



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

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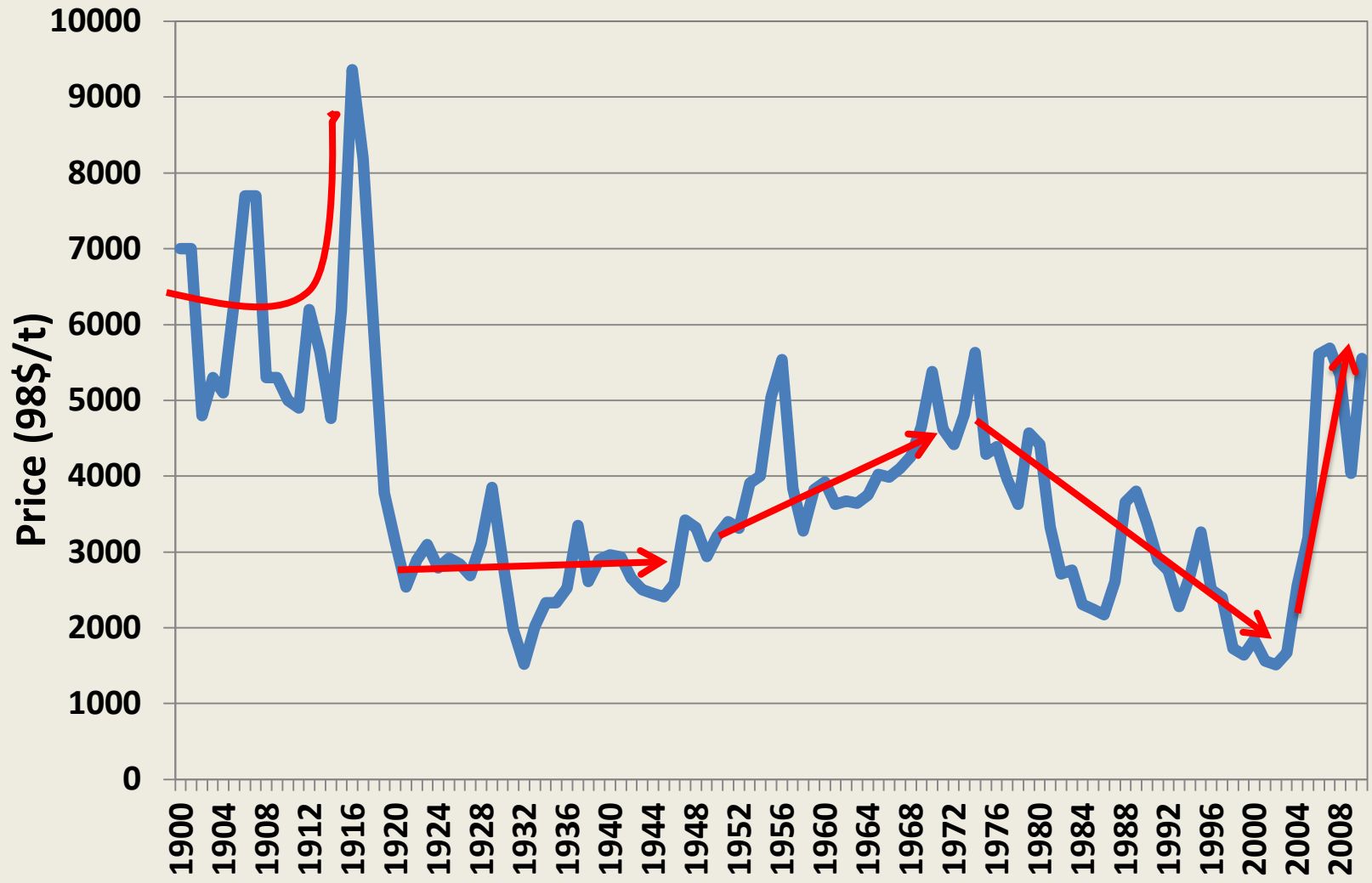


Professor Alban Lynch

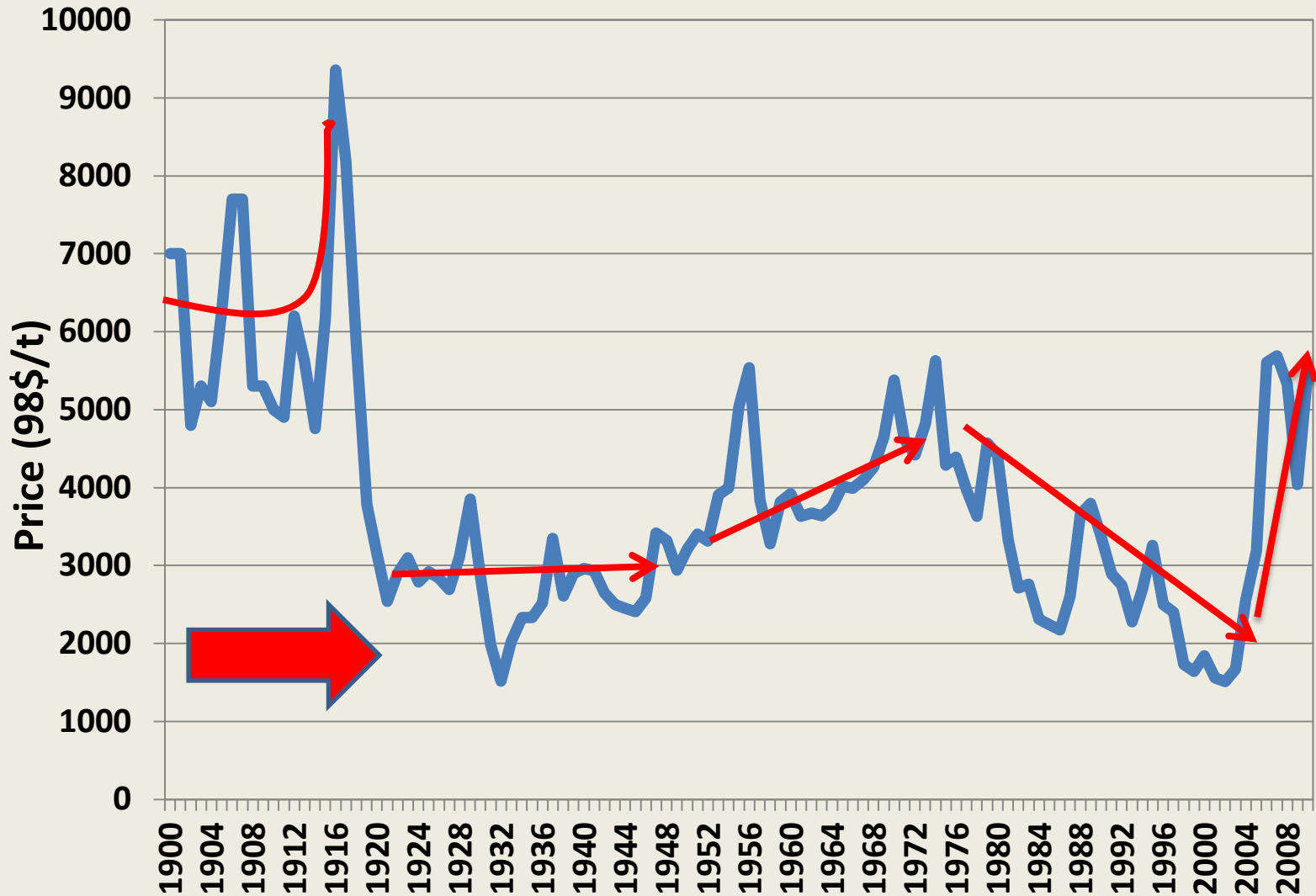
Mineral processing during the 20th century:

The highlights, why they occurred, what comes next?

