Nickel-cobalt laterite deposits are now the world's major source of nickel accounting for 70% of global supply in 2020. Notable deposits from which cobalt is produced are found in Australia, Cuba, New Caledonia, Madagascar, Papua New Guinea, and the Philippines.

Figure 8: Cobalt resources by mine producing country and main deposit type, 2020



Source: Roskill
Note: The classification into three deposit types represents a simplification for illustrative reasons

Large concentrations of cobalt also occur in other geological settings. Notably, manganese nodules and cobalt-rich crusts on the ocean floor could contain as much as 1Bnt of speculative cobalt resources according to the United States Geological Survey (USGS). These resources are not presently accessible given obvious technological and economic constraints. However, numerous research groups and companies continue to research the viability of deep-sea drilling and mining.

Total world reserves are estimated by the USGS at around 7.1Mt of contained cobalt.

Table 1: World: Estimated cobalt reserves, 2020

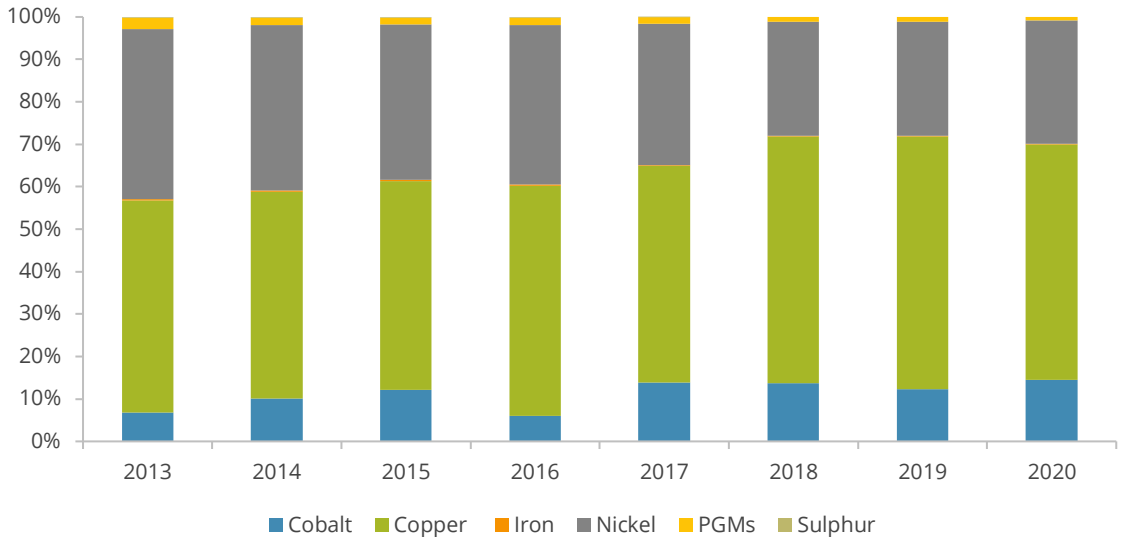
Country	Reserves
Australia	1,400,000
Canada	220,000
China	80,000
Cuba	500,000
DRC	3,600,000
Madagascar	100,000
Morocco	14,000
Papua New Guinea	51,000
Philippines	260,000
Russia	250,000
South Africa	40,000
USA	53,000
Others	560,000
Total	**7,100,000**

Source: USGS 2021

Cobalt is predominantly mined as a by-product of copper (55% in 2020) and nickel (29% in 2020) and, as such, cobalt supply is dependent on demand for, and subsequent production of, these metals. There are some exceptions. In Morocco, cobalt is produced as a primary commodity at the Bou Azzer mine. Cobalt can also be considered a primary product at numerous artisanal and small-scale mining (ASM) sites in the DRC (see box below). In 2020, these primary sources accounted for 14% of global cobalt mine supply. The balance comes from China, where some cobalt production occurs as a by-product of iron ore extraction, and from South Africa and Zimbabwe, where cobalt is recovered as a by-product of PGM production.

The dynamics of ASM cobalt production are complex. Estimates of the number of individuals engaged in the mining, sorting, washing, transporting, and trading of cobalt in the DRC vary widely but consensus is that in excess of 100,000 individuals may be involved. The number of people involved, and the volumes produced, swing considerably from year to year depending on the cobalt price itself and the cobalt price relative to the prices of other raw materials, principally copper. Owing to the geology of the southern DRC, copper and cobalt are extracted from the same ores. It is important to note the interrelated nature of ASM copper and cobalt supply.

Figure 9: Mine production of cobalt, by primary product, 2013-2020 (%)



Source: Roskill

Cobalt supply trends in 2020 were, as in any year, shaped considerably by copper and nickel dynamics. Copper mine production dropped 1.7% year on year in 2020 to 20.3Mt, owing largely to COVID-19-related shutdowns and mine closures, most notably in Peru. Nickel mine production fell more sharply, by 5.2% year-on-year, from a record high of 2.5Mt in 2019 to 2.4Mt in 2020. This was also largely because of the COVID-19 pandemic causing suspensions of mining operations in countries including Canada, Madagascar and the Philippines. However, the decline was also the result of a large drop in Indonesian output following the Indonesian ore export ban.

