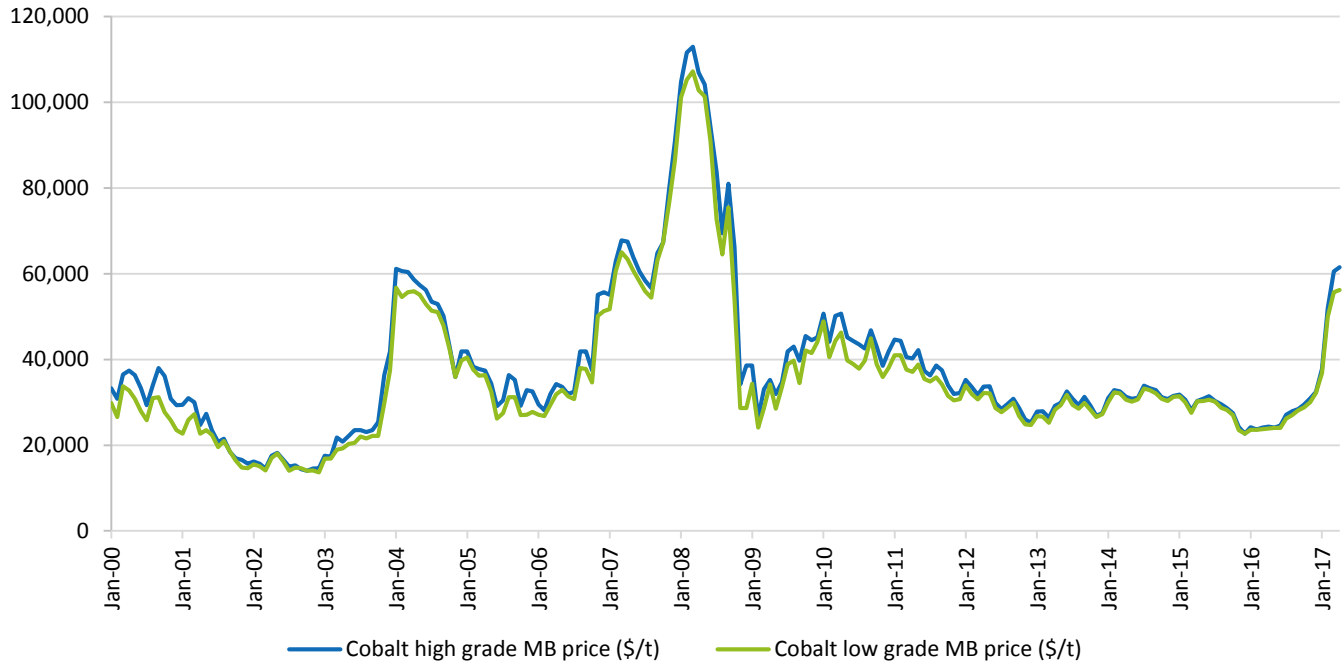








Historical cobalt prices (US\$/t) – LME 3m forward contracts trades at \$55,000/t



- Price induced increase in recycling?
- Substitutes?

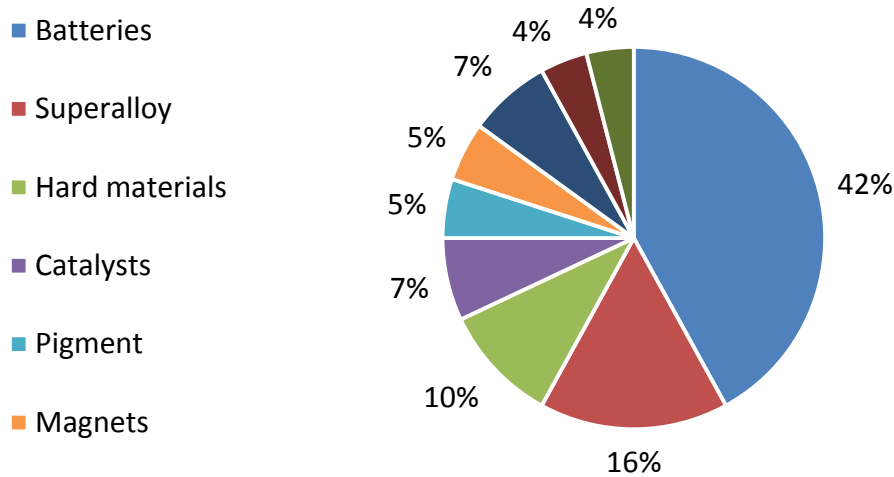
Cobalt substitutes

Batteries	Iron-phosphorous, manganese
Superalloy	Nickel-based alloys or ceramics jet engines
Catalysts	Nickel, rhodium, hydroformylation catalysts
Hard tools	Iron-copper in diamond tools
Pigments	Cerium, iron, lead, manganese, vanadium
Magnets	Barium, strontium ferrites, neodymium-iron-boron or nickel-iron al

