British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

High-purity limestone assessment : from mine to market

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Outline

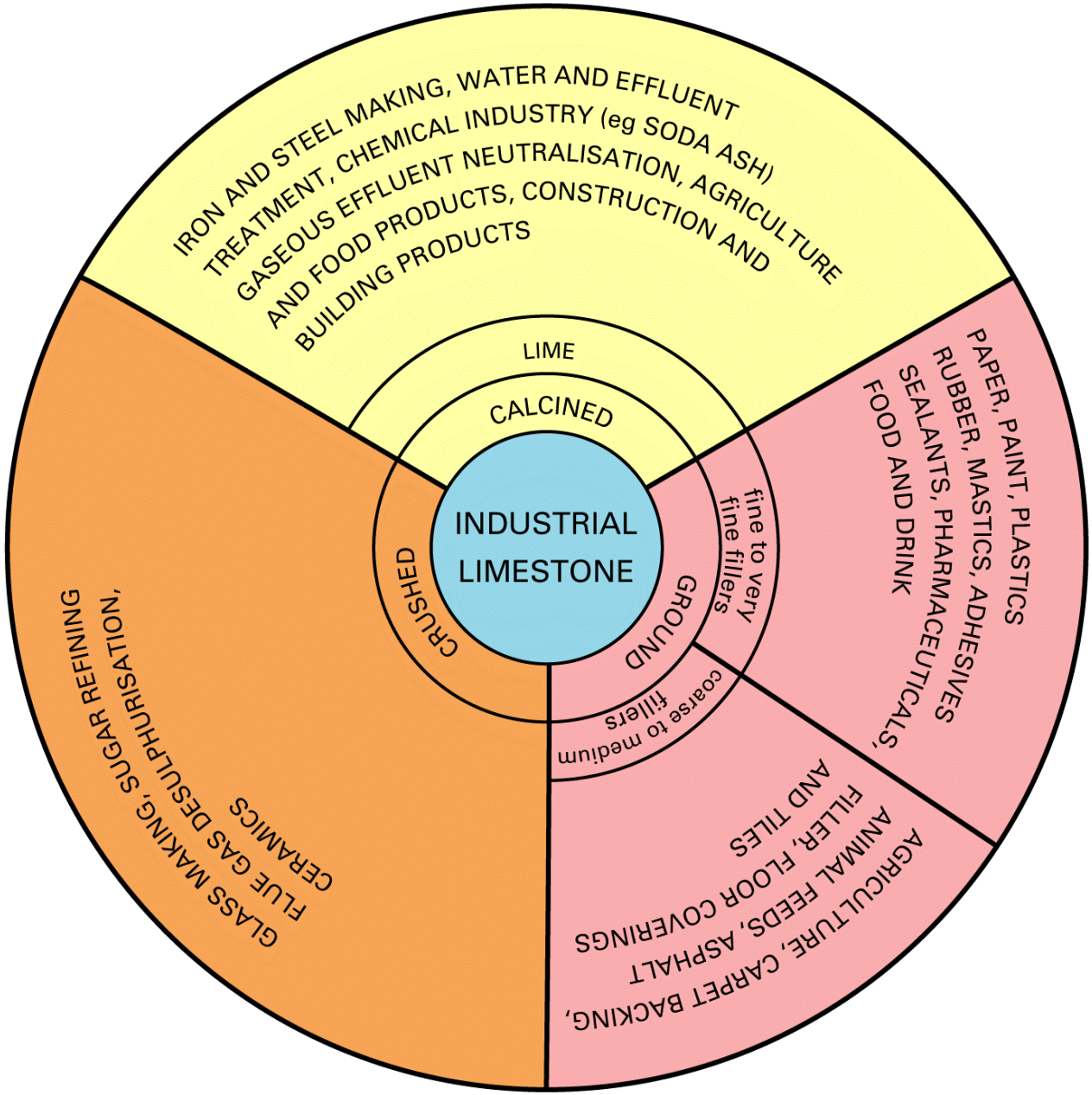
- Introduction
- Limestone uses
- Planning
- Exploration
- Evaluation
- High-purity limestone in Saudi Arabia
- Conclusions

Introduction

- High-purity limestone >97% $CaCO_3$ (Calcium Carbonate)
- Suitability defined by industrial end-use
- Chemical, mineralogical & physical properties
- Assessment is guided by industrial requirements
- National Geosurvey role
- Mineral promotion

