# Metakaolin for Geopolymers

Geopolymer Institute Camp - Saint Quentin - July 2013

Alf Baker CEO WA Kaolin & Pacific Polymers R&D JV

## Why Bother?

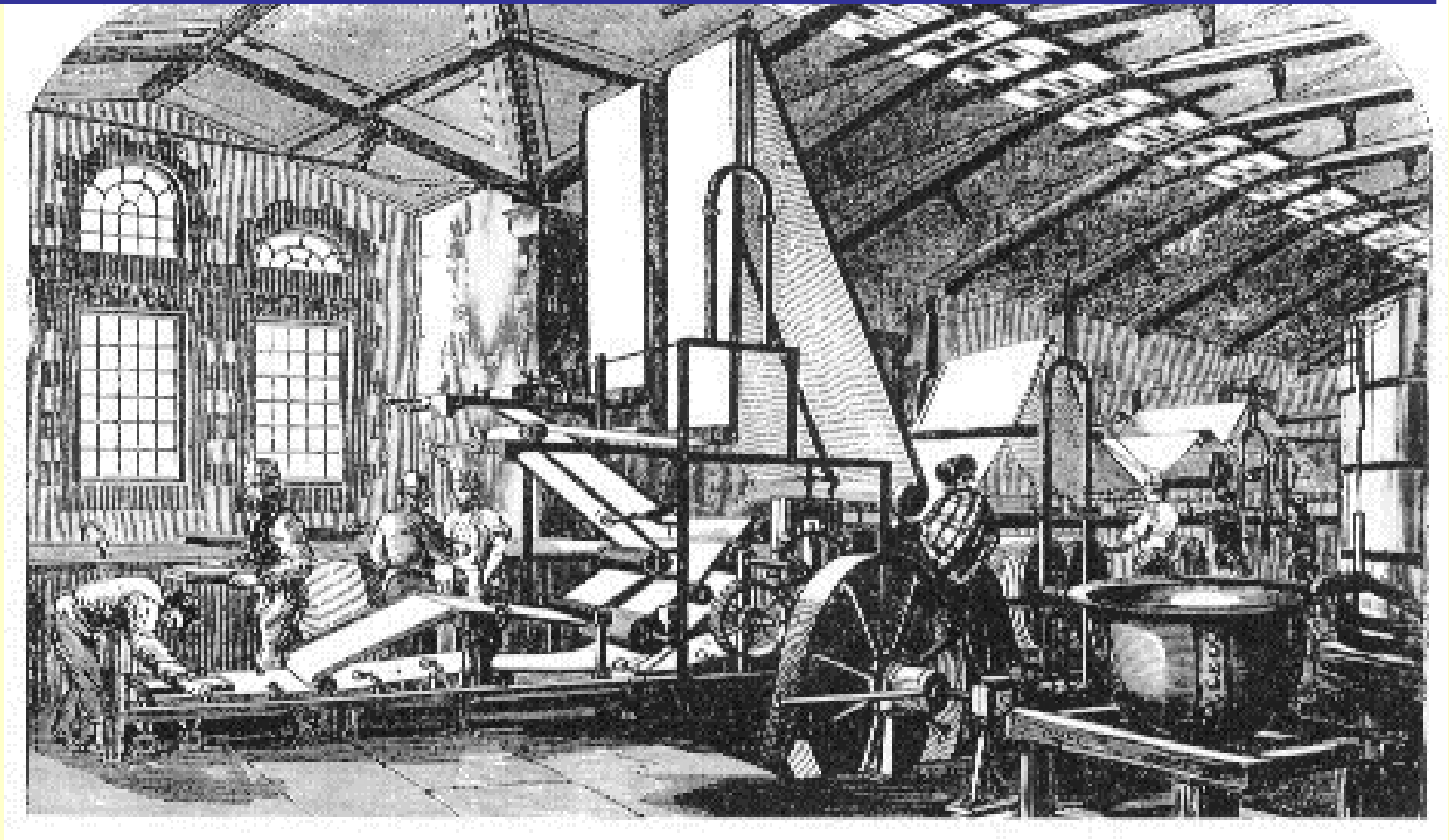
- **Responsibility** > 4 billion tonnes cement production – major emitter CO2
- **Availability** Kaolin is global resource – quality of kaolin probably not critical
- **Universality** We can develop this in all of our countries and economies

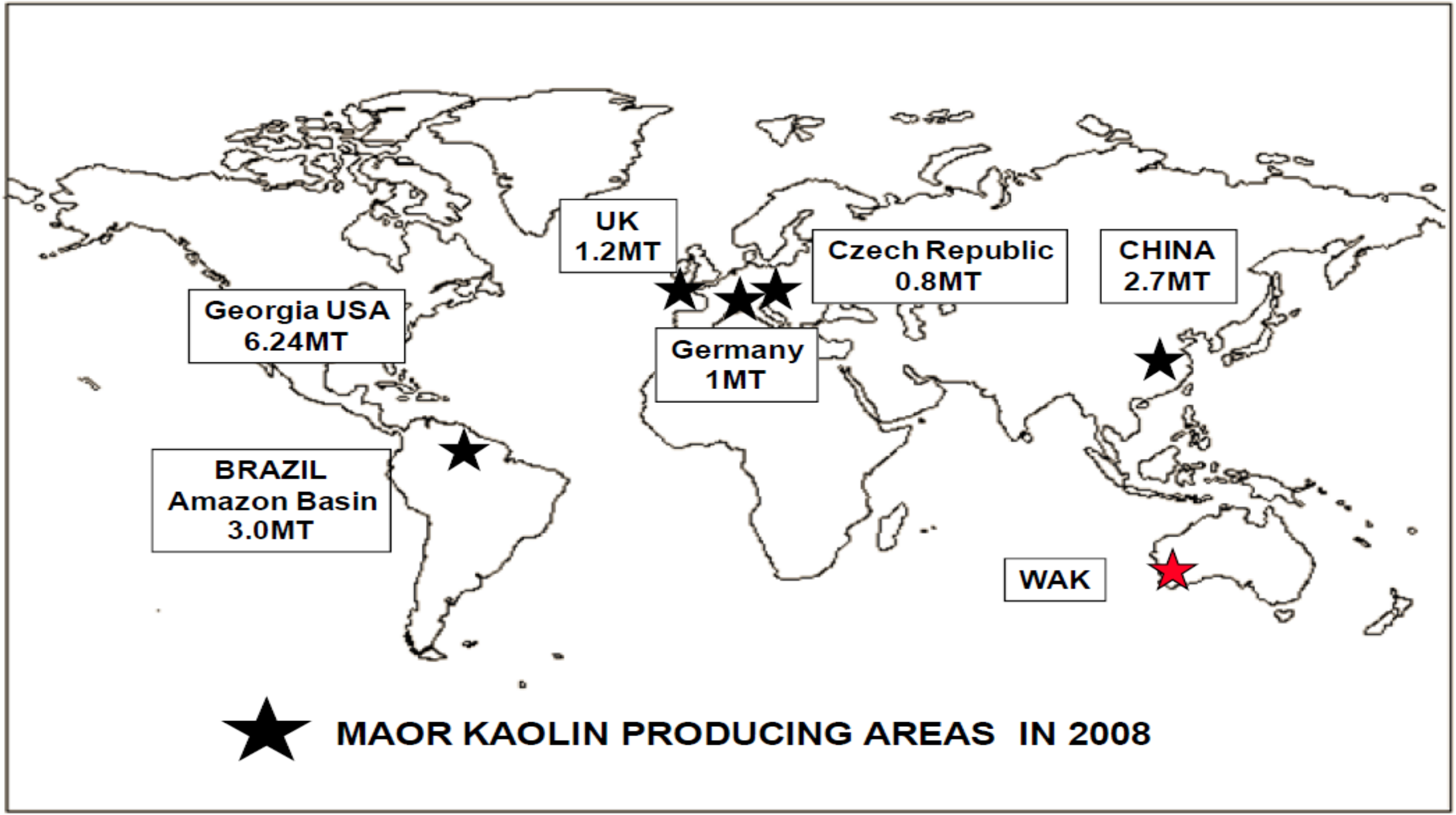
## The Challenges:

- **Technology** Becoming Mature (with help from Geopolymer Institute and academia)
- **Commercialise** Industry slow to move unless COST ADVANTAGE

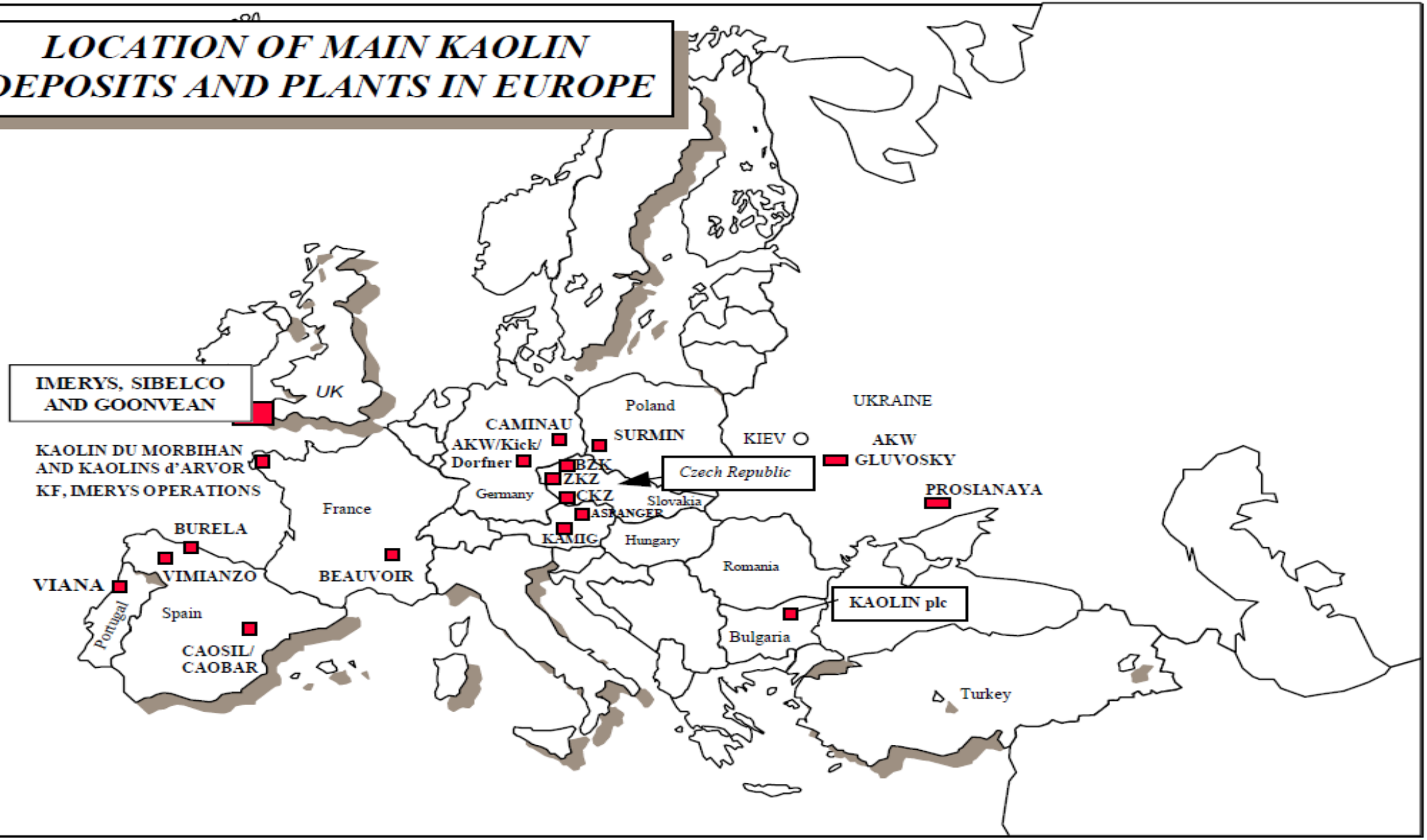
Village of Gaoling (Kao-ling) where the clay was mined until the late Ming Dynasty

