Industrial Uses of Major Metals that occur on the Seabed

A summary of the uses of major metals that occur in seabed polymetallic mineral deposits is tabulated below:

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
<th>Uses</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>Mn</td>
<td>Manganese is a metal with important industrial metal alloy uses</td>
<td>Found often in combination with iron, and in many other minerals</td>
</tr>
<tr>
<td>Nickel</td>
<td>Ni</td>
<td>Chalky-white to black in color, and in some cases, the most valuable of all metallic elements</td>
<td>Nickel is magnetic, and is often found in combination with cobalt</td>
</tr>
<tr>
<td>Copper</td>
<td>Cu</td>
<td>Copper is malleable and ductile, a good conductor of heat, and a very poor conductor of electricity</td>
<td>Minerals such as the sulphides: chalcocite (Cu2S), bornite (CuFeS2), covellite (CuS), chalcocite (Cu2S) are sources of copper</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Co</td>
<td>Used in the production of magnetic, wear- and high-strength alloys as are the electrical, communications, aerospace, and engine tool manufacturing industries</td>
<td>Cobalt is usually not mined alone, and tends to be produced as a by-product of nickel and copper mining activities</td>
</tr>
<tr>
<td>Iron</td>
<td>Fe</td>
<td>Iron is a grey or black metallic element and is the most widely used of all the metals, accounting for 95% of worldwide metal production.</td>
<td>Iron can be found in many other minerals</td>
</tr>
<tr>
<td>Gold</td>
<td>Au</td>
<td>Used as money, a store of value and in jewellery. Pure gold is too soft for ordinary use and is typically hardened by alloying with copper or other base metals.</td>
<td>It is a highly sought-after precious metal and occurs as nuggets or grains in muds.</td>
</tr>
<tr>
<td>Silver</td>
<td>Ag</td>
<td>Used in many industries, the major ones being jewellery, ornamental, and alloys.</td>
<td>It has the highest electrical conductivity of any element and the highest thermal conductivity of any metal.</td>
</tr>
</tbody>
</table>

Conclusion

Based on previous exploration results, the potential of deep sea metals that occur on the seabed within national jurisdictions of PICs are variable ranging from mere mineral occurrences to highly prospective zones. With increased geological knowledge and confidence mineral resources can be upgraded from which the explorability of any deposits become clearer.

Recent interest in deep sea mining is mostly confined to Seafloor Massive Sulphides (SMS) and this is because of the exceptionally high metal grades associated with SMS compared to Manganese Nodules and Cobalt-rich crusts. However, with the generally increasing trend of commodity prices coupled with the development of new seabed mining technologies the economic viability of manganese nodules and cobalt-rich crust deposits may also be realised in the foreseeable future. If this happens, many PICs are expected to become involved with and benefit from the extraction of seabed minerals.

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Exploration History

Ever since the discovery of polymetallic Nodules in the Atlantic Ocean in 1873, there has been persistent curiosity about seafloor minerals. It was not until after World War II that significant effort was placed on exploring Manganese Nodules in response to increased demand for metals during the post-war economic boom.

In the Pacific Islands region, marine minerals exploration was at a modest level until the early 1970s when increased in metal prices and the need for secure supplies of strategic minerals generated renewed interest in deep sea minerals. SOPAC was engaged in deep sea minerals exploration in the region between the early 1970s to mid-2000 in partnership with Pacific Island countries and multinational agencies.

Exploration History

This information brochure presents a general overview of deep sea minerals exploration history and their potential in the Pacific Islands region today.

Resource Economic Potential

Manganese Nodules

- Mid 1970s – Mid 1980s: Manganese Nodules, Precious Coral, Metaliferous Sediments, Phosphates
- 1980: Commencement of Cobalt-rich crust exploration in the Phoenix Islands, Kiribati
- 1982 and 1984: Discovery of hydrothermal vents in the Lau Back-arc Basin
- 1985: Discovery of SMS deposit in the Manus Basin PNG
- 1991: High base and precious metal grades in SMS deposits were confirmed in the Manus Basin by the Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- 1997: Exploration license was issued to Nautilus by the government of PNG for SMS exploration in the Manus Basin
- 2005: Nautilus commenced SMS exploration in the Manus Basin PNG
- 2011: Nautilus was granted a mining license by the PNG Government.

Cobalt-rich Crust

Based on geological, geophysical, and geochemical conditions, the central equatorial Pacific offers the best potential for crust mining, particularly within the EEZ of Johnston Island (USA), the Marshall Islands, and international waters in the Mid-Pacific Seamounts. The BEZ of French Polynesia, Kiribati, and the Federated States of Micronesia must also be considered as potential crust locations (Figure 4) and minor occurrences of crusts have also been recorded in Tuvalu, Samoa and Niue.

Cobalt-rich crust mining is much more technologically challenging than Manganese Nodule mining as crusts are attached to rock substrates. For successful mining, it is essential to recover crusts without collecting substrate materials, which would significantly dilute the ore grade. Cobalt is the most important of the elements in nodules and crusts with respect to the price and as a strategic metal that is indispensable for superalloys used in jet aircraft engines. A 1985 preliminary economic assessment of crust mining and processing operations concluded that they were not at that time economically viable.

Seafloor Massive Sulphide

More than 200 sites of hydrothermal mineralisation are known to occur on the seafloor and based on previous exploration and resource assessments about ten of these deposits may have sufficient size and grade to be considered for future mining.

These potential sites include the Atlantis II Deep in the Red Sea (Saudi Arabia & Sudan), Middle Valley (Canada), Explorer Ridge (Canada), Galapagos Rift (Ecuador), and the East Pacific Rise 13°N in the Pacific Ocean, the TAG hydrothermal field in the Atlantic Ocean, as well as the Manu Basin (Papua New Guinea), the Lau Basin (Tokelau), the Daveson Basin (Fiji), and the North Fiji Basin (Fiji) in the western and south-western Pacific (Figure 5). All of these sites except two (East Pacific Rise 13°N and TAG hydrothermal field) are located within the EEZs of coastal states.

Apart from PNG, Fiji and Tonga, SMS deposits or indications of SMS deposits are also reported to have occurred with the waters of Solomon Islands, Vanuatu and Palau. Ongoing exploration and resource evaluation of these areas continues.