Applications

- Limestone has more uses than any other IM
- Low value, bulk volume construction material
  e.g. aggregate, ballast, dimension stone
- High value, lower volume speciality mineral
  e.g. GCC & PCC (Ground & Precipitated Calcium Carbonate)
- High-purity limestone used for lime, glass, metallurgical flux, FGD, sugar refining, mineral fillers (GCC & PCC) and calcium chemicals



Planning

- High-purity resources in ‘low-grade’ uses is an issue
  e.g. Carboniferous limestone in the UK used as speciality mineral and construction aggregate
- Many consider this an inefficient use of resources
- Strategic value of high-purity resources
- UK ‘Mineral Safeguarding Areas’, avoid sterilisation
- Competing land use with other environmental designations
  e.g. National Parks & AONBs

Exploration

- Exploration starts with existing geological information
- Calcium carbonate deposits can occur as:
  - Sedimentary (limestone, chalk, shell, travertine, vein & marl)
  - Metamorphic (marble)
  - Igneous (carbonatite)
- Mineral impurities include:
  - Other carbonate minerals (dolomite, siderite)
  - Silica (quartz, chert)
  - Clay minerals (kaolinite, illite, smectite)
  - Mineralisation (fluorite, galena, sphalerite)
  - Organic matter
  - Others (pyrite, iron oxides, etc…)

Sampling limestone in Zambia (2000) and Afghanistan (2007)

Fieldwork & sampling

Reconnaissance Survey

- National Geosurvey explore at national/ regional scale
- Prioritisation of potential high-purity resources
- GIS of existing information
- Field work to collect (representative) samples
- Technical testing:
  - XRF
  - XRD
  - TGA
  - Whiteness (“Brightness”)

Portable XRF (used in recent limestone survey)

Laboratory Testwork

Chemical composition

Oxide	Wt %	Oxide	Wt %	Oxide	Wt %
SiO_2	<2.0	Na_2O	<0.1	BaO	<0.1
TiO_2	<0.1	K_2O	<0.1	NiO	<0.1
Al_2O_3	<0.3	P_2O_5	<0.1	CuO	<0.1
Fe_2O_3	<1.0	SO_3	<0.5	ZnO	<0.1
Mn_3O_4	<0.1	Cr_2O_3	<0.1	PbO	<0.1
MgO	<3.0	SrO	<0.2	LOI	>42.7
CaO	>54.3	ZrO_2	<0.1	Total	100.0

Typical chemical composition of high-purity limestone; standard range of major element oxides analysed by XRF at BGS.

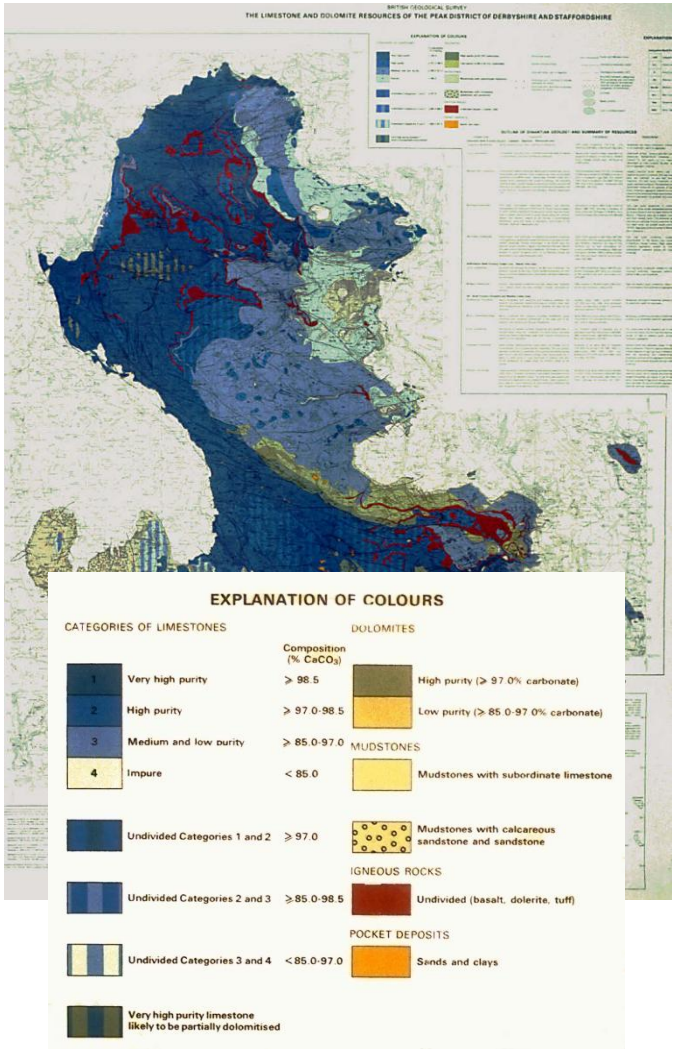
Calcium Carbonate content

Limestone classification	**CaO** (wt%)	**$CaCO_3$** (wt %)
100% limestone	56.03	100.0
Very high purity	> 55.2	> 98.5
High purity	54.3 - 55.2	97.0 - 98.5
Medium purity	52.4 - 54.3	93.5 - 97.0
Low purity	47.6 - 52.4	85.0 - 93.5
Impure	< 47.6	< 85.0