4. Supply and production trends

4.1 Feedstock production

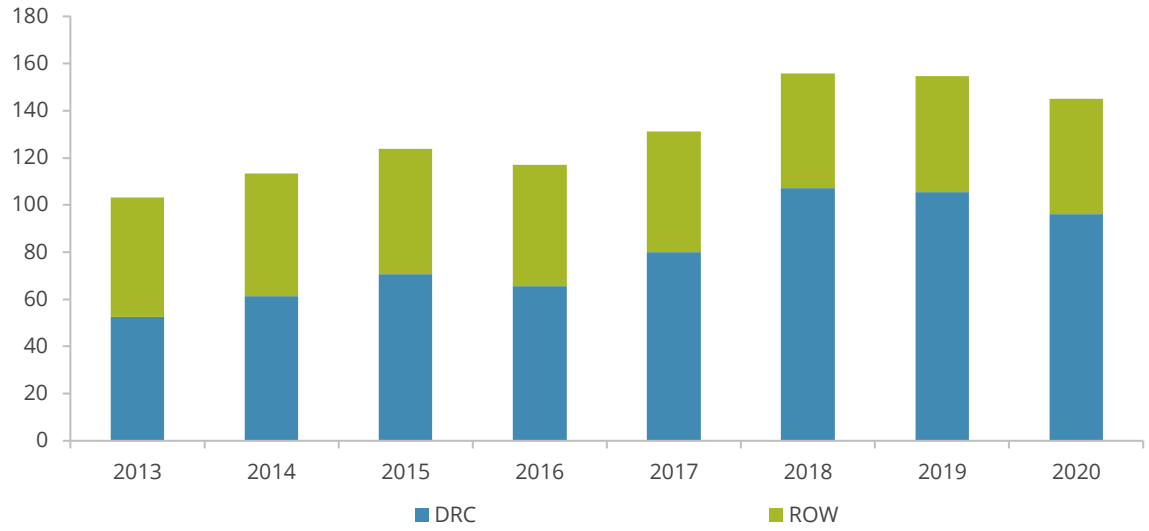
The two key sources of cobalt feedstock are mining and recycling. In 2020, cobalt mine production fell back 6% from 2019 levels, largely because of the closure of the world's biggest cobalt mine (Glencore's Mutanda) in late 2019. Global mine production was 145kt Co for 2020.

The DRC retained its well-established status as the world's main source of mined cobalt in 2020, accounting for 66% of global supply, or 96kt. By far the biggest producer in the DRC is Glencore, the world's largest cobalt producer. It maintained this position, accounting for 29% of DRC mine production, although its Mutanda operation was on care and maintenance. All Glencore output in the DRC in 2020 was, therefore, from its Katanga Mining assets.

The second-largest producer was China Molybdenum (CMOC) which operates the Tenke Fungurume mine and accounted for 17% of DRC cobalt output. In third place was ERG, where most cobalt units now come from its Metalkol Roan Tailings Reclamation (RTR) project (11% of DRC supply in 2020).

Other smaller operations in the DRC produced the balance of supply in 2020, together with an estimated 8.5kt (9% of DRC output) from ASM. Levels of cobalt supply from artisanal sources remained subdued in 2020 because of cobalt price levels and the risks brought about by COVID-19.

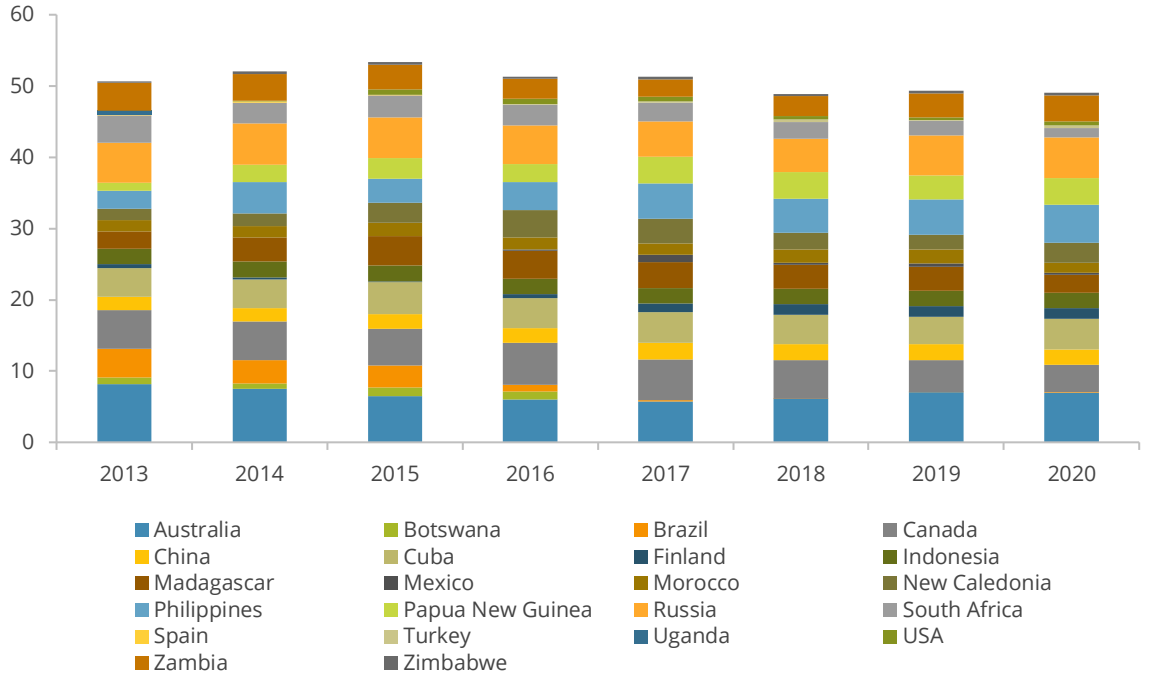
Figure 10: World: Mine production of cobalt, DRC and ROW, 2013-2020 (kt Co)