Copper price 1900 to 2010



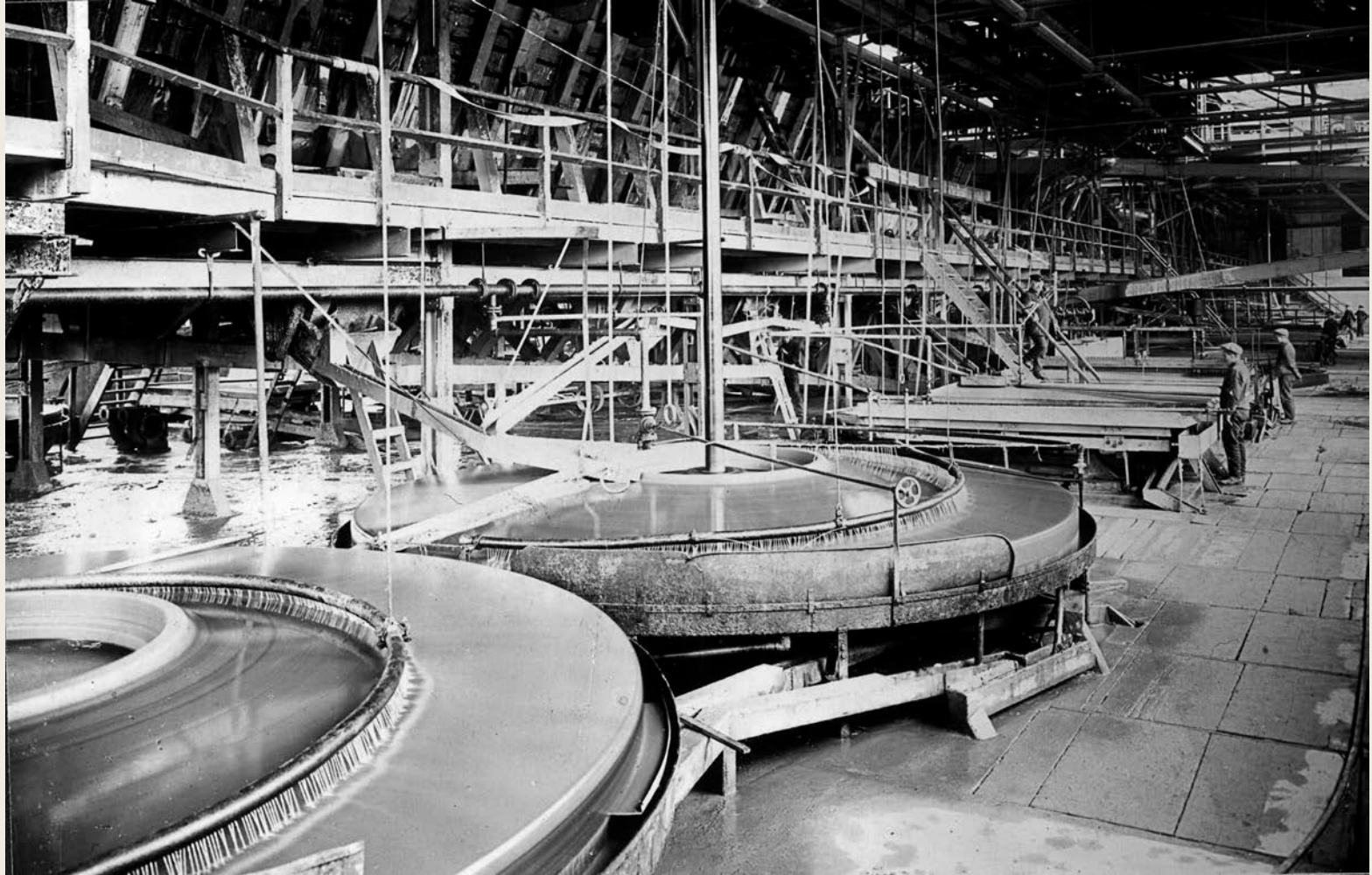
Copper price 1900 to 2010



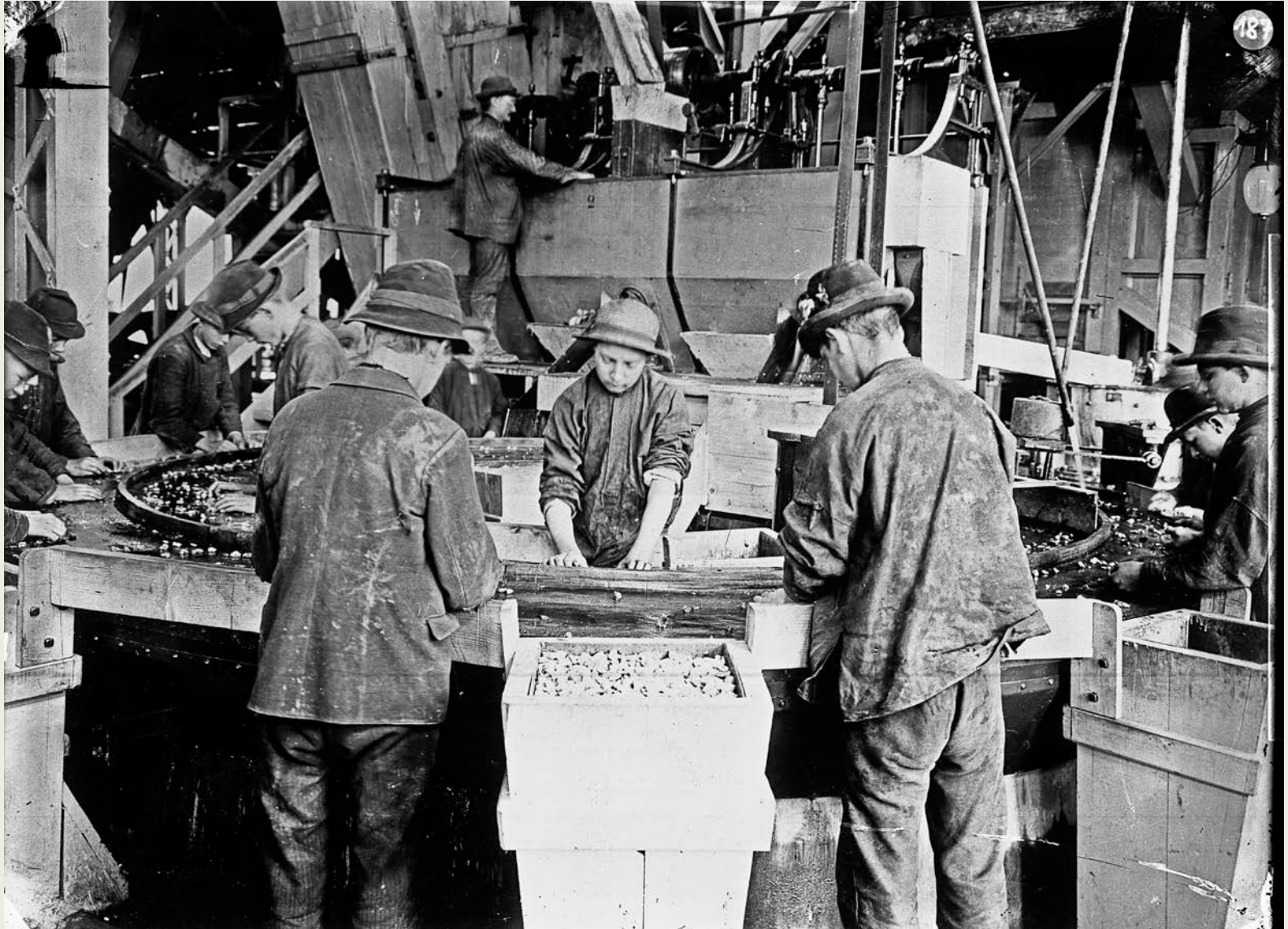
Water powered stamp mill - 1880



Gravity plant – 1870s



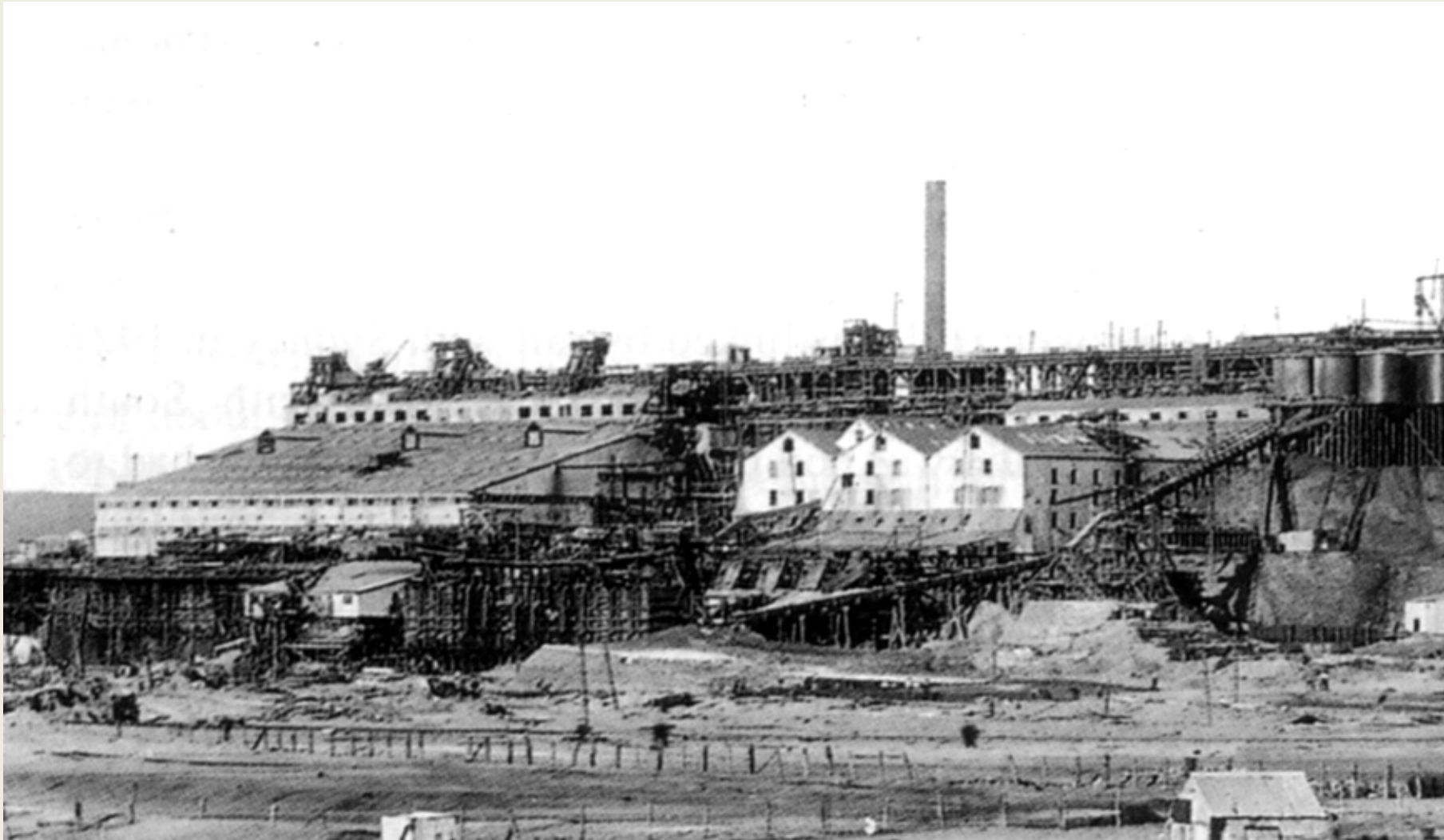
Picking and sorting - 1870



