Deep Sea Minerals: A New Development Opportunity for the Pacific?

5th Regional DSM Training Workshop
Rarotonga Cook Islands
13th – 16th May 2014

Akuila Tawake
SOPAC Division, SPC
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, Lihir Gold Mine, PNG; Gold Ridge, Solomon Islands.

- Deep sea mining is a new frontier in mineral development.
From Exploration to Ore Processing…

- Exploration
  - Exploration license
- Advanced Exploration
- Feasibility
  - EIA, Environmental approval
  - Mining license
- Construction
- Extraction
  - Permits, enforcement, consent conditions, monitoring, EIA commitments
- Rehabilitation
- Processing
  - (milling, smelting, refining)
- Use
Global Deep Sea Minerals Occurrence

Unconfirmed vent fields

Mid-ocean ridge
- Active
- Unconfirmed

Arc volcano
- Active
- Unconfirmed

Back-arc spreading center
- Active
- Unconfirmed

Intra-plate volcano & Other
- Active

Source: S. Beaulieu, K. Joyce, and S.A. Soule, 2010, Interridge and Woodshole
Deep Sea Minerals Occurrence

- Back arc Basin
- Mid-ocean Ridge
- Seamount
- Island Arc
- Ocean Floor
- Trench
- Subduction

- SMS Deposit
- Manganese Nodules
- Cobalt-rich Crust

- Depth ranges:
  - 350-5,000m
  - 4,000-6,000m
  - 400-4,000m
Small Island and Big Ocean Pacific States

- Pacific Island Countries (PICs) have a total area of 38.5 million km$^2$ of EEZ compared to a land area of around 550,000 km$^2$ (a ratio of 70:1);
- Additional 2.0 million km$^2$ in Extended Continental Shelf;
- In the last 40 years, SOPAC in collaboration with partners, have been involved in DSM activities;
- DSM have been discovered within the EEZ of many PICTs.
## Mineral Occurrence/Potential in the Region

<table>
<thead>
<tr>
<th>Country</th>
<th>MN</th>
<th>CRC</th>
<th>SMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiribati</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Cook Islands</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuvalu</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Samoa</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Tonga</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>PNG</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Solomon Islands</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Vanuatu</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Fiji</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Marshall Islands</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Federated States of Micronesia</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Palau</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Niue</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>

*No economic potential for Metalliferous Sediment, Precious Coral and Phosphate*
Recent Exploration and DSM Interest

- Exploration companies that are active in the region:
  - Nautilus Minerals
  - Bluewater Metals
  - Korea Institute of Ocean Science and Technology (KIOST)

- Exploration licenses are issued in PNG, Tonga, Solomon Islands, Fiji and Vanuatu.

- Nauru and Tonga have sponsored foreign companies to conduct DSM exploration in the International Seabed Area (‘the Area’);

- Kiribati has established and supported its own company to conduct exploration in ‘the Area’.
Economic Issues

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

<table>
<thead>
<tr>
<th>Metal</th>
<th>On-land</th>
<th>SMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>0.5-2%</td>
<td>5-15%</td>
</tr>
<tr>
<td>Gold</td>
<td>0.5-8g/t</td>
<td>2-20g/t</td>
</tr>
<tr>
<td>Zinc</td>
<td>5-20%</td>
<td>5-50%</td>
</tr>
<tr>
<td>Lead</td>
<td>5-20%</td>
<td>3-23%</td>
</tr>
</tbody>
</table>

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

Attractive High Grades for Deep-Ocean Deposits, e.g. Copper:

Mean composition of Nautilus Solwara 1 marine mine compared to all major types of land-based copper deposits
### Value of Selected Metals in 1 tonne of Cobalt-rich Crusts from the Central Pacific

<table>
<thead>
<tr>
<th>Metal</th>
<th>Mean Price of Metal (2011 $/kg)</th>
<th>Mean Content in Crusts (g/tonne)</th>
<th>Value in Tonne of Ore ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt</td>
<td>$2,760.00</td>
<td>6899</td>
<td>$272.20</td>
</tr>
<tr>
<td>Dysprosium</td>
<td>$2,760.00</td>
<td>60</td>
<td>$165.60</td>
</tr>
<tr>
<td>Cerium</td>
<td>$81.00</td>
<td>1605</td>
<td>$130.01</td>
</tr>
<tr>
<td>Titanium</td>
<td>$10.30</td>
<td>12035</td>
<td>$123.96</td>
</tr>
<tr>
<td>Europium</td>
<td>$5,210.00</td>
<td>13</td>
<td>$65.13</td>
</tr>
<tr>
<td>Nickel</td>
<td>$20.74</td>
<td>4125</td>
<td>$42.49</td>
</tr>
<tr>
<td>Zirconium</td>
<td>$64.00</td>
<td>618</td>
<td>$39.55</td>
</tr>
<tr>
<td>Platinum</td>
<td>$55,299.20</td>
<td>0.5</td>
<td>$27.65</td>
</tr>
<tr>
<td>Tellurium</td>
<td>$360.00</td>
<td>60</td>
<td>$21.60</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>$34.90</td>
<td>445</td>
<td>$15.53</td>
</tr>
<tr>
<td>Copper</td>
<td>$8.91</td>
<td>896</td>
<td>$7.98</td>
</tr>
<tr>
<td>Total</td>
<td>--</td>
<td>--</td>
<td>$911.70</td>
</tr>
</tbody>
</table>