Source: Roskill

Outside the DRC, a number of other countries contributed broadly similar levels to global mine supply in 2020, such as Australia (5%), Russia (4%), the Philippines (4%), Cuba (3%), Canada (3%), Papua New Guinea (3%), and Zambia (3%). For the most part, producers outside the DRC (where mine supply dropped by 9% year on year) saw production volumes increase in 2020, although there were also sizable drops in Canada, Madagascar, Morocco, and South Africa owing to COVID-19-related suspensions.

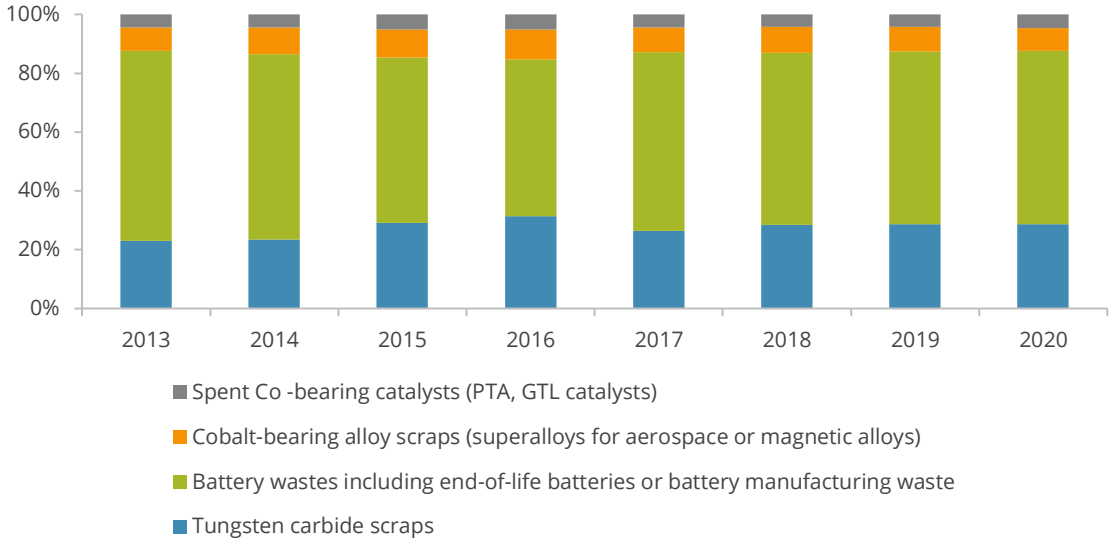
Figure 11: World: Mine production of cobalt, ROW ex-DRC, 2013-2020 (kt Co)



Source: Roskill

Secondary recovery, or recycling, of cobalt is a fast-growing and important source of cobalt feedstock to the supply chain. The Cobalt Institute estimates cobalt recovery from secondary sources at 10.6kt for 2020. An estimated 65% of this recycled cobalt came from battery recycling, while at 24% the contribution from tungsten carbide recycling was the second largest secondary source. The recycling of alloy scraps and catalysts made up the balance (11%).

Figure 12: World: Estimated secondary recovery of cobalt, by source, 2013-2020 (% total)