Source: USGS

[Not irreplaceable, though involves a loss in product performance in some applications](#)

Demand dominated by chemical applications: batteries + catalysts + pigments + feedstuffs = 58% (IDC, 2015)



Cathode Type	Chemistry	Example Metal Portions	Example Use
NCA	LiNiCoAlO ₂	80% Nickel, 15% Cobalt, 5% Aluminum	Tesla Model S
LCO	LiCoO ₂	100% Cobalt	Apple iPhone
LMO	LiMn ₂ O ₄	100% Manganese	Nissan Leaf
NMC	LiNiMnCoO ₂	Nickel 33.3%, Manganese 33.3%, Cobalt 33.3%	Tesla Powerwall
LFP	LiFePO ₄	100% Iron	Starter batteries

Main cobalt uses by type of product

Batteries	Hydroxide, powder, LiCoO ₂
Superalloy	Metal, recycle
Hard materials	Powders (fine and very fine)
Catalysts	Salts including carbonate, sulphate, nitrate, acetate, metal
Pigment	Oxide, sulphates, hydroxide, carbonate
Magnets	Metal, powders, recycle
Hardfacing	Metal & mesh powders, recycle
Tyre adhesives, soaps, driers	Soaps & complexes made from metal startgin point
Feedstuffs	Mainly sulphate, but some carbonate and hydroxide

Source: CDI (2011)

Chemical applications dominated by batteries: Li-ion batteries (cathodes are 60% Co), Ni metal hydride (NMH, cathodes are 15% Co), Ni cadmium (NiCd, cathodes are 1-5% Co)

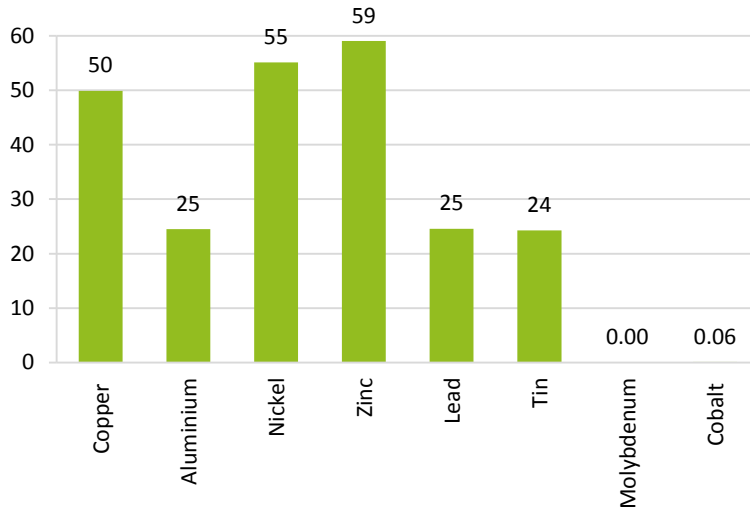
Catalytic applications: wide use in petrochemical sector to remove sulphur from crude oil

Metallurgical applications: cobalt based “superalloys” have better temp resistance, hardness and wear characteristics (found in jet engines, power generation turbines and even prosthetic hips/joints that can contain up to 62% Co)

