Global Potassium Reserves and Potassium Fertilizer Use

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Potassium (K) and Potash

• K present in most rocks and soils

• Economic sources ...
  – sedimentary salt beds remaining from ancient inland seas (evaporite deposits)
  – salt lakes and natural brines

• Potash refers to a variety of K-bearing minerals
## Common K Minerals

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Composition</th>
<th>K$_2$O, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sylvite</td>
<td>KCl</td>
<td>63.1</td>
</tr>
<tr>
<td>Sylvinite</td>
<td>KCl/NaCl mixture</td>
<td>~ 28.0</td>
</tr>
<tr>
<td>Carnallite</td>
<td>KCl$\cdot$MgCl$_2$$\cdot$6H$_2$O</td>
<td>17.0</td>
</tr>
<tr>
<td>Kainite</td>
<td>4KCl$\cdot$4MgSO$_4$$\cdot$11H$_2$O</td>
<td>19.3</td>
</tr>
<tr>
<td>Langbeinite</td>
<td>K$_2$SO$_4$$\cdot$2MgSO$_4$</td>
<td>22.7</td>
</tr>
<tr>
<td>Polyhalite</td>
<td>K$_2$SO$_4$$\cdot$2MgSO$_4$$\cdot$2CaSO$_4$$\cdot$H$_2$O</td>
<td>15.6</td>
</tr>
<tr>
<td>Niter</td>
<td>KNO$_3$</td>
<td>46.5</td>
</tr>
</tbody>
</table>
Common K Minerals

• Sylvite (KCl) ... abundant in commercial deposits
• Sylvinite (KCl + NaCl) also common
• Hartsalz ... ore deposits with SO₄ salts (kieserite [MgSO₄] or anhydrite [CaSO₄]) are limited ... Europe
• Langbeinite occurs New Mexico and Ukraine
World Potash Reserves

• About 100 large buried deposits + 100 brine deposits of commercial potential

• The world has an estimated 250 billion metric tons of $K_2O$ resources

Source: U.S. Geological Survey
Potash Resources and Reserves

• Resources include proven, probable, and inferred reserves
  – Reserves: deposits of sufficient quantity and quality that are currently mined
  – Reserve base: reserves + deposits that are marginally economic or sub economic

• U.S. Geological Survey estimates global reserves at 18 billion t K₂O ... 8.3 billion t considered commercially exploitable.

Potash Reserves and Reserve Base

Reserves, ‘000 t K₂O
- 8 - 90
- 91 - 300
- 301 - 750
- 751 - 4400

Reserve Base, ‘000 t K₂O
- 30 - 300
- 301 - 1000
- 1001 - 2200
- 2201 - 9700

Potash Deposits – North America

- World’s largest reserves occur in Saskatchewan
- Ore is exceptionally high grade (25-30% K₂O) at depths of 950-1,100 m increasing to > 3,500 m
- Uniform thickness (2.4-3 m) and mineralization and no structural deformations
- Sylvinitc, some carnallite, and clay

Potash Reserves In Saskatchewan

Source: PPIC 1989
Potash Deposits – FSU

• FSU has extensive proven reserves of K minerals … second only to the deposits in Saskatchewan

• Russia – Verkhnekamsk deposit in the Urals near Solikamsk
  – Potash depth at 75 to 450 m in 13 potentially minable beds ranging in thickness from 26 to 30 m (sylvinite) and 70 to 80 m (zone of sylvinite-carnallite).
  – Mined beds 1.2 to 6 m thick with 15% K$_2$O with 3 to 5% insolubles

• Belarus – Starobinsk deposit is 2$^{nd}$ largest in ore body in FSU near Soligorsk
  – 30 potash beds in 4 horizons. Most mining 350 to 620 m depth in second horizon (1.8 to 4.4 m thick)
  – Sylvinite ore averaging 11% K$_2$O and 5% insolubles

Stone, 2002, Canadian Minerals Yearbook
**Potash Deposits – Western Europe**

- Oldest deposits are the Hessen and Thüringen beds in southern Germany
  - contain 15 to 20% sylvite, kieserite, and carnallite (~10% K₂O)
  - Beds are relatively flat-lying, but also folding, with some barren zones, sudden thickness changes, etc. making mining difficult

- Also carnallite and kieserite deposits in central Germany and sylvite and carnallite in northern Germany

- Sylvite deposits in England and sylvinite in Spain

Potash Deposits

• Middle East: K extracted from Dead Sea
  – contains an estimated 1 billion t KCl

• Latin America
  – sylvinite and carnallite in the Sergipe basin in Brazil
  – KNO₃ in Chile in Atacama Desert (est. 1 billion t NaNO₃ and 100 million t KNO₃) and Salar de Atacama, a high-attitude dry lake (brine est. at 120 million t KCl and 80 million t K₂SO₄)

