Deep Sea Minerals and Mining in the Pacific Islands region

"National DSM Stakeholder Consultation Workshop"

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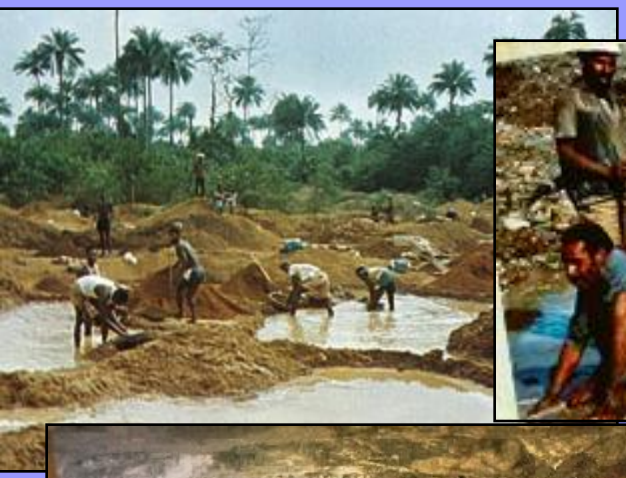
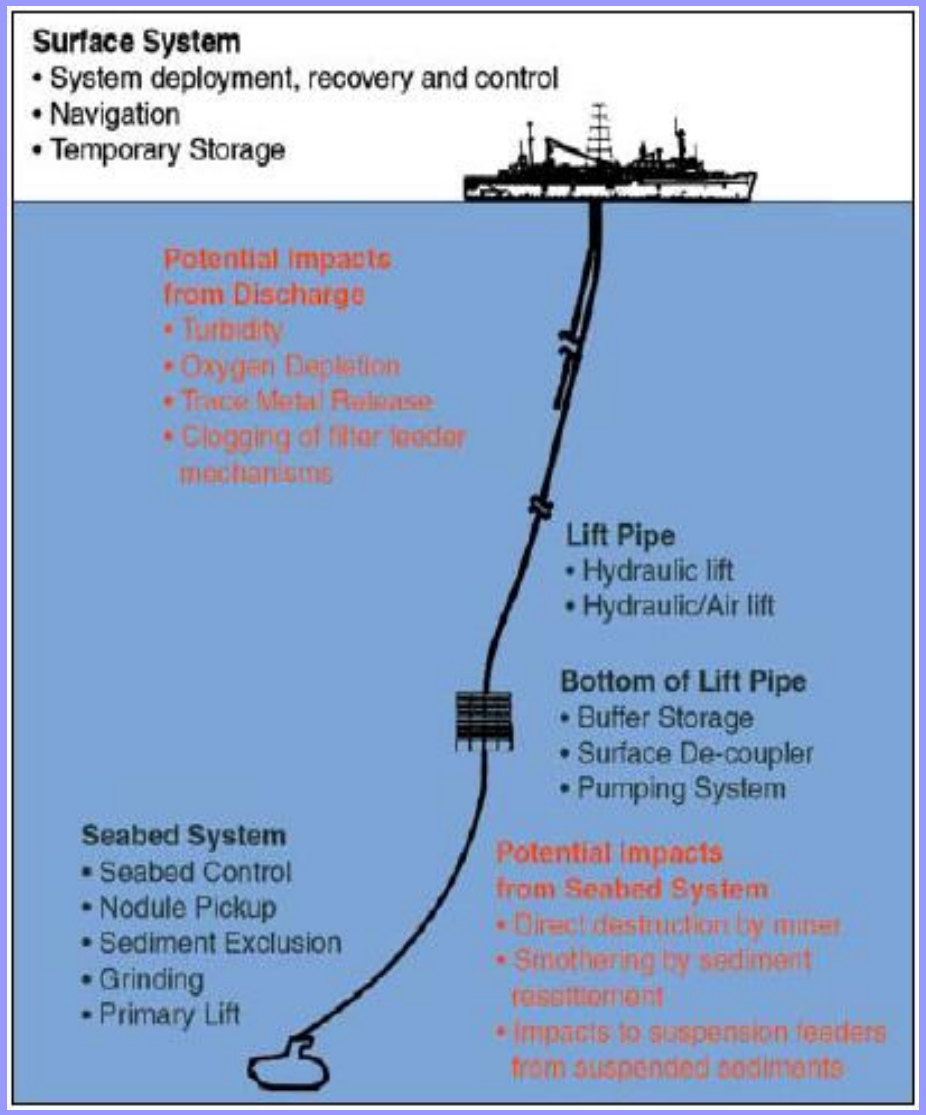


Mining History…

- On-land mining methods:
  - Alluvial Mining: PNG, Solomon Islands
  - Underground mining: e.g. Vatukoula Gold Mine, Fiji
  - Open pit: e.g. Ok Tedi Copper Mine, PNG; Gold Ridge, Solomon Islands.
- Marine mining is a relatively new method of developing mineral deposits and ongoing since the 1960s;
- Deep sea mining is a new frontier in mineral development.

Trend of Marine Mineral Exploration in the Region

- 1960s – Mid 1970s: Manganese Nodules;
- Mid – Late 1970s: Manganese Nodules, Precious Coral, Metalliferous Sediments, Phosphate.
- 1980 – 1983: Ongoing assessment of Manganese Nodules, Precious Coral, Metalliferous Sediments, Phosphate.
- 1981: Commencement of Cobalt-rich Crust exploration;
- 1984 – 1987: Ongoing assessment of Manganese Nodules;
- 1982 and 1984 – discovery of hydrothermal vents in the Lau Back-arc Basin.
- 1991 – confirmation of high grade Seafloor Massive Sulphide (SMS) deposits in the Manus Basin PNG by the CSIRO.



1985-2005 Japan-SOPAC Survey

PNG, Solomon Islands, Vanuatu, Fiji, Tonga, Samoa, Niue, Cook Islands, Kiribati, Tuvalu, FSM, Marshall Islands

1st phase: 1985 - 1999

2nd phase: 2000 - 2005

Recent Offshore Exploration in the Region

- **Nautilus Minerals:**

  - Canadian Company but Australian based.

  - Currently exploring in PNG, Solomon Islands, and Tonga.

- **Bluewater Metals:**

  - a subsidiary of Neptune Minerals (US) and based in Australia.

  - Exploring in PNG, Solomon Islands, Vanuatu, and Tonga.

- **Korea Ocean Research and Development Institute (KORDI)**

  - Exploring in Tonga and Fiji.

