The AusIMM Metallurgical Society in association with the AusIMM Southern Queensland, Melbourne, Tasmania & Perth Branches and JKTech present the 2012 series of the G D Delprat Distinguished Lecture on Flotation

Sponsored by

FLSmidth

Outotec

Professor Alban Lynch

Mineral processing during the 20th century: The highlights, why they occurred, what comes next?
Copper price  1900 to 2010
Copper price 1900 to 2010

Price (98$/t)
Gravity plant – 1870s
Picking and sorting - 1870
Metallurgical Inventions 1880-1920

- **Breakage** – Dynamite, Air driven hammer drills, Crushers, Ball mills, Roller mills
- **Classification** – Centrifugal separators, Rake classifiers
- **Concentration** – Wilfley tables, Cyanidation, Flotation,
- **Cement** – Rotary kilns
BHP gravity mills – 1894 and 1897
Mining dumps for flotation at Broken Hill - 1904
Inspiration Copper in Arizona
The first large porphyry copper plant
Copper price  1900 to 2010

Price (98$/t)

1920s – Start of mineral processing research

**Flotation**

- Control of circuits using xanthates, activators, depressants
- USBM flotation studies at field stations
- Research on fundamentals – Taggart, Wark, Gaudin, Fahrenwald

**Comminution**

- Pulverised coal and Rosin Rammler equation
- Bond and Work Index
Copper price 1900 to 2010

Price (98$/t)
Innovations in the 1960s and 1970s

• **Breakage** - SAG mills, Tower mills (stirred bead mills) for fine grinding, Gearless mill drives, Large mills

• **Classification** – Hydrocyclones, Heavy media cyclones, High efficiency air separators

• **Concentration** - Flotation columns, High intensity cells, Large cells, Microbial leaching

• **General** – AMIRA, Modelling, On stream analysis, Process control
Cement Production 1900 to 2010
Copper price 1900 to 2010
Copper price 1900 to 2010

Price (98$/t)
Copper global production growth
Copper price
Improvements in the late 20th century

• 1970s / 1980s – HPGRs
  High rate thickeners
  High volume pressure filters

• 1980s / 1990s – High energy bead mills
  Processing Argyle diamond ore

• Very high capacity plants
Codelco Annual Reports 1994 to 2011
C1 Cash cost and Copper price
Pre-concentration - Why is it Important?

- As grade declines more ore is required to achieve metal targets.
- Using existing approaches we will:
  - reach the limits for existing equipment / methods;
  - consume dramatically higher levels of energy;
  - need a proportional increase in water;
- Alternative is to break only what must be broken to make a saleable product. This is the role of Pre-concentration.
## Energy used in different comminution circuits

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Decrease (%)</th>
</tr>
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<tbody>
<tr>
<td>SAG milling, ball milling</td>
<td>-</td>
</tr>
<tr>
<td>SAG milling, pebble crush, ball milling</td>
<td>6.4</td>
</tr>
<tr>
<td>AG milling, pebble crush, ball milling</td>
<td>22.1</td>
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<td>Three-stage crushing, ball milling</td>
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<td>Two-stage crush, HPGR, ball milling</td>
<td>34.6</td>
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<tr>
<td>Two-stage crush, HPGR, stirred milling</td>
<td>41.4*</td>
</tr>
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<td>Improved classification</td>
<td>46*</td>
</tr>
</tbody>
</table>

* To be verified
Copper and cement price indexes (real)
1926 to 2010
Copper and cement global production indexes 1926 to 2010

Copper
Cement
Iron Ore Carajas 1980-2011