Challenges to the supply of materials and minerals

April 17, 2024

APERC Annual Conference 2024

Yoshikazu Kobayashi
The Institute of Energy Economics, Japan (IEEJ)

A new energy security concern

- Energy transition creates a new energy security concern.
- There is a risk that both types of energy security concerns could worsen simultaneously.

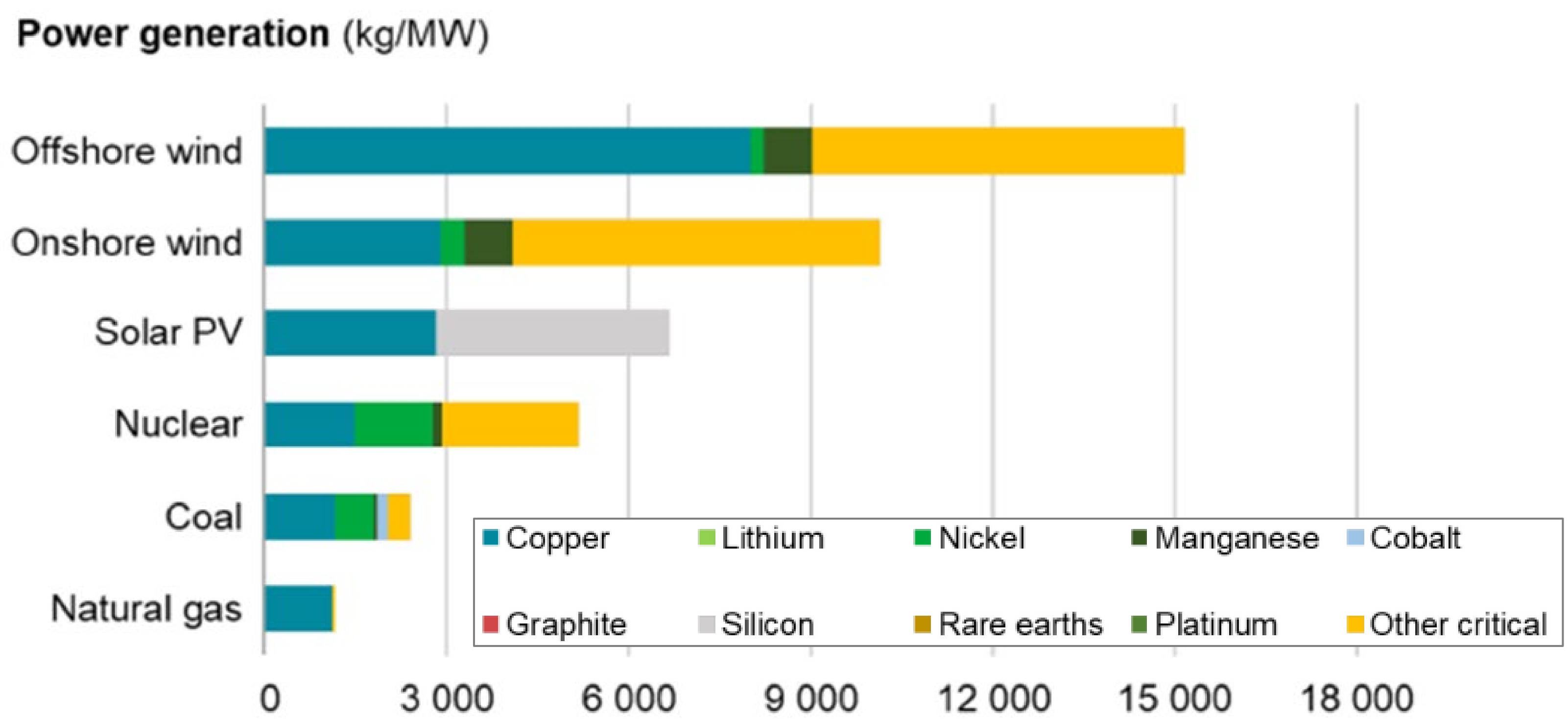
Energy systems	**Fossil energy**	**Clean energy**
	• Majority of primary energy supply was fossil fuels • Some large economies highly depend on import for fossil fuels	• Final energy is primarily supplied by electricity generated from renewable energy
Core technologies	**Combustion technologies (Boiler, turbine, engine, etc.)**	**Clean technologies (Renewables, batteries, nuclear, etc.)**
	• Limited consumption of critical minerals.	• Dependence on import of critical mineral supply for manufacturing.
Origin of energy security risks	**Geopolitics in Major oil and gas producers** **Pipeline / maritime import**	**Stable electricity supply** **Import of clean technologies and critical minerals**

