The Development of Chrome and Nickel Projects in Kazakhstan & Russia

presented by
Nic Barcza

Oriel Resources Ltd
A Chrome Nickel & Ferroalloy Growth Company
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Company information

- Oriel Resources Ltd is a London-based chrome and nickel mining and processing company formed in July 2003 and acquired by Mechel (NYSE: MTL) in March 2008
- Mechel is one of the leading Russian mining and metals companies
- Oriel’s primary focus has been the acquisition and development of chrome and nickel projects, primarily in Kazakhstan and the Russian Federation
- Mechel consolidated its ferroalloy assets into its subsidiary Oriel Resources in November 2008
- Oriel comprises:
  - The Voskhod Chrome mine and Plant (Kazakhstan)
  - The Tikhvin (Ferrochrome) Smelting Plant (St. Petersburg region)
  - The Southern Urals Nickel Plant (Orenburg region in Russia)
  - The Shevchenko Nickel Deposit (Kazakhstan) and
  - The Bratsk Ferroalloy (Ferrosilicon) Plant (Irkutsk region in Russia)
Oriel Resources assets in Kazakhstan and Russia

- Tikhvin Smelting Plant
- Shevchenko Nickel
- Voskhod Chrome
- Moscow
- Southern Urals Nickel Plant
- Bratsk Ferroalloy Plant
- St Petersburg
- Vladivostok

Kazakhstan

Russia
Voskhod Chrome Mine and Plant

- The deposit is located in North West Kazakhstan 90km from Aktobe.

- Average annual output of 1.3 million tonnes of mined chrome ore and 900,000 ton of lump, chip and concentrate.

- Production based on development ore commenced Q4 2008.

- Indicated resource of 19.1 million tons at 48.5% Cr₂O₃ with potential extension from the adjacent Karaagash deposit of 4 up to 8 million tons.

- Mintek (Study Manager) and Bateman carried out the pre-feasibility study in 2005.

- SRK (DFS Study Manager), DRA designed the plant based on Mintek’s MPD test work data from Voskhod core samples.
Voskhod chrome project satellite imagery

- Voskhod chrome project satellite imagery
- Karaagash Licence
- Road to Sarysai Railhead
- Tailings Dam
- Return Water Dam
- Mine Water Dam
- Access Road to Site
- ROM Pad
- DMS Plant
- Khromtau
- Donskoy GOK
- Road to Aktobe – 90km
- Rail Line
- Decline
- Mine Camp
Voskhod chrome ore zones/types in deposit

Metallurgical Ore Types

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHG</td>
<td>Competent High Grade</td>
</tr>
<tr>
<td>PHG</td>
<td>Powdery High Grade</td>
</tr>
<tr>
<td>CMG</td>
<td>Competent medium grade</td>
</tr>
<tr>
<td>PMG</td>
<td>Powdery medium grade</td>
</tr>
<tr>
<td>CSO</td>
<td>Competent Subordinate</td>
</tr>
<tr>
<td>PSO</td>
<td>Powdery Subordinate</td>
</tr>
</tbody>
</table>
CHG (competent high-grade) ore disaggregating to PHG
Voskhod chrome ore grade vs. recovery
Voskhod ore wet tumbling tests

Figure 8-8: Results of Wet Tumbling Tests

Cumulative mass passing [%] vs Screen size [mm]

- 1min
- 2min
- 5min
- 10min
2007 Boxcut backfilling & ventilation installation
Early 2008 process plant construction
Decline to Voskhod chrome mine and ore processing plant

Construction completed
Q4 2008
## Chromite products from Voskhod plant

<table>
<thead>
<tr>
<th>Products</th>
<th>Yield</th>
<th>Cr$_2$O$_3$</th>
<th>Fe$_2$O$_3$</th>
<th>SiO$_2$</th>
<th>MgO</th>
<th>Al$_2$O$_3$</th>
<th>Cr/Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Lumpy</td>
<td>52.3</td>
<td>48.0</td>
<td>11.5</td>
<td>8.5</td>
<td>20.0</td>
<td>7.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Chip</td>
<td>9.9</td>
<td>48.0</td>
<td>11.5</td>
<td>8.5</td>
<td>20.0</td>
<td>7.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Concs.</td>
<td>7.6</td>
<td>57.0</td>
<td>12.5</td>
<td>&lt;3.0</td>
<td>17.0</td>
<td>8.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>