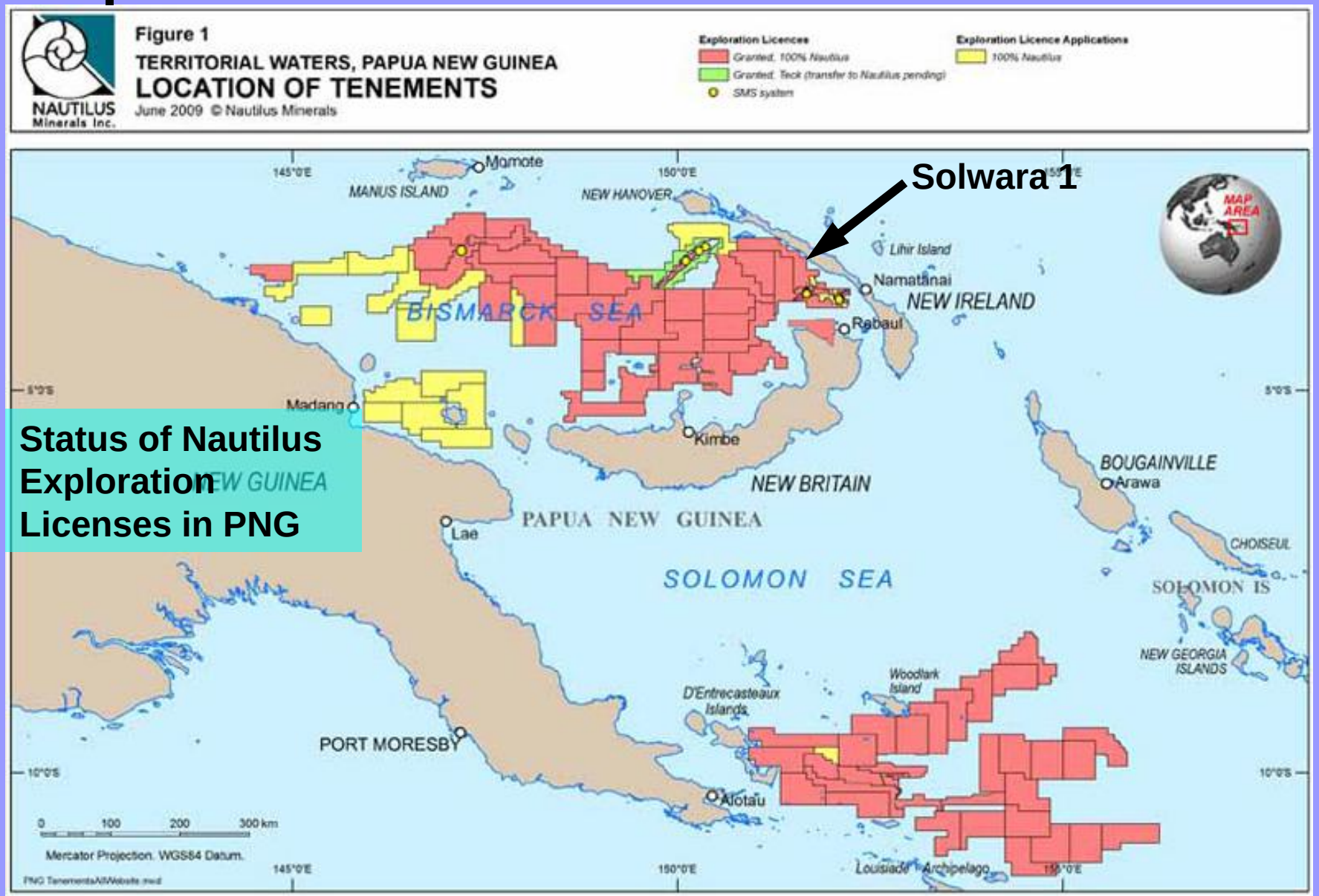
Tenement Holdings of Companies

Company	Granted (km^2)	Application (km^2)
Nautilus Minerals	450,462	276, 980
Neptune Minerals (NZ)	450,600	200,000
KORDI	20,000	-
Bluewater Metals	146,000	-
Total	**1,067,062**	**476,980**

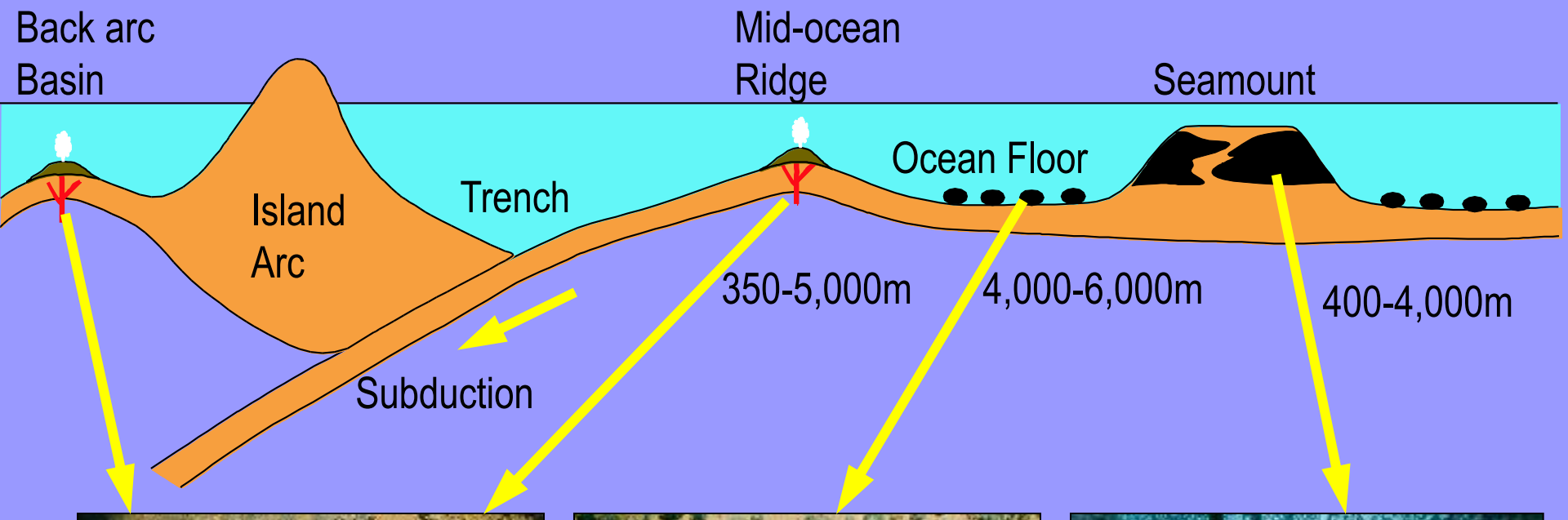
- Total land area of PICs: 550,000km^2

Nautilus SMS Exploration in PNG

- Central Manus Basin - first SMS deposit discovered in the region in 1986.