There are also transitional risks

Critical Minerals in clean energy technology

- Clean energy technologies require more minerals than traditional energy technologies.
- The demand for critical minerals is expected to increase rapidly and significantly as clean energy technologies become more extensively utilized.

Consumption of critical minerals for power generation



Source: IEA, Energy Technology Perspective 2023

Geographical resource endowments

- There are the haves and the have-nots also in the world of critical minerals.
- Reserves of many critical minerals are distributed unevenly to specific economies.

Economy-wise share of reserves in selected minerals

	Cu (copper)	Co (cobalt)	Ni (nickel)	Li (lithium)	V (vanadium)	PGM (platinum group)	REO (rare earth)
United States	5%	1%	0%	3%	0%	1%	2%
Canada	1%	3%	2%	0%	0%	0%	1%
Mexico	6%	0%	0%	0%	0%	0%	0%
Brazil	0%	0%	17%	0%	1%	0%	18%
Peru	9%	0%	0%	0%	0%	0%	0%
Chile	23%	0%	0%	42%	0%	0%	0%
Argentina	0%	0%	0%	10%	0%	0%	0%
Cuba	0%	7%	0%	0%	0%	0%	0%
Australia	11%	18%	22%	26%	25%	0%	3%
Indonesia	3%	8%	22%	0%	0%	0%	0%
Philippines	0%	3%	5%	0%	0%	0%	0%
Viet Nam	0%	0%	0%	0%	0%	0%	18%
China	3%	1%	3%	7%	40%	0%	37%
Kazakhstan	2%	0%	0%	0%	0%	0%	0%
Russia	1%	3%	8%	0%	21%	6%	18%
Zimbabwe	0%	0%	0%	1%	0%	2%	0%
DR Congo	4%	46%	0%	0%	0%	0%	0%
South Africa	0%	0%	0%	0%	15%	90%	1%
Others	33%	9%	21%	11%	0%	0%	4%

Source: IEEJ, IEEJ Outlook 2023

Geographical locations of value chain

- Ore production and downstream processes are also distributed unevenly among countries
- Unexpected supply interruption in downstream segment may also cause significant problem in the entire mineral supply.

Share of nickel ore and primary nickel production by country in 2019

	Ore production	Primary nickel production
Americas	11%	12%
Europe	2%	17%
Japan	0%	8%
China	4%	34%
Indonesia	35%	16%
Philippines	13%	0%
Other Asia	8%	3%
Oceania	6%	8%
Russia	9%	0%
Africa	2%	3%
Others	10%	0%

Source: IEEJ, IEEJ Outlook 2023

Is critical material issue really critical?

- When it comes to the future of critical minerals issues, there are both optimistic and pessimistic perspectives.

Optimistic perspective

- If demand outstrips supply, prices will rise, prompting increased investments in upstream development and boosting supply.
- Increased price will also incentivize the development of alternatives, resource conservation, and recycling technologies, reducing the required amount
- Fallacy of "Peak Oil" theory: The wolf so far has not come to the oil market.