**Plant production**

**Estimated:** 900 kt/a chrome products

- **Lumpy** 75 % 675 kt/a max
- **Chip** 14 % 128 kt/a min
- **Concs.** 11 % 99 kt/a min
Tikhvin ferrochrome smelter, NW Russia
Tikhvin Ferroalloys Plant

- Located in Tikhvin, 200km South East of St Petersburg, Russia.

- Tikhvin’s chrome ore feed (340,000 tpa) sourced from Oriel’s Voskhod chrome mine in Kazakhstan.

- Production capacity of 140ktpa HC FeCr commenced April 2007

- 4 x 22.5MVA semi-closed submerged arc AC furnaces.

- Option to briquette chrome ore fines.

- Mintek’s Minstral controllers and Atoll MRP have been evaluated.
Chrome ore fines briquetting plant

Briquetting presses

TSP: schematic flowsheet of the chromite briquetting section

**Figure 4.3**
Tikhvin ferrochrome plant flow sheet

4 x 22.5 MVA SAF’s
Chromite smelting characteristics vs. SA ore

Kazak

SA

Canadian
### Slag & alloy Mintek test results achieved at 1750 °C

<table>
<thead>
<tr>
<th>Description</th>
<th>MgO</th>
<th>Al₂O₃</th>
<th>SiO₂</th>
<th>CaO</th>
<th>TiO₂</th>
<th>V₂O₃</th>
<th>Cr₂O₃</th>
<th>MnO</th>
<th>FeO</th>
<th>Ni</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mass %</td>
<td>mass %</td>
<td>mass %</td>
<td>mass %</td>
<td>mass %</td>
<td>mass %</td>
<td>mass %</td>
<td>mass %</td>
<td>mass %</td>
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<tr>
<td>Slag 28</td>
<td>48</td>
<td>19</td>
<td>33</td>
<td>0.3</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Slag 29</td>
<td>42</td>
<td>32</td>
<td>23</td>
<td>0.3</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>0.2</td>
<td>0.0</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Slag 30</td>
<td>47</td>
<td>21</td>
<td>32</td>
<td>0.8</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>101</td>
<td></td>
</tr>
<tr>
<td>Slag 31</td>
<td>49</td>
<td>16</td>
<td>34</td>
<td>0.3</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>99</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Si mass%</th>
<th>Cr mass%</th>
<th>Fe mass%</th>
<th>Ni mass%</th>
<th>C mass%</th>
<th>Total mass%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alloy 28</td>
<td>4.9</td>
<td>68.4</td>
<td>17.6</td>
<td>0.2</td>
<td>9.5</td>
<td>92*</td>
</tr>
<tr>
<td>Alloy 29</td>
<td>4.4</td>
<td>71.9</td>
<td>16.6</td>
<td>0.2</td>
<td>9.2</td>
<td>93*</td>
</tr>
<tr>
<td>Alloy 30</td>
<td>5.3</td>
<td>68.5</td>
<td>16.7</td>
<td>0.2</td>
<td>9.3</td>
<td>100</td>
</tr>
<tr>
<td>Alloy 31</td>
<td>6.4</td>
<td>67.1</td>
<td>18.3</td>
<td>0.2</td>
<td>8.4</td>
<td>92*</td>
</tr>
</tbody>
</table>

* low total – possible slag contamination
## Tikhvin ferrochrome grades

Tikhvin High Carbon Ferrochrome grades from ore blend and Voskhod ore

<table>
<thead>
<tr>
<th>TYPICAL (ORE BLEND)</th>
<th>VOSKHOD ORE BASED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cr</td>
<td>65.0% min</td>
</tr>
<tr>
<td>C</td>
<td>6.5-9%</td>
</tr>
<tr>
<td>Si</td>
<td>1.0% max.</td>
</tr>
<tr>
<td>S</td>
<td>0.05% max</td>
</tr>
<tr>
<td>P</td>
<td>0.03% max</td>
</tr>
<tr>
<td>Ti</td>
<td>0.04% max</td>
</tr>
</tbody>
</table>
Pre-reduction of Voskhod ore

60% reduction @ 1300 to 1400 °C in 60 mins.
The Voskhod plant can supply the Tikhvin ferrochrome plant 340 kt/a of chrome ore lump and chips to produce 140kt/a HCFeCr.

