National
Qualifications
2026

X826/76/11 Environmental Science
Paper 1 — Supplementary source booklet

WEDNESDAY, 22 APRIL
12:45 PM – 1:30 PM

Supplementary sources of information

Source A is a diagram showing known locations of polymetallic nodule deposits.

Source B describes zones and energy sources in ocean waters.

Source C shows images of polymetallic nodules.

Source D is a diagram showing steps in the proposed polymetallic nodule collection process.

Source E shows information about commercially desirable minerals.

Source F shows some minerals used in the renewables sector and their current supply risk.

Source G shows uses of selected minerals in clean energy technologies.

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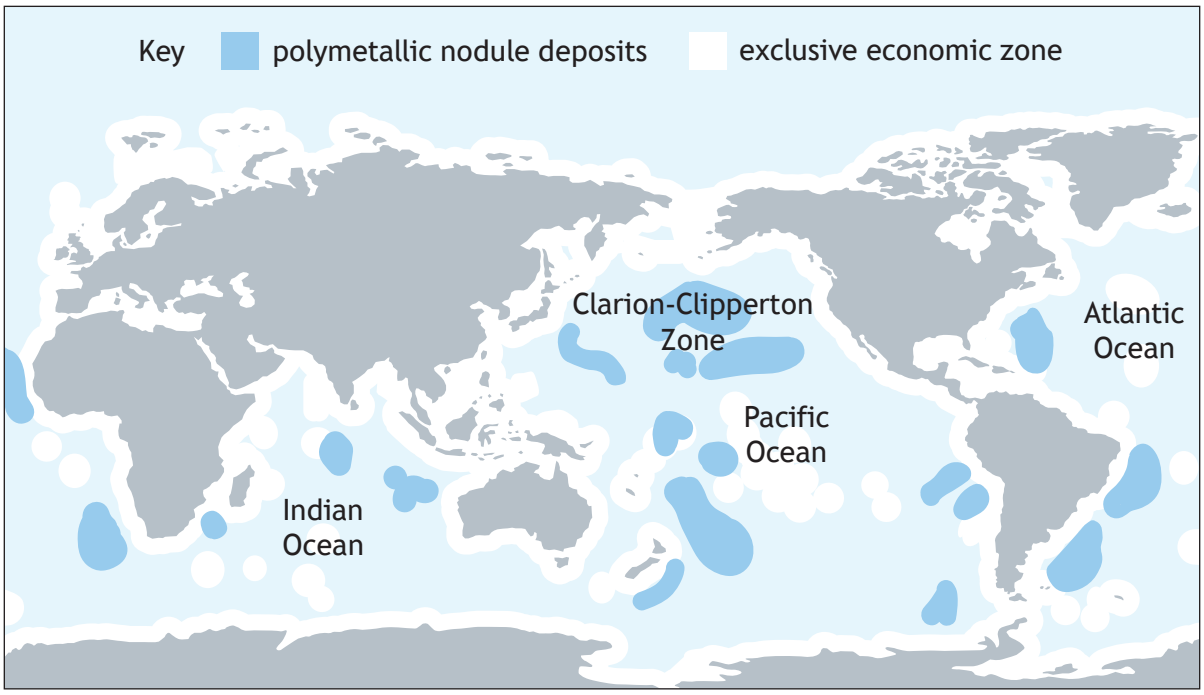
Source A A diagram showing known locations of polymetallic nodule deposits



Source B Zones and energy sources in ocean waters

The marine water column is divided into three major zones based on depth and light penetration:

- the **photic** zone (0–200 m depth) — light penetration, which reduces with depth
- the **twilight** zone (200–1000 m) — very little light penetration
- the **aphotic** zone (>1000 m) — no light penetration.

Despite the complete absence of light in the aphotic zone, it is thought to support a high biodiversity. Many species are rare and/or highly adapted for survival in this zone.

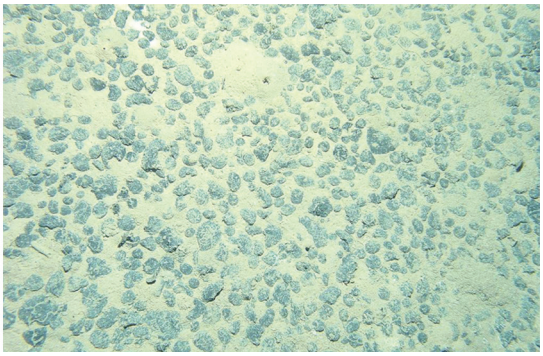
It is estimated that less than 1% of primary productivity at the surface reaches the deep seabed. This is in the form of 'marine snow' (organic and inorganic debris) sinking down from the photic zone. Marine snow is a vital energy source for organisms living on or in the seabed, and is important for the overall functioning of the marine ecosystem and the global carbon cycle.