(USGS, 2011)
## Uses of Metals in Marine Minerals

<table>
<thead>
<tr>
<th>Metal</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>Generators, fuels cells, electrical appliances, transformers for renewable energy technologies, mobile phones, computers, transportation, etc</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Mobile phones, laptops, super alloys, hybrid car batteries, artificial joints, etc</td>
</tr>
<tr>
<td>Nickel</td>
<td>Stainless steel, high nickel alloy, Chemicals and Batteries, Catalysts, etc</td>
</tr>
<tr>
<td>Manganese</td>
<td>Steel production, rechargeable batteries, animal feed, plant fertilizer, bactericide in waste water treatment, etc</td>
</tr>
<tr>
<td>REEs</td>
<td>Smart phones, flat TV screens, advanced military technology, permanent magnets for wind power generation, hybrid vehicles, fuels cells, etc</td>
</tr>
</tbody>
</table>

E.g. of REEs: Cerium, Neodymium, Samarium, Europium, Terbium
Drivers of Marine Minerals Development

- Increasing global demand for metals;
- High metal prices;
- Decreasing metal concentration in terrestrial mineral deposits;
- High concentration of certain metals in offshore mineral deposits;
- Significant improvement in marine mining technologies;
- Increasing demand for non-traditional metals such as REE.
Copper: mine production 1800 - 2000 showing average output growth rates and background events.

- Electrification
- World Wars
- Reconstruction
- Oil Hike
- Internet
- Chinese factor

World Demand for Copper Has Never Declined

Data: BGS

2005

2012
How PICTs will Benefit from Offshore Mining?

- Opportunity to participate in a new economic sector;
- Revenue generation;
- Employment;
- Opportunity for revenue saving scheme (sustainability opportunity);
- Stimulation of other economic sectors;
- DSM can contribute to poverty alleviation.
## Comparison of Terrestrial and Offshore Mining

<table>
<thead>
<tr>
<th>Terrestrial</th>
<th>Marine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant overburden</td>
<td>Huge water body (ocean) that needs to be dealt with</td>
</tr>
<tr>
<td>Generate significant amount of waste (overburden, tailings, leachates)</td>
<td>Reasonably less amount of waste generated</td>
</tr>
<tr>
<td>Huge footprint</td>
<td>Small footprint (SMS) Reasonable footprint (MN &amp; CRC)</td>
</tr>
<tr>
<td>Often isolated and difficult to access</td>
<td>Located with national EEZ</td>
</tr>
<tr>
<td>Huge infrastructure development</td>
<td>Far less infrastructure to be built</td>
</tr>
<tr>
<td>Acid Rock Drainage</td>
<td>Sulphuric acid cannot form in ocean (seawater being “alkaline”)</td>
</tr>
<tr>
<td>Complex resource ownership system</td>
<td>Common heritage of the nation</td>
</tr>
<tr>
<td>Reasonable knowledge of environment</td>
<td>Limited knowledge of environment</td>
</tr>
</tbody>
</table>
SPC-EU Deep Sea Minerals Project
Objective: to strengthen the system of governance and capacity of Pacific ACP States in the management of deep-sea minerals through:

(i) development and implementation of sound and regionally integrated legal frameworks;

(ii) improved human and technical capacity, and

(iii) effective monitoring systems.

Four Key Result Areas of the Project:

• (1) Regional Legislative and Regulatory Framework (RLRF) for offshore minerals exploration and exploitation;

• (2) National DSM policy, legislation and regulations;

• (3) Building national capacities – supporting active participation of PICs nationals in deep sea mineral activities; and

• (4) Effective management and monitoring of offshore exploration and mining operations.
Development of Regional and National DSM Framework

Pacific ACP States Regional Legislative and Regulatory Framework (RLRF) for Deep Sea Minerals Exploration and Exploitation

In the 2012 Forum Communiqué, Leaders expressed their appreciation to the SPC and the EU for the work carried out under the DSM Project.

Development of National DSM Policy, Legislation and Regulations
Capacity Building Initiatives

- Regional Training Workshops
- Legal Internship
- Short-term training attachments
- Data and database management training
- Participation in international DSM seminars / conferences
- Multi-stakeholder training
DSM Project
Communication and
Information Sharing

- Regional and national stakeholder consultation workshops;
- Project reports;
- Information brochures;
- Newsletters and media releases;
- DSM documentaries.
- Community awareness
- DSM Project webpage http://www.sopac.org/dsm
Proposed Way Forward for the Region

- A regional collaborative approach is considered the best way forward;
- Consider the whole cycle of DSM activities;
- Address regional / national issues highlighted in stakeholder consultations;
- SPC is well placed to continue to take a lead role in the DSM Sector;
- SPC to collaborate with international organisations: USP, SPREP, ISA, USGS, NIWA, UNEP/GRID, etc;
- DSM Project Phase 2 to be funded through EDF11, GIZ, etc