Critical mineral resources

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Increasing metal use and complexity

- Electric cars: 2-4 x copper in regular cars (~50Kg) + Al, Li, Co, Ni, Ti, B, Au … and buses, trains, planes, ferries

- Wind turbine: ~185t steel (+coal), ~3t Cu, ~0.5kg Nd

- Solar PV: Si, Cd, Ga, Te, Se, In, Zn, Mo, REE

- LED lighting: Si, As, Ga, In, Te, Se, Ba, B, REE
Copper – technology and infrastructure
Global copper provinces

Chile-Peru: ~35% of global copper
Zambia-DRC: ~ 25% of global copper

- Expansions
- New discoveries

Supply growth but...
- Complexity
- Grade challenges
- ESG

Belts with distinct types of copper deposits concentrated in different countries
Li ion batteries – sufficient lithium?

- Mine production: ~85,000 tonnes in 2018 (~60% from Australia)
- Global reserves: 14 million tonnes (~70% in the Andes)
- Global resources: ~55 million tonnes (~60% in the Andes)
- Supply
  - Current supply: pegmatites (Australia, Canada, Zimbabwe) and brines (Chile, Argentina, USA) – 80% of supply: 7 producers (5 in Australia, 2 in Chile)
  - Resources (future supply): dominantly brines in Argentina, Chile and Bolivia – but production, quality, water use and community challenges

*All data for Li metal
USGS Mineral Summaries 2019
Co – LiMO$_2$ cathodes in Li ion batteries – Supply issues

- DRC: ~60% of current supply
- Sovereign risk: socio-political uncertainty
- 10-30% of Co supply from informal small miners (ASM) – 12M people
  - Issues: safety, child labour, human rights, environment- ~5 child deaths/month
  - Mine heterogenite – Co-rich mineral, weathering product + U (Decrée et al., 2014)

USGS 2017
Clean energy, technology, human development

increasing demand for metals

Global resource availability – not a major issue

Challenges:

- Discovery + quality, managing complexity
- Knowledge gaps
- Sustainability, clean/efficient mining
- Environment, social, governance – ESG
- Volatility
Cobalt price

- Volatile – price peaks in 1979 and early 2018
- Current price: US$16.10/lb or US$35,460/tonne

1980: Angola – substitution,