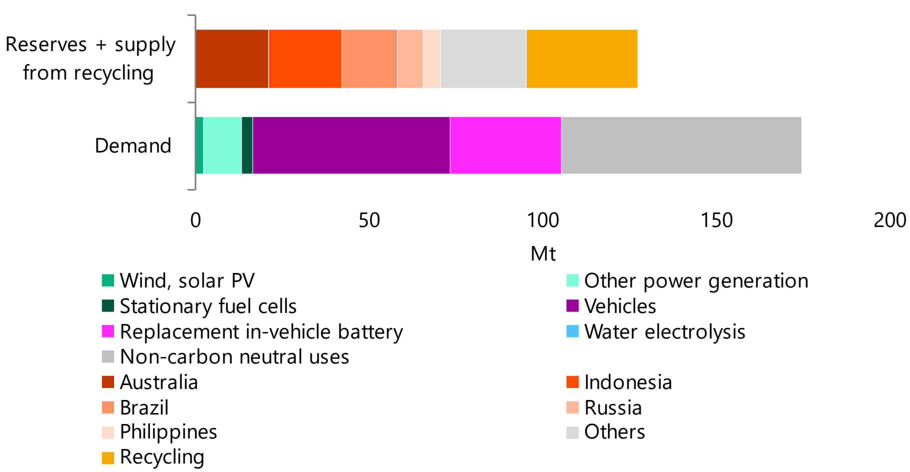
Pessimistic perspective

- Various types of minerals exit, and certain minerals are concentrated in specific countries (the issue is not as simple as oil or natural gas).
- Expanding processing capacities is difficult in the short term.
- International market is not well developed for some minerals.
- "Security dilemma" in minerals procurement. In which one country’s action to secure stable supply causes a security concern for other countries.

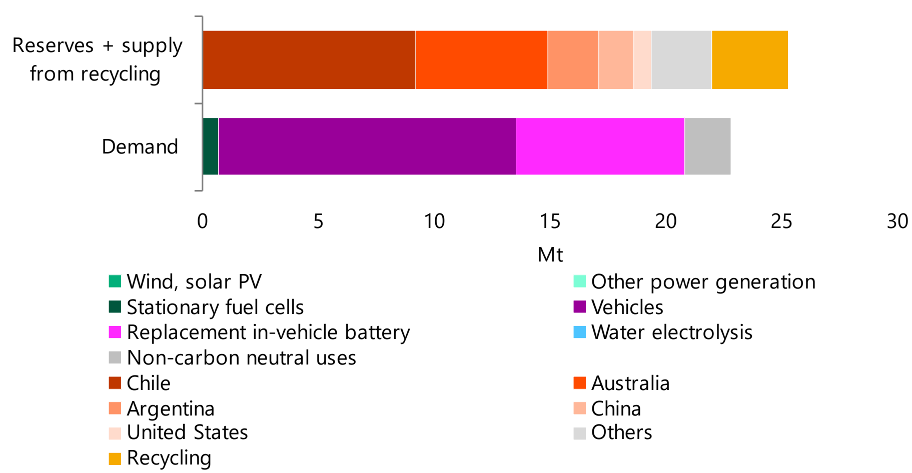
Which "critical mineral" is truly critical?

- The criticality of each important mineral varies depending on its applications, required volume, size of reserves, and the potential for alternative materials.
- Whereas both nickel and lithium are expected to have tight demand-supply balance in the future alike, ultimately, Nickel will have tighter balance.

