

UNIVERSITY OF ZAMBIA

GGY3051: ENGINEERING GEOLOGY

**INDUSTRIAL / CONSTRUCTION MATERIALS &
CONCRETE**

1. Non-Metallic (Industrial / Building) Minerals



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Introduction

Virtually everything we **use** or **build** or **create**
in modern life **involves rock, mineral and**
fuel resources taken from the Earth

Introduction.....contd.

Earth has **92 natural elements**. About **99.7%** of it's crust is comprised of only **EIGHT** of these:

Oxygen	O	46.3%
Silicon	Si	28.2%
Aluminum	Al	8.2%
Iron	Fe	5.6%
Calcium	Ca	4.1%
Sodium	Na	2.4%
Magnesium	Mg	2.3%
Potassium	K	2.1%
Titanium	Ti	0.5%

Introduction.....contd.

- The **EIGHT** common elements combine with 1000's of rare elements to form +/- 3,000 **different minerals**
- Key here is that:
 - Each mineral is potentially a resource, if people find a use for it.
- Minerals are valued primarily for their mechanical or chemical properties
 - As technologies evolve, so too do the related values of mineral resources.

Introduction.....contd.

- Minerals are either *metallic* or *nonmetallic*
- *Weight-wise, 90% of minerals that humans use are nonmetallic!!*
- *Metallic minerals have other, economic-based value...*

Introduction.....contd.

- 90% of **nonmetallic** mineral extraction is used for:
 - Building materials
 - ✓ Building stones / large stones
 - ✓ Coarse gravel
 - ✓ Fine sand

Non-Metallic (Industrial/Building) Materials

These are rocks, minerals, or other naturally occurring substances:

➤ **of economic value, but which generally excludes metals, fuels, & gemstones.**

Classification of Industrial Rocks

Two of the methods of classification include:

1. Genetic classification – how they have formed.

So Industrial **ROCKS** fall into;

A. Igneous Rocks – e.g. Granite, Basalt & Diabase,
Pumice and pumicite....



Granite



Basalt



Pumice

Classification of Industrial Rocks.....contd.