Deep Sea Minerals Occurrence



SMS Deposit

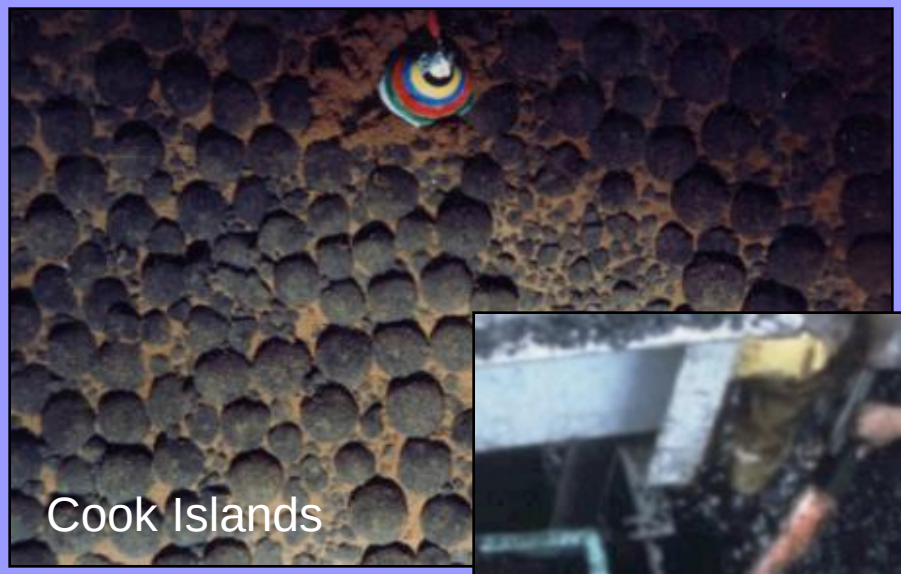
Manganese Nodules

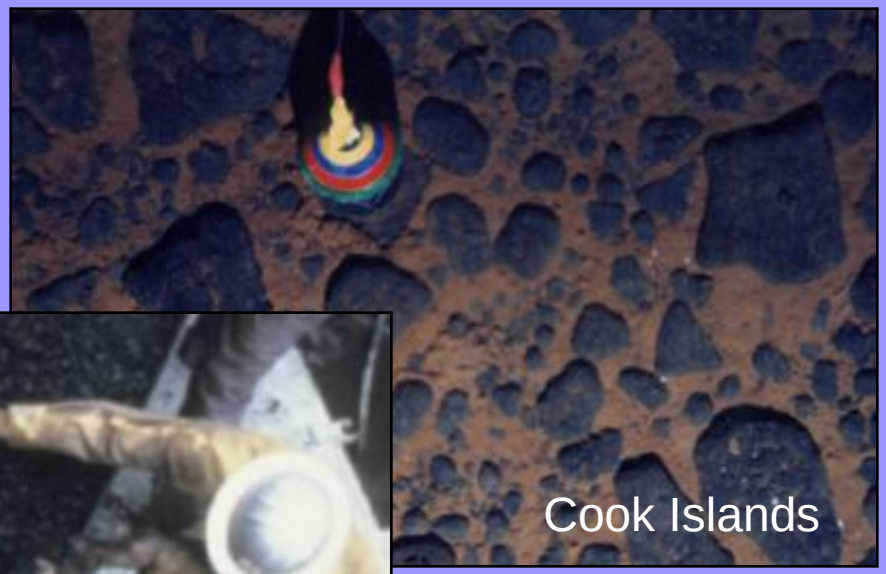
Cobalt-rich Crust

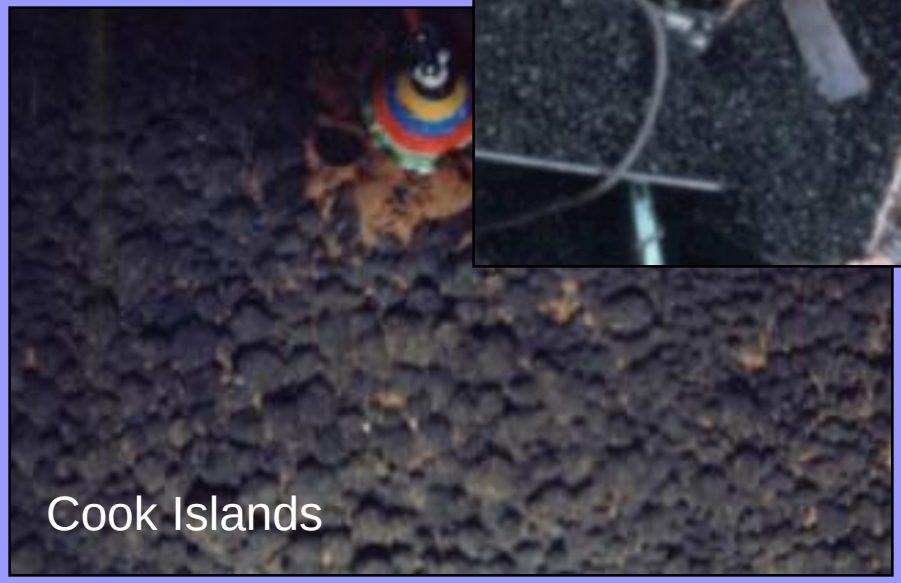
Manganese Nodules and Cobalt-rich Crusts

	Manganese Nodules	Cobalt-rich Crust
Where they occur?	All oceans	Flanks of volcanic islands and seamounts
Mode of Occurrence	Nodular and encrustations	Widespread but thin encrustation on the rock surface
Depth (m)	4,000 – 6,000	400 – 4,000
Major Minerals	Manganese (20 %), Iron (14 %),	Manganese, Iron
Minor Minerals	Nickel (0.55%), Copper (0.35%), Cobalt (0.25%)	Nickel, Cobalt (0.5 – 2.5%), Platinum