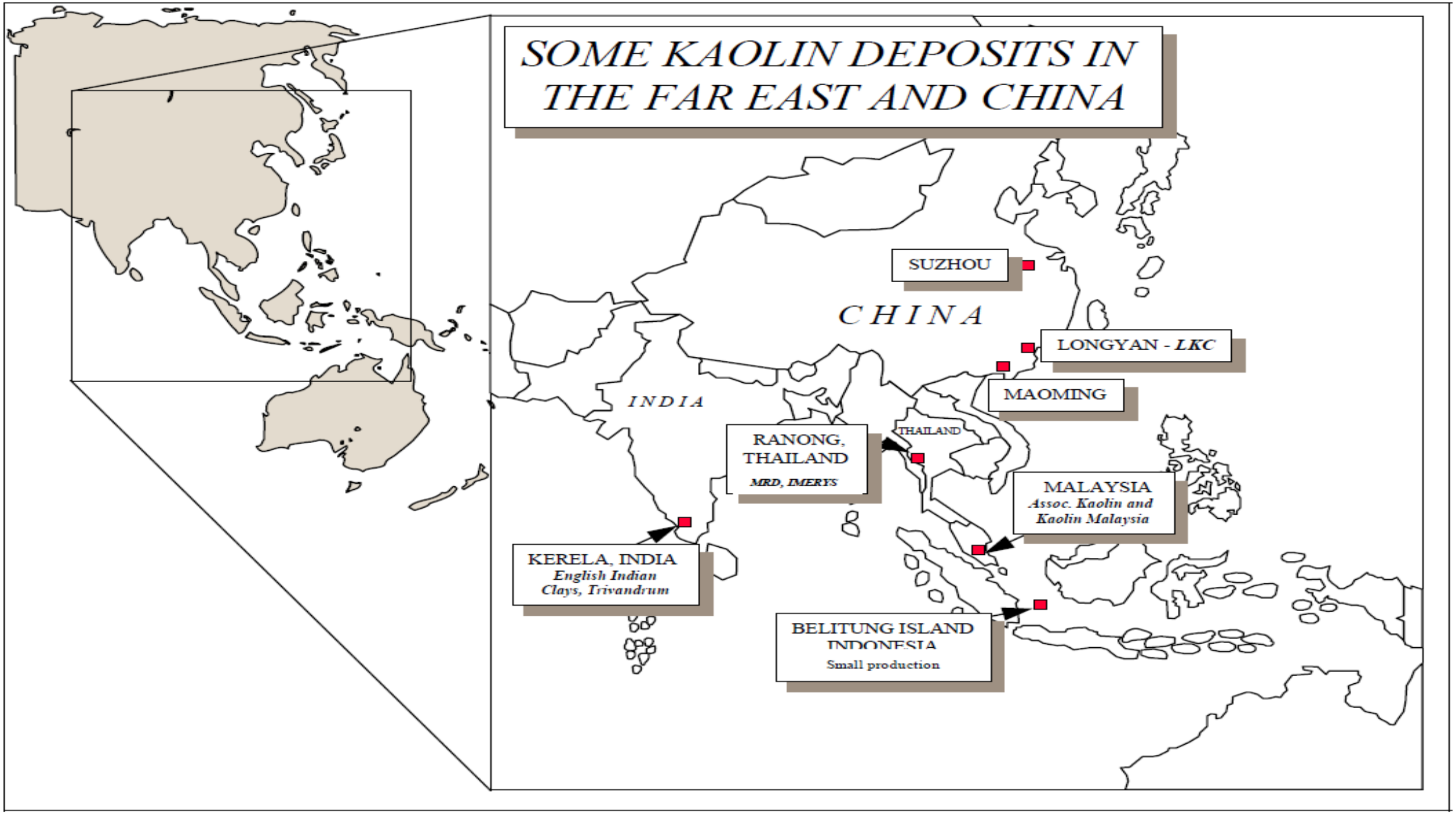
# 1880 - Georgia kaolins mined for paper coating