Estimate cumulative demand and reserves (+ recycled supply) for Nickel



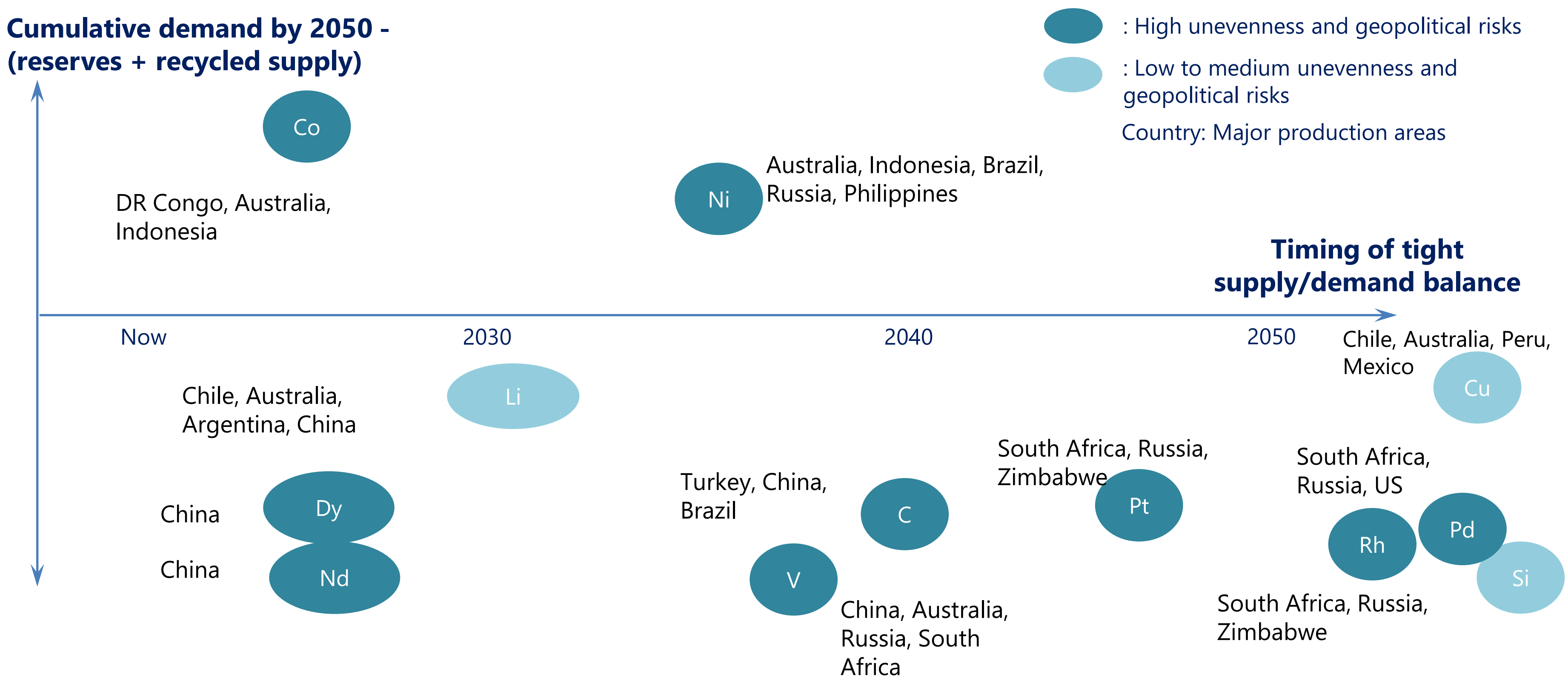
Estimate cumulative demand and reserves (+ recycled supply) for Lithium



Source: IEEJ, IEEJ Outlook 2023

Which "critical mineral" is truly critical?

- Cumulative demand of Ni and Co will exceed supply until 2050.
- Li, Co, Dy, and Nd may have supply at an earlier timing.
- Ni, Co, graphite, platinum group metals, Nd, Dy, and V have uneven geographical distribution.



Note: Cu (copper), Li (lithium), Si (silicon), Ni (nickel), Co (cobalt), C (graphite), Pt (platinum), Pd (palladium), Rh (rhodium), Nd (neodymium), Dy (dysprosium), V (vanadium). Source: IEEJ Outlook 2023

Policy actions for resource security

- Actions to secure critical minerals are accelerating in the US, Canada, Europe, and Australia.

Examples of critical mineral policies in the US and the EU

	US	Europe (EU)
Strategy	America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition (2022)	European Action Plan on Critical Raw Materials (2020)
Resource conservation, recycling	Support for strengthening domestic supply network ($675M, 2022) R&D Support ($30M, 2021)	Circular Economy Action Plan (2020) Battery R&D Support (€3.2B, 2019)
Expanding supply, stockpiling	Support for strengthening domestic supply network ($675M, 2022) Tax cuts under the Inflation Reduction Act (2022) R&D Support ($30M, 2021) Support under the Infrastructure and Jobs act (2021)	European Raw Materials Alliance (2021)
International cooperation, expansion	Critical Mineral Mapping Initiative (US, Canada, Australia)	EU External energy engagement in a changing world (2022) Minerals Security Partnership (2022, Europe, US, Canada, Australia, Japan, Korea)

Source: IEA, Critical Mineral Policy Tracker, as of June 2023

Critical mineral policies by Japan

New International Resource Strategy (2020)

- Includes strengthening rare metals security for industrial competitiveness as one of the pillars.
- Establishes measures to secure critical minerals
- Promotes diversification of supply sources
- Reviews stockpiling programs
- International cooperation to secure resources
- Stronger industrial base

Policy on Initiatives to Ensure Stable Supplies of Critical Minerals (2023)