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

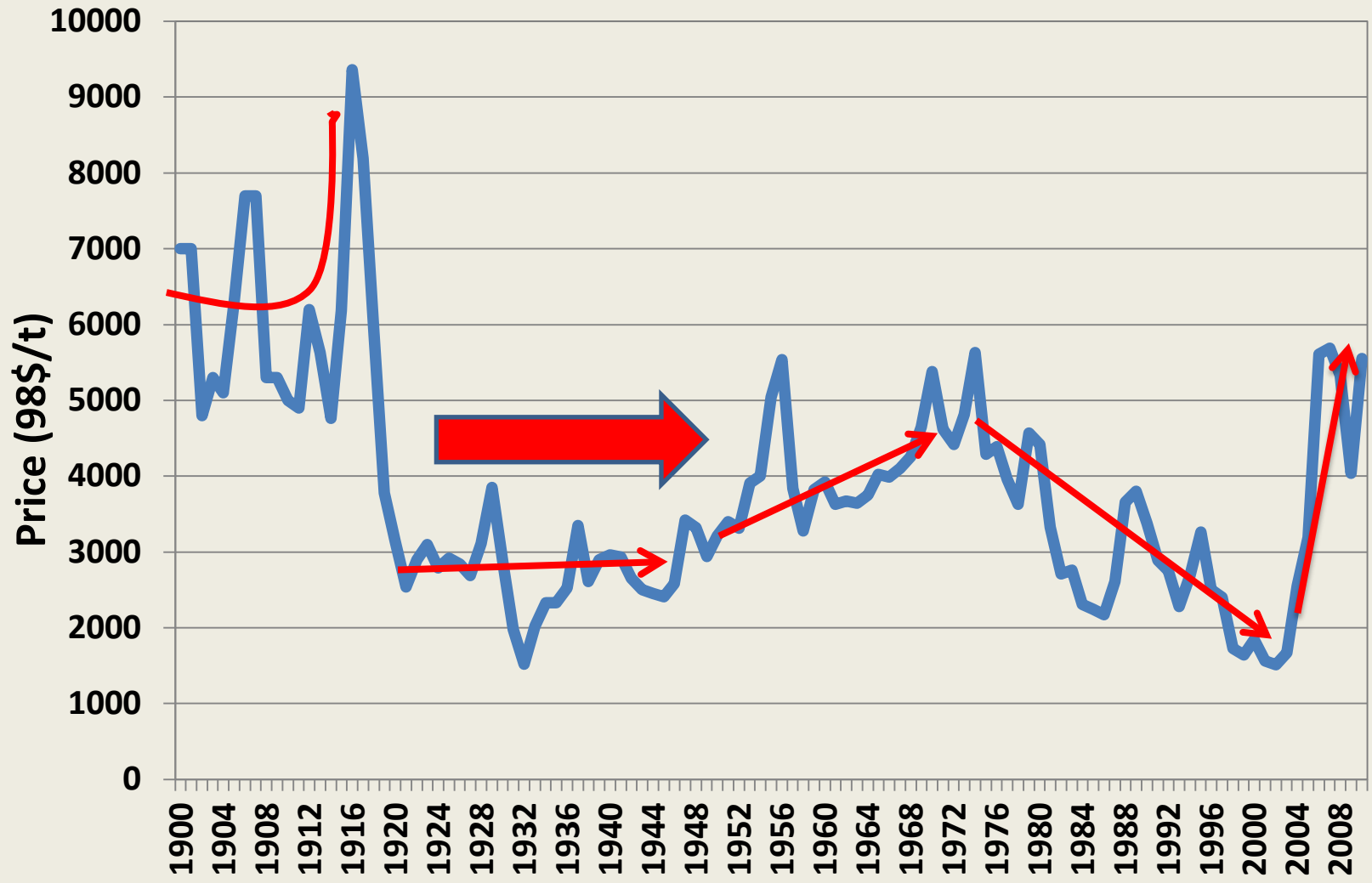


Inspiration Copper in Arizona

The first large porphyry copper plant



Copper price 1900 to 2010



1920s – Start of mineral processing research