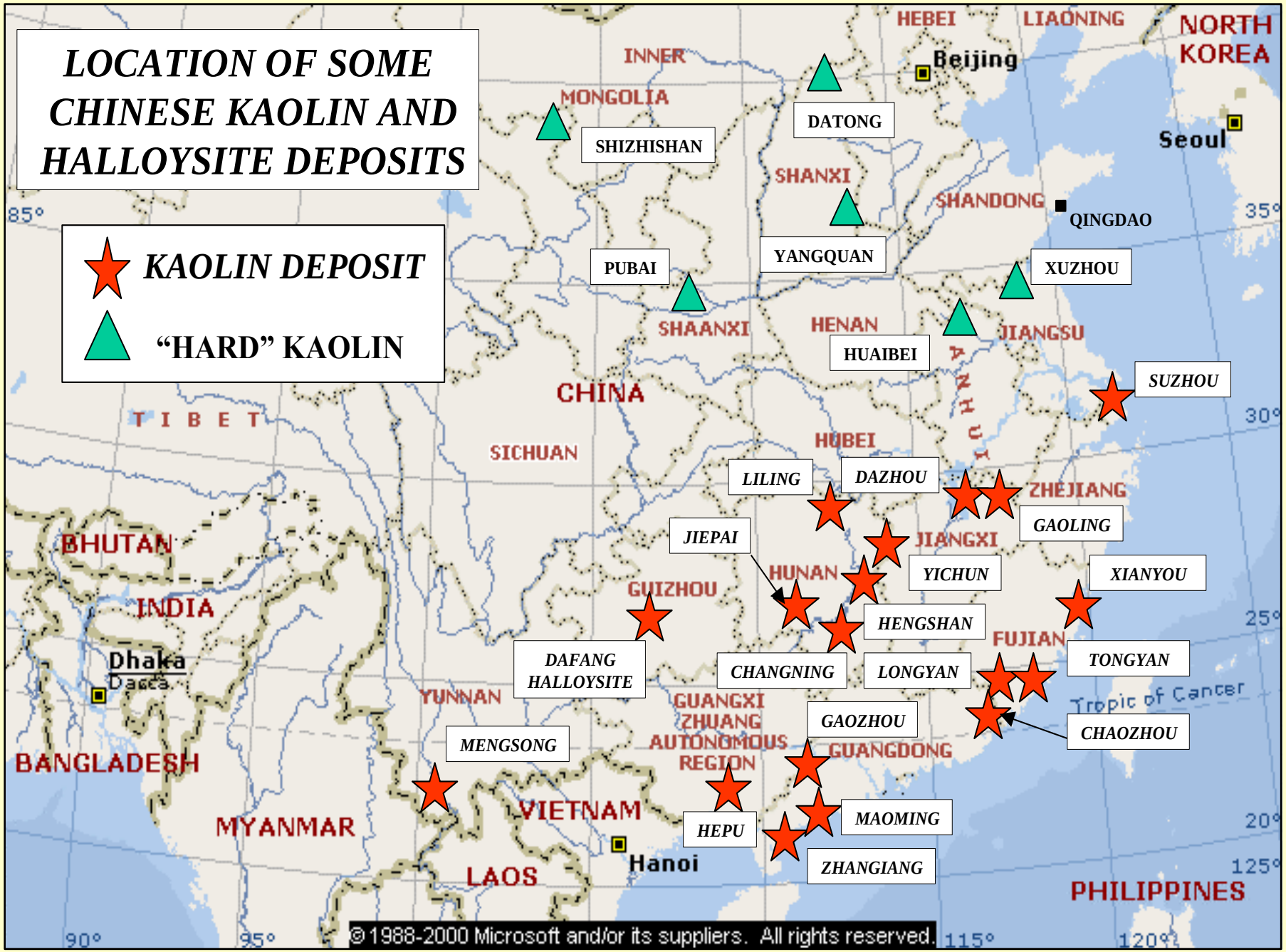



UK
1.2MT
Czech Republic
0.8MT
CHINA
2.7MT
Georgia USA
6.24MT
Germany
1MT
BRAZIL
Amazon Basin
3.0MT
WAK
MAOR KAOLIN PRODUCING AREAS IN 2008

# LOCATION OF MAIN KAOLIN DEPOSITS AND PLANTS IN EUROPE




SOME KAOLIN DEPOSITS IN THE FAR EAST AND CHINA
SUZHOU
CHINA
LONGYAN - LKC
MAOMING
INDIA
THAILAND
RANONG, THAILAND
MRD, IMERYS
MALAYSIA
Assoc. Kaolin and Kaolin Malaysia
KERELA, INDIA
English Indian Clays, Trivandrum
BELITUNG ISLAND
INDONESIA
Small production


LOCATION OF SOME CHINESE KAOLIN AND HALLOYSITE DEPOSITS
KAOLIN DEPOSIT
"HARD" KAOLIN
HEBEI
LIAONING
NORTH KOREA
Beijing
Seoul
INNER MONGOLIA
SHIZHISHAN
DATONG
SHANXI
SHANDONG
QINGDAO
YANGQUAN
PUBAI
XUZHOU
SHAANXI
HENAN
HUAIBEI
JIANGSU
SUZHOU
CHINA
TIBET
HUBEI
SICHUAN
LILING
DAZHOU
ZHEJIANG
GAOLING
JIEPAI
JIANGXI
BHUTAN
HUNAN
YICHUN
XIANYOU
GUIZHOU
INDIA
HENGSHAN
FUJIAN
Dhaka
Dacca
DAFANG HALLOYSITE
CHANGNING
LONGYAN
TONGYAN
YUNNAN
GUANGXI ZHUANG AUTONOMOUS REGION
GAOZHOU
Tropic of Cancer
MENGSONG
CHAOZHOU
GUANGDONG
BANGLADESH
VIETNAM
MAOMING
HEPU
MYANMAR
Hanoi
ZHANGIANG
LAOS
PHILIPPINES
85°
35°
30°
25°
20°
125°
90°
95°
115°
120°
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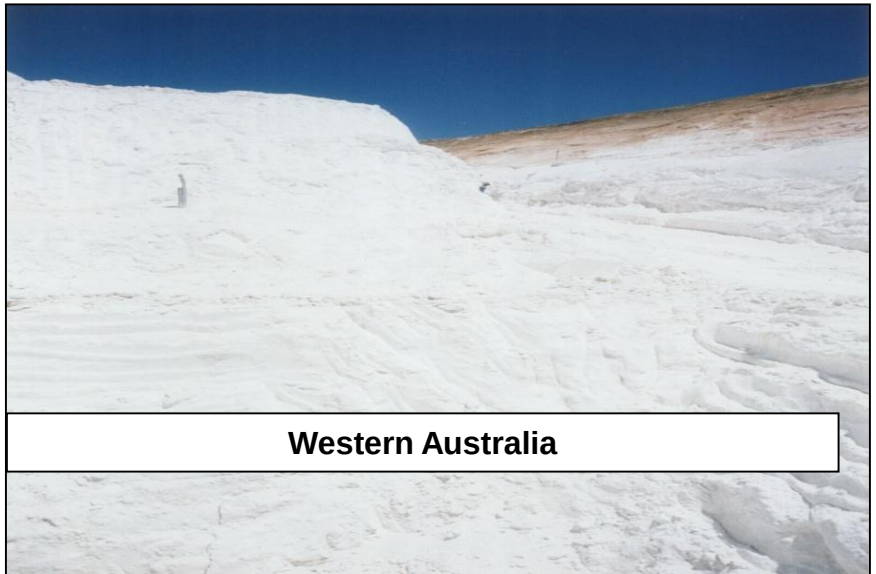
# MAJOR KAOLIN PRODUCERS 1980-2012