B. Metamorphic Rocks – e.g. Gneiss, Slate, Quartzite, Marble...



Marble



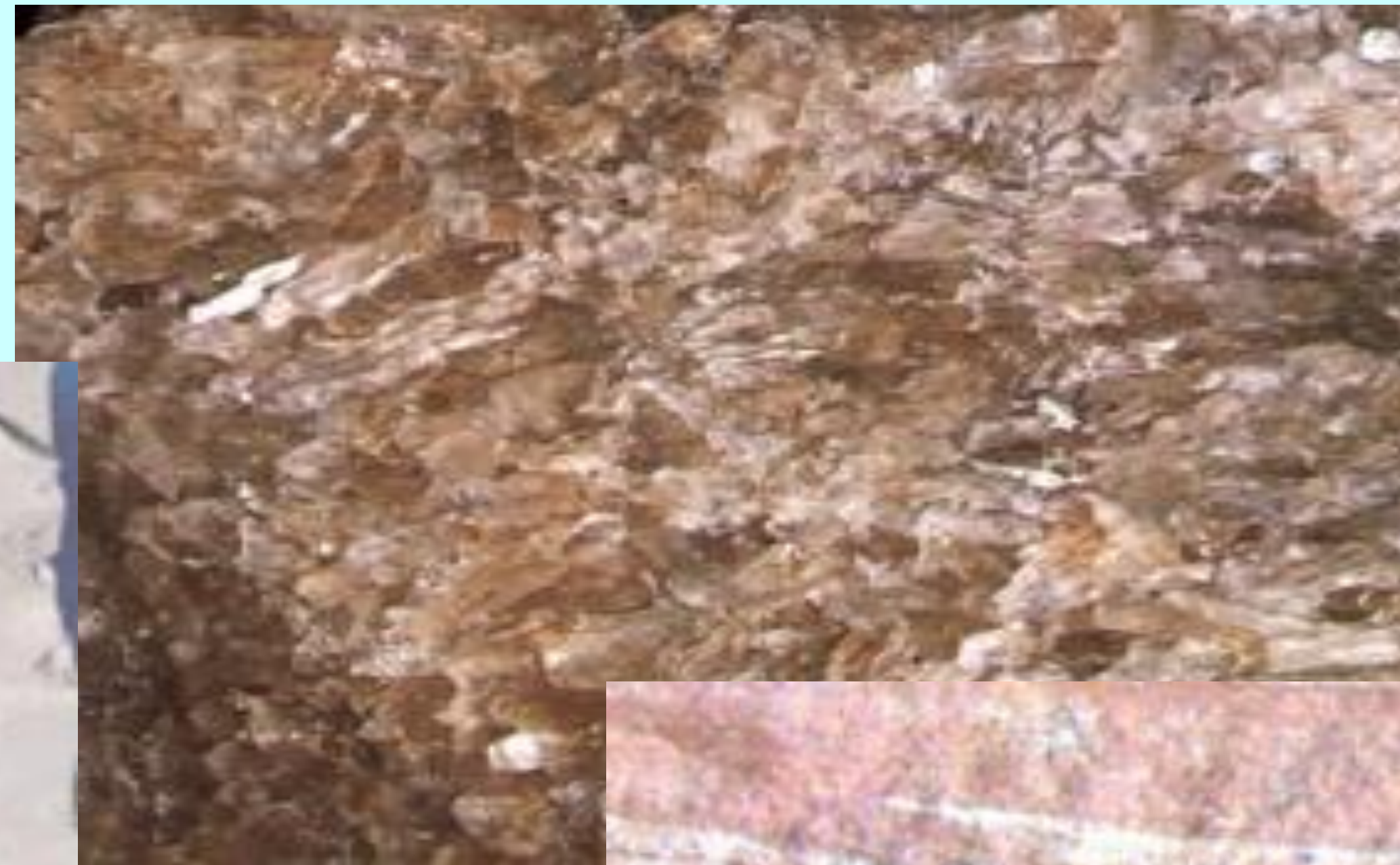
Gneiss



Quartzite

Classification of Industrial Rocks.....contd.