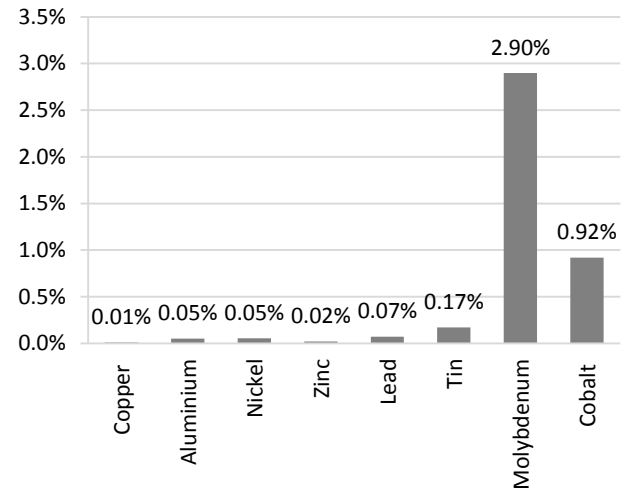
Very little liquidity for specialty metals on LME –low trading volumes and wide bid/ask spreads for cobalt/moly



Volumes traded (LME) relative annual mine supply 2016



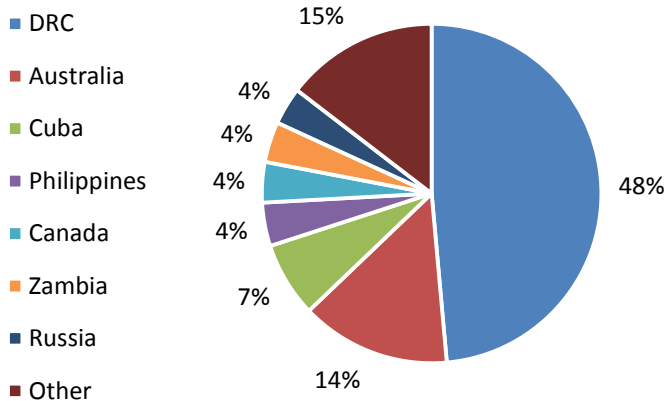
Bid/Ask spread as % of mid price



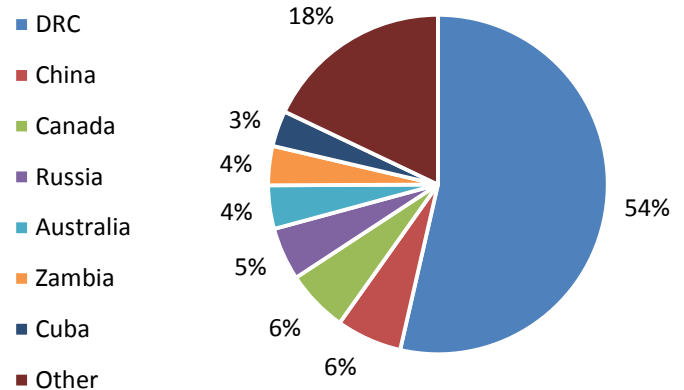
Around 8,000 of cobalt futures contracts one ton each have been traded in 2016 versus 1.4bn t, 1.0bn t and 0.7bn t in aluminium, copper and zinc futures/options contracts

Supply and reserves are highly concentrated DRC accounts for c.90% of Co Chinese imports

World reserves, 7mt as of 2016 (USGS)