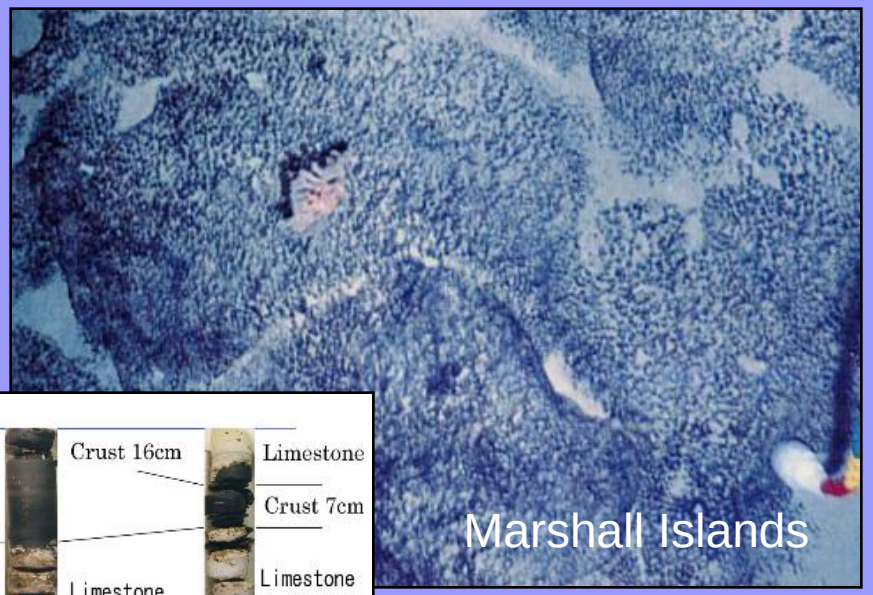
Manganese Nodules

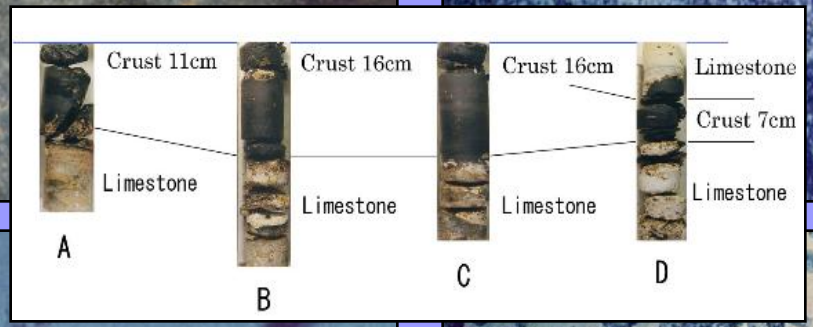


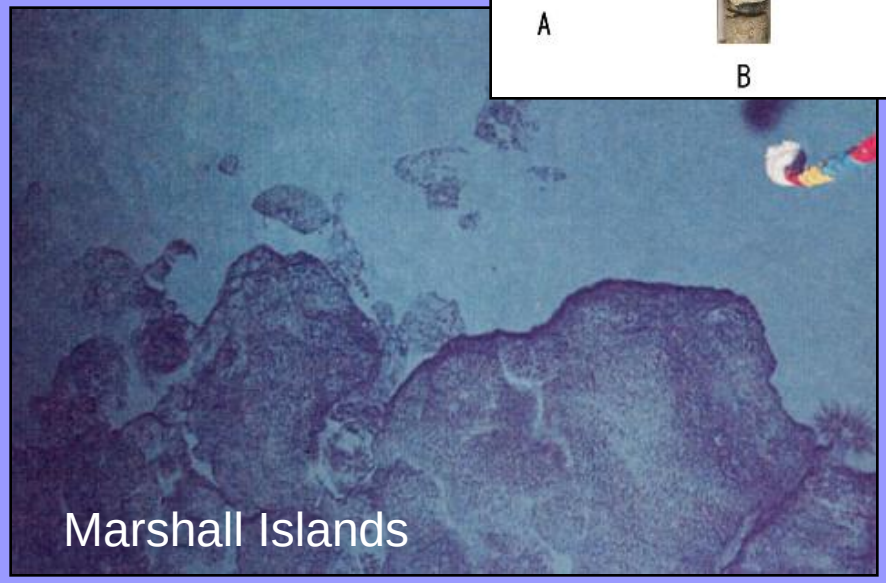


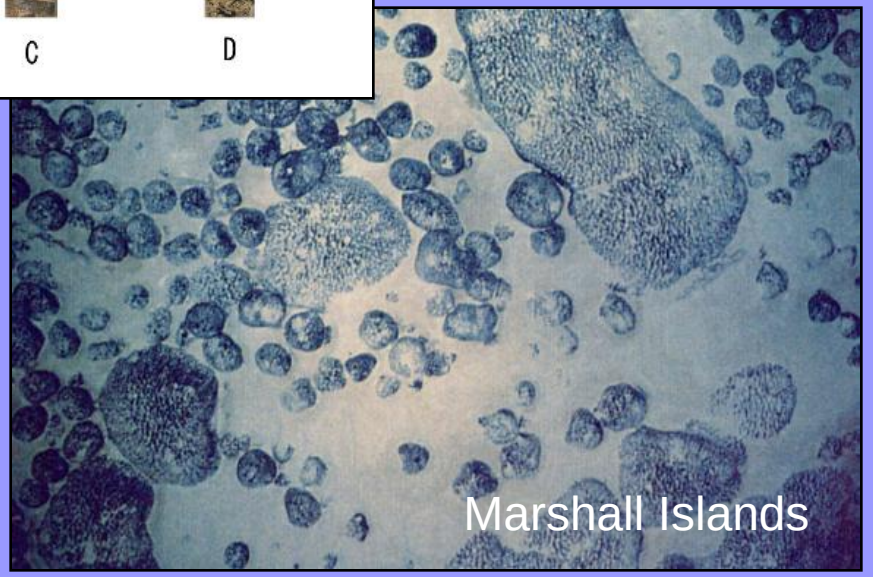


Cobalt-rich Crusts



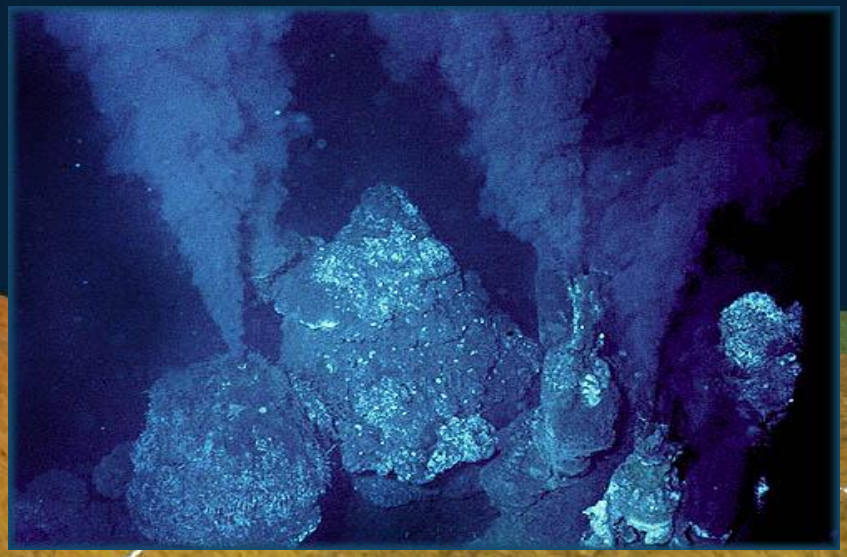






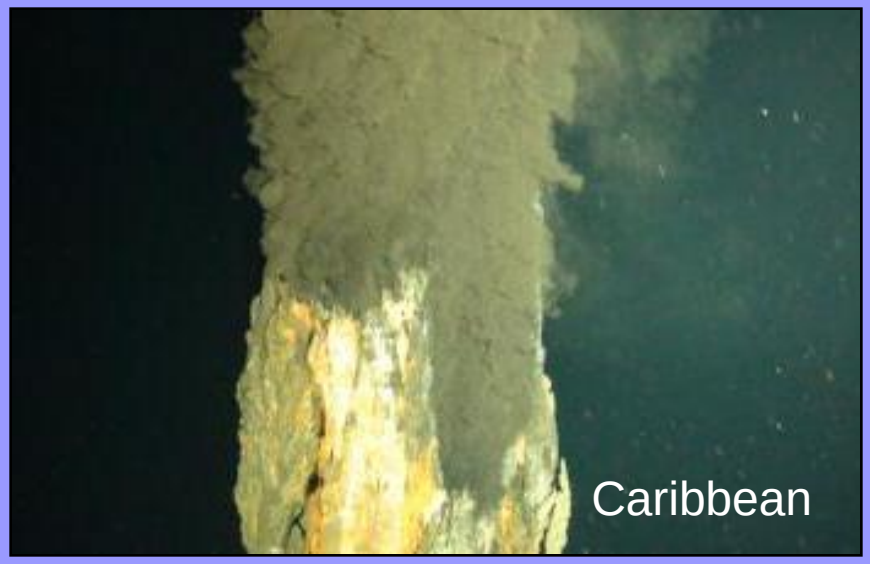
Seabed 1581.47m Cam 1420.70m E 399010.81m N 9581030.87m