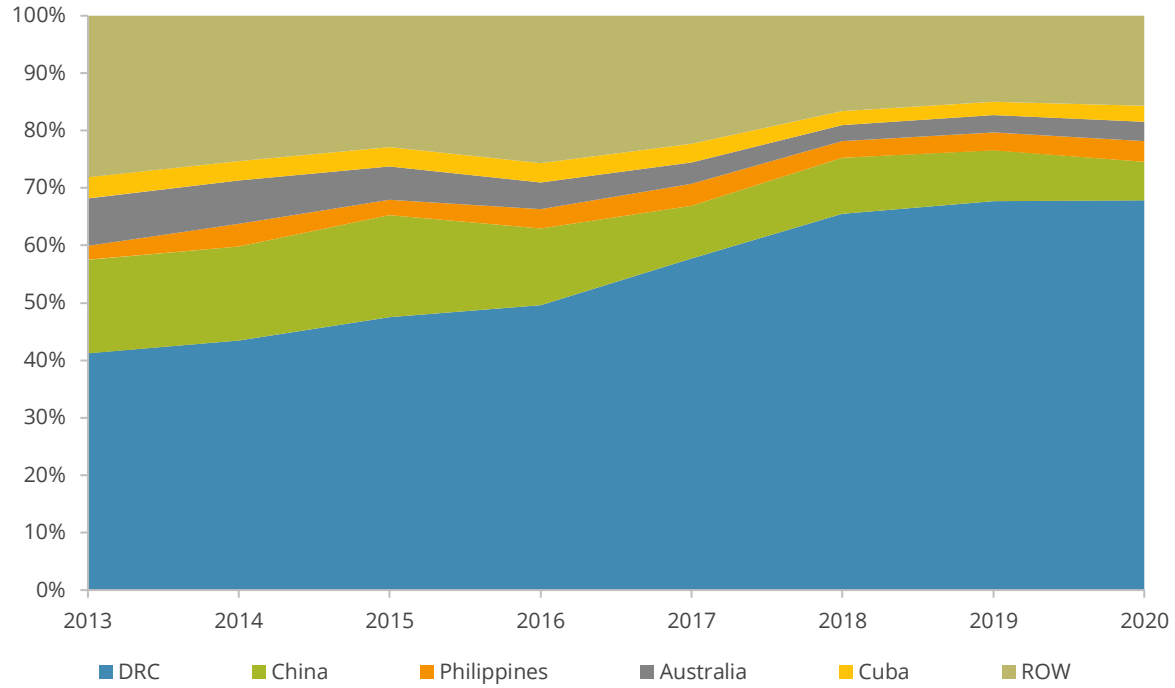


Source: Roskill

A wide range of cobalt intermediates are produced from mined cobalt. In 2020, the main form of intermediate produced by volume was crude cobalt salts (mostly crude hydroxide and carbonate typically containing more than 30% Co), the majority of which comes from the by-product stream of copper operations employing hydrometallurgical processes in the DRC. The next largest group of cobalt intermediates includes nickel and cobalt bearing mattes, and hydroxide and sulphide products, which are a by-product of the smelting of nickel sulphide or laterite ores from countries including Australia, Cuba and the Philippines.

As it is the largest cobalt mining country globally, the DRC is also by far the largest producer of cobalt intermediates. The DRC produced 87.7kt Co contained in intermediates in 2020, accounting for 68% of global supply. This represents a 10% drop on 2019 levels, broadly in line with falling mine supply in the country resulting mainly from the closure of Mutanda. China was the world's second-largest producer of cobalt intermediates in 2020, accounting for 7% of global production. Chinese intermediates are mainly based on imported ores and concentrates from the DRC, with the balance accounted for by Jinchuan Group's (JNMC) integrated production.

Figure 13: Production of cobalt feedstock, top five producing countries and ROW, 2013-20 (%)