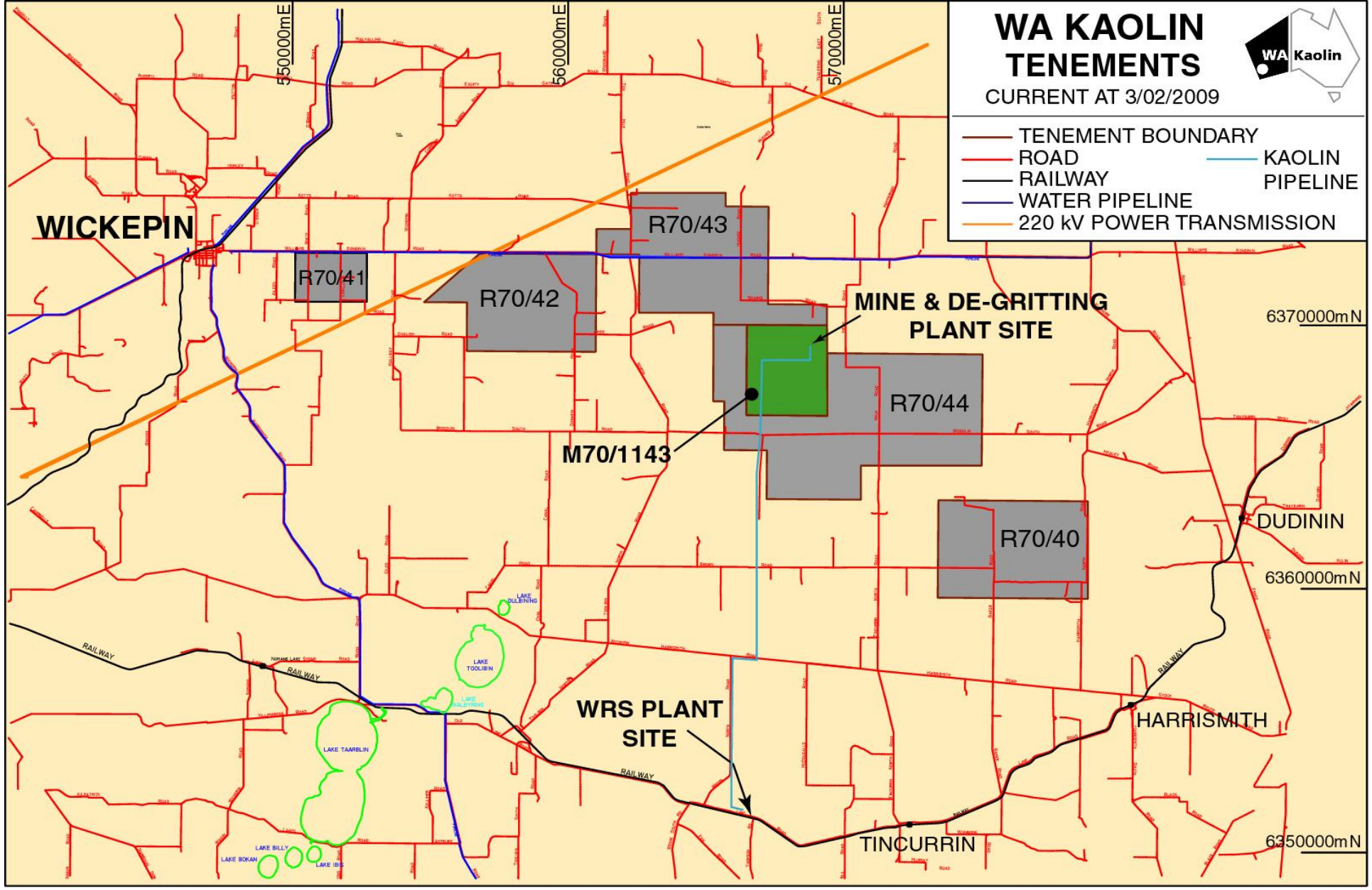
| 1980 | 1990 | 2000 | 2008 | 2012 |
|---|---|---|---|---|
| ECCI | ECCI | IMERYS | IMERYS | IMERYS |
| HUBER | HUBER | HUBER | KAMIN | KAMIN |
| THIELE | THIELE | THIELE | THIELE | THIELE |
| AKW | AKW | AKW | AKW | AKW |
| ENGELHARD | ENGELHARD | ENGELHARD | BASF | BASF |
| CADAM | CADAM | CADAM | VALE | SIBELCO |
| GEORGIA KAOLIN | DRY BRANCH | PPSA | SIBELCO | |
| FREEPORT | NORD | UNIMIN | | |
| NORD | *COMALCO* | | | |
| CYPRUS | EVANS | | | |
| *COMALCO* | KENTUCKY-TENNESSEE | | | |
| EVANS | ALBION | | | |
| KENTUCKY-TENNESSEE | | | | |
| R.T. VANDERBILT | | | | |
| ALBION | | | | |

# MAJOR GLOBAL KAOLIN DEPOSITS






# WAK MINING
# Free Dig, Shallow Open Pits down to 40m


- Mining Lease M70/1143 10sqKm - 112mt reserve.
- Retention Licenses 106sqKm WAK

Note: WAK owners control 12sqkm of farmland in the resources area.

# RESOURCE STATEMENT

**JORC COMPLIANT**

Dr Ian Wilson and confirmed by CVRD/ Vale

| RESOURCE | AREA REF | Million Tonnes |
|---|---|---|
| **Proved Ore Reserve** | **ML 1143** | **112.0** |
| **TOTAL PROVED ORE RESERVES** | | **112.0** |
| **Inferred Resources** | **RL 70/40** | **13.6** |
| | **RL 70/41** | **6.7** |
| | **RL 70/42** | **122.7** |
| | **RL 70/43** | **128.0** |
| | **RL 70/44** | **192.5** |
| **TOTAL INFERRED RESOURCES** | | **463.0** |