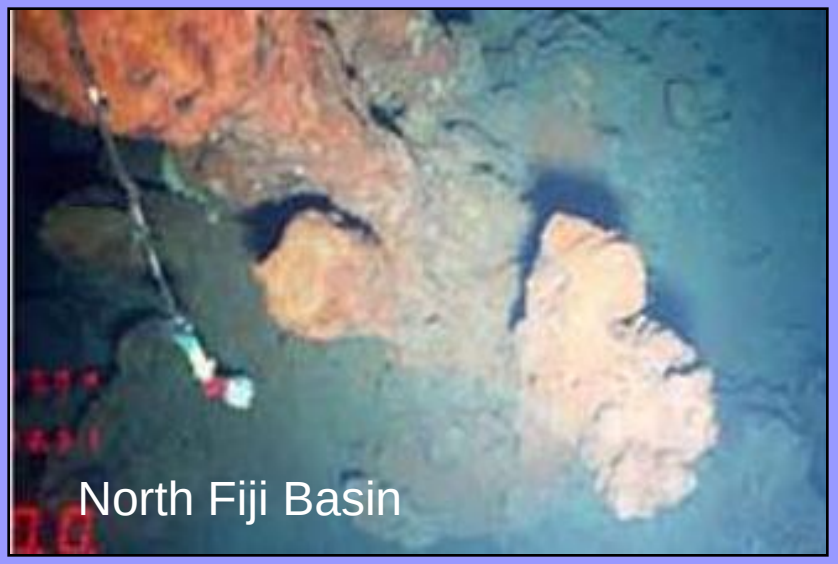
SMS Deposits

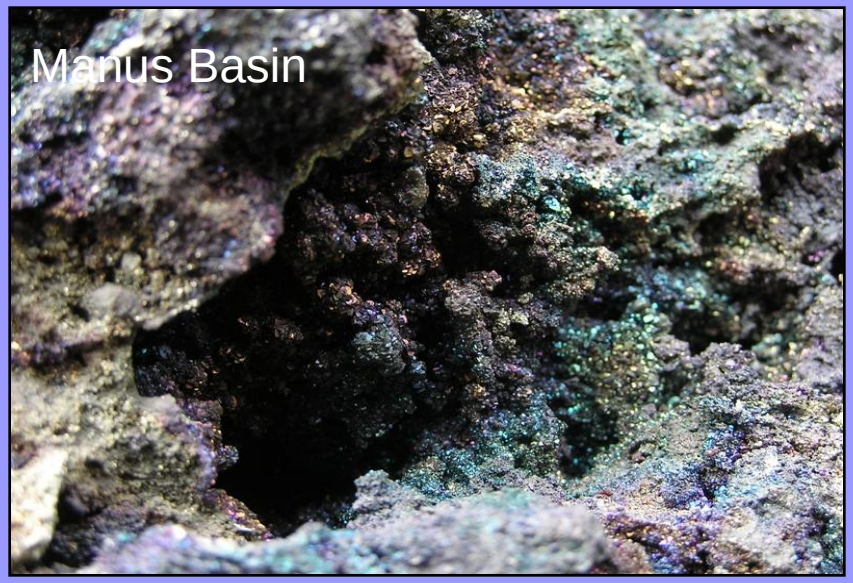


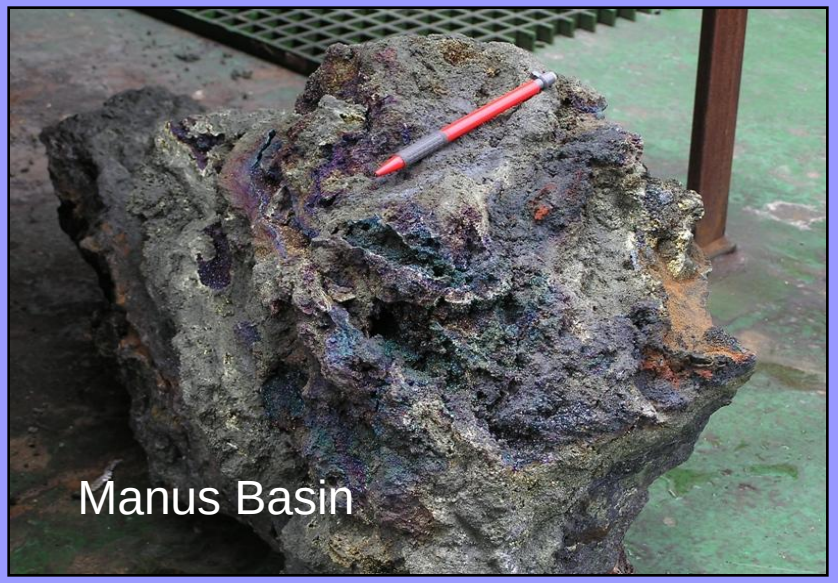
- Often associated with submarine volcanoes or volcanic activity.
- Form in different settings:
  - Mid-Ocean Ridges (e.g. Mid-Atlantic Ridge).
  - Back-Arc Basins (e.g. Manus Basin, Lau Basin).
  - Fore-Arc Volcanic Ridges (e.g. Kermadec Ridge – north of NZ).
- Found in water depths of 350m – 3,700m (latest discovery at 5,000m in the Caribbean).
- More than 200 seafloor hydrothermal vent sites have been discovered world-wide.

Seafloor Massive Sulphide







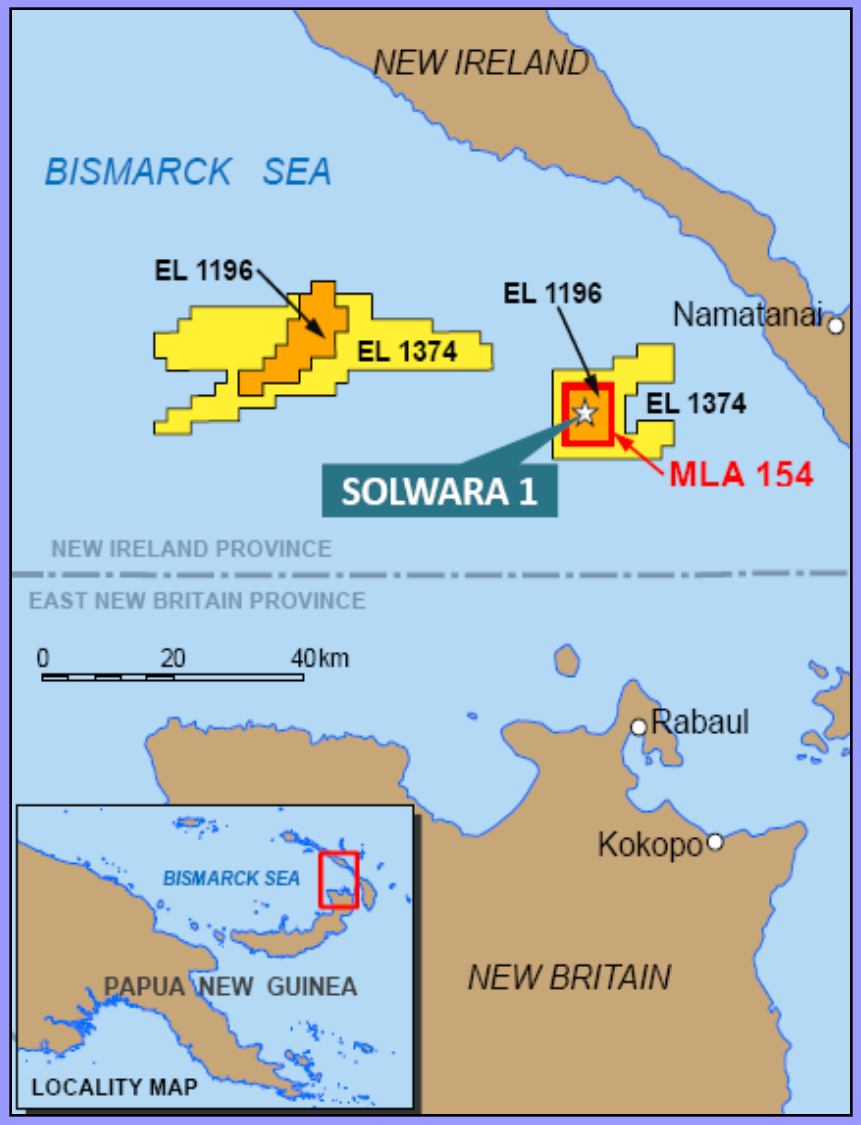


Mineral Occurrence in the Region

Country	MN	CRC	SMS
Kiribati	√	√	
Cook Islands	√		
Tuvalu	√	√	
Samoa		√	
Tonga			√
PNG			√
Solomon Islands			√
Vanuatu			√
Fiji			√
Marshall Islands		√	
Federated States of Micronesia		√	
Niue	√	√	

- **No economic potential for Metalliferous Sediment, Precious Coral and Phosphate**

PNG – Solwara 1 Resource Definition



- High resolution bathymetry and Sidescan Sonar;
- Geophysical surveys (magnetic, electromagnetic and seismic);
- Grab surface sampling (using ROVs);