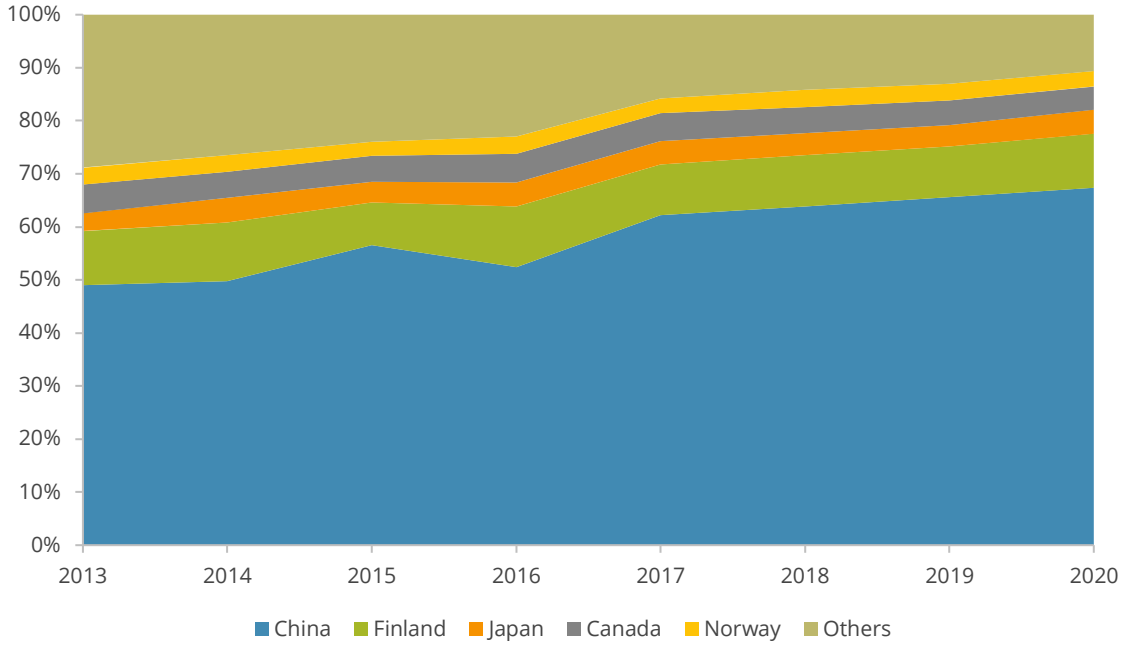


Source: Roskill

4.2 Refined production

Intermediate cobalt products are further processed into refined cobalt products. Global production of refined cobalt totalled 132kt in 2020, down 5% on 2019 levels. The drop is explained by a combination of factors including reduced availability of (mainly DRC) feedstocks, some suspensions owing to COVID-19-related shutdowns, and weaker demand in certain segments such as aerospace as a result of the impact of the pandemic. Owing to the lack of feedstock, only 30-40% of the refining capacity in China was operational in H1 2020, although capacity utilisation recovered quickly in H2. China was the largest cobalt refining country globally in 2020, with refined production totalling 89.2kt or 67% of the global total. Finland was the second largest producer (10%), followed by Japan (5%), Canada (4%) and Norway (3%).

Figure 14: Production of refined cobalt, top five producing countries and ROW, 2013-2020 (%)

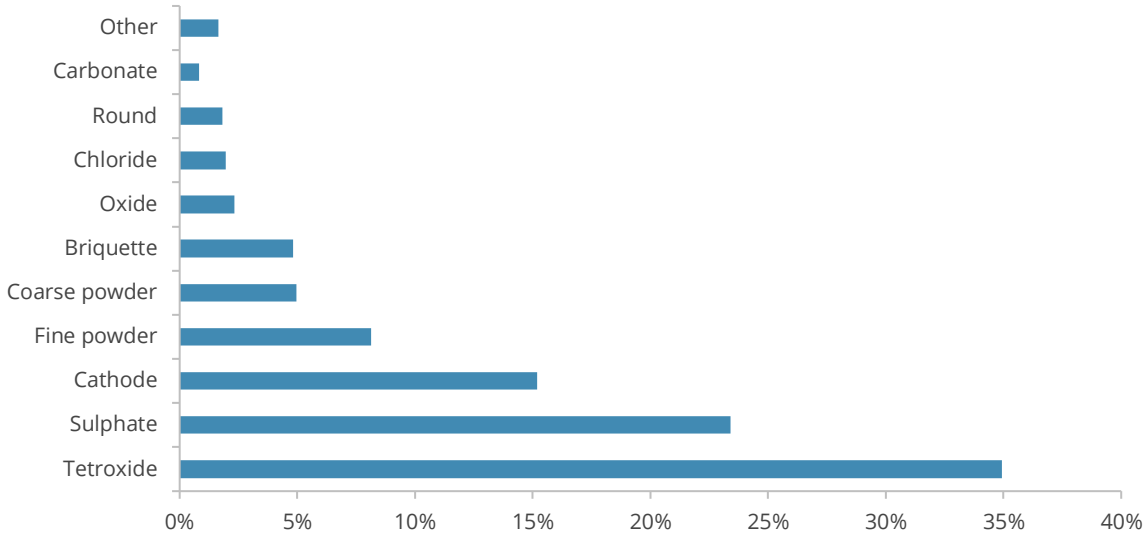


Source: Roskill

Refined cobalt is produced into a variety of metal and chemical forms. A decade ago, production of cobalt metal and chemicals was broadly in balance. However, the commercialisation and growth in demand for lithium-ion batteries has resulted in significant new demand for cobalt chemicals (mainly tetroxide and sulphate). The share of chemicals increased to 65% in 2020 and such a shift is set to continue over the coming years.

There are five main types of cobalt metal product (cathode, briquette, coarse powder, fine powder, and rounds) with no ingot production since 2017, and nine types of chemical product (carbonate, chloride, hydroxide, monoxide, oxalate, oxide, sulphate, tetroxide and other). Conversions from one refined product to another are not uncommon – for instance, chloride can be converted to tetroxide, carbonate and oxalate can be processed into powders, hydroxide can be a feedstock for sulphate production, and metals are sometimes dissolved to produce chemicals. In 2020, cobalt tetroxide saw the highest production volumes, followed by sulphate and cathode.