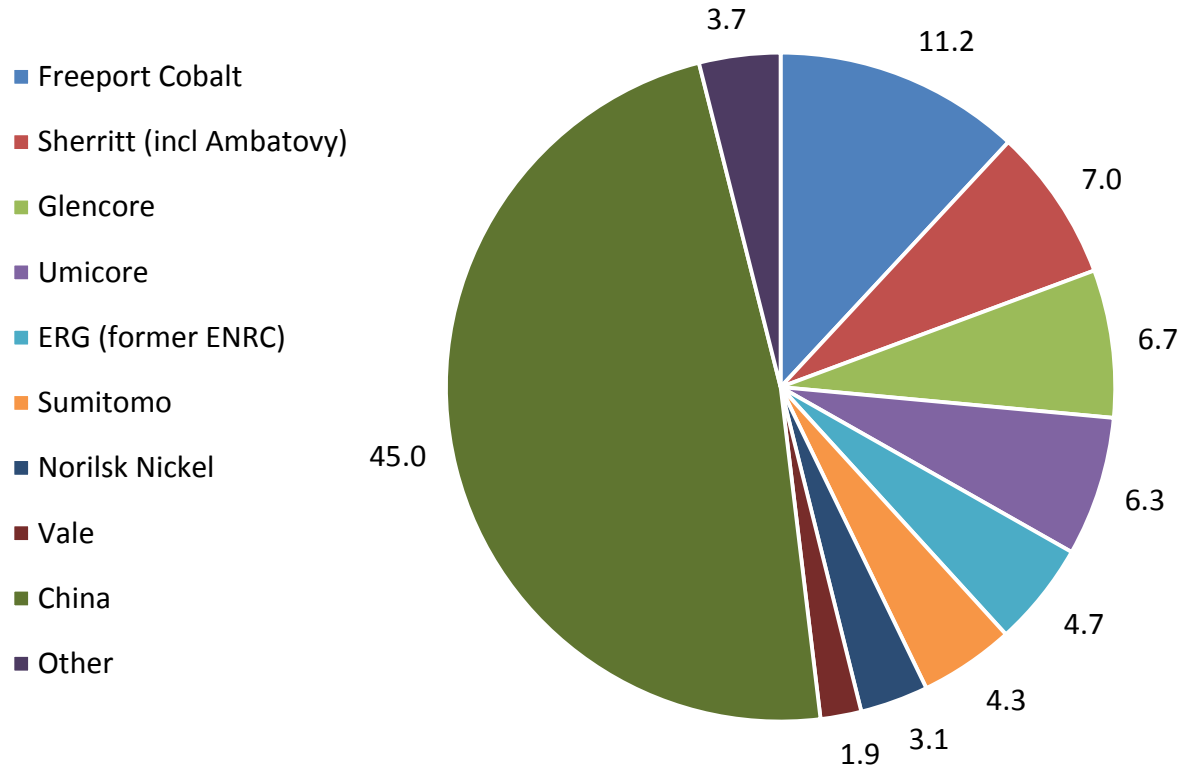


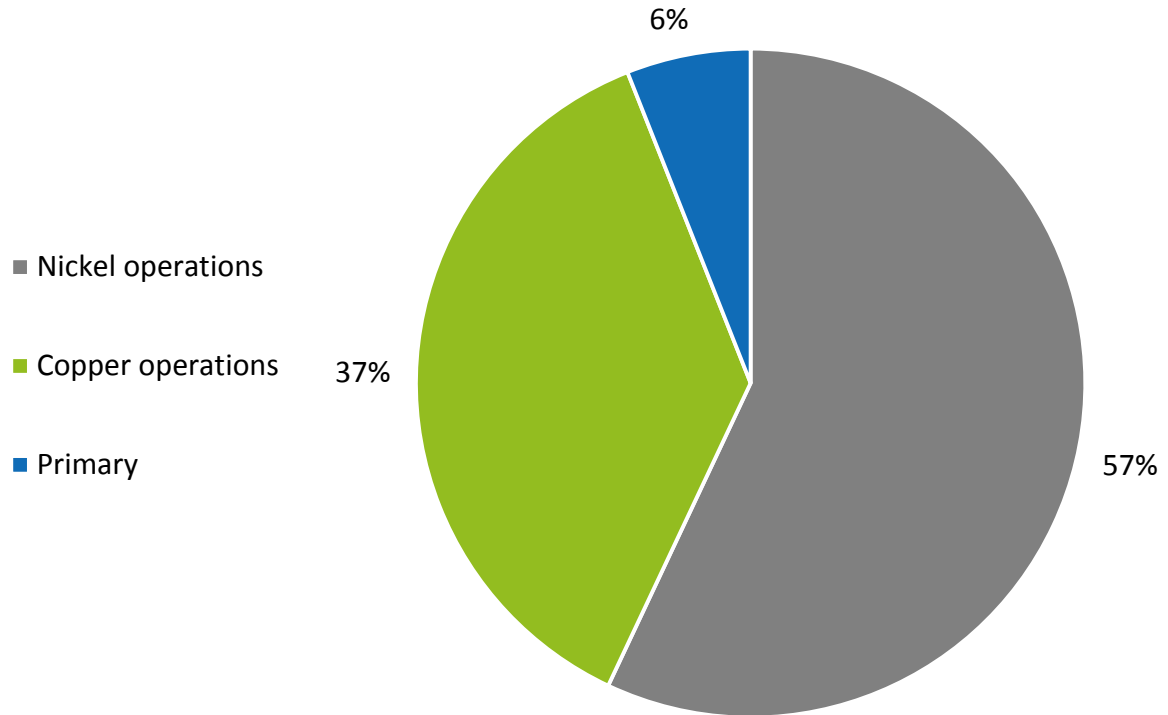
Mine production, 123kt in 2016 (USGS)