- Video camera (using ROVs);
- Drilling (diamond core);
- Geotechnical testing of drill core;
- Metallurgical test of ore material;
- Independent resource estimation;
- Environmental Impact Study.

Resource Estimates Comparison

Potential and Operating Mines	Type of Deposit	Resource (Mt)	Average Grade				
			Cu (%)	Zn (%)	Pb (%)	Au (g/t)	Ag (g/t)
Triple Junction (Fiji)	SMS	0.5 (Inferred)	6.93	0.61	-	0.85	24.39
Solwara 1* (PNG)	SMS	0.87 (Indicated)	6.8	0.4	-	4.8	23
		1.3 (Inferred)	7.5	0.8	-	7.2	37
Whim Creek ~ (WA)	VMS	3.4	1.6	1.3	0.2	-	8.6
Kidd Mine ^ (Canada)	VMS	115	2.2	5.77	0.25	-	75
Ok Tedi Mine (PNG)	Porphyry Cu-Au	910 (resource & reserve)	0.8	-	-	1.0	-

* (Golder Associates, 2008); ~ (Collins et al, 2004); ^ (Wilton, 1998)

Economic Issues

- SMS deposits are higher in mineral content than on-land deposits:

Metal	On-land	SMS
Copper	0.5-2%	5-15%
Gold	0.6-8g/t	2-20g/t
Zinc	5-20%	5-50%
Lead	5-20%	3-23%

- Typical value of a tonne of land based ore: US$50-180.
- Typical value of a tonne of SMS ore: US$800-1500.
- One full mining operation could produce export revenues of up to US$500m pa and taxes/royalties of up to US$50m pa.

