



# GGY3051 – GEOLOGY FOR ENGINEERS

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## Matter and Minerals

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GEOLOGY DEPARTMENT

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## Learning Goals

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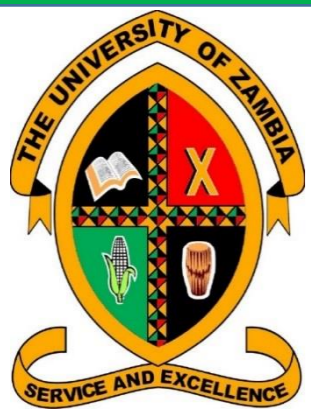
In this lecture, participants will learn how to identify:

- common minerals using different Properties.



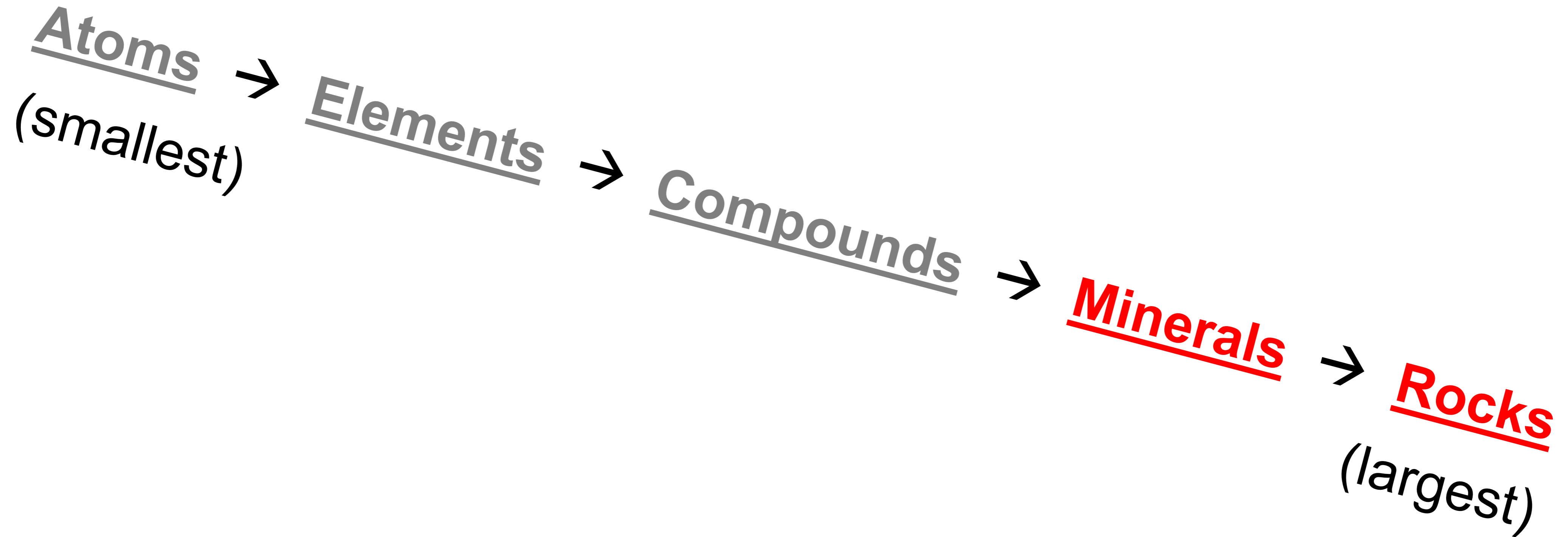
# 1. Matter

- Is a substance of which any physical object is composed.
- Occurs in three states:
  - Solid
  - Liquid
  - Gas
- Each of the states is controlled by:
  - Temperature
  - Pressure
  - Exemplified by
    - Gold – SOLID
    - Water – LIQUID
    - Oxygen - GAS



## 1. Matter.....contd.

The make-up of **solid** matter on Earth comprises:





## 2. Minerals

- are building blocks of rocks
- defined as being naturally occurring
  - ✓ inorganic
  - ✓ solid
  - ✓ characteristic crystalline structure
  - ✓ definite chemical composition



## 2. Minerals.....contd.

- has following **DEFINITIVE** properties:
  - ✓ is made of an element or a chemical compound
  - ✓ has a definitive chemical composition
  - ✓ has an orderly, regular repeating internal atomic arrangement and crystalline structure
  - ✓ is made of inorganic solids
  - ✓ is formed by geologic processes.



## 2. Minerals.....contd.

### ➤ **Naturally formed**

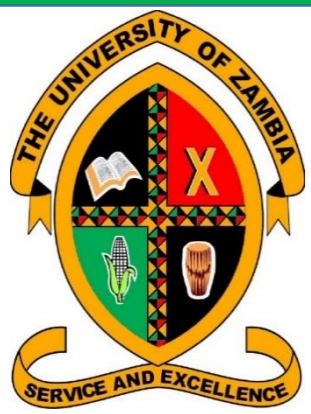
- Means that any substance that is created artificially is NOT a mineral – *plastic, steel, sugar, paper*

### ➤ **Inorganic**

- Means that anything formed by/from a living organism, and containing organic materials, is not a mineral – *wood, plants, shells, coal*

### ➤ **Solid**

- Means liquids and gases – *water, petroleum, lava, oxygen*  
– are not minerals.