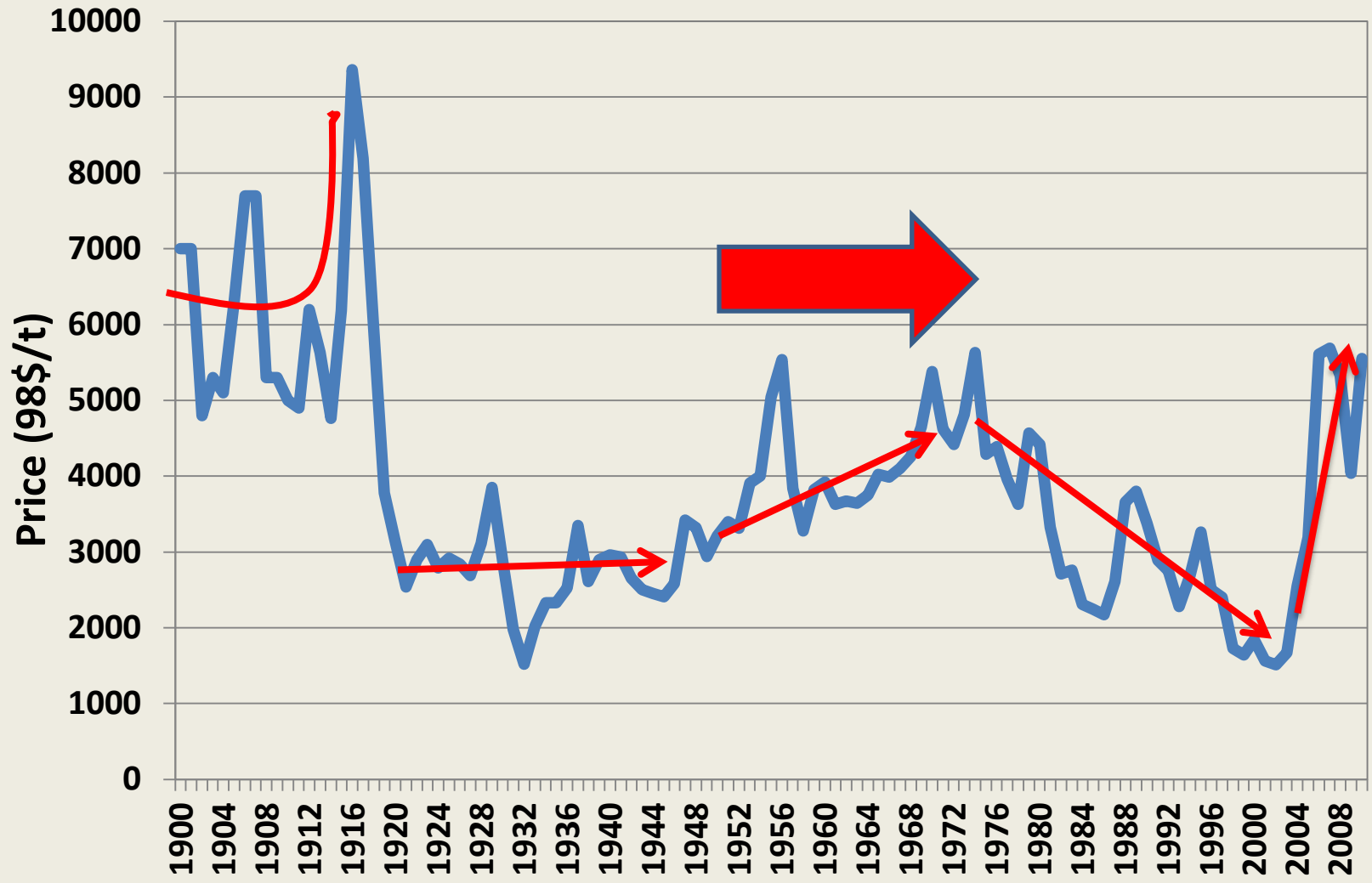
Flotation

- 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

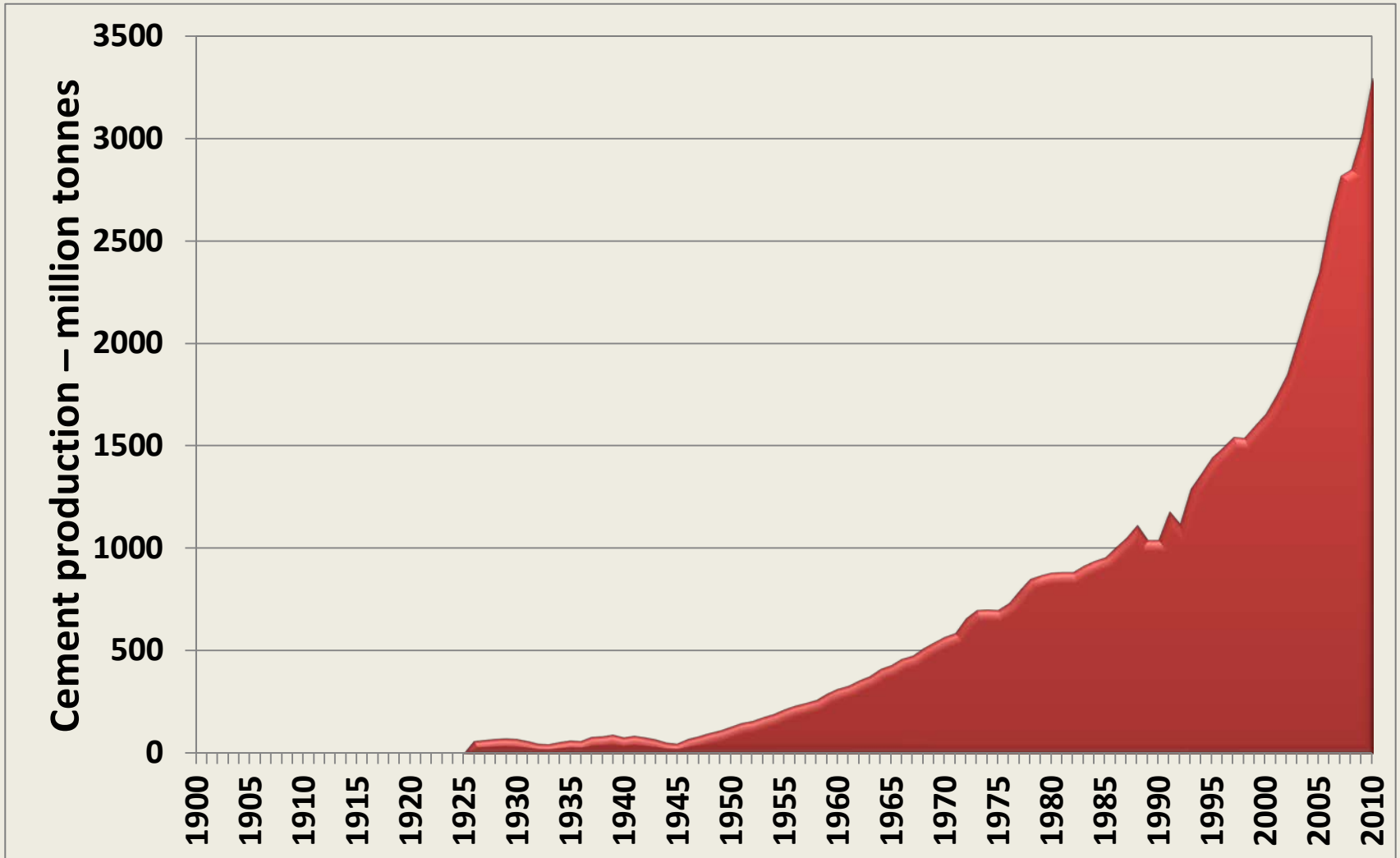
Copper price 1900 to 2010



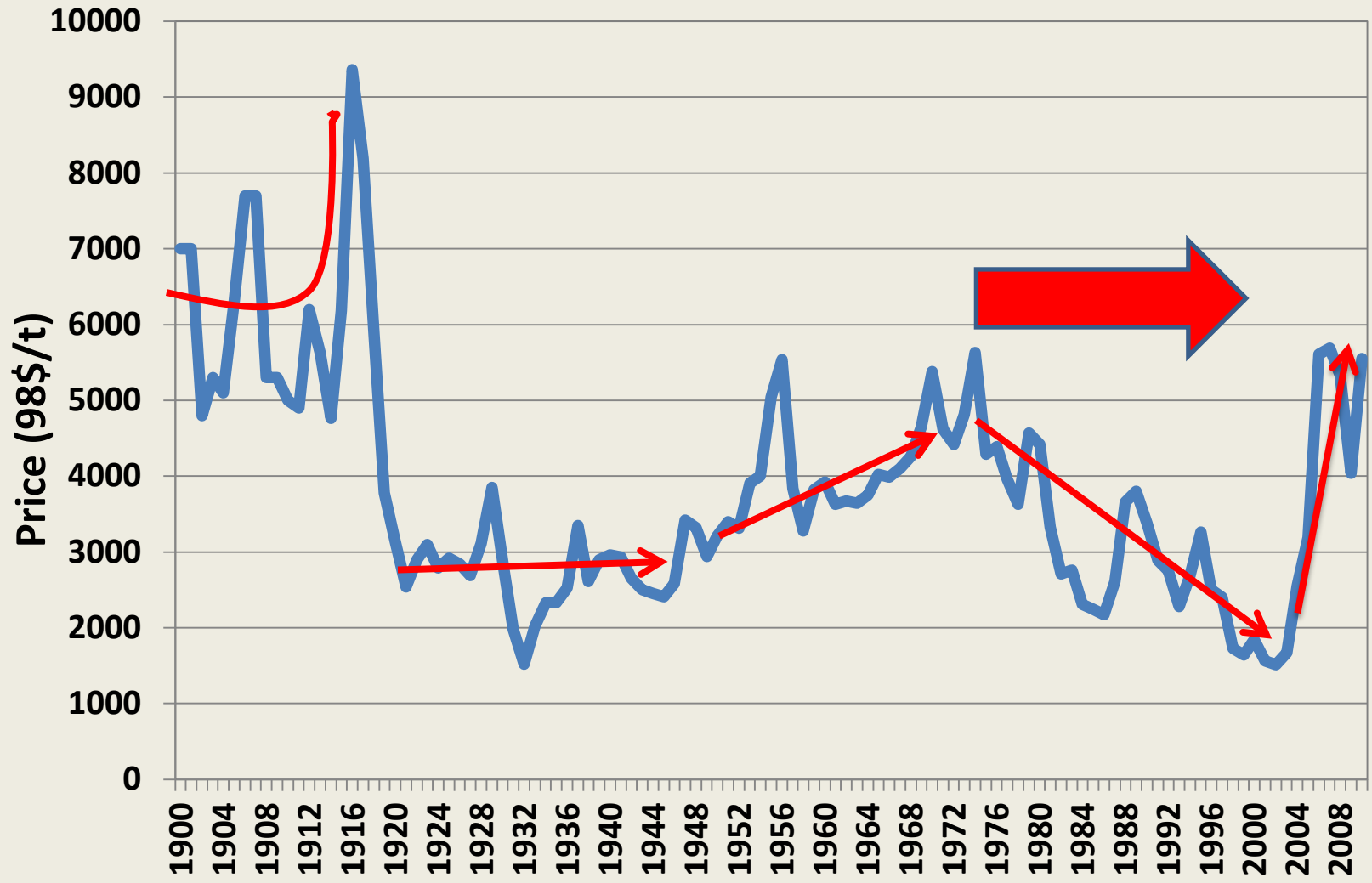
Innovations in the 1960s and 1970s