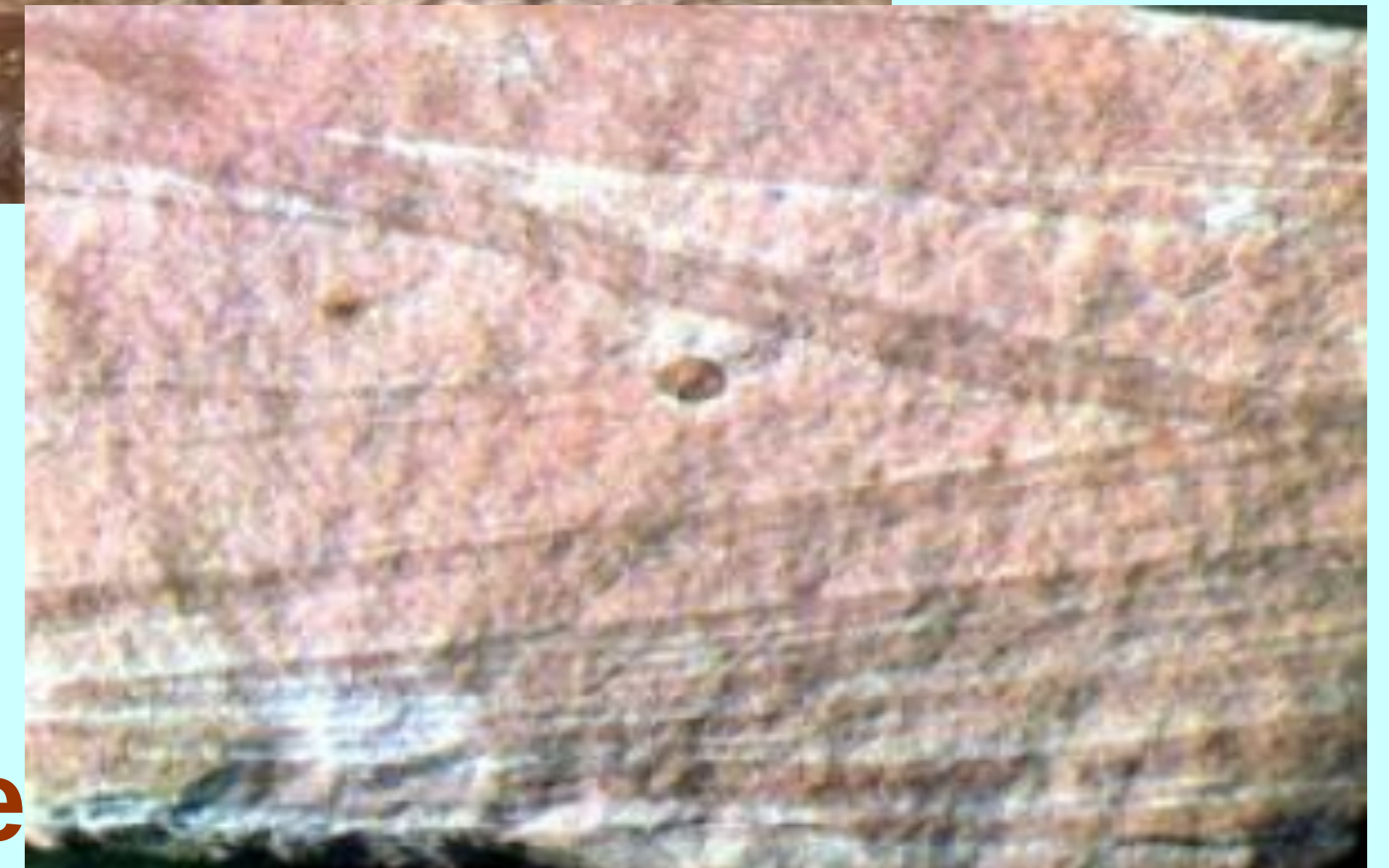
C. Sedimentary Rocks – e.g. Sandstone, Gypsum, Sand & gravel; Salt, Clay, Limestone & dolomite, Phosphate rock....