Benefits of Offshore Mining

- **Host country and the region will benefit:**

(1) Wealth worth millions of dollars will be generated.

(2) Significant share of the wealth shall be returned to government and the people through tax revenues, royalty and employment.

(3) Mining revenue will enable government to stimulate other economic sectors.

(4) Indirectly supporting other local economic activities.

(5) Contribute to a well educated labour force.

(6) Increase in labour mobility.

Deep Sea Mining a Possibility?

- Viability of offshore mining hinges on:
  - world demand;
  - commodity prices;
  - technological development (mining and processing);
  - sound environmental management.
- Any offshore mining operation has to compete with terrestrial mining;
- Previous studies revealed mining of manganese nodules and CRC are not feasible but these may not be the case;
- Recent studies of SMS deposits have indicated excellent potential for mining.

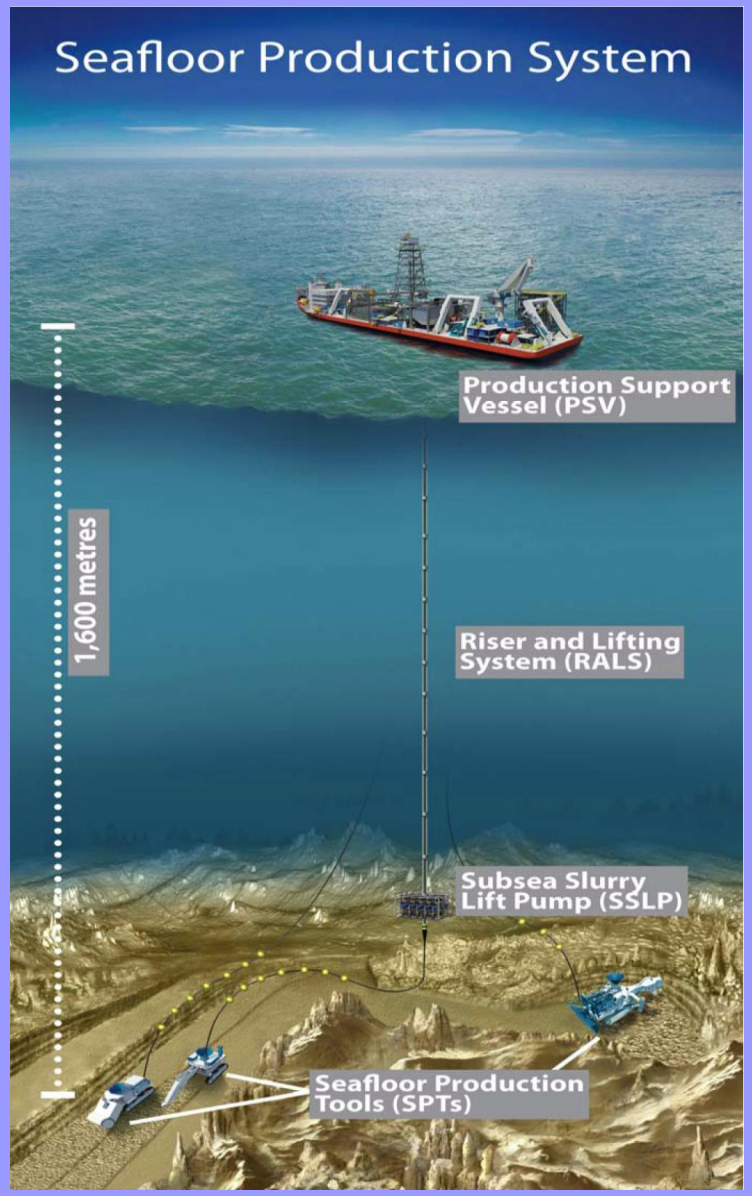
Mining Technology Development

- Rapid expansion of marine technology in the 1990s driven by:
  - military and marine research;
  - gas and oil production;
  - relatively shallow marine mining (i.e. diamond mining in Africa).

- Extensive use of Remotely Operated Vehicles (ROVs) in offshore diamond mining in Africa (e.g. Namibia and South Africa);

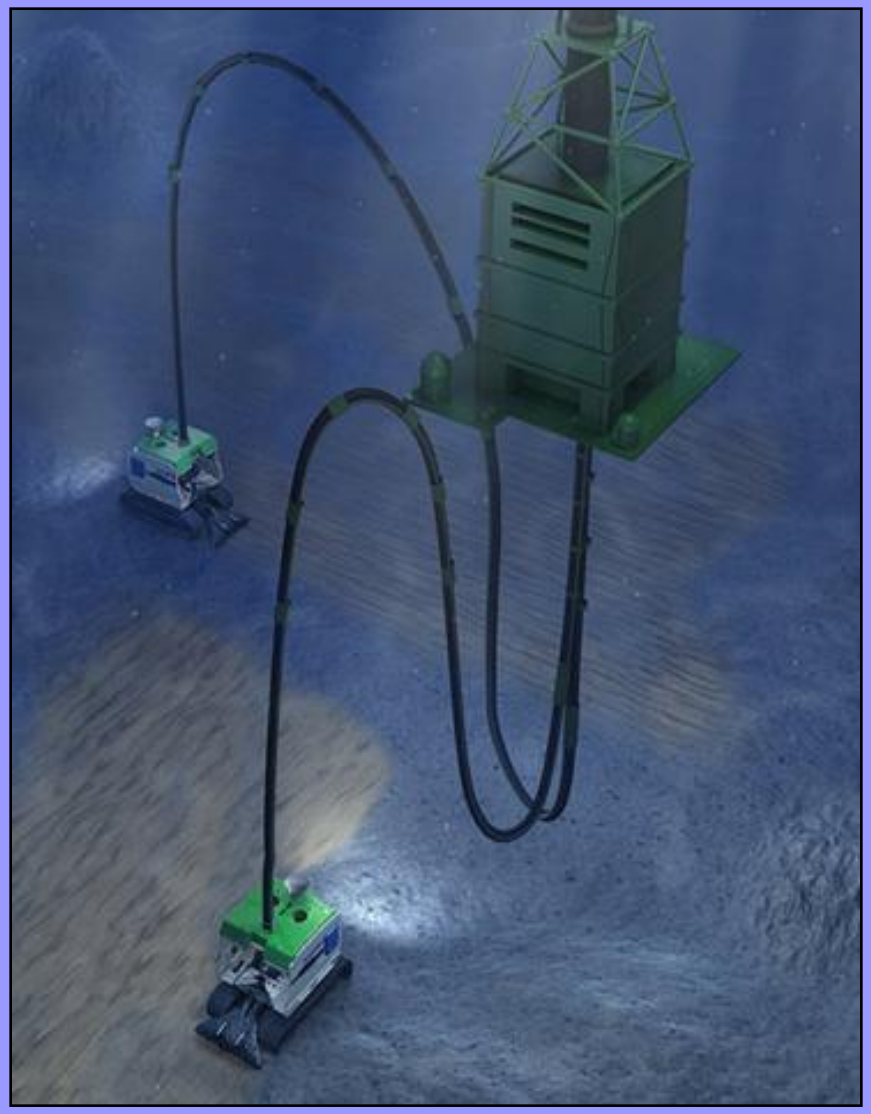
- Existing mining technologies are transferable to deep sea mining including the use of ROVs.