- **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

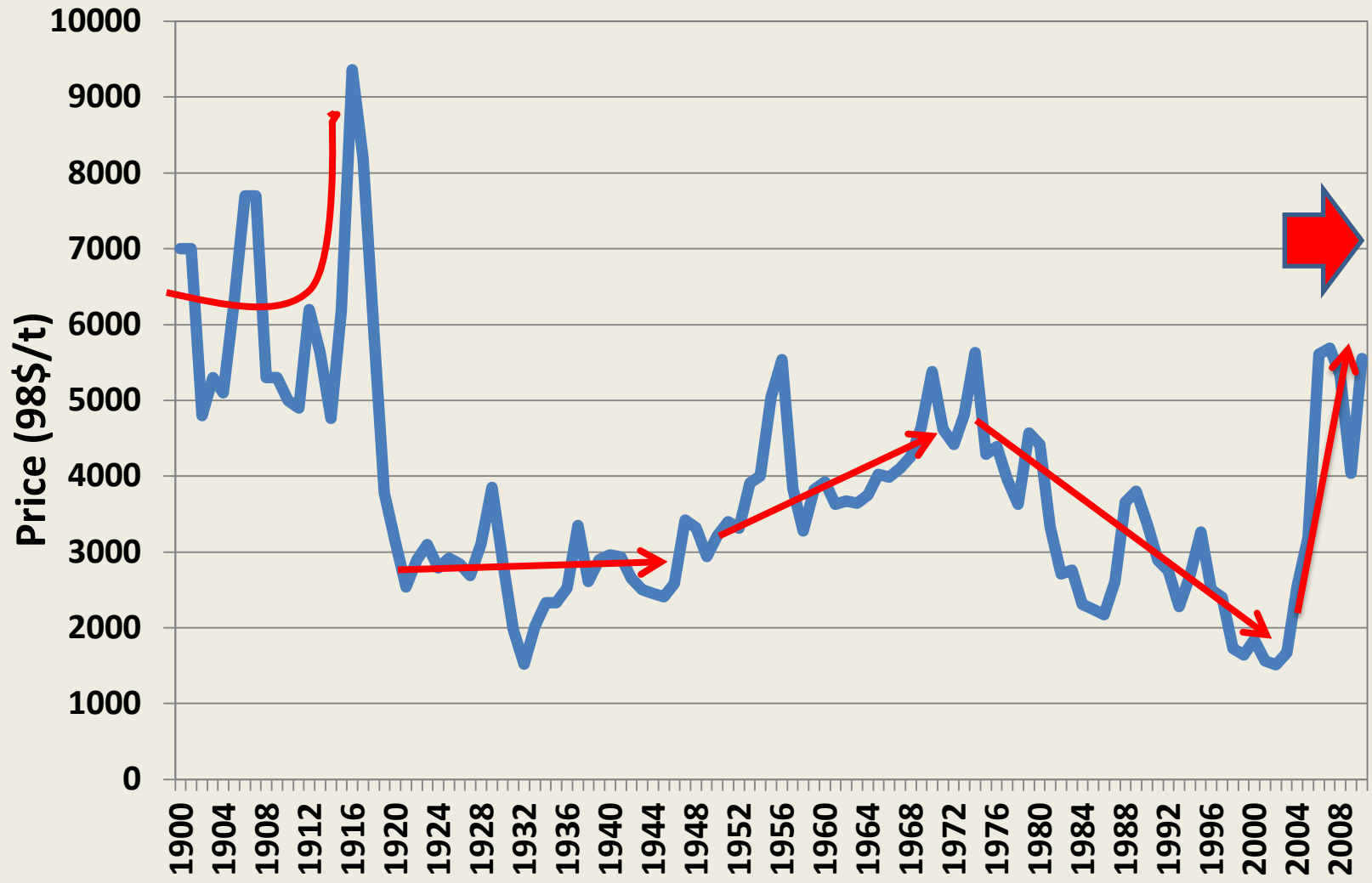
Cement Production 1900 to 2010



Copper price 1900 to 2010

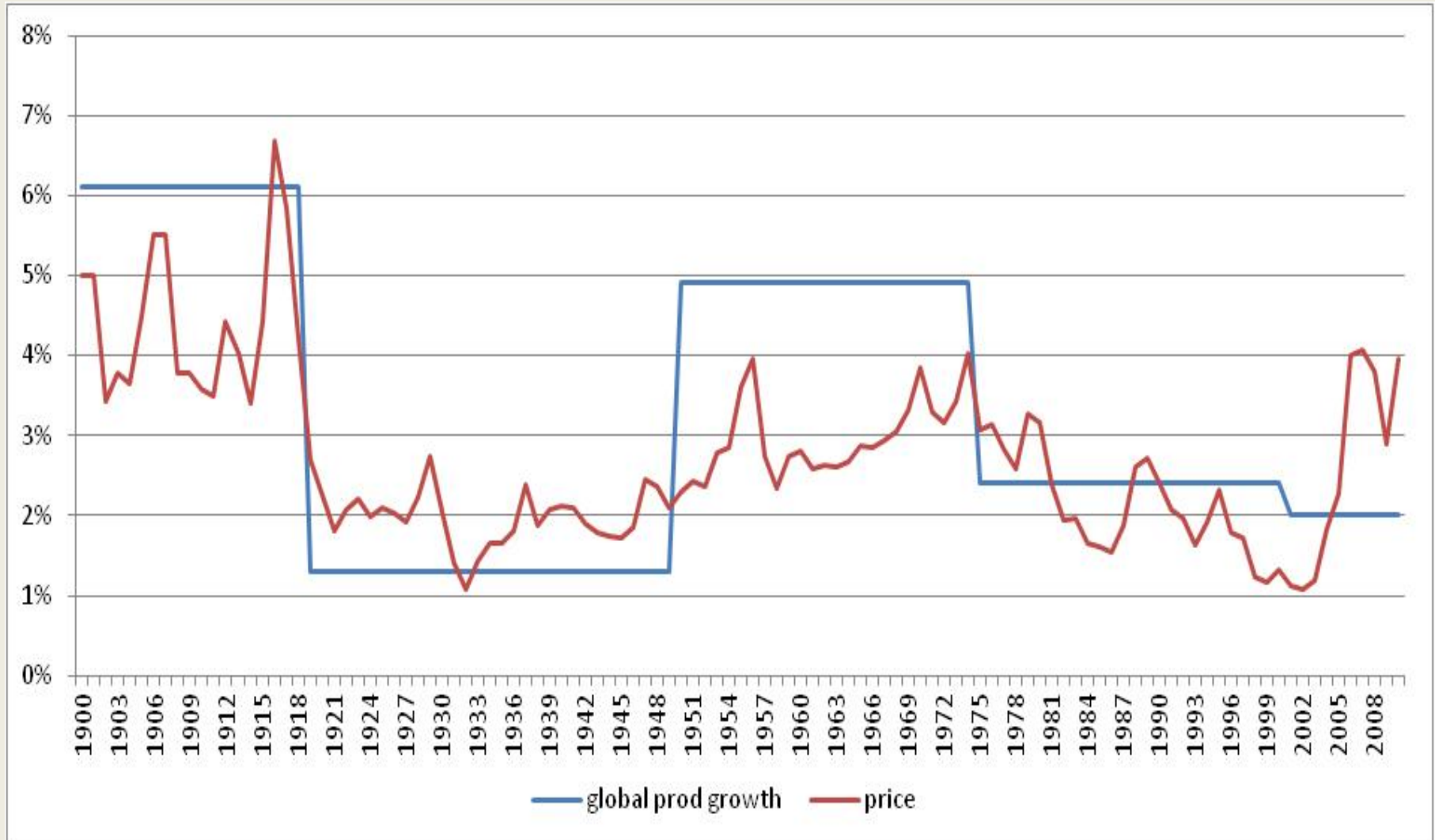


Copper price 1900 to 2010



Copper global production growth

Copper price