- Aims to secure the minerals required to meet 2030 domestic production goals for storage batteries (150GWh) and permanent magnets.
- Support for securing resources and developing technologies overseas.
  - Exploration and feasibility study support; Mine development support; Support for smelting businesses; Technology development support (higher efficiency and lower cost in smelting)

Economic Security Promotion Act (2022)

- Includes securing a stable supply of critical minerals as a pillar.
- Designates 11 specific critical commodities by Cabinet Order.
  - Antimicrobial medications, fertilizers, **permanent magnets,** machine tools and industrial robots, aircraft components, semiconductors, **storage batteries**, cloud applications, natural gas**, critical minerals**, and ship components.

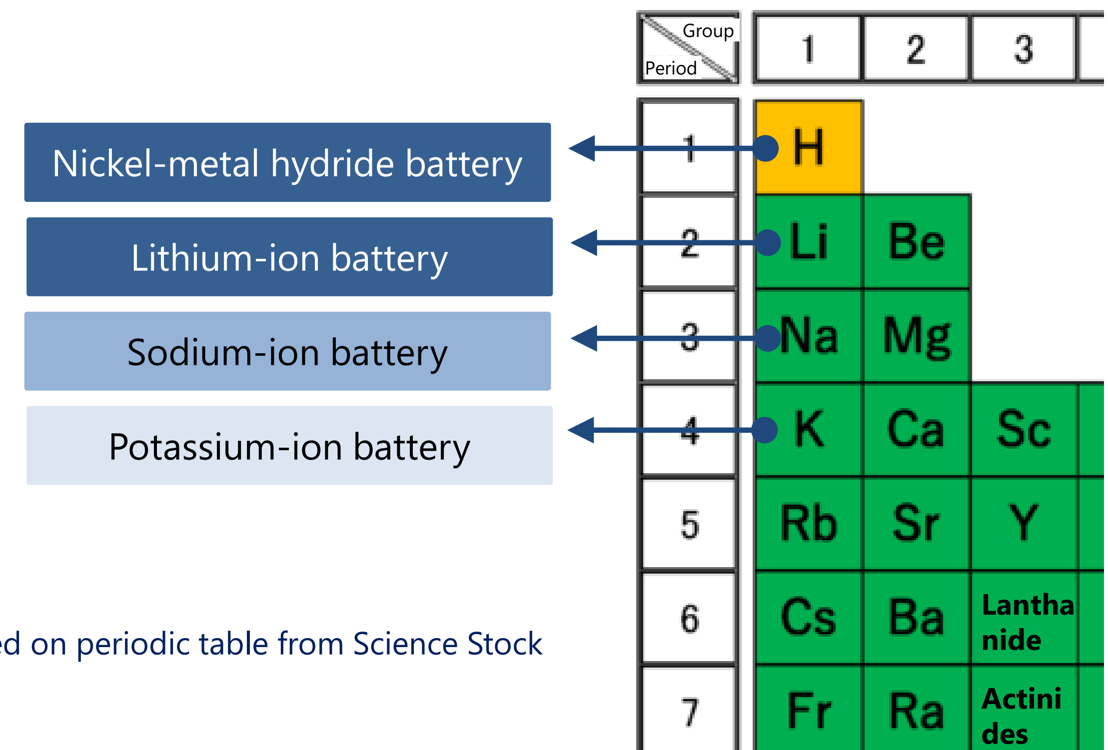
Japan-U.S. Critical Minerals Agreement (2023)

- Adheres to free trade between the two econmies.
- Cooperation on global supply chain problems and disruptions.
- Cooperation to build sustainable supply chains (transparency, environmental protection, labor conditions, etc.)

Potential alternative technologies

- Progress is being made in developing batteries using alternative materials in place of lithium, which has uneven distribution.
- Commercialization of sodium-ion batteries, for instance, would effect major changes in the risks related to battery materials.

Periodic table and battery potential



Source: compiled based on periodic table from Science Stock and other sources.