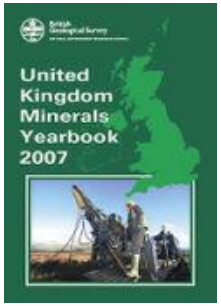
Other Criteria

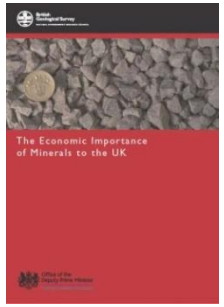
Purity classification	**MgO** (wt%)	**SiO_2** (wt%)	**Fe_2O_3** (wt%)
Very high purity	< 0.8	< 0.2	< 0.05
High purity	< 1.0	< 0.6	< 0.1
Medium purity	< 3.0	< 1.0	< 1.0
Low purity	> 3.0	< 2.0	> 1.0
Impure		> 2.0	

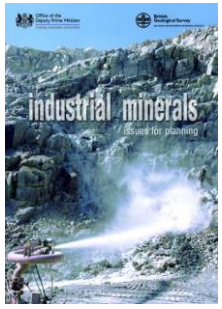
Mineral Promotion

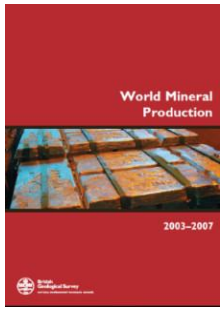


- Resource maps and reports
- Web pages/ downloads: www.mineralsuk.com
- Workshops and seminars









MineralsUK
Centre for sustainable mineral development

Saudi High-purity Limestone

Deposit	CaO Wt%	MgO Wt%	SiO_2 Wt%	Fe_2O_3 Wt%	Purity
Al Kharj: Umm al Ghirban (Aruma Fm)	54.13	0.26	0.52	0.09	High
Al Kharj (Tuwaiq Mountain Limestone)	55.0	0.38	0.94	0.27	Medium to high
Al Kharj (Salaiy Fm)	54.42	0.35	0.7	0.06	High
Riyadh area: Khasm Mazali (Sulaiy Fm)	53.4-55.6	0.2	0.1-0.56	0.08-0.13	High to very high
Riyadh area: Sudus (Tuwaiq Fm)	54.87	0.07	1.18	0.1	Medium to high
Wadi at Tarbah area: Umm Wa'al	> 55	n/a	< 5	n/a	Medium to high
Ad Dammam area (Middle Eocene)	51.8	1.17	1.5	0.25	Low
Red Sea Coast Wadi Misser (Shayban Fm)	49.6	3.23	1.4	n/a	Low
Red Sea Coast Wadi Minsah (Proterozoic)	55	0.6	0.7	0.4	Medium to high
Red Sea Coast Ra's Marjah (Quaternary)	47.15	2.2	1.7	n/a	Low

Limestone data from: Ministry of Petroleum and Mineral Resources (1994) Limestone and dolomite. Chapter 24 in Mineral Resources of Saudi Arabia, Directorate General of Mineral Resources, Special Publication SP-2, p.162-172.

Saudi High-purity Limestone

- Purity by lime, magnesia, silica & Iron oxide contents
- Several are not “high-calcium” limestones
  (require 97% $CaCO_3$, equivalent to 54.3% CaO)
- Only one limestone considered very high-purity
- Khasm Mazali, Riyadh area
  (Lower Cretaceous, Sulaiy Formation)
- Micritic (very fine grained), homogeneous, cohesive limestone with enormous potential resources

(Ministry of Petroleum and Mineral Resources (1994) Limestone and dolomite. Chapter 24 in Mineral Resources of Saudi Arabia, Directorate General of Mineral Resources, Special Publication SP-2, p.162-172)

Conclusions

- Limestone resources are often widespread
- National Geosurveys work at reconnaissance scale
- Technical assessment needs market information
- Ongoing challenge to maintain knowledge base
- Laboratory capabilities a key component
- Outputs largely via the web (www.mineralsuk.com)

Thank you for your attention

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