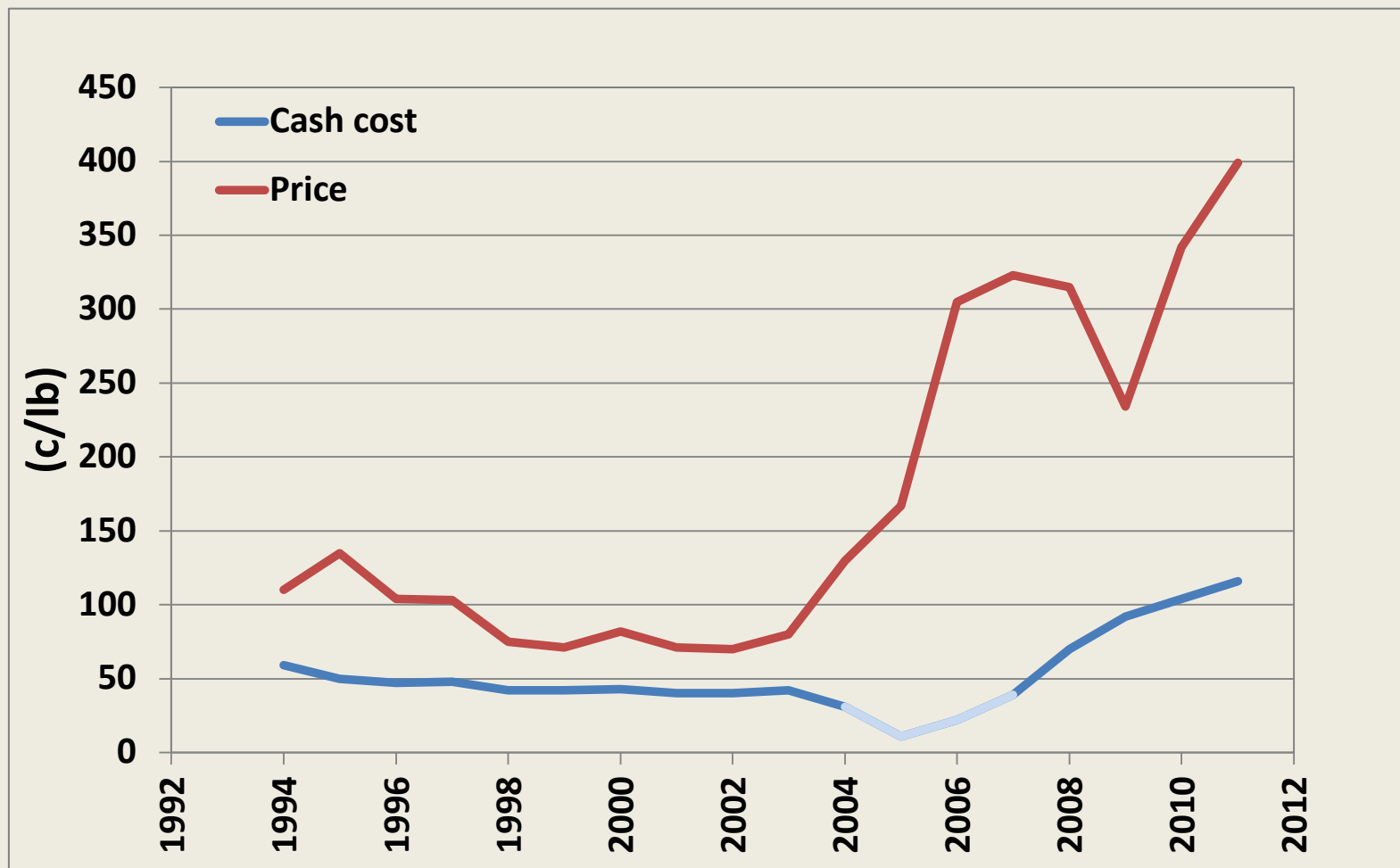


Improvements in the late 20th century

- **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 ?

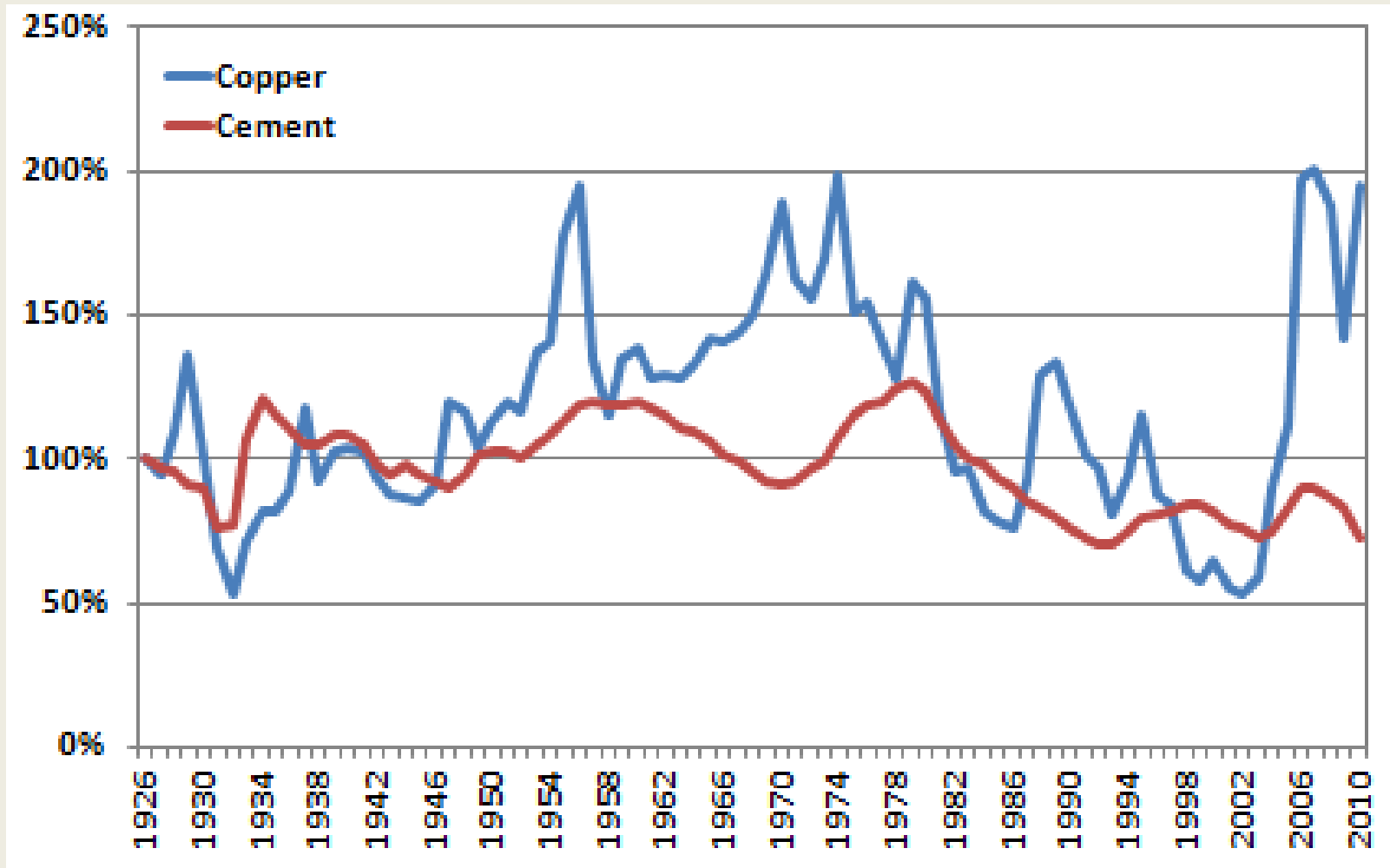
- **As grade declines more ore is required to achieve metal targets**
- **Using existing approaches we will:**
 - **reach the limits for existing equipment / methods;**
 - **consume dramatically higher levels of energy;**
 - **need a proportional increase in water;**
- **Alternative is to break only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