Gypsum



Crystalline Limestone



Sandstone

Classification of Industrial Minerals

1. Genetic classification – how they formed. Industrial MINERALS fall into;

A. Igneous Minerals – Mica, Nepheline, Feldspar, Lithium minerals, Beryl....



Feldspar



Mica

Classification of Industrial Minerals.....contd.

B. Vein & Replacement Minerals – Quartz crystal, Fluorspar, Barite, Magnesite...



Quartz Crystal



Fluorspar



Barite

Classification of Industrial Minerals.....contd.

C. Metamorphic Minerals – Vermiculite, Talc, Graphite, Asbestos ...



Graphite



Asbestos



Talc

Classification of Industrial Minerals.....contd.

D. Sedimentary Minerals and sulfur – Diamond, Diatomite, Borate, Potash minerals, Sodium minerals, Nitrates, Sulfur



Diamond



Calcium Nitrate

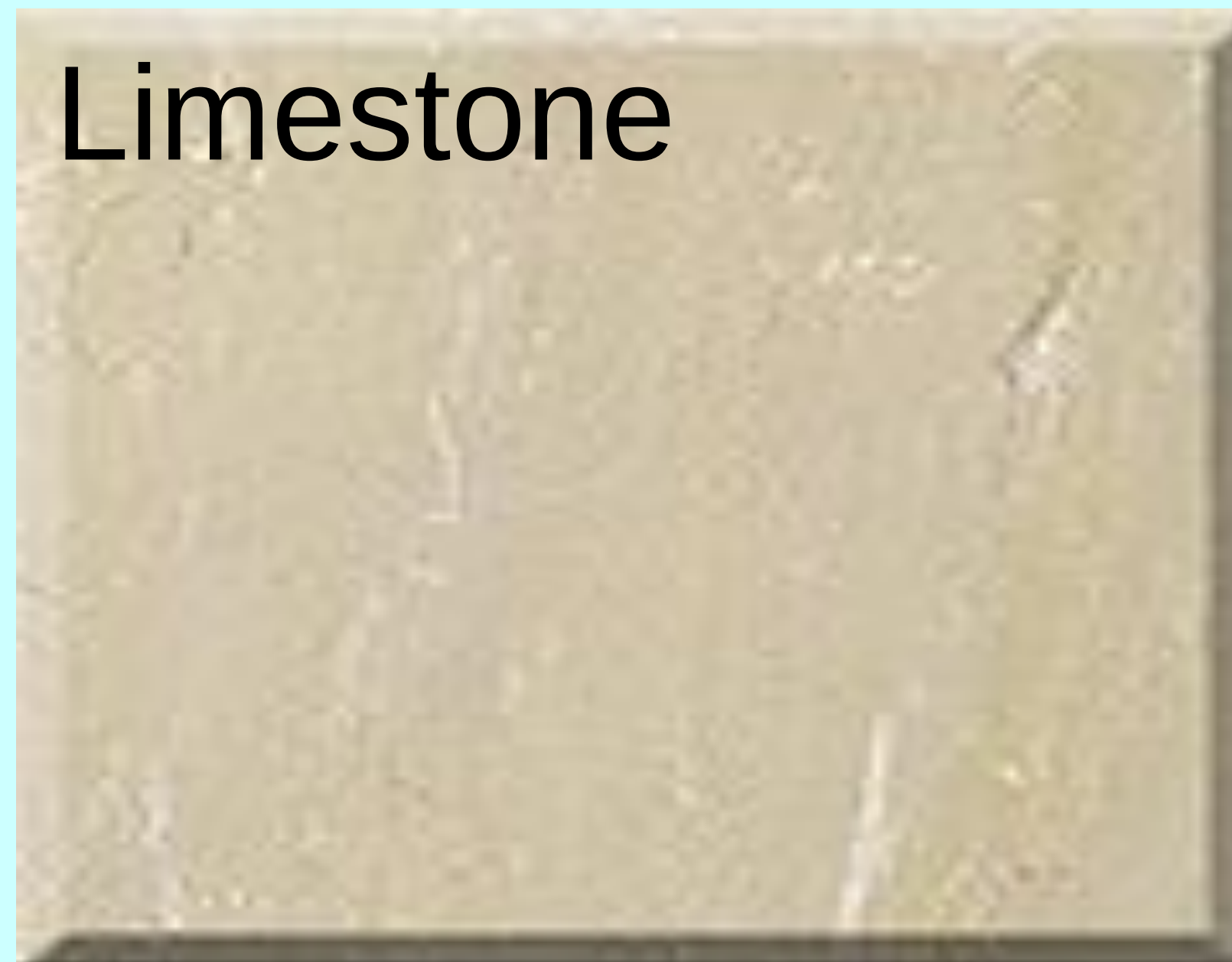


Sulphur

Examples of Industrial Minerals & their Uses

1. Limestone/Calcite

- is a **sedimentary rock** composed largely of **Calcite** (calcium carbonate – CaCO_3)
- often contains variable amounts of **silica** in form of **chert** or **flint**, as well as varying amounts of **clay**, **silt** and **sand**.



Construction Materials

In this section, we shall discuss:

- ✓ Aggregate

- ✓ Asphalt

- ✓ Brick

Aggregate

- Collective term for *sand*, *gravel* & *crushed stone* mineral materials in their natural/processed state.
 - ✓ Roads & highways constitute largest single use of aggregate at 40 percent of total usage.



Aggregate – Origin & Production

Aggregate can either be **natural** or **manufactured**

- **Natural aggregates** – generally extracted from larger rock formations from quarrying (open excavations)
- **Manufactured rock** – typically consists of industrial by-products, e.g. slag (by-product of metallurgical processing of **steel, tin & copper**)

Aggregate Physical Properties

- **Toughness & resistance to abrasion** – Aggregates **must be hard & tough** enough **to resist crushing, degradation & disintegration** from activities, e.g. *manufacturing, stockpiling, placing & compaction*.
- **Durability and soundness**. Aggregates **must be resistant to breakdown & disintegration** from weathering (wetting/drying), or else, they might break apart prematurely & cause pavement distress.

Aggregate Physical Properties.....contd.

- **Particle shape & surface texture** – are important for proper compaction, load resistance & workability.

Generally, **angular-shaped particles** with a **rough surface texture** are best.

materials that are dangerous to health, or which might cause failures in buildings, or are damaging to environment.

- **Cleanliness & deleterious materials** – **Aggregates must be clean**.... vegetation matter, soft particles, clay lumps, & excess dust might prevent binder-aggregate bonding & affect **performance by quick degradation**.

Asphalt

- ✓ Is also known as **bitumen**
- ✓ Is dark **brown to black**, in colour
- ✓ Is **hydrocarbon** product of **petroleum distillation** residue.
- ✓ At least **80%** carbon, which explains its deep black color, & has sulphur.
- ✓ Primarily used as **sealant for rooftops** & a **durable surface coat for roads**, airport runways, playgrounds & parking lots.