**VERY LARGE DEPOSIT IN WORLD TERMS**

**Proven Reserves give Mine Life of 100+ years at 1Mtpa Production**

# Existing WAK Operations

Open Pit Mine

Loading

Wet Screening

Full size Centrifuge

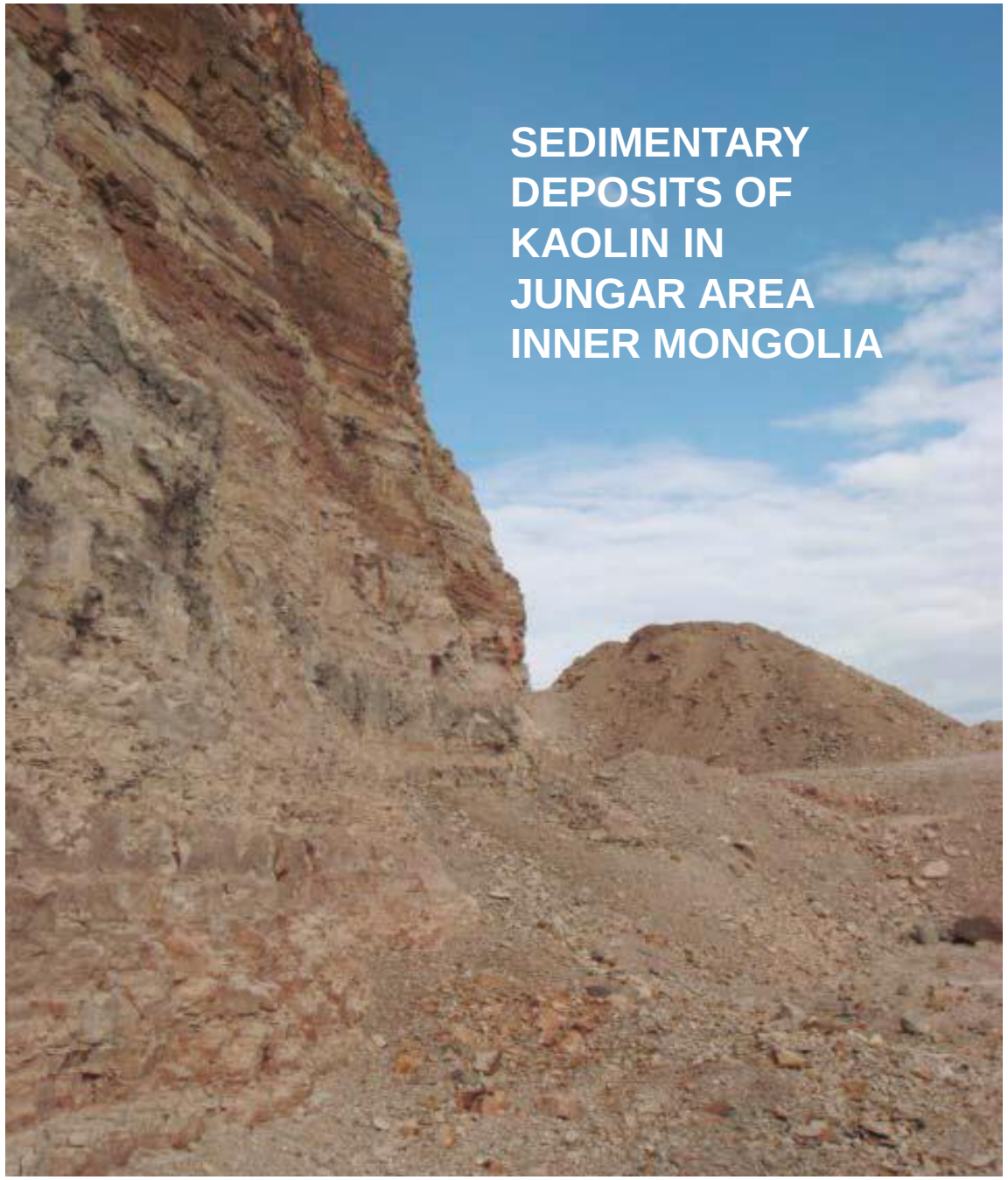
# Existing WAK Operations

Full scale mixing and granulation

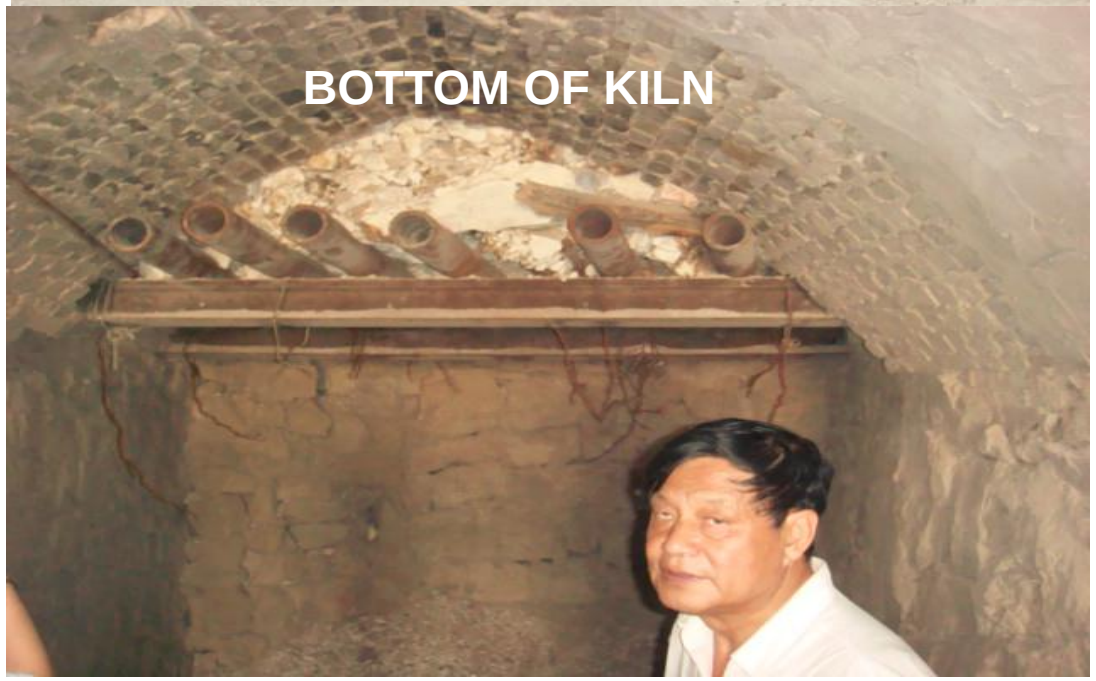
Drying

Finished Product
(1 tonne bulk bags)


