World Reserves and Production of Potash

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World Reserves and Production of 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>$K_2O$, %</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
Potash Reserves

- ~100 large buried deposits + 100 brine deposits of commercial potential worldwide

- The world has an estimated 250 billion metric tons of $K_2O$ resources
Potash 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
- Global reserve estimated at 17 billion t $\text{K}_2\text{O}$ ... 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
- Sylvinitie, some carnallite, and clay
Potash Deposits – FSU

- FSU has extensive proven reserves of K minerals ... second only to the deposits in Saskatchewan
- Russia – Verkhnekkamsk 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
Potash Deposits – W. 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
  - sylvinitite 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-altitude dry lake (brine est. at 120 million t KCl and 80 million t K₂SO₄)
- Asia
  - Carnallite and K-bearing brines in Qinghai Province
- Undeveloped Deposits
  - Thailand, Argentina, Amazon Basin in Brazil, Morocco, Poland, and additional deposits in the FSU
World Potash Production and Consumption
(Million metric tons K₂O)

Source: USGS, FAO, IFA
Location of Potash Producers

2003 Production, ‘000 t K₂O

- 60
- 61 - 800
- 801 - 1250
- 1251 - 4700
- 4701 - 9100
Production of KCl and K$_2$SO$_4$ Products

Source: IFA
World Mine Production 2003

Million metric tons, K₂O

- Canada: 33
- Russia: 30
- Belarus: 17
- Germany: 15
- Israel: 13
- Jordan: 13
- United States: 13
- United Kingdom: 13
- Spain: 13
- China: 13
- Chile: 13
- Brazil: 13
- Ukraine: 13

78% of total K₂O produced

Source: IFA
World Operating Capacity

Operating capacity use, %

Source: IFA and Natural Resources Canada
North America

**PotashCorp**
- 5 underground mines and 2 solution mines in Saskatchewan
- 1 underground mine in New Brunswick

**Intrepid Mining**
- 2 underground mines in New Mexico
- A brine operation and solution mine in Utah

**Agrium**
- 1 underground mine in Saskatchewan

**IMC Global**
- 3 underground mines and 1 solution mine in Saskatchewan
- 1 underground mine in New Mexico and a solution mine in Michigan

**Compass Minerals Group**
- 1 brine operation in Utah
Russia and Belarus are the 2nd and 3rd leading producers ... 17% and 15% of 2003 global production

2003 Operating capacity:

- Russia – 71% (63% in 1999)
- Belarus – 78% (66% in 1999)
Western Europe

...17% of world production in 2003

13% from Germany

<table>
<thead>
<tr>
<th></th>
<th>K₂O Production, ‘000 metric t</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1994</td>
</tr>
<tr>
<td>France</td>
<td>870</td>
</tr>
<tr>
<td>Germany</td>
<td>3,286</td>
</tr>
<tr>
<td>Spain</td>
<td>684</td>
</tr>
<tr>
<td>UK</td>
<td>580</td>
</tr>
</tbody>
</table>
- Israel and Jordon represented 11% of world production in 2003
- Arab Potash, the only producer in Jordan is being privatized
- Dead Sea Works (DSW), with production in Israel and recent acquisitions in Spain and UK is the world’s 5th largest producer
Latin America

- Produced 3% of world’s K$_2$O in 2003
- Companhia Vale do Rio Doce (CVRD) ... one mine in Sergipe
- Sociedad Quimica y Minera de Chile S.A. (SQM) in northern Chile produces KCl/SOP by solar evaporation and KNO$_3$ from NaNO$_3$
- Both producing close to capacity ... CVRD plans to increase capacity
- China is a small producer, but production has been increasing ~8% per year since 1994
  - est. 440,000 t K₂O in 2003
- KCl by solar evaporation around Lake Qarhan in Qinghai Province
  - 1 million t project under development by Qinghai Yanhu Potash Fertilizer … 0.3 million t in 2003/04 and 0.7 million t by 2006/07
Potash Trade

- Export
- Domestic

Exports exceed domestic consumption across most countries.

Canada, Russia, Belarus, Germany, Israel, Jordan, United States, Spain, China, Chile, Brazil, Ukraine.
Potash Trade

- Grown ~ 3% for two-thirds of potash imports in 2003 annually for the last 10 years
- 4 countries accounted for two-thirds of imports
  - U.S. 21%
  - Brazil 16%
  - China 15%
  - India 7%
- U.S. market is mostly mature ... modest future growth expected
- Markets in Asia and Latin America are rising and are expected to continue in the future
2003 World Trade
(‘000 metric tons K₂O)

From Canada

- 4,470 metric tons K₂O to Europe
- 1,311 metric tons K₂O to Asia
- 120 metric tons K₂O to South America
- 1,024 metric tons K₂O to Africa
- 1,726 metric tons K₂O to North America
2003 World Trade
(‘000 metric tons K₂O)

From Russia/Belarus
2003 World Trade
(‘000 metric tons K$_2$O)

From Germany
2003 World Trade
(‘000 metric tons $\text{K}_2\text{O}$)

From Israel/Jordan

Map showing trade flows from Israel/Jordan with numbers indicating trade volumes.
**Concluding Remarks**

*Potash consumption*

![Graph showing potash consumption from 1961 to 2001 for the U.S., China, Brazil, and India. The graph indicates a steady increase in consumption over time, with the U.S. and China showing the highest consumption. The source of the data is FAO.](image-url)
Concluding Remarks

Potash Production Capacity

Production capacity, $10^6$ metric tons $K_2O$

- Asia
- Latin America
- Middle East
- West Europe
- East Europe
- North America

Source: IFA
Concluding Remarks

- Increasing potash consumption in Brazil, India, and China
  - Global K₂O consumption is ~24 million t and forecast to reach 29 million t in next 5 years
- Potash industry has been operating in a surplus
  - Exporting countries … 70 to 75% of capacity
  - Production capacity is expected to grow ~8% in next 4 to 5 years
  - 70% of new growth in exporting countries and the balance in China and Brazil
Concluding Remarks

- At present levels of production (~28 million t K₂O per year) and with current/planned capacity, the industry can easily meet future demand.
- At present levels of production, minable reserves and the known reserve base are sufficient to supply potash for at least 600 years.
  - Considering known resources … there is sufficient potash to meet demand for thousands of years.
Thank You