• Asia: Carnallite and K-bearing brines in Qinghai and Xinjiang Provinces

• Undeveloped Deposits
  – Thailand, Argentina, Amazon Basin in Brazil, Morocco, Poland, and additional deposits in the FSU

Production of KCl and K$_2$SO$_4$, Mt

Source: IFA Statistics
World Mine Production, 2007

% of total production, 2007

Source: IFA Statistics
Canada: potash export by destination in 2007, ‘000 t K$_2$O

Source: IFA Production and Trade Statistics
Russia: potash export by destination in 2007, '000 t K₂O

Source: IFA Production and Trade Statistics
Germany: potash export by destination in 2007, '000 t K₂O

Source: IFA Production and Trade Statistics
Israel/Jordan: Potash export by destination in 2007, ‘000 t K₂O

Source: IFA Production and Trade Statistics
WORLD POTASH PRODUCTION AND CONSUMPTION,
MT K₂O

Source: IFA Statistics
Regional potash consumption,
‘000 t K₂O

Source: IFA Production and Trade Statistics
Potash consumption, ‘000 t K₂O

- 4 countries accounted for two-thirds of potash imports
  - US 18%, Brazil 16%, China 21%, and India 9%

Source: IFA Production and Trade Statistics
## Global Fertilizer Consumption Forecasts to 2012/13 (Mt nutrients)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave. 2005/06 to 2007/08 (e)</td>
<td>95.5</td>
<td>38.6</td>
<td>27.6</td>
<td>162.1</td>
</tr>
<tr>
<td>2012/13 (f)</td>
<td>115.6</td>
<td>45.7</td>
<td>33.0</td>
<td>194.3</td>
</tr>
<tr>
<td>Ave. Annual Change</td>
<td>+3.2%</td>
<td>+2.8%</td>
<td>+3.0%</td>
<td>+3.1%</td>
</tr>
</tbody>
</table>

Forecast Potash Demand Through 2012/13

% Average Annual Increase
2005/06–07/08 vs. 2012/13

WORLD POTASH SUPPLY/DEMAND BALANCE

World Potash Supply/Demand Balance

World potash supply/demand balance

World potash supply/demand balance

• Supply/demand balance is considered very tight and is expected to be so for the next few years ... triggered an increase in world potash prices
# New Potash Capacity
## 2008 to 2012

<table>
<thead>
<tr>
<th>Year</th>
<th>Mt K₂O</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>0.84</td>
<td>Jordan, Russia, Israel, Canada, USA</td>
</tr>
<tr>
<td>2010</td>
<td>1.02</td>
<td>Canada, Russia, Israel</td>
</tr>
<tr>
<td>2011</td>
<td>1.14</td>
<td>Canada, Russia, Israel</td>
</tr>
<tr>
<td>2012</td>
<td>4.74</td>
<td>Canada, Argentina, Belarus, Jordan</td>
</tr>
<tr>
<td>Total</td>
<td>7.74</td>
<td></td>
</tr>
</tbody>
</table>

**Tight supply/demand balance … new interest in potash mining**

- Saskatchewan is the world’s largest producer with 37% of supply and > 50% of global potash reserves
  - No potash exploration permits issued 15 years prior to 2004 … next 3 years the area under lease increased from 250,000 to 3 million hectares
- Estimated capital cost for a conventional mine … $2.8 billion, excluding infrastructure outside the plant gate and with no production for 5-7 years.
Why the increased demand for fertilizer?

- Increased food demand and less land to produce it

Source: FAO
Why the increased demand for fertilizer?

• Diets are changing ... more protein
• Requires more feed grains to produce protein
  – 7 kg/kg beef,
  – 4 kg/kg pork, and
  – 2 kg/kg poultry

![Meat consumption chart]

Source: FAO
Why the increased demand for fertilizer?

- Biofuels ... continued expected growth ... leads to increasing demand for corn and other crops

Source: FAPRI 2008
Why the increased demand for fertilizer?

World wheat plus coarse grains ending stocks

Source: USDA-FAS, 12/2007
Low crop yields in the developing world
(Ave. 2005 – 2007)

Source: FAO
Concluding Remarks

• Global potash supply/balance will remain tight through 2012
  – During this time demand will absorb capacity increases
  – Potential surplus ... 2.2 and 3.9 Mt K₂O, which is considered marginal given plant’s production configuration and ramp-up stages

• 2012 ... potential capacity should exceed demand
Concluding Remarks

• At present levels of production (33 Mt K₂O per year) and with current/planned capacity, the industry can easily meet future demand
• Reserves (8.3 billion t) are sufficient to supply potash for 250 years ... another 250+ considering the reserve base (18 billion t)
• Allowing for known resources (250 billion t) ... there is sufficient potash to meet demand for thousands of years
Thank You