Energy used in different comminution circuits

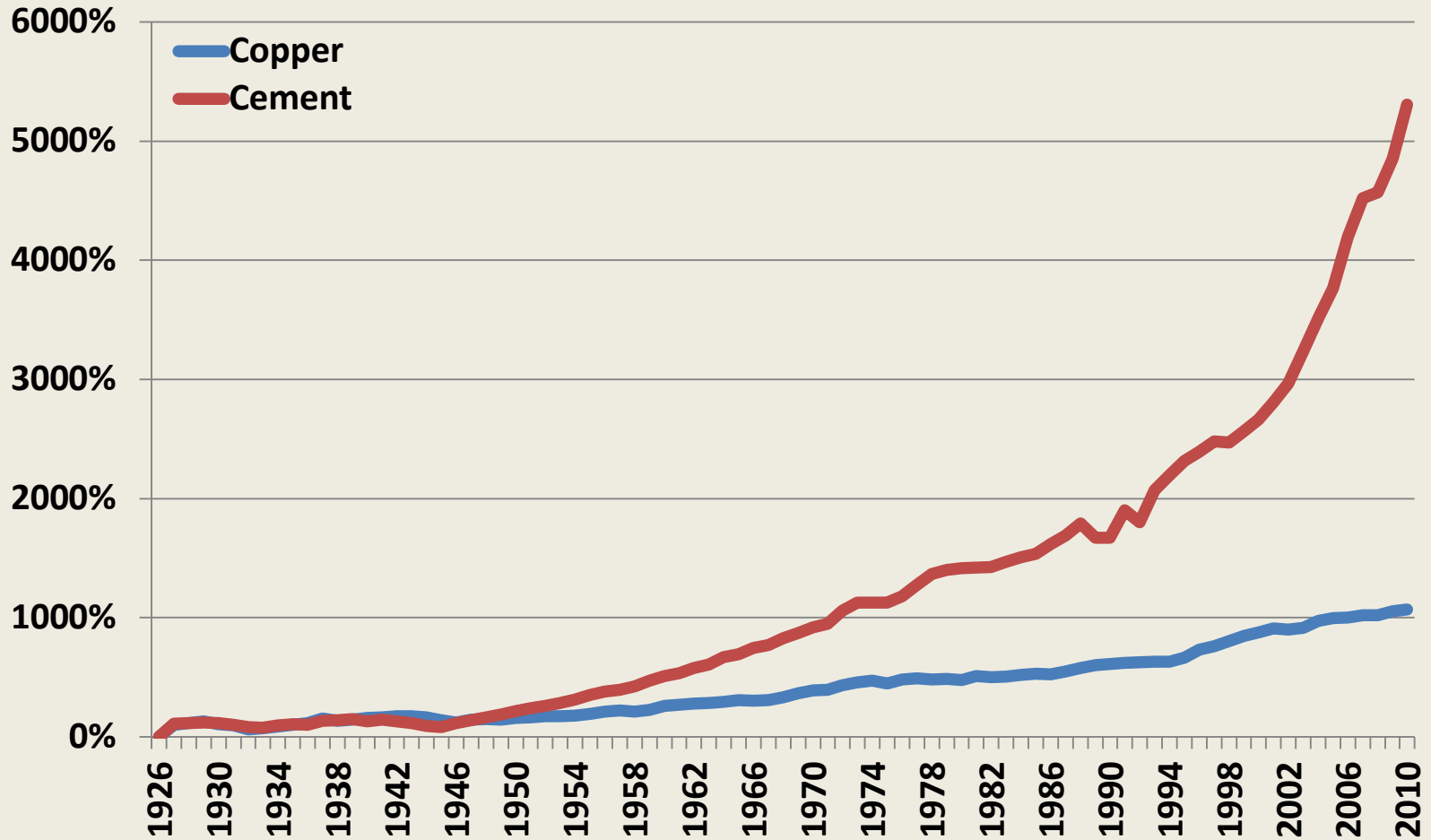
<u>Circuit</u>	<u>Decrease (%)</u>
SAG milling, ball milling	-
SAG milling, pebble crush, ball milling	6.4
AG milling, pebble crush, ball milling	22.1
Three-stage crushing, ball milling	25.7
Two-stage crush, HPGR, ball milling	34.6
Two-stage crush, HPGR, stirred milling	41.4*
Improved classification	46*

* To be verified

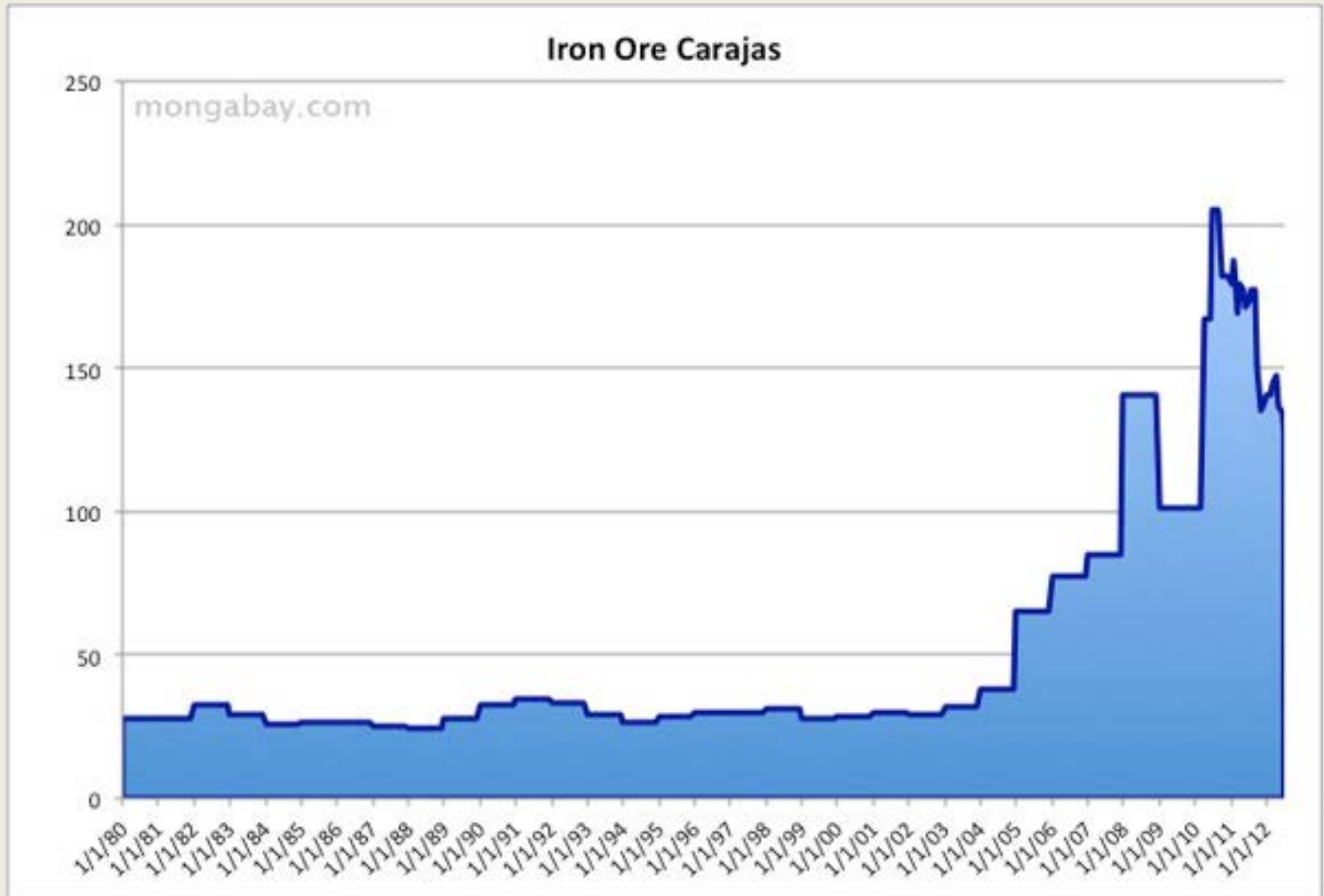
Copper and cement price indexes (real) 1926 to 2010



Copper and cement global production indexes 1926 to 2010



Iron Ore Carajas 1980-2011



Steaming and Coking Coal Prices 1980 to 2010