Recent Technology Development - Nautilus



- Design for mining MS deposits:
  - Mining Support Vessel (MSV)
  - Riser and Lifting Systems (RALS)
  - Seafloor Mining Tools (SMT)
- The pioneering of deep sea mining in the region will lead to improved deep sea mining technology in the future.
- The development of new seabed mining technologies will increase the economic viability of Manganese Nodules and Cobalt-rich Crust deposits.

Ocean – the Overburden that won't go away

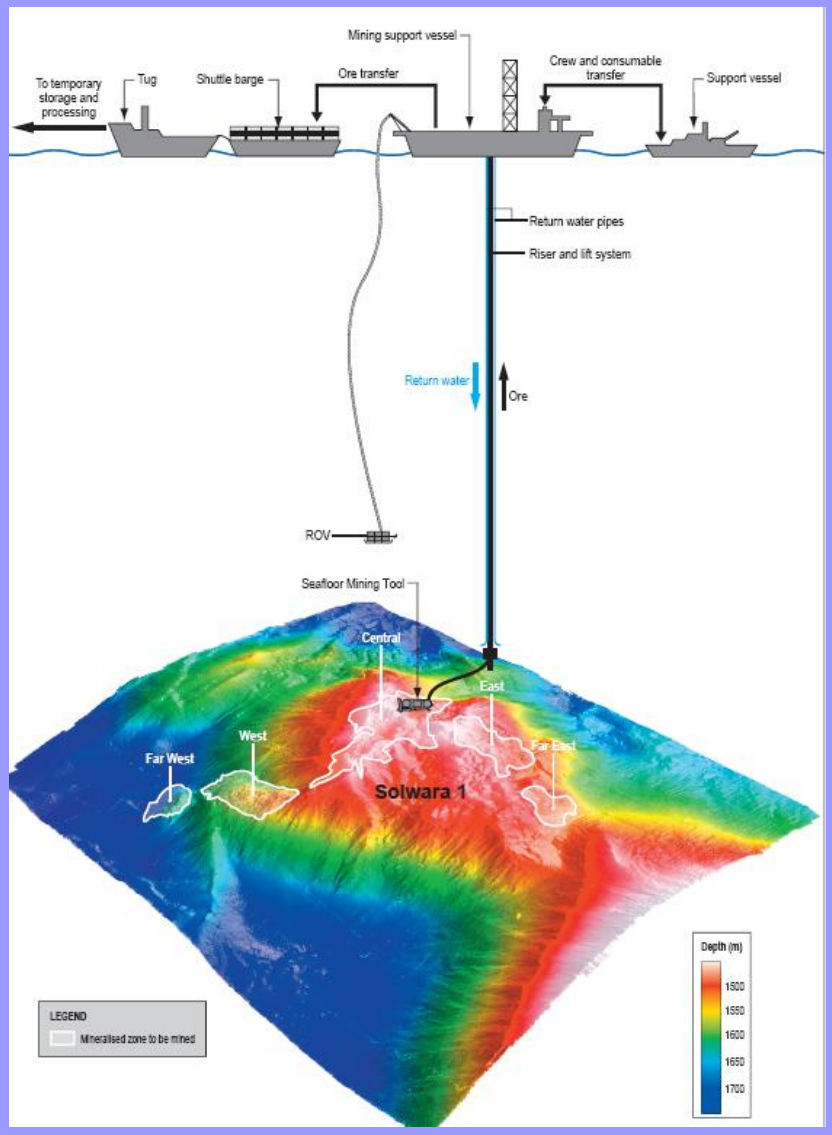


- Any mining operation has to constantly deal with the overlying huge body of seawater.
- Ocean cannot be shifted elsewhere for easy access to seabed minerals.
- Significant distance (i.e. water depth) separates the mineral deposit from the mining platform.
- Need to develop robust seabed mining tools including the ore lifting system to ensure environmentally sound mining practice.
- Mining and hoisting processes will demand reasonable amount of energy and time.

Comparison of Terrestrial and Offshore Mining

Terrestrial	Marine
Significant overburden	Huge water body (ocean) that needs to be dealt with
Generate significant amount of waste (overburden, tailings, leachates)	Reasonably less amount of waste generated
Huge footprint	Small footprint (SMS) Reasonable footprint (MN & CRC)
Often isolated and difficult to access	Located with national EEZ
Huge infrastructure development	Far less infrastructure to be built
Acid Rock Drainage	Sulphuric acid cannot form in ocean (seawater being “alkaline”)
Complex resource ownership system	Common heritage of the nation
Reasonable knowledge of environment	Limited knowledge of environment

Recent Developments on DSM



- PNG has granted Nautilus Minerals with the world's second deep sea mining lease in January 2011.
- Nauru (NORI) and Tonga (TOML) registered companies have been granted exploration license in the International Seabed Area (the Area).
- PICs such such Kiribati, Samoa, Tuvalu and Fiji have shown interest to participate in exploring 'the Area'.

Clarion-Clipperton Fracture Zone