QC Analysis Lab


SEDIMENTARY
DEPOSITS OF
KAOLIN IN
JUNGAR AREA
INNER MONGOLIA


FEED FROM TOP


BOTTOM OF KILN

# SANHE–MULLITE PRODUCTION OF MC-0

CLAY SELECTION

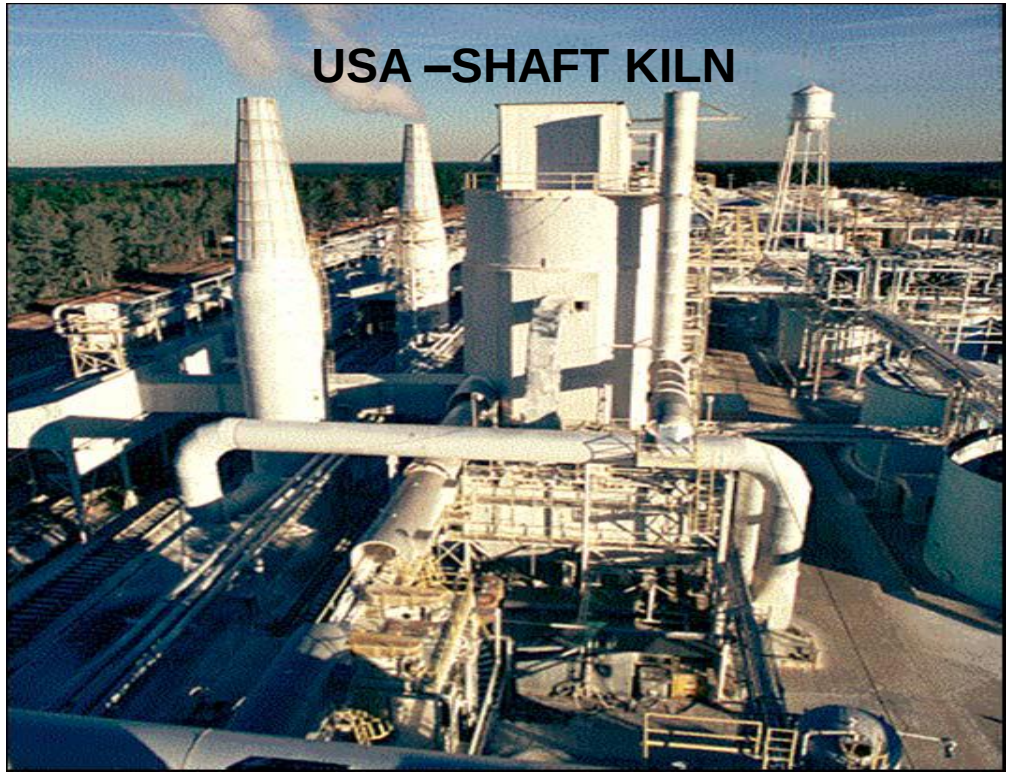
BRICK MAKING

STACKING IN ROUND KILN

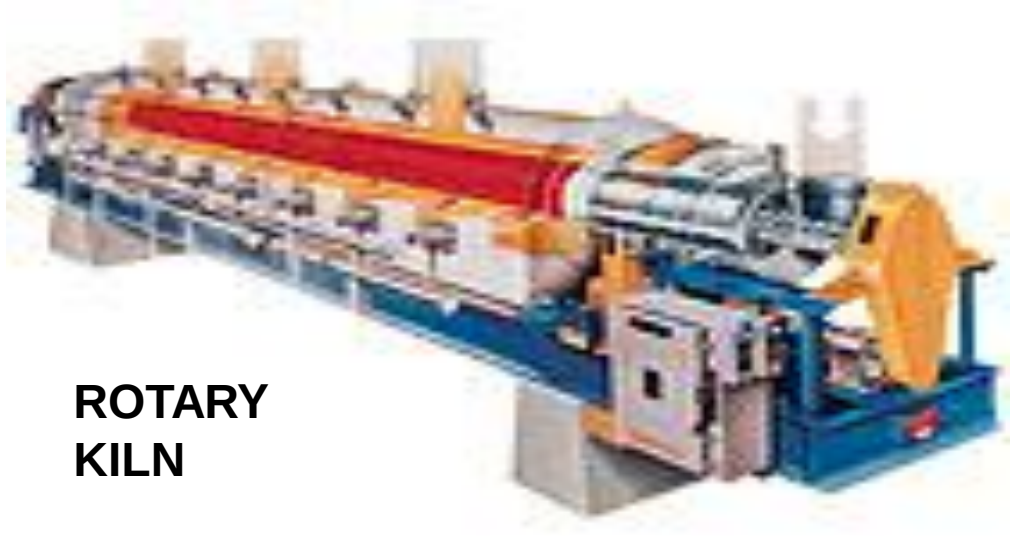
UNLOAD ROUND KILN

CRUSHING

FINAL PRODUCTS


USA –SHAFT KILN


ROUND KILN -CHINA

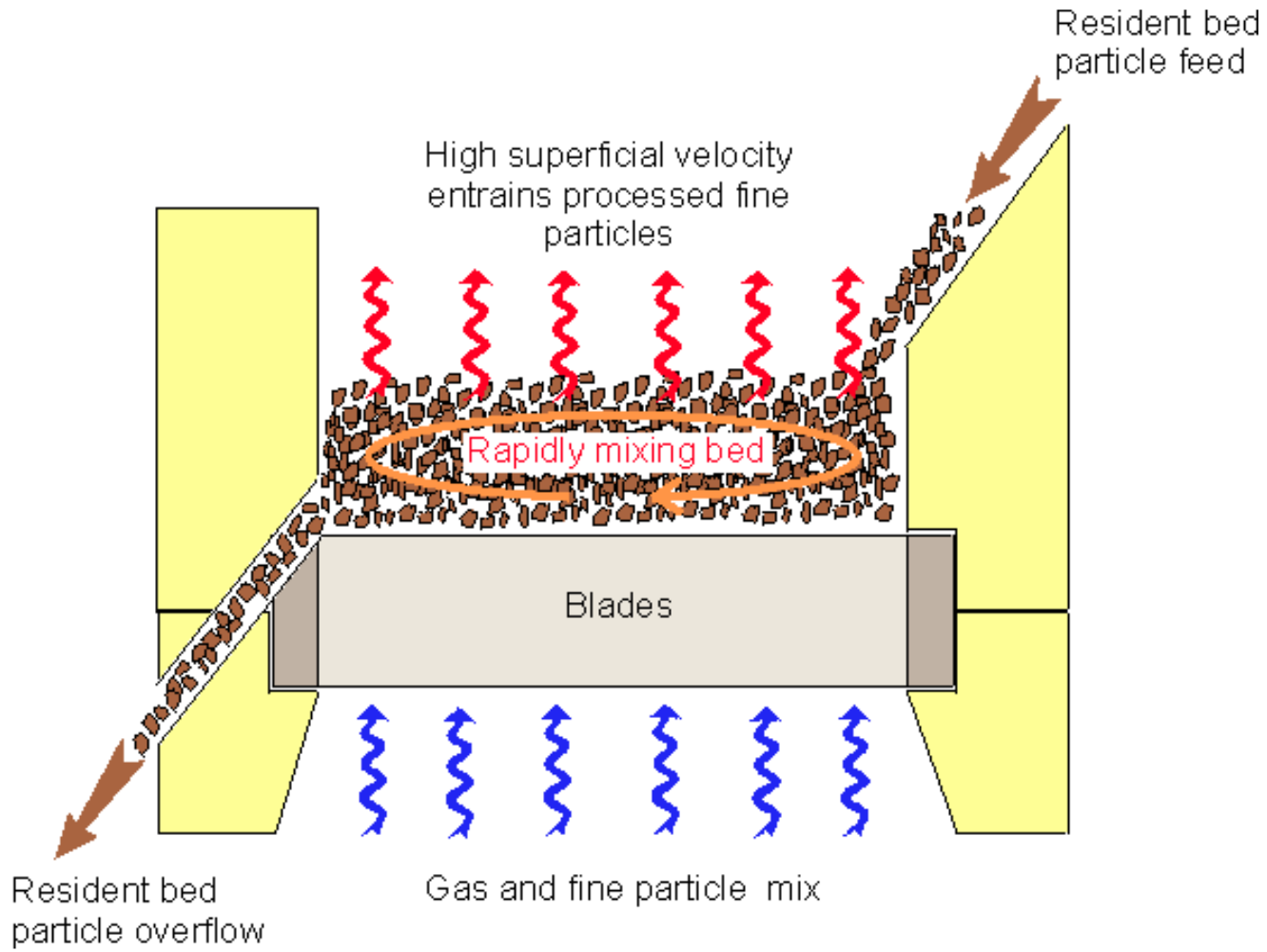

ROTARY
KILN


TORBED –FLASH CALCINER

# TORBED* Process Reactor Technology

Torftech

The fine powder injection process



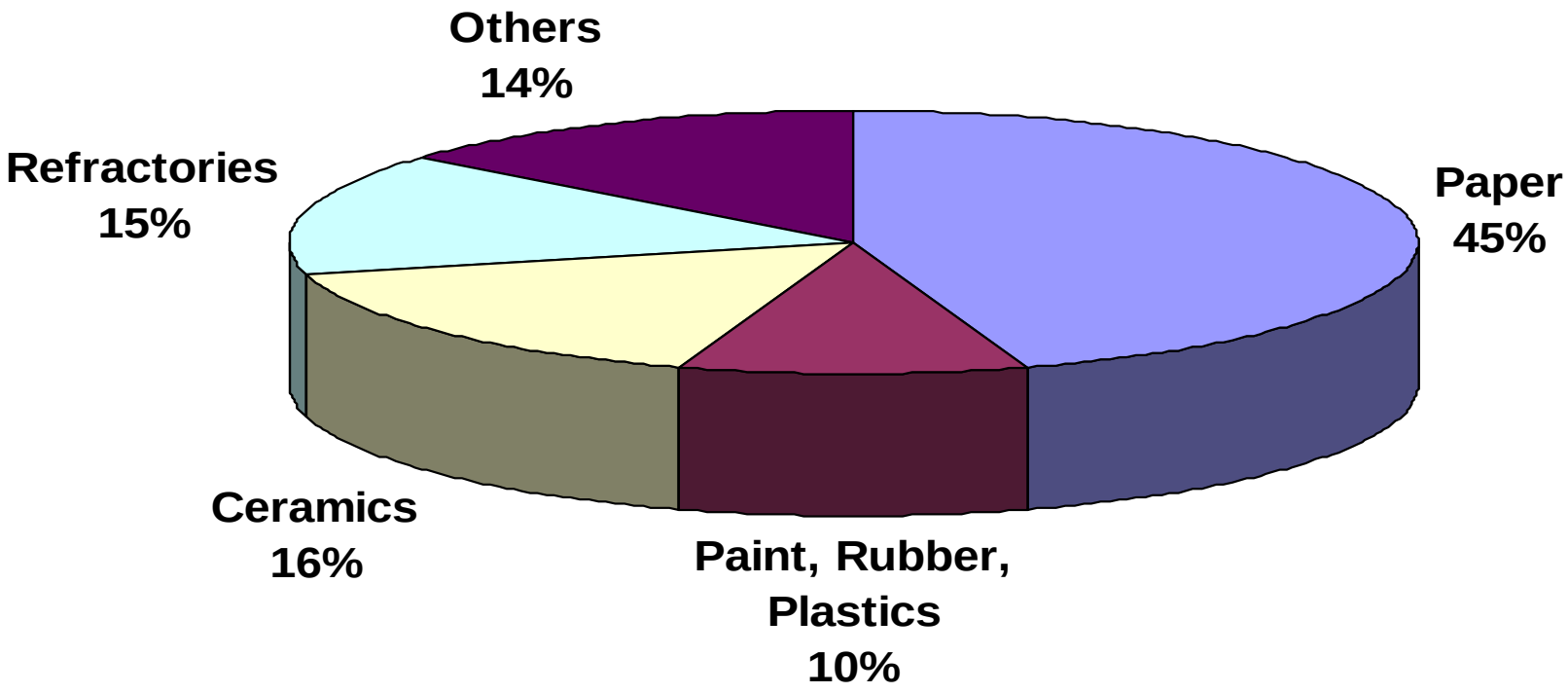

**KAOLIN PARTICLES ARE PASSED RAPIDLY THROUGH HEATING ZONEWHERE THEY ARE FLASH CALCINED. RESIDENCE TIME IS LESS THAN ONE SECOND IN A TOROIDAL FLUID FLOW HEATING ZONE. KAOLINITE IS BLISTERED CAUSED BY RAPID DEHYDROXYLATION.**

# Traditional Calcination

- China Hard Black Kaolin – naturally occurring with a form of coal
- Hearth furnaces
- Rotary Kilns
- Flash Calcining – Herreschoff – US/UK agglomerates and pillows
- Torbed Driers

- Issues relate to:
  - Energy consumption
  - Dusting
  - Agglomeration requiring regrind

# 25mt World consumption by industry 2010




**What would this chart look like if kaolin used in GPC?**

**If Kaolin is used in Geopolymer Cement (GPC) and, lets say:**

- **Global OPC production is 4bt**
- **by 2025 20% of OPC is substituted by GPC**
- **GPC formula contains 20% kaolin**

**World consumption of kaolin could rise to 200mt!**

**Australia produces close to 10mt OPC**
**On same basis - kaolin consumption would be 400kt**

**Question: Overall, how much kaolin could be used?**

# CONCLUSION

## Commercialisation of Kaolin for GPC requires:

## >Focussed Development of Dehydroxylation/Activation of Kaolin<

## >Lowest Possible Cost of Production<

The quest and opportunity to displace OPC requires an extraordinary focus to collate all of the technologies available in an innovative way to minimize the energy and cost of preparing the raw materials for GPC

- Temperature
- Atmosphere
- Chemical Environments
- Mechanical Environments
- Particle Shape Engineering

**Somehow I think the future for kaolin it will be driven by downstream niche products such as light weight fire panels, waste containment.**

**WAK in association with Pacific Polymers has built a 1t capacity pilot plant in Melbourne to examine these factors and work hard towards optimization**

**I look forward to learning much more from the camp, the institute and interactions**

**THANK YOU**