<http://www.ekocozum.com/blog/wp-content/uploads/2008/05/asfalt.jpg>

Types of Asphalt

Two major types of Asphalt are used in construction:

- ✓ Rolled asphalt
- ✓ Mastic asphalt.



1) Rolled Asphalt

- ✓ Made of *aggregate, or solid materials*, e.g., sand, gravel, or recycled concrete, with an asphalt binder.
- ✓ Used to make roads & other surfaces, e.g., parking lots, by being applied in layers and compacted.
- ✓ Different types of rolled asphalt are distinguished according to process used to bind aggregate with asphalt.

Types of Rolled Asphalt

a) Hot mix asphalt concrete (HMAC):

- Is produced at 160° C.
- this high temperature **serves to decrease moisture & viscosity** during manufacturing process, resulting in a **very durable material**.
- is most commonly used for high-traffic areas, e.g., busy highways and airports.



Types of Rolled Asphalt.....contd.

b) Cold mix asphalt concrete,

- Is emulsified in soapy water before mixing it with aggregate, to eliminate need for high temperatures altogether.
- The asphalt produced is **not nearly as durable as HMAC**
- Is typically used for **low traffic areas**, or to patch damaged HMAC.



2) *Mastic Asphalt*

- ✓ Is also called **sheet asphalt**.
- ✓ Has lower bitumen content than rolled asphalt.
- ✓ Is used for some roads & footpaths.
- ✓ Also used in roofing and flooring.



2) *Mastic Asphalt.....contd.*

- **Stone Mastic Asphalt** (SMA), is another variety.
- Becoming **increasingly popular** as an alternative to rolled asphalt.
- Benefits include
 - ✓ **Anti-skid property**
 - ✓ **Absence of air pockets**

But if improperly laid, it might cause slippery road conditions.

3) *Brick*

- Is **masonry unit** and does not infer any particular material
- Most bricks are made from some form of clay, while
- Others are made of concrete, crushed rock aggregate, and Portland cement, while
- yet others, are **made from** sand & lime, sometimes with addition of crushed flint.

Types of Brick

- **Common unit** - suitable for general construction, with no special claim to give an attractive appearance.



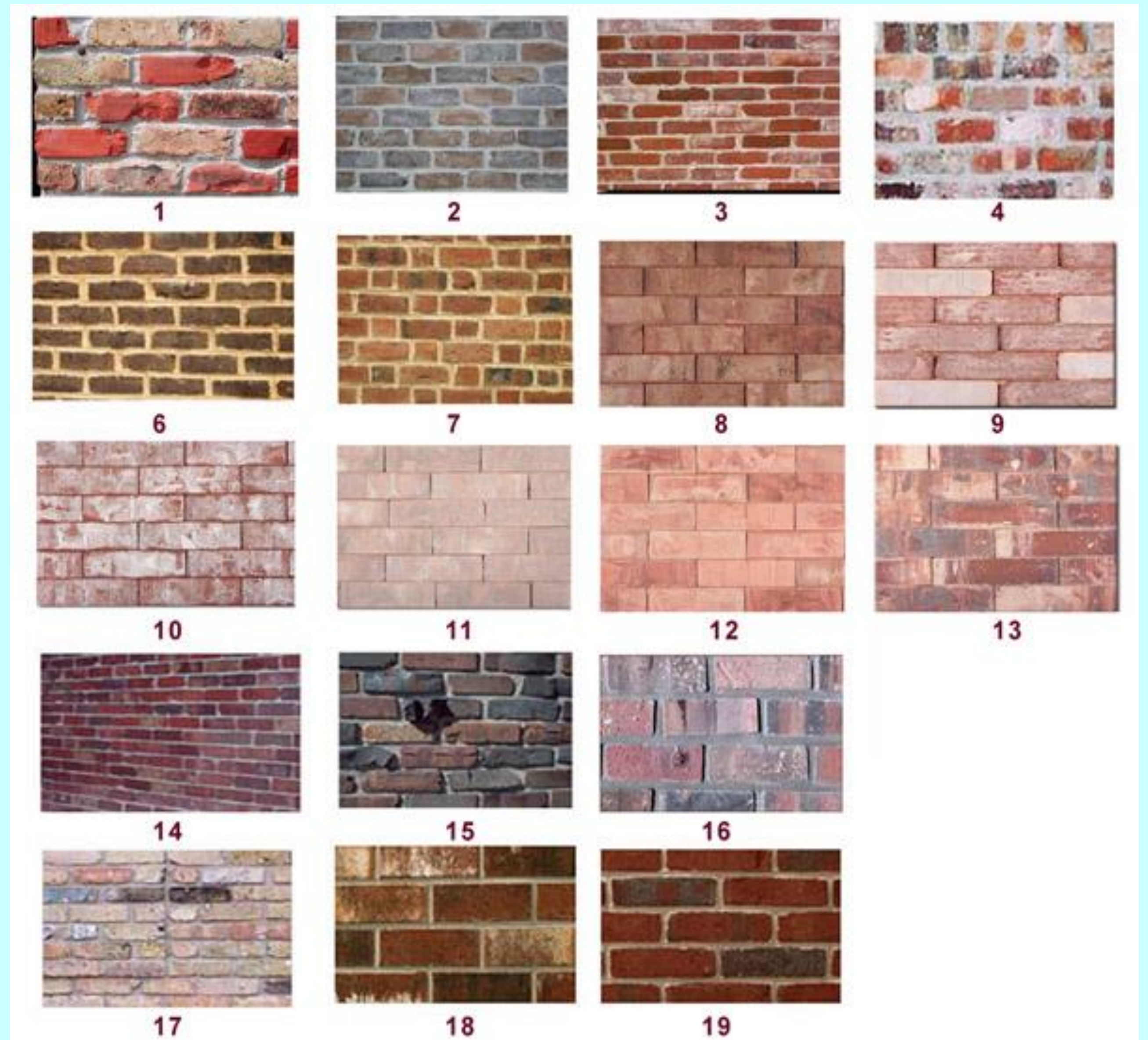
Types of Brick.....contd.