There is scope to produce up to 250kt/a of additional HCFeCr from the remaining 560kt/a tons of ore.

Preliminary studies indicate that based on using 400kt/a ore around 180 kt/a of HCFeCr would be produced.

The smelting options include the conventional SAF but a preliminary evaluation of DC arc furnace and pre-reduction technology indicates that these may offer benefits and could complement the SAF approach.

The selection of technology depends on the lump to fines ratio as a minimum of 300 kt/a of fines is required to justify one of the following:

- 1 x 65 MW DC arc furnace
- 1 x 300 kt/a sinter belt plant plus pre-heated feed to 1 x 55 MW SAF
- 1 x 300 kt/a pre-reduction plant plus x 40 MW SAF
- The balance of 260 kt/a of lumpy ore could be fed into a single 60 MW SAFor sold
**Southern Urals Nickel Plant**

- Built and commissioned in 1938, in the Town of Orsk, Orenburg Region.
- Integrated into Mechel in 2001 and Oriel in Q4 2008
- Two nickel laterite ore mines: Sakhara and Buruktal
- Process is based on a sulphide technology using coke fed shaft furnaces.
- Produces a high grade 85% Ni-containing ferronickel.
- Output in 2008 was equivalent to 16,000 tons of nickel contained in ferronickel.
- 30% of ferronickel is consumed intra-group, the rest is exported.
Shevchenko Ferronickel development project - Kazakhstan

Shevchenko Nickel Deposit

• The Shevchenko nickel deposit – green field project in the North-West Kazakhstan.

• Project at an evaluation/development stage.

• Proven reserves of 21.4Mt of 0.85% Ni, probable reserves of 83.0Mt of 0.77% Ni.

• Plans for development being determined from large scale pilot plants testwork including and extensive smelting campaign carried out at Mintek in 2005.
## Nickel laterite profile

<table>
<thead>
<tr>
<th>SCHEMATIC LATERITE PROFILE</th>
<th>COMMON NAME</th>
<th>APPROXIMATE ANALYSIS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RED LIMONITE</td>
<td>Ni  Co  Fe  MgO</td>
</tr>
<tr>
<td></td>
<td>Low MgO</td>
<td>Ni  Co  Fe  MgO</td>
</tr>
<tr>
<td></td>
<td>High Fe2O3</td>
<td>Ni  Co  Fe  MgO</td>
</tr>
</tbody>
</table>

Oxide zone:  
Low MgO  
High Fe2O3

<table>
<thead>
<tr>
<th>SCHEMATIC LATERITE PROFILE</th>
<th>COMMON NAME</th>
<th>APPROXIMATE ANALYSIS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>YELLOW LIMONITE</td>
<td>Ni  Co  Fe  MgO</td>
</tr>
<tr>
<td></td>
<td>High MgO</td>
<td>Ni  Co  Fe  MgO</td>
</tr>
<tr>
<td></td>
<td>Low Fe2O3</td>
<td>Ni  Co  Fe  MgO</td>
</tr>
</tbody>
</table>

Silicate zone:  
High MgO  
Low Fe2O3
Shevchenko nickel ore particle size distribution

~70% < 5mm 50% < 1mm
Mintek twin electrode DC arc furnace pilot plant
# Shevchenko nickel ore composition (laterite ore type)

