Mineral Processing by Bioheapleaching at The Talvivaara Nickel Mine in Sotkamo, Finland

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• Talvivaara Mining Company established in 2003

• Listed on London Stock Exchange Main Market since June 2007.
  Listed on Nasdaq OMX Helsinki since May 2009.

• Targeted full scale production from 2012
  – Nickel 50,000 tonnes p.a.
  – Zinc 90,000 tonnes p.a.
  – Copper 15,000 p.a.
  – Cobalt 1,800 tonnes p.a.

• Estimated mine life over 40 years
A world-class asset

- One of the largest known sulphide nickel deposits in Europe
- Favourable waste-to-ore ratio at 1:1
- Commercially significant amounts of copper, cobalt and zinc
- Uranium and manganese extraction being evaluated

### Talvivaara mineral resources

**Nickel cut-off 0.07%**

<table>
<thead>
<tr>
<th>Category</th>
<th>Mt</th>
<th>Nickel%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured</td>
<td>364</td>
<td>0.23</td>
</tr>
<tr>
<td>Indicated</td>
<td>278</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>642</strong></td>
<td><strong>0.23</strong></td>
</tr>
<tr>
<td>Inferred</td>
<td>362</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,004</strong></td>
<td><strong>0.22</strong></td>
</tr>
</tbody>
</table>
First metal production achieved on time – ramp-up continues

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
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</thead>
<tbody>
<tr>
<td>Environmental permit; earthworks</td>
<td>1.4.2007</td>
<td>1.11.2007</td>
</tr>
<tr>
<td>Leveling of ore</td>
<td></td>
<td>1.11.2007</td>
</tr>
<tr>
<td>Mining</td>
<td></td>
<td>1.4.2008</td>
</tr>
<tr>
<td>Materials handling</td>
<td></td>
<td>1.7.2008</td>
</tr>
<tr>
<td>Metals recovery</td>
<td></td>
<td>1.10.2008</td>
</tr>
</tbody>
</table>

Star: Work commenced on schedule
Environment, Health and Safety – a priority for Talvivaara

Environment

• Environmental processes being prepared for ISO 14001 certification; audit of environmental system targeted for Q4 2010

Personnel

• Current number of personnel 340
• Training programmes and recruiting continuing

Safety

• Launch of successful Work Group Safety Challenge in February 2009
• 6 minor LTI’s recorded in 2009
• 11 LTIs/million man hours safety rating
Recent highlights

- Zinc streaming agreement with Nyrstar NV; USD 335m purchase price received
- Early repayment in full of USD 320m Project Term Loan Facility
- Closing of all nickel, zinc and foreign exchange risk hedging positions with EUR 45m net proceeds
- Plans to recover uranium as a by-product of leaching process announced; 350 tpa estimated production
- Ramp-up progressing; bioheapleaching performing above budgeted levels
Production targets for 2010

• **Mining**
  – Ore 24 mt
  – Waste 16 mt
  – Stripping ratio 0.67

• **Metals recovery**
  – Nickel: approx. 30,000 t
  – Zinc: approx. 50,000 t
  – Insignificant amounts of copper and cobalt
A technically simple and safe uranium extraction process

- Solvent extraction unit to be added to Talvivaara’s metals recovery plant
- Planned production approx. 350 tpa
- Estimated capital expenditure approx. EUR 30m
- Production costs estimated at approx. EUR 2m pa
- Permit applications delivered to authorities

Price of yellow cake 2005-2010 (USD/lb)
Deposit Geology

- One of the largest known sulphide nickel deposits in Europe (total mineral resources >1000 Mt @ 0.22% Ni)

- Proterozoic metamorphosed and folded black schist

- Area explored since the 1970’s
  - Detailed exploration by GSF 1977-1983
  - Outokumpu exploration 1989-1992
  - Work by Talvivaara since 2004
  - Significant exploration potential

(Loukola-Ruskeeniemi and Heino, 1996)
Modal Mineral Composition (Wt%)
Sulphide Minerals

- Pyrrhotite: 49%
- Pentlandite: 0%
- Pyrite: 25%
- Chalcopyrite: 2%
- Sphalerite: 3%
- Alabandite: 6%
- Oxidized po: 14%

Distribution of Ni

- Altered pentlandite: 59%
- Pyrrhotite + oxidized po: 33%
- Pyrite: 1%
- Pentlandite: 7%

Ahonen, 2006
Cross-section of the Kuusilampi Deposit
Kuusilampi and Kolmisoppi - long section looking West
Kuusilampi and Kolmisoppi - long section looking West
New 2009 drilling profiles
Kolmisoppi profile 15180 – new 2009 drillholes

2008 resource outline

New resource outline
Process flow sheet

1. Open pit mining

2. Crushing
   - Primary crushing
   - Tertiary crushing
   - Secondary crushing
   - Quaternary crushing

3. Bioheap leaching
   - Stacker
   - Primary heaps
   - Reclain stacker
   - Air
   - Bacteria
   - H₂SO₄
   - PLS
   - Raffinate pond

4. Metals processing
   - Copper sulphide
   - Zinc sulphide
   - Nickel cobalt sulphide

Agglomeration
H₂SO₄
Stacker
Primary heaps
Reclain stacker
Air
Bacteria
H₂SO₄
PLS
Raffinate pond
Kuusilampi Open Pit March 2009
Description of Bioheapleaching

- Naturally occurring process, endemic bacteria
- Bacteria catalyse leaching of metals from ore to solution
- Substantially lower capex and opex than in traditional smelting and refining processes
- Cleaner and more environmentally friendly process compared to smelting
Bioheapleaching

- Key process parameters include particle size, aeration, irrigation and acid consumption

- Process run in two stages
  - Primary leaching for 15-18 months; expected nickel recovery approx. 80%
  - Secondary leaching for additional 3.5 years; total expected nickel recovery >90%
Bioheapleaching in operation

Heap

Aeration

Irrigation

Pregnant Leach Solution
A) Chemical leaching

B) Microbiological leaching

**pH**
- Between 2 and 2.5
- Compromise between leaching yield and cost of pH control

**Particle size**
- \( P_{80} < 8 \text{ mm} \)

**Temperature**
- Between 20 and 90 °C
Acidithiobacillus Ferrooxidans

10,000,000,000 bacteria in a teaspoon of solution
Metal Recoveries in the Pilot Heap

Nickel and zinc

Cobalt and copper

Days

% recovered

Days

% recovered

Nickel

Zinc

Cobalt

Copper
Bioheapleaching – secondary leaching

- Secondary heap areas to be developed during 2010-2011
• Large multimetal deposit
• Exothermic process in subarctic conditions
• Particle size, pH control, temperature control
Thank you!

www.talvivaara.com