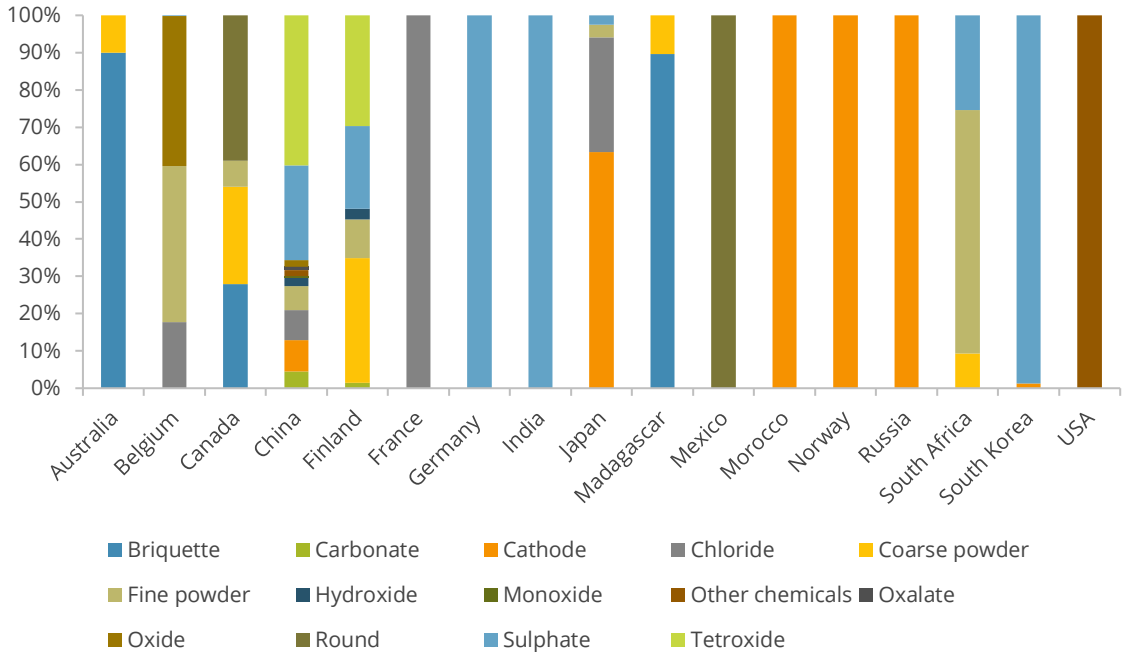
Figure 15: World: Production of refined cobalt, by form, 2020 (% of total)



Source: Roskill
Note: Production estimates exclude conversions from one refined product to another

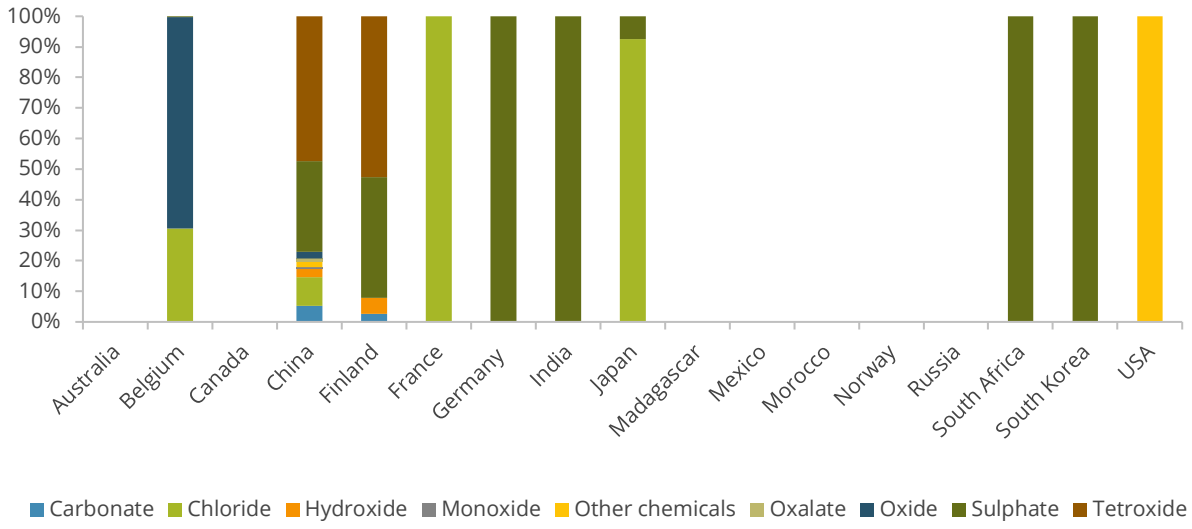
The charts below combine country and form data for refined cobalt production to show which materials were produced where in 2020. In China, the world's largest producer, all refined forms were produced although sulphate and tetroxide, used in lithium-ion batteries, dominated market share. In Finland, the world's second largest producer, production by form was also mixed although coarse power saw the highest output levels. In Japan, the world's third largest producer, most production was of cobalt metal in the form of cathode.