<table>
<thead>
<tr>
<th>Dry Ore Basis Mass %</th>
<th>Average Limonite</th>
<th>Average Nontronite</th>
<th>Average Saprolite</th>
<th>Average Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>MgO</td>
<td>4.41</td>
<td>9.93</td>
<td>17.6</td>
<td>11.28</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>6.87</td>
<td>4.83</td>
<td>3.70</td>
<td>5.05</td>
</tr>
<tr>
<td>SiO₂</td>
<td>36.4</td>
<td>46.0</td>
<td>46.5</td>
<td>43.0</td>
</tr>
<tr>
<td>CaO</td>
<td>1.34</td>
<td>0.92</td>
<td>1.40</td>
<td>1.26</td>
</tr>
<tr>
<td>Cr₂O₃</td>
<td>1.22</td>
<td>0.97</td>
<td>0.77</td>
<td>0.97</td>
</tr>
<tr>
<td>MnO</td>
<td>0.51</td>
<td>0.37</td>
<td>0.25</td>
<td>0.37</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>37.6</td>
<td>24.3</td>
<td>17.1</td>
<td>25.8</td>
</tr>
<tr>
<td>CoO</td>
<td>0.13</td>
<td>0.07</td>
<td>0.04</td>
<td>0.08</td>
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<tr>
<td>NiO</td>
<td>1.15</td>
<td>1.34</td>
<td>1.29</td>
<td>1.26</td>
</tr>
<tr>
<td>CuO</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>TiO₂</td>
<td>0.30</td>
<td>0.26</td>
<td>0.20</td>
<td>0.25</td>
</tr>
<tr>
<td>LOI</td>
<td>10.1</td>
<td>11.0</td>
<td>11.1</td>
<td>10.7</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

# Ratios

<table>
<thead>
<tr>
<th></th>
<th>Average Limonite</th>
<th>Average Nontronite</th>
<th>Average Saprolite</th>
<th>Average Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂/MgO</td>
<td>8.3</td>
<td>4.6</td>
<td>2.6</td>
<td>3.8</td>
</tr>
<tr>
<td>Fe/SiO₂</td>
<td>0.722</td>
<td>0.370</td>
<td>0.257</td>
<td>0.420</td>
</tr>
<tr>
<td>Fe/Ni</td>
<td>32.6</td>
<td>18.2</td>
<td>13.2</td>
<td>20.5</td>
</tr>
<tr>
<td>Ni/Co</td>
<td>8.9</td>
<td>19.4</td>
<td>30.8</td>
<td>16.1</td>
</tr>
</tbody>
</table>
Shevchenko nickel ore/slag compositions

- Saprolite
- Nontronite
- Limonite
- Average
The effect of Fe/SiO2 ratio on slag viscosity & conductivity

Viscosity and Resistivity of Slag at 1700°C versus Fe/SiO2 ratio

- Viscosity < 150 cP
- Resistivity 1.5 to 2 ohm.cm

Fe/SiO2 0.3 to 0.4
## Composition of smelting sample vs resource data

<table>
<thead>
<tr>
<th>Test Samples:</th>
<th>Average Test Shevchenko</th>
<th>Average Test Tarasov</th>
<th>Average Test Blizhny</th>
<th>Average Test June 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO$_2$/MgO</td>
<td>7.1</td>
<td>4.9</td>
<td>3.0</td>
<td>3.3</td>
</tr>
<tr>
<td>(CaO+MgO)/SiO$_2$</td>
<td>0.154</td>
<td>0.217</td>
<td>0.373</td>
<td>0.332</td>
</tr>
<tr>
<td>MgO/CaO</td>
<td>10.9</td>
<td>14.9</td>
<td>7.4</td>
<td>9.2</td>
</tr>
<tr>
<td>Fe/SiO$_2$</td>
<td>0.290</td>
<td>0.225</td>
<td>0.216</td>
<td>0.321</td>
</tr>
<tr>
<td>Fe/Ni</td>
<td>11.7</td>
<td>15.0</td>
<td>10.2</td>
<td>12.9</td>
</tr>
<tr>
<td>Ni/Co</td>
<td>7.5</td>
<td>24</td>
<td>31</td>
<td>23</td>
</tr>
<tr>
<td>Ni in calcine</td>
<td>1.59</td>
<td>0.98</td>
<td>1.25</td>
<td>1.41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>May 2005 Resource Data</th>
<th>Average Limonite</th>
<th>Average Nontronite</th>
<th>Average Saprolite</th>
<th>Average Resource</th>
</tr>
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<tbody>
<tr>
<td>SiO$_2$/MgO</td>
<td>8.3</td>
<td>4.6</td>
<td>2.6</td>
<td>3.8</td>
</tr>
<tr>
<td>(CaO+MgO)/SiO$_2$</td>
<td>0.16</td>
<td>0.24</td>
<td>0.41</td>
<td>0.29</td>
</tr>
<tr>
<td>MgO/CaO</td>
<td>3.3</td>
<td>12.6</td>
<td>12.6</td>
<td>8.9</td>
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<td>Fe/SiO$_2$</td>
<td>0.722</td>
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<td>Ni/Co</td>
<td>8.9</td>
<td>19.4</td>
<td>30.8</td>
<td>16.1</td>
</tr>
<tr>
<td>Ni in calcine</td>
<td>1.01</td>
<td>1.18</td>
<td>1.15</td>
<td>1.11</td>
</tr>
</tbody>
</table>
Shevchenko slag SiO2/MgO ratio and FeO content

Electric Furnace Slag Compositions Superimposed
On the FeO-MgO-SiO2 Phase Diagram
(plotted as temperature vs SiO2/MgO at different FeO contents)

SiO2/MgO >3 <4

Average for deposit

NOTE 1: Japanese Fe-Ni Smelters and SLN
NOTE 2: Cerro Matoso (FeO ~ 20%)
Shevchenko Ni recovery vs. Ni alloy grade
Nickel alloy grade vs. carbon addition

Experimental Nickel in Alloy

- Nickel in Alloy for Tarasov
- Nickel in Alloy for Shevchenko
- Nickel in Alloy for Blizhny

Carbon addition, kg/ton calcine

Nickel in alloy, mass %
Shevchenko nickel in slag vs. carbon addition

Carbon Addition vs Ni in Slag for Tarasov & Blizhny

% Ni in Slag vs. % Carbon Addition

Tarasov
Blizhny
Linear (Tarasov)
Linear (Blizhny)
Shevchenko nickel vs. iron recovery

Estimated Fit for Experimental Data
To Theoretical curve ($k_{\text{gamma}} = 20$)
Actual Grades produced 15 to 20%

Theoretical Curve ($k_{\text{gamma}} = 50$)

Ni Recovery, %

Fe Recovery, %

Graph showing nickel and iron recovery rates with different theoretical and experimental data points.
Shevchenko nickel energy requirements

Influence of Operating Temperature on SER

SER (kWh/kg calcine)

Temperature (°C)

- Shevchenko
- Tarasov
- Blizhny

571 kWh/t
Shevchenko nickel furnace lining measurements

Individual Heatlosses for CFM Circuits on Panels 1, 2, 5 & 6 (Heats 111 to 120)

- Power off: Slipped electrode, Off gas cleaning and Bath Inspection
- Slag Tap 111
- Slag Tap 112
- Slag Tap 113
- Slag Tap 114
- Feed off, CFM High Alam
- Slag Tap 115
- Slag Tap 117
- Slag Tap 118
- Slag & Metal Tap 110
- Slag & Metal Tap 116
- Slag & Metal Tap 119

Date and Time:
- 20-Mar-05 14:24:00
- 20-Mar-05 16:48:00
- 20-Mar-05 19:12:00
- 20-Mar-05 21:36:00
- 20-Mar-05 00:30:00
- 21-Mar-05 02:24:00
- 21-Mar-05 04:48:00
- 21-Mar-05 07:12:00
- 21-Mar-05 09:36:00
- 21-Mar-05 12:00:00
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nickel in Calcine</td>
<td>0.93 %</td>
</tr>
<tr>
<td>Nickel in Slag</td>
<td>0.10 %</td>
</tr>
<tr>
<td>Calcine</td>
<td>0% LOI fed at 900°C</td>
</tr>
<tr>
<td>Dust losses from the furnace (% of Calcine)</td>
<td>2 %</td>
</tr>
<tr>
<td>Hearth Power Density</td>
<td>500 kW/m²</td>
</tr>
<tr>
<td>Process Energy (kWh/kg calcine)</td>
<td>0.571 kWh/kg</td>
</tr>
<tr>
<td>100% thermal efficiency</td>
<td></td>
</tr>
<tr>
<td>Slag Operating Temperature</td>
<td>1650°C</td>
</tr>
<tr>
<td>Maximum Operating Voltage</td>
<td>1200V</td>
</tr>
<tr>
<td>Operating Voltage (20 to 50kA)</td>
<td>900 to 1200V</td>
</tr>
<tr>
<td>Arc Length:</td>
<td>20 to 30cm</td>
</tr>
<tr>
<td>Bath Depth:</td>
<td>50cm</td>
</tr>
<tr>
<td>Slag resistivity:</td>
<td>2 to 3 ohm.cm</td>
</tr>
<tr>
<td>Ni in crude ferronickel product</td>
<td>18 to 22% nickel</td>
</tr>
<tr>
<td>Electrode Consumption</td>
<td>2 kg/MWh</td>
</tr>
<tr>
<td>Reductant Addition, Kazakhstan Coal</td>
<td>3.45%</td>
</tr>
<tr>
<td>Dolime Addition, Alexeyevka Dolime</td>
<td>5.0%</td>
</tr>
<tr>
<td>Metal Make per ton Calcine (~20% nickel)</td>
<td>41.3 kg</td>
</tr>
<tr>
<td>Slag Make per ton Calcine</td>
<td>975 kg</td>
</tr>
</tbody>
</table>
Process flow sheet for 80 MW DC arc furnace

**Calcined Dclomite**
- 23,552 tpa
- 3.0 tph

**Calcined Ore**
- 788,400 tpa
- 100.0 tph
- 1.1 Ni %
- 8,735 tpa Ni

**POWER**
- 68.9 MWh/t Ni tapped

**Coal**
- 31,221 tpa
- 4.0 tph
- 44.7% fixed C
- 25 °C

**DC Smelting**
- 900 °C

**Off gas**
- 62,220 tpa
- 7.9 tph
- 84,953 m³/h

**Crude FeNi**
- 39,239 tpa
- 5.0 tph
- 75.6% Fe
- 20.4% Ni
- 7,993 tpa Ni

**Furnace Slag**
- 741,813 tpa
- 94.1 tph
- 0.10 Ni %
- 742 tpa Ni
Shevchenko Ferronickel Process Flow Sheet

- COAL
- Reductant Drying
- Calcining
- Off Gas Treatment
- Consumers
- Slag Granulation
- SLAG DUMP
- 3 x 80 MW
- ~2.5 million tpa
- ~450 ktpa
- Dolomite Milling & Drying
- Dynamic Separator
- Recycling
- Disposal
- Dolomite
- Natural or Furnace Gas
- ROM ORE Stockpiles
- ~5 million tpa
- Aerofall Mill
- Reductant
- ~200 ktpa
- Refining Agents
- Alloy Shotting
- Alloy Packaging
- Ladle Furnace Alloy Refining
- ~150 kpa
- Product Dispatch
- ~150 kpa Product Dispatch

Shevchenko nickel process flow sheet
Shevchenko nickel extraction technology

- Atmospheric Tank and Heap acid leach technologies to produce a mixed nickel hydroxide product (MHP) are being evaluated.

- Mintek and SGS carried out bench and pilot plant-scale testwork with favourable extraction results and generated MHP samples for further evaluation and development.

- Test work in stirred tanks gives up to 90% nickel recovery in 12-14 hours on Shevchenko ores, with favourable acid consumption rates <500 kg/t dry ore.

- Demonstration scale MHP production and smelting would provide baseline technological, operational & commercial parameters for future full scale production.

- Sulphur readily available in-country at competitive rates.

- Competitive operating costs are expected due to availability of low-cost acid and use of DC furnace technology to smelt calcined nickel-rich MHP.
Shevchenko mixed nickel hydroxide product (MHP)
MHP CHARACTERISTICS

TYPICAL AVERAGE COMPOSITION (% DRY BASIS)

<table>
<thead>
<tr>
<th></th>
<th>Ni</th>
<th>Co</th>
<th>Fe</th>
<th>Mg</th>
<th>Al</th>
<th>Mn</th>
<th>Cu</th>
<th>Zn</th>
<th>Ca</th>
<th>Si</th>
<th>Cr</th>
<th>S*</th>
<th>P</th>
<th>LOI (1270°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36.6</td>
<td>1.90</td>
<td>0.21</td>
<td>0.593</td>
<td>0.98</td>
<td>4.91</td>
<td>0.014</td>
<td>0.496</td>
<td>0.1</td>
<td>0.167</td>
<td>0.014</td>
<td>4 to 5</td>
<td>&lt;0.002</td>
<td>~30 to 35</td>
</tr>
</tbody>
</table>

* SULPHUR AS SULPHATES
Thermal characterisation of MHP

TGA

DSC

Mass Change: -3.22%  
Mass Change: -17.15%  
Mass Change: -11.34%
Calcined MHP product prior to smelting

Calcined MHP at 750 and 1275 deg C
CALCINED MHP CHARACTERISTICS FROM SHEVCHENKO SAMPLES

TYPICAL AVERAGE COMPOSITION (%)

<table>
<thead>
<tr>
<th>Element</th>
<th>Ni*</th>
<th>Co*</th>
<th>Fe</th>
<th>Mg</th>
<th>Al</th>
<th>Mn</th>
<th>Cu</th>
<th>Zn</th>
<th>Ca</th>
<th>Si</th>
<th>Cr</th>
<th>S</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>59.2</td>
<td>3.38</td>
<td>2.60</td>
<td>2.88</td>
<td>0.65</td>
<td>5.48</td>
<td>0.014</td>
<td>0.54</td>
<td>0.24</td>
<td>0.58</td>
<td>0.007</td>
<td>&lt;0.007</td>
<td>&lt;0.002</td>
</tr>
</tbody>
</table>

* NICKEL AND COBALT CONTAINED (AS OXIDES)
Estimated Ferronickel production for different grades of alloy based on smelting calcined MHP in the 12 MW DC arc furnace

<table>
<thead>
<tr>
<th>ALLOY GRADE</th>
<th>POWER CONS.</th>
<th>EFFECTIVE POWER</th>
<th>PRODUCTION TONS/h</th>
<th>FENI ALLOY TONS/YEAR</th>
<th>NICKEL UNITS TONS/YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni %</td>
<td>MWh/t Alloy</td>
<td>MW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>1.6</td>
<td>10</td>
<td>6.38</td>
<td>50,260</td>
<td>45,235</td>
</tr>
<tr>
<td>45</td>
<td>1.1</td>
<td>10</td>
<td>9.27</td>
<td>73,110</td>
<td>32,900</td>
</tr>
<tr>
<td>30</td>
<td>0.9</td>
<td>10</td>
<td>11.33</td>
<td>89,350</td>
<td>26,810</td>
</tr>
</tbody>
</table>

Assumptions:

FeNi (85% NiO & CoO) in calcined MHP feed

NiFe alloy melting energy requirement 0.6 MWh/t

Thermal efficiency - 85 %  Plant availability 95 %
• Smelt upgraded scalped ore in 2 x 80 MW DC arc furnaces to produce 20 kt/a (20% Ni FeNi)
• Leach balance of ore from high-grading mining from deposits and downgraded scalped ore fraction to produce crude MHP
• Enrich calcined ore for smelting with intermediate nickel units to produce 25% Ni FeNi
• Smelt some calcined MHP in 1 x 12 MW DC arc furnace to produce high grade 85% Ni FeNi
Acknowledgements

Mintek
Bateman
DRA
SGS
Tenova Pyromet

Any Comments or Questions?

Oriel Resources Ltd
An Integrated Ferroalloy Growth Company
June 2009

A subsidiary of