## 2. Minerals.....contd.

- **Characteristic crystalline structure**, means it must:
  - have an ordered arrangement of atoms
  - display repetitive geometric patterns in 3-D, implying that glass (*which has no internal crystalline structure*) is **not** a mineral.
  
- **Definite chemical composition**, means it must have:
  - consistent chemical formula – quartz ( $\text{SiO}_2$ )



## 2. Minerals – Exercise

### Minerals are:

1. naturally occurring
2. inorganic
3. solid
4. characteristic crystalline structure
5. definite chemical composition

Steel

No, #1

Gold

YES

Plastic

No, #1

Paper

No, #1,2

Sugar

No, #1,2

Chalk

No, #2

Table salt

YES

Ice

YES

Mercury

No, #3

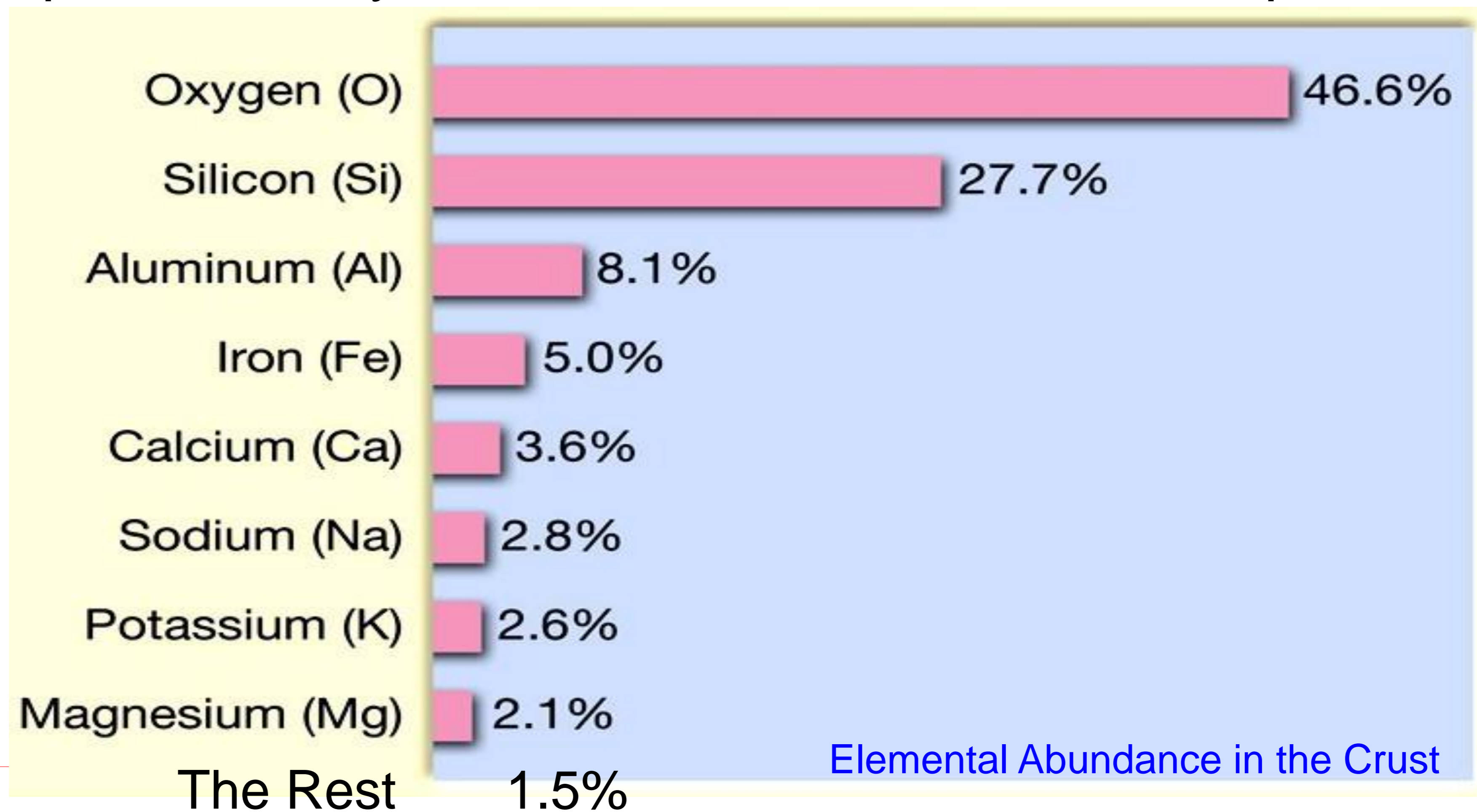
Coal

No, #2



## 2.1 Rock-Forming Mineral Groups

- Ca. 30 common minerals make up most rocks in Earth's crust
- Composed mainly of **EIGHT** elements that make up over 98% of crust





