Lecture 14

Heap Bioleaching Technology For Nickel

Keywords: Polymetallic Schist, Heap Bioleaching, Talvivaara Experience

Heap bioleaching of a polymetallic nickel ore at Talvivaara, Finland.

Talvivaara deposits located 350 Km south of the Arctic circle in Finland comprise of one of the largest nickel sulfide resources. The deposits are situated in the southern part of the early Proterozoic schist belt and the Ni-Cu-Co-Zn mineralizations are part of a high-grade, meta morphosed black schist, consisting of micas, quartz, graphite and sulfides. Sulfide minerals such as pyrite, pyrrhotite, sphalerite, pentlandite, chalcopyrite and violarite are present with an average composition of 0.23% Ni, 0.50% Zn, 0.13% Cu, 0.02% Co, 10.3% Fe and 8.4% S.

Bioheap leaching was considered as the most economic option. In May 2005, a 17,000 tonnes on-site pilot heap was started with initial heap bioleaching in August 2005. In April 2008, ore mining started at open pit and in July 2008, heap bioleaching was started. Metal sulfides through bioleaching were produced in October 2008.

The ore is crushed and screened in four stages into p80 < 8 mm. Materials less than 10 mm were agglomerated for heap bioleaching in the presence of sulfuric acid. After agglomeration, ore is stacked eight meters high on primary pad for about 18 months for bioleaching. The heaps were aerated and irrigated from the top. After this period, the leached ore was restacked on secondary heap to leach metals further through a secondary heap leach cycle.

Indigenous microorganisms are used and viable conditions for bacterial growth created in the heaps.[85 – 86]
Heap bioleaching conditions are summarized below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ore supply</td>
<td>25 Mtpa</td>
</tr>
<tr>
<td>Particle size</td>
<td>P 80 – 8 mm</td>
</tr>
<tr>
<td>Temperature</td>
<td>20 – 80°C</td>
</tr>
</tbody>
</table>
| Duration      | 13 – 14 months for primary  
               | 3.5 years for secondary. |
| Acid consumption | 15 Kg / tonne and 2 Kg / tonne for primary and secondary heaps. |
| Heap dimensions | 8m high (dynamic) for primary.  
                   | Secondary permanent pad (4 x 15m). |

Bioleaching tests with black schist samples were carried out with iron and sulfur – oxidizing acidophilic bacteria which included both mesophiles and thermophiles. Water samples and bioleach solutions were found to contain many of the above microbes.

The following organisms were detected in column tests at acidic pH.

- *Acidithiobacillus ferrooxidans*
- *At. thiooxidans*
- *A.caldus*
- *Leptospirillum ferrooxidans*
- *Ferrimicrobium*
- *Sulfobacillus*
- *L.ferriphilum*
- *Ferroplasma*

Bacterial inoculum for the pilot heap was from near-by metal-rich ponds and the enrichment was grown on sulfur, ferrous ions as well as the ore. Enrichment culture contained *At.ferrooxidans*,...
L. ferrooxidans and At. caldus. During some periods of leaching, moderate thermophiles like At. caldus and Sulfobacillus thermosulfidooxidans were observed to be dominant. Photographs illustrating heap bioleaching at Talvivaara are shown in fig. 14.1.

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Fig. 14.1: Photographs of Talvivaara heap bioleaching (A) General outline of heap bioleaching (B-C) Actual heaps (D) Irrigation

(Photographs kind courtesy from Dr. Marja Riekkola-Vanhanen, Senior Biotechnology Adviser, Talvivaara Mining Company Plc, Espoo, Finland).

(Permission from Talvivaara Mining Company Plc, Finland thankfully acknowledged)
Metals recovery flowsheet is illustrated in fig. 14.2.

![Metals recovery flowsheet diagram]

Fig. 14.2: Metals recovery flowsheet.

(Kind courtesy from Dr. Marja Riekkola-Vanhanen, Senior Biotechnology Adviser, Talvivaara Mining Company Plc, Espoo, Finland).

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Demonstration leaching resulted in good recoveries. 80% nickel could be recovered within 400 days with 80% zinc in about 480 days. Copper and cobalt recoveries were lower for 500 days. Secondary leaching was continued till November 2008.

Mineralogical data with respect to original heap material and the ore after secondary leaching are shown in table 14.1:

<table>
<thead>
<tr>
<th>Table 14.1: Heap leaching data for various minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral</td>
</tr>
<tr>
<td>Pentlandite</td>
</tr>
<tr>
<td>Chalcopyrite</td>
</tr>
<tr>
<td>Sphalerite</td>
</tr>
<tr>
<td>Sulfur</td>
</tr>
</tbody>
</table>

Anticipated total recoveries from both primary and secondary heap bioleach systems are 85% Ni, 80% Zn and about 50% for Cu and Co. The leached metals are precipitated using hydrogen sulfide.
References (Lectures 13-14):


86. Riekkola-Vanhanen M., Talvivaara mining company – from a project to a mine. Paper presented at Biohydrometallurgy-12, Falmouth, Cornwall, UK (June 2012).