Manganese nodules as a possible source of precious metals

In the earth system, the precious metals include silver (Ag), gold (Au) and Platinum Group Elements (PGE) consisting of platinum (Pt), palladium (Pd), rhodium (Rh), iridium (Ir), ruthenium (Ru) and osmium (Os). There are no comprehensive data on PGE in sedimentary environments. Marine geochemistry of Pt and Ir shows that both the elements are relatively enriched in manganese nodules with concentrations of up to 900 ppb and 7 ppb respectively (compared with ~ 3 ppb Pt and 0.2 ppb Ir in pelagic clays). Pt and Ir are incorporated into hydrogenous Fe–Mn oxyhydroxide minerals, and these phases might control the distribution of Pt and Ir in manganese nodules as well as in sediments. It is also observed that Ir and Pt enrichments in oceanic sediments are accompanied by enhanced Fe, Mn, Cu and Ni concentrations.

Compared to Pt concentration in the earth’s upper continental crust (5 ppb), the oceanic manganese nodules contain, on an average, 100 times more Pt. It is observed that relative to sea water, the manganese encrustations and nodules contain, on an average, ~10⁷ times more Pt. Also, while the Pt/Pd ratio in sea water is about 4.5, that of extraterrestrial iron meteorites varies between 2 and 10 and that of manganese nodules varies between 23 and 42. Enrichment of PGE, especially of Pt and Ir, in oceanic sediments therefore serves as excellent fingerprints of inputs from extraterrestrial sources.

A. K. BIYANI1*  
S. K. GUPTA2

1Department of Geology,  
2Department of Zoology,  
D. B. S. College,  
Dehradun 248 001, India  
*For correspondence

7. Shiva, V. and Jalees, K. Suljam, River Linking Project: Right Approach or Hallow Claim, Navdhanya, New Delhi, 106.
extraterrestrial matter as seen at the K–T boundary.

Manganese crusts and nodules from the Pacific Ocean are distinctly enriched in Pt concentration that varies between 6 and 940 ppb. Samples from shallower regions (<200 m) tend to have higher Pt values than those from deeper ones (>2000 m). Pt concentration in Pacific seamount crusts varies between 0.14 and 1.02 ppm (avg. 0.51 ± 0.24 ppm). A weakly positive relationship between Pt and Mn, Ni and Co in these crusts might suggest that Pt is partially incorporated in the Mn-oxide fraction. This correlation pattern also suggests that Pt has an atomic bond of multiple nature. Pt concentration in the manganese crusts and nodules could be explained by assuming co-precipitation of Pt with colloidal ferromanganese flocks, possibly by surface adsorption of [PtCl₆]⁻ complexes onto positively charged amorphous Fe-hydroxide particles. However, detailed thermodynamic studies are necessary to establish this concept more clearly. It is postulated that two immediate sources may be responsible for the Pt concentration in the oceanic manganese crusts and nodules, namely sea water and cosmic spherules.

Table 1. Estimated quantity and cost of three precious metals (Pt, Pd and Ag) in the manganese nodules at Central Indian Ocean covering an area of about 75,000 km²

<table>
<thead>
<tr>
<th>Element</th>
<th>Maximum (ppb)</th>
<th>Minimum (ppb)</th>
<th>Mean (ppb)</th>
<th>Tonnage (million tons)</th>
<th>Total cost (billion Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt</td>
<td>300</td>
<td>245</td>
<td>273</td>
<td>0.0002</td>
<td>122</td>
</tr>
<tr>
<td>Pd</td>
<td>3668</td>
<td>3668</td>
<td>3668</td>
<td>1.404</td>
<td>635</td>
</tr>
<tr>
<td>Ag</td>
<td>1869</td>
<td>1869</td>
<td>1869</td>
<td>0.0007</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 2. Comparison of concentration of a few precious metals in the manganese deposits of the Indian Ocean and Pacific Ocean

<table>
<thead>
<tr>
<th>Element</th>
<th>Indian Ocean⁸,⁹</th>
<th>Central Pacific Ocean¹⁰</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
</tr>
<tr>
<td>Pt</td>
<td>300</td>
<td>245</td>
</tr>
<tr>
<td>Pd</td>
<td>3668</td>
<td>3668</td>
</tr>
<tr>
<td>Ag</td>
<td>1869</td>
<td>1869</td>
</tr>
<tr>
<td>Rh</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

In addition, it is also estimated that 0.4 million tons of REE (including 0.3 mt of Ce)¹¹, 0.2 million tons of Mo and 0.3 million tons of Pb could be present in the Indian nodule mine site at CIB. Although the projected economic implications of the Indian Ocean manganese nodules, as the possible source of a large quantity of precious metals cannot be correctly evaluated based on a limited set of data, it points to the possibility of existence of a huge economic potential in these nodules, which has not been looked into so far, and needs further detailed investigation.

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RANADIP BANERJEE

Geological Oceanography Division, National Institute of Oceanography, Dona Paula, Goa 403 004, India
e-mail: banerjee@daryag.nio.org