➤ **Facing unit - specially**

made, or selected, to

give an attractive

appearance to blg.



Types of Brick.....contd.

- **Engineering bricks** – are fired clay bricks, having a dense and strong semi-vitreous body, conforming to defined limits for water absorption and compressive strength
- **Soft mud bricks**- are the most economical, burned at high temperature to achieve strength.

Uses of Brick

- ✓ In **metallurgical** and **glass** industry for lining furnaces.
- ✓ Used as a refractory (silica, magnesia bricks)
- ✓ Used to make walls, fences, barbeques, etc.



General Properties of Brick

- ✓ Hard
- ✓ Compact
- ✓ Durable
- ✓ Cheap
- ✓ Come in several earth-tone colors
- ✓ Holds heat well/insulates

Characteristics of Industrial Minerals

Geologically, most industrial minerals:

- ✓ are widespread
- ✓ have enormous reserves
- ✓ are easily accessible

Characteristics of Industrial Minerals.....contd.

Economically:

- development of industrial minerals needs relatively less investments
- are cheaper to obtain
 - If they are closer to the market
 - As some specialty minerals demand a higher market price than metals

Characteristics of Industrial Minerals.....contd.

Technologically, industrial minerals:

- ✓ need less processing
- ✓ need less energy
- ✓ have less –ve impact on the environment
- ✓ possess exceptionally attractive properties for industry

Characteristics of Industrial Minerals.....contd.

- *Without a market, an industrial mineral deposit is merely a geological curiosity.*
- Demand for IMs feeds back from the end-use market, to the end product, to the intermediate end product, and back to the mineral supplier.

Characteristics of Industrial Minerals.....contd.

- existence and performance of a **Mineral consuming market** directly affects demand for mineral raw materials, i.e. industrial minerals
- When there is no market demand, there will be no mineral supply, & therefore, no mineral development

Characteristics of Industrial Minerals.....contd.

Factors influencing Industrial Minerals' pricing:

- ✓ Source & Volume of mineral
- ✓ Quality of mineral as dictated by desired end use
- ✓ Further processing requirements
- ✓ Freight/shipping costs of mineral

Characteristics of Industrial Minerals.....contd.

Factors influencing Industrial Minerals' pricing (*contd.*)

- ✓ Port handling
- ✓ Warehousing/storage costs
- ✓ Mineral inspection & Insurance costs
- ✓ Relationship of buyer & seller

Summary & Conclusions

Industrial Minerals:

- are high volume, low value, but **vital** commodities
- are prerequisite raw materials for a wide range of industrial and domestic products
- Supply is driven by Market demand
- supply chain employs people & businesses

End of lecture