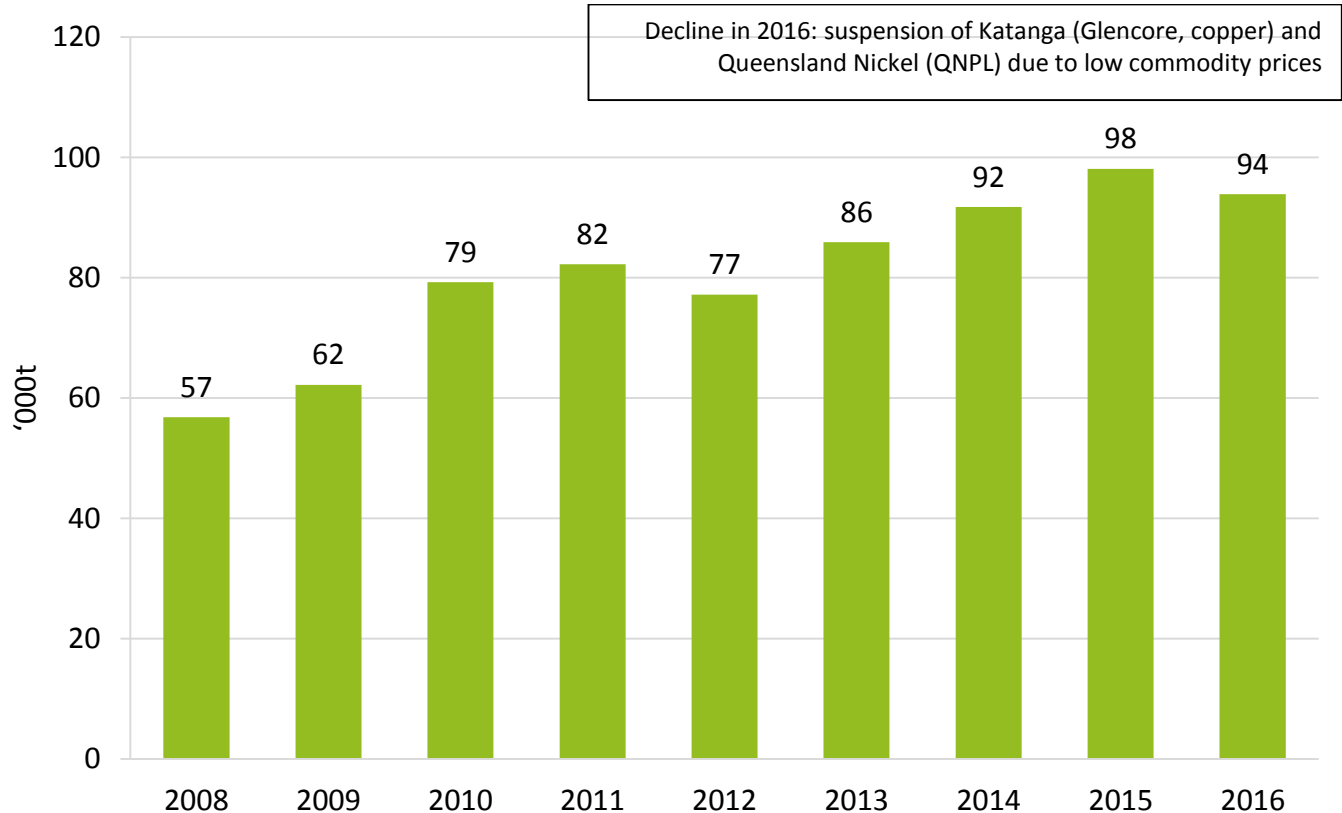
- DRC accounts for 50% of output/reserves
- top five destinations account for 70-78% of production/reserves
- in total c.25mt in identified in total resources, most of which associated with sediment hosted copper deposits in DRC and Zambia and nickel bearing laterites in Australia, Philippines, and Cuba
- although, the largest cobalt resource remains untapped with more than 120mt identified in resources in seabed nodules and crusts of the Atlantic, Indian and Pacific oceans

Ex China 3/4s of refined production is split b/n five producers sourced as a by-product from copper/nickel projects





Refined cobalt production down in 2016 on suspensions at copper and nickel operations



- If you think Cobalt mining is bad, just look at how they refine Rare Earths in China