Figure 16: World: Production of refined cobalt, by form and country, 2020 (%)



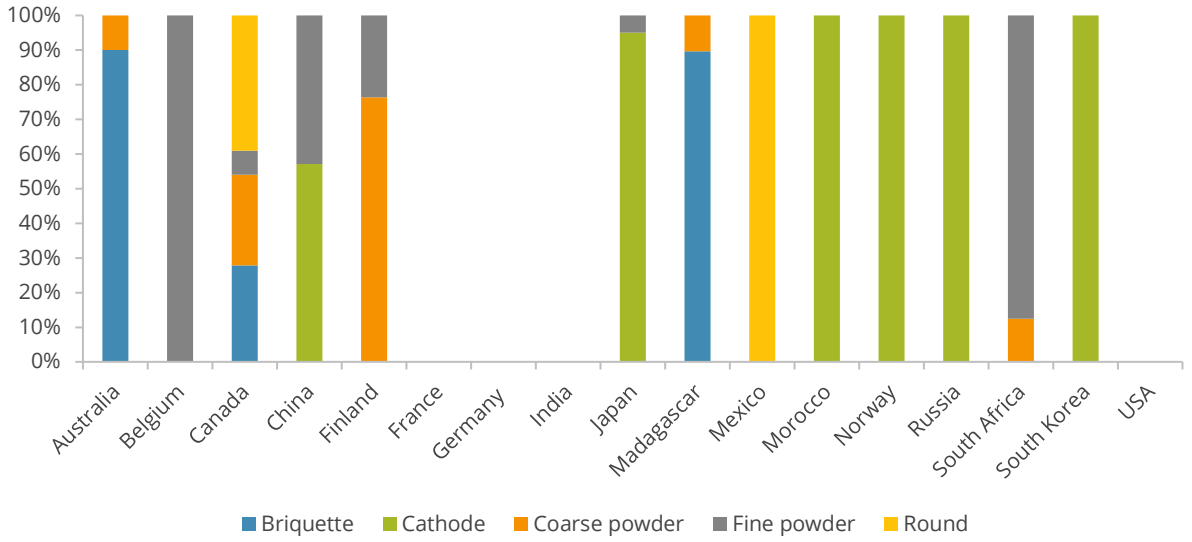
Source: Roskill

Figure 17: World: Production of refined cobalt chemicals, by form and country, 2020 (%)



Source: Roskill

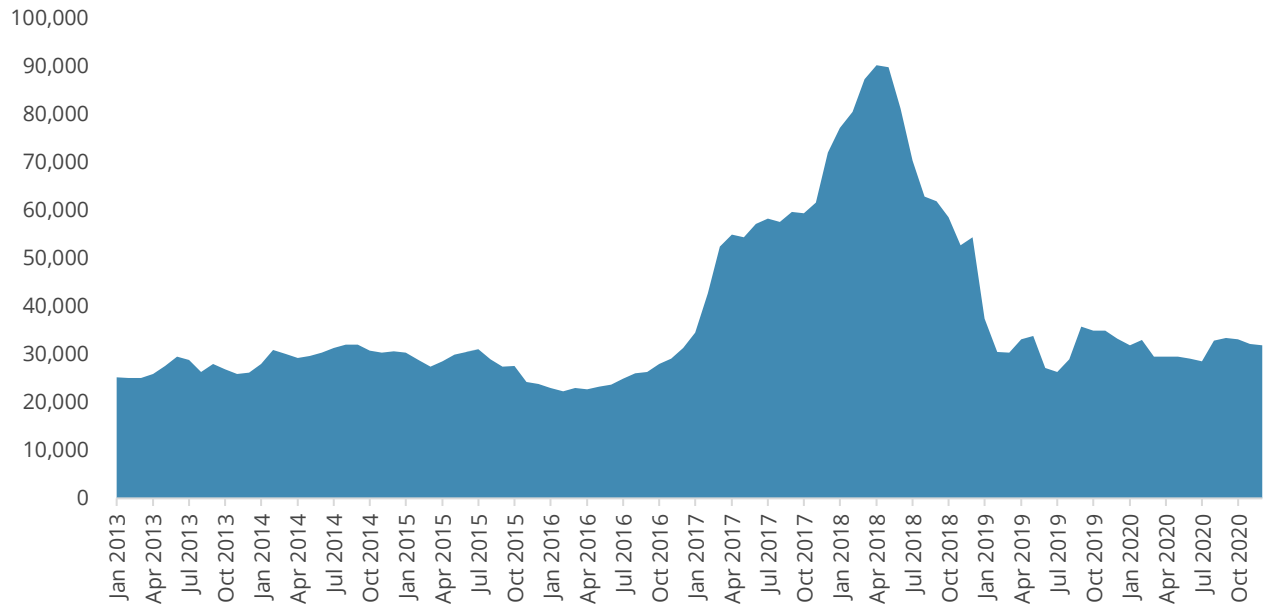
Figure 18: World: Production of refined cobalt metal , by form and country, 2020 (%)



5. Prices and premiums

Cobalt prices have a history of volatility, although they remained in a narrow range of US$22,000-US$32,000/t between 2013 and 2016. In Q1 2017, there was an enormous uptick in the cobalt metal price. Prices increased quarter on quarter throughout the year to reach an average of US$64,000/t in Q4 2017. In 2018, the price rise continued until Q2, when prices peaked at over US$90,000/t, a ten-year high. But, because of market oversupply and sluggish demand, prices dropped sharply in H2 2018 and early 2019. There was some movement in the price in response to news that Glencore intended to mothball Mutanda, and prices rebounded a little in Q3, before falling back at the end of the year.