Heterotrophs present in the aphotic zone use bioluminescence (light emitted from chemical reactions) or vibration sensitivity to find mates, catch prey, or evade capture, and many communicate and navigate by sound.

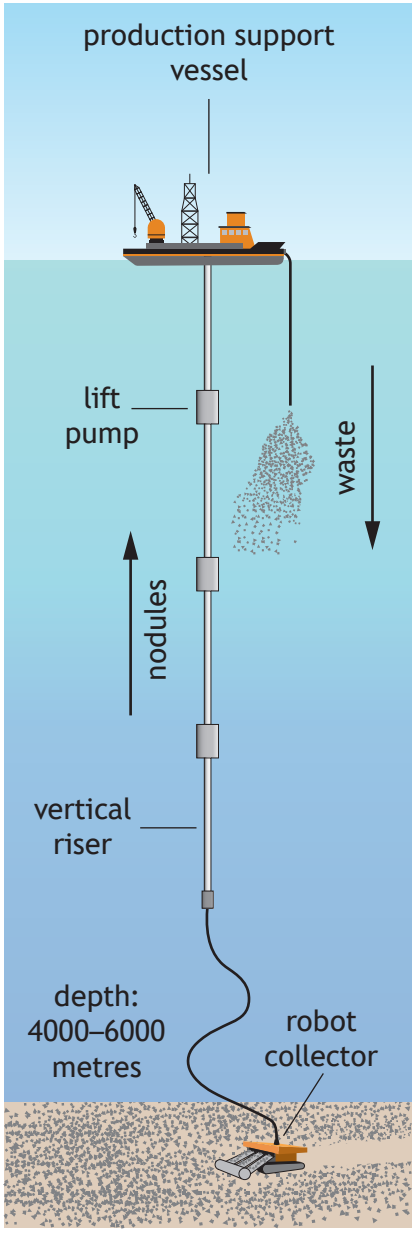
Source C Images of polymetallic nodules

(a) example of a polymetallic nodule

(b) polymetallic nodules on the seabed



Source D A diagram showing steps in the proposed polymetallic nodule collection process



not to scale

3. The collected materials will be cleaned on the production support vessel.
   The nodules will be separated out and retained.
   Wastewater, sediments, and biota will be discharged into the photic zone.
   The nodules will be shipped to a shore-based processing unit to extract the metals.

2. A lift pump and vertical riser system will raise the nodules and any attached sediments or biota to the production support vessel.

1. The 16 m wide robot collector will remove the top 10 cm of the seabed.
   The nodules will be sifted out.
   Around 90% of the collected seabed sediments will be discharged behind the collector.
   These should settle out within a few hundred metres.

Source E Information about commercially desirable minerals

Mineral	Information
Manganese	• Abundance in the continental crust of 950 parts per million (ppm). • Extracted onshore using open cast mining or underground mining. • Can be recycled but recycling rates are low due to abundance and relatively low cost of manganese ore.
Nickel	• Abundance in the continental crust of 84 ppm. • Extracted onshore using open cast mining. • Can be recycled but is complex and expensive, so only economically feasible if the global market price of nickel ore is high.
Copper	• Abundance in the continental crust of 60 ppm. • Mostly extracted onshore using open cast mining. • Can be recycled without any loss of quality.
Cobalt	• Abundance in the continental crust of 25 ppm, usually in association with copper or nickel. • Is often a by-product of copper and nickel mining, so supply relies on global copper and nickel prices. • Can be recycled efficiently using new technology that reduces high energy costs and dangerous waste.

Source F Some minerals used in the renewables sector and their current supply risk

Very high risk	High risk	Moderate risk	Low risk	Very low risk
• rare earth metals	• magnesium • niobium • germanium • scandium	• strontium • cobalt • platinum • graphite	• vanadium • lithium • tungsten • titanium • gallium	• manganese • chromium • zirconium • nickel • copper

Source G Uses of selected minerals in clean energy technologies

Clean energy technology	Mineral			
	Manganese	Nickel	Copper	Cobalt
Electricity networks			✓	
Solar (photovoltaic)		✓	✓	
Electric vehicles	✓	✓	✓	✓
Wind turbines	✓	✓	✓	
Other low emissions power generation	✓	✓	✓	✓
Grid battery storage	✓	✓	✓	✓
Hydrogen technologies		✓	✓	✓

[END OF SUPPLEMENTARY SOURCE BOOKLET]

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