## 2.1 Rock-Forming Mineral Groups.....contd.

Comprise:

➤ **Silicates** (most abundant minerals – **ca. 92%** – in Earth's Crust)

➤ **Non-silicates** (~8% of Earth's crust):

✓ Oxides -  $O^{2-}$

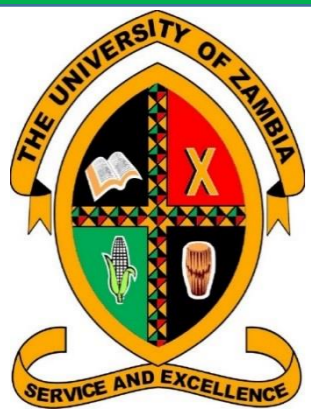
✓ Carbonates -  $CO_3^{2-}$

✓ Sulfides -  $S^{2-}$

✓ Sulphates -  $SO_4^{2-}$

✓ Halides - Cl<sup>-</sup>, F<sup>-</sup>, Br<sup>-</sup>

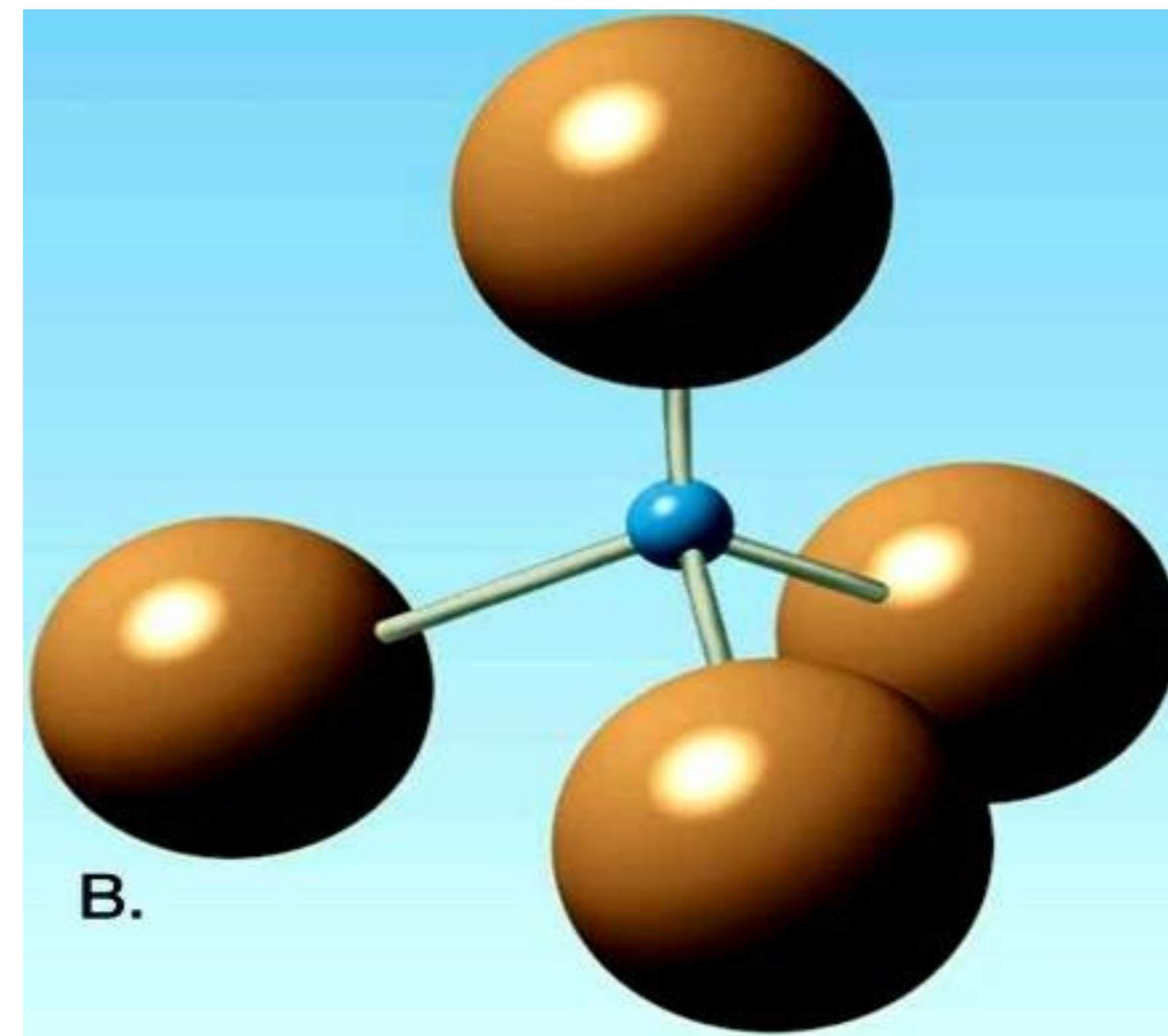