Figure 19: LME daily official cobalt metal prices, 99.8% Co, 2013-2020 (USD/t)



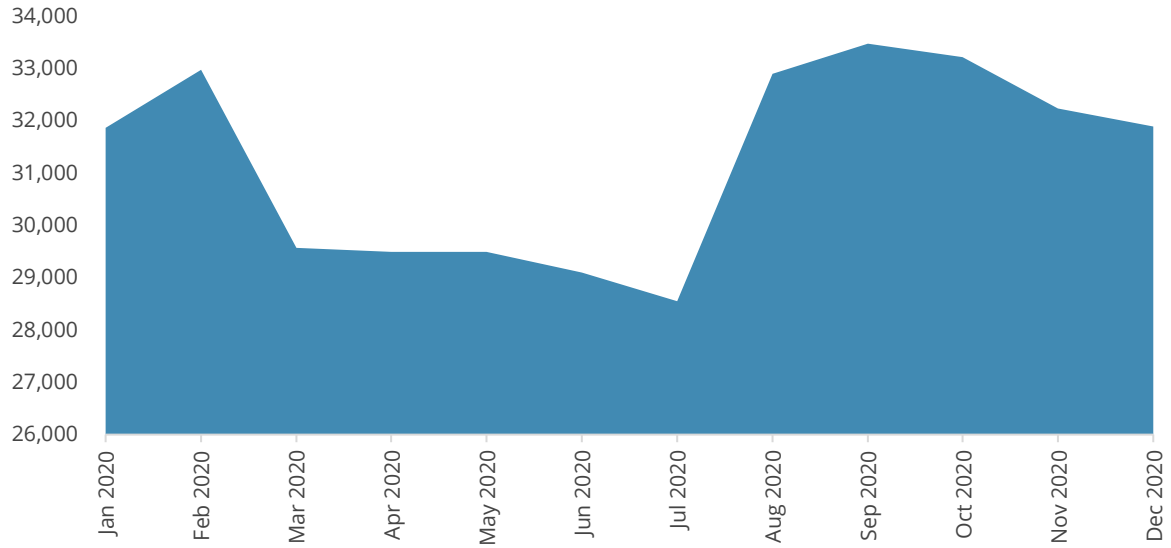
Source: LME nominal prices

Early 2020 saw some purchasing activity in the cobalt market, with prices supported by restocking. Hydroxide payables in Q1 were in a range of 65-70%. But by March, the impact of COVID-19 had taken hold, and bearish market sentiment weighed on buyers' appetite to restock. As economic activity ground to a halt, first in China and then the rest of the world, the cobalt metal price fell back in Q2. Payables also retreated to the 60-65% range.

In the second half of the year prices started to recover, driven by three main factors. The first was a recovery in China, where demand for cobalt (and most other raw materials) strengthened considerably in Q3 and Q4. The second was related to issues around logistics and shipments from Africa starting in Q2. Strict lockdowns in South Africa had an impact on the port of Durban, from where the vast majority of Congolese cobalt begins its journey by sea to ports in China. Virus control measures in South Africa caused severe delays in cobalt shipments, leading to a tightness in cobalt feedstock availability which pushed both hydroxide payables and metal prices higher in Q3. Payables sat in the 70-75% range for most of Q3. While metal prices retreated a little towards the end of the year, payables remained strong and finished the year at levels in excess of 80% on average. As a result of increasing raw material costs and stronger demand, prices for cobalt sulphate and tetroxide, however, rose sharply in Q4 2020, with both products sold at sizable premiums over the benchmark metal price.

News that China's State Reserve Bureau (SRB) was preparing for a fresh round of stockpiling also help support prices in Q3. An announcement was made in September that the SRB planned to stockpile 2kt Co in Q4 2020. This was increased to a total of 5kt in early 2021.

Figure 20: LME cobalt metal prices, 99.3% Co, 2020 (USD/t)



Source: LME nominal prices (LME daily official cobalt metal prices, monthly average)

6. Conclusions

With annual market growth of over 5% since 2013 and a robust and growing market for cobalt in Lithium-ion batteries for Electric Vehicle applications, demand looks set to continue growing with increased focus on the battery sector. Strong growth is expected in electric vehicle demand and NEV sales are forecast to increase by nearly 30% year on year to 2025.

New measures to regularise the ASM sector in the DRC, including the creation of a new state-owned company to buy and market all ASM cobalt, as well as the responsible sourcing initiatives implemented by industry, will ensure the cobalt supply chain is more transparent and that the cobalt on international markets is procured in a safe and ethical manner free of child labour.

World reserves remain at a comfortable level although cobalt is primarily mined as a by-product of copper and nickel and to some extent dependent on those industries.

With more traditional cobalt applications such as aerospace and tooling expected to recover after the COVID-19 pandemic, and with more stability in world cobalt markets, prospects for cobalt look bright for the coming five-year period.