Potential of recycling

- Recycling is technically possible, but many used items are exported overseas.
- Major challenges to promote recycling are:
  - Efficient collection of products from the market.
  - Disassembling the product and extraction the critical minerals.
  - Incremental cost to pursue the recycling vis-à-vis procuring new materials

Material flow of lithium and nickel for lithium-ion batteries in Japan

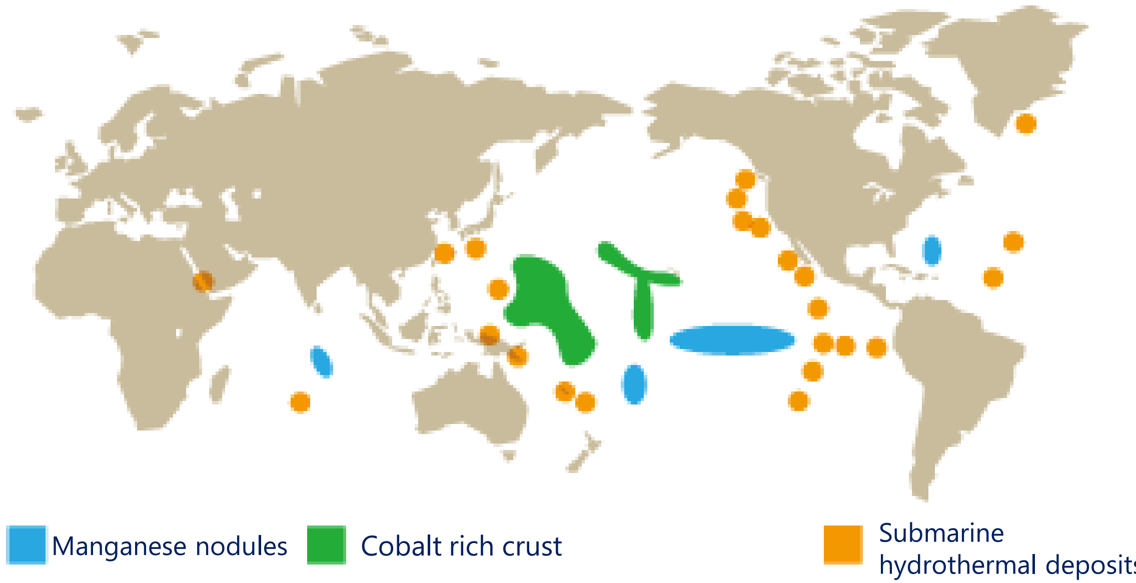
Net tonnes		Lithium	Nickel
Final product input		765 tons	2,549 tons
Used volume collected [a]		246 tons	660 tons
	Exported used	127 tons	600 tons
	Wasted	108 tons	17 tons
	Recyclable raw material [b]	11 tons	43 tons
	Domestic recycling rate [b]/[a]	4%	7%

Source: Mitsubishi UFJ Research and Consulting, Summary of Results of the FY2022 Survey on Mineral Resources Recycling Flow/Stock, March 10, 2022.

Possibility of marine resources

- The presence of mineral resources has been confirmed in the Asia Pacific, and initiatives are taking place to develop them.

■Global distribution of deep-sea bottom mineral resources



Manganese nodules: widely distributed on flat regions of the seabed at depths of 4,000 to 6,000 meters. The main components are iron and manganese, and also includes nickel, copper, and cobalt.
Cobalt-rich crusts: found widely between 500 and 6,000 meters depth. The main components are iron and manganese, and also includes cobalt, nickel, tellurium, platinum, and rare earth minerals.
Submarine hydrothermal deposits: polymetallic sulfide deposits are formed when metallic components precipitate from hydrothermal fluids erupting on the seabed. They consist of copper, lead, zinc, gold, and silver, and also contain rare earth metals such as germanium and gallium.

Source: based on data from Deep Ocean Resources Development Co.

Conclusions

- High uncertainty exists in both demand and supply for the future.
  - Timely and accurate statistical information and its regular updates are necessary.

- Criticality of each critical minerals needs to be closely analyzed.
  - For truly critical minerals, policy intervention for stable supply is necessary, whereas for non-critical critical minerals, market mechanisms should be utilized.
  - Vigorous resource and technology development is taking place, whose success (or failure) could have a significant impact on the future supply and demand of critical minerals..

- Major policy actions to ensure stable supply of truly critical minerals are to reduction of require volume, development of alternatives, recycling, stockpiling, and assistance to exploration and processing capacities.