An overview of the future production and demand of ferronickel

Robert Cartman – Hatch
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- Hatch
  - Overview of FeNi market
  - Demand analysis
  - Supply analysis
  - Conclusions
Hatch services and sectors

Consulting
- Process consulting
- Technologies
- Business consulting

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- Engineering
- Project management
- Construction management

Operations Support
- In-house engineering services for operations

SECTORS
- Energy
- Infrastructure
- Metals

SERVICES

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HATCH

Global reach and resources

8000 people

Canada
- Calgary, Alberta
- Hamilton, Ontario
- Montreal, Quebec
- Sorel-Tracy, Quebec
- Sudbury, Ontario
- Mississauga, Ontario
- Niagara Falls, Ontario
- Sorel-Tracy, Quebec
- Sorel-Tracy, Quebec
- Sudbury, Ontario

USA
- Boston, Massachusetts
- Buffalo, New York
- Millburn, New Jersey
- Monroeville, Pennsylvania
- New York, New York
- Pittsburgh, Pennsylvania
- Pleasanton, California
- San Francisco, California
- Seattle, Washington

USA
- Boston, Massachusetts
- Buffalo, New York
- Millburn, New Jersey
- Monroeville, Pennsylvania
- New York, New York
- Pittsburgh, Pennsylvania
- Pleasanton, California
- San Francisco, California
- Seattle, Washington

South America
- Antofagasta, Chile
- Santiago, Chile
- Lima, Peru
- São Paulo, Brazil
- Belo Horizonte, Brazil
- Vitoria, Brazil

South Africa
- Johannesburg
- Richards Bay

Europe
- London, England
- Moscow, Russia

India
- Delhi

China
- Beijing
- Shanghai

Australia
- Brisbane
- Gladstone
- Mackay
- Melbourne
- Newcastle
- Perth
- Sydney
- Townsville
- Whyalla
- Wollongong

South Africa
- Johannesburg
- Richards Bay

3400

170

120

700

600

2300

(Yellow indicates regional hub)
Hatch counts many of the world’s major mining and steelmaking companies and financial institutions among its core client base

<table>
<thead>
<tr>
<th>Mining</th>
<th>Steel</th>
<th>Financial institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcan</td>
<td>ArcelorMittal</td>
<td>ADB</td>
</tr>
<tr>
<td>Alcoa</td>
<td>BlueScope Steel</td>
<td>Bank of America</td>
</tr>
<tr>
<td>Anglo American</td>
<td>Celsa</td>
<td>Bear Stearns</td>
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<tr>
<td>Assmang</td>
<td>CMC</td>
<td>CIBC</td>
</tr>
<tr>
<td>BHP Billiton</td>
<td>Tata/Corus Group</td>
<td>Citibank</td>
</tr>
<tr>
<td>De Beers</td>
<td>Evraz Group</td>
<td>Commonwealth Bank</td>
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<tr>
<td>ENRC</td>
<td>Gerdau Group</td>
<td>Credit Lyonnais</td>
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<tr>
<td>Falconbridge</td>
<td>Mechel</td>
<td>CSFB</td>
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<tr>
<td>Impala Platinum</td>
<td>Metallinvest</td>
<td>Deutsche Bank</td>
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<tr>
<td>Lonmin</td>
<td>Metinvest</td>
<td>EBRD</td>
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<tr>
<td>Newmont Mining</td>
<td>NuCor</td>
<td>HSBC</td>
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<tr>
<td>Norilsk</td>
<td>POSCO</td>
<td>IFC</td>
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<tr>
<td>Placer Dome</td>
<td>Ruukki</td>
<td>JP Morgan Chase</td>
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<tr>
<td>QIT</td>
<td>Severstal</td>
<td>Mellon Bank</td>
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<tr>
<td>Rio Tinto</td>
<td>Shougang</td>
<td>NM Rothschild &amp; Sons</td>
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<tr>
<td>SUAL</td>
<td>TMK</td>
<td>RBS</td>
</tr>
<tr>
<td>Vale Inco</td>
<td>U.S. Steel</td>
<td>UBS Warburg</td>
</tr>
<tr>
<td>Xstrata</td>
<td>voestalpine</td>
<td>World Bank</td>
</tr>
</tbody>
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Annual FeNi production is typically ~250kt, with BHP and Eramet the largest producers in 2009.

Global primary Ni production by type

Global FeNi production by producer

Source: ISSF, Hatch
Ni demand is dominated by stainless steel production, particularly in the case of FeNi. Stainless steel production has fallen since 2006.

Ni demand by end-use:
- Stainless steel: 57%
- Non-ferrous: 14%
- Foundry: 3%
- Other: 6%
- Plating: 12%
- Alloy steel: 8%

FeNi demand by end-use:
- Stainless steel: 98%
- Alloy steel: 2%

Global stainless steel production by series (2004-09):

Source: ISSF, Hatch
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Long-term stainless steel production has risen at a CAGR of 4.5% since 1965

Source: Vale, ISSF, Hatch
Stainless steel production is forecast to continue rising in order to meet the expected growth in consumption by the developing world.

Per capita consumption of stainless steel vs income per capita for selected countries, 1997-2008

Source: Vale, IMF, Hatch
Long-term stainless steel production will move toward 40Mt by 2020. Further substitution is possible but most of this has already taken place.

**Stainless steel production**

- **Percentage point shift from 300-series**
  - Change 2001 - 2008
  - Potential future change

- **300-series ratio**

Source: ISSF, Hatch
FeNi faces substitution threats from other refined nickel products and secondary sources of nickel i.e. scrap

Breakdown of nickel consumption by stainless steel mills

Breakdown of scrap ratios by regions

Source: ISSF, Hatch
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Long-term Ni supply fluctuates between waves of investment, followed by exploitation.

**Ni production, mined**

**Long-term real Ni prices (2008 $)**

Source: INSG, USGS, LME, Hatch
The next wave of investment could add another ~500kt of capacity.

<table>
<thead>
<tr>
<th>Ore type and process</th>
<th>Capacity</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambatovy</td>
<td>Laterite – HPAL</td>
<td>60kt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barro Alto</td>
<td>Laterite – RKEF</td>
<td>36kt</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Eagle (?)</td>
<td>Sulphide</td>
<td>10kt (?)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fenix (?)</td>
<td>Laterite – RKEF</td>
<td>23kt</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Gladstone (?)</td>
<td>Laterite – HPAL</td>
<td>63kt</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Goro</td>
<td>Laterite – HPAL</td>
<td>60kt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Koniambo</td>
<td>Laterite – RKEF</td>
<td>60kt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoc (?)</td>
<td>Laterite - HPAL</td>
<td>40kt (?)</td>
<td></td>
<td></td>
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<tr>
<td>Nunavik</td>
<td>Sulphide</td>
<td>12kt</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Onca Puma</td>
<td>Laterite – RKEF</td>
<td>52kt</td>
<td></td>
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<tr>
<td>Ramu</td>
<td>Laterite – HPAL</td>
<td>31kt</td>
<td></td>
<td></td>
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<tr>
<td>Shevchenko</td>
<td>Laterite – Heap</td>
<td>22kt</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Tagaung Taung</td>
<td>Laterite – RKEF</td>
<td>23kt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vermelho (?)</td>
<td>Laterite – HPAL</td>
<td>46kt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weda Bay (?)</td>
<td>Laterite – HPAL</td>
<td>60kt</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Company reports, Hatch
Nickel is increasingly being extracted from lateritic ores.

Source: Hatch
Laterite resources are mainly found in countries that require large spending on infrastructure.

Source: BGS, Hatch
Lateritic ores need to be subdivided into limonites or saprolites in order to understand the respective mining and processing costs.

<table>
<thead>
<tr>
<th>Depth</th>
<th>% content</th>
<th>Ni</th>
<th>Co</th>
<th>Fe</th>
<th>MgO</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5m</td>
<td>Limonite</td>
<td>0.8 – 1.5</td>
<td>0.1 – 0.2</td>
<td>40 – 50</td>
<td>0.5 – 5</td>
</tr>
<tr>
<td></td>
<td>Transition zone</td>
<td>1.5 – 4</td>
<td>0.02 – 0.1</td>
<td>25 – 40</td>
<td>5 – 15</td>
</tr>
<tr>
<td>10m</td>
<td>Saprolite</td>
<td>1.8 – 3</td>
<td>0.02 – 0.1</td>
<td>10 – 25</td>
<td>15 – 35</td>
</tr>
<tr>
<td></td>
<td>Bedrock</td>
<td>0.3</td>
<td>0.01</td>
<td>5</td>
<td>35 – 45</td>
</tr>
</tbody>
</table>

**Oxides**
- High Fe, low MgO, low SiO$_2$
- Processing – Dependent on presence of clay minerals. Typically hydrometallurgy (HPAL, Heap, Caron)

**Silicates**
- Low Fe, high MgO, high SiO$_2$
- Processing – Pyrometallurgy. End product (FeNi, matte) dependent on mineralogy

Source: Mick Elias, Hatch
Summary of nickel ores and their pros and cons

Nickel ore

Sulphides
- High mining costs
  - Underground mining
- Low processing costs
  - Proven technology
  - Often associated with valuable by-products (Cu / Pd / Pt)

Laterites
- Low mining costs
  - Surface mining
- High processing costs
  - Unproven technology
  - Protracted startup
  - Expensive materials of construction
  - High acid consumption

Limonites
- Low mining costs
  - Surface mining
- Falling processing costs
  - Proven technology
  - Large-scale operations
  - Vulnerable to energy costs
  - Slag disposal

Source: Hatch
Mining and processing costs will depend on a variety of factors. It is too simplistic to categorise as laterites vs. sulphides.

**Resource**
- Higher grade = better
- >1.5% ≈ saprolite
- Saprolite = proven processing technology
- Larger size = better
- Lower capex per tonne

**Inputs**
- Merchant vs. captive
- Hydroelectricity vs. fossil fuels
- Hydrocarbons
- Labour availability / skills

**Project management**
- Project phasing
- Project team continuity
- New technologies

**Ore mineralogy**
- Content of clay minerals
  - Lower = better
- Magnesium content
  - Lower = less acid consumption in hydrometallurgy
- SiO₂ / MgO ratio
  - Impacts on choice of end-product

**Infrastructure**
- Power / Acid / Lime plants
- Transportation
  - Road / Sea / Air
- Conveyors / Pipelines
- Difficulty of terrain / climate
- Accommodation
- Permits / Compensation

Source: Hatch
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## Conclusions

### Demand
- Stainless steel production to increase
  - Approaching 40Mt by 2020
  - Production increase will offset effects of substitution
- China/India + other EMs to drive consumption growth
  - Beneficial for local laterite-based suppliers
  - FeNi likely to supersede NPI
- Increase in scrap ratio a key threat
  - Development of collection networks in EMs

### Supply
- New supplies to arrive from lateritic ores
  - Not just FeNi though
  - FeNi to account for 20-25% of refined Ni production
    - Compared with 15-20% at present
- Other things being equal, production costs will rise
  - Increased spend on infrastructure
  - Unproven technologies
- Technological advance likely to minimise LT real price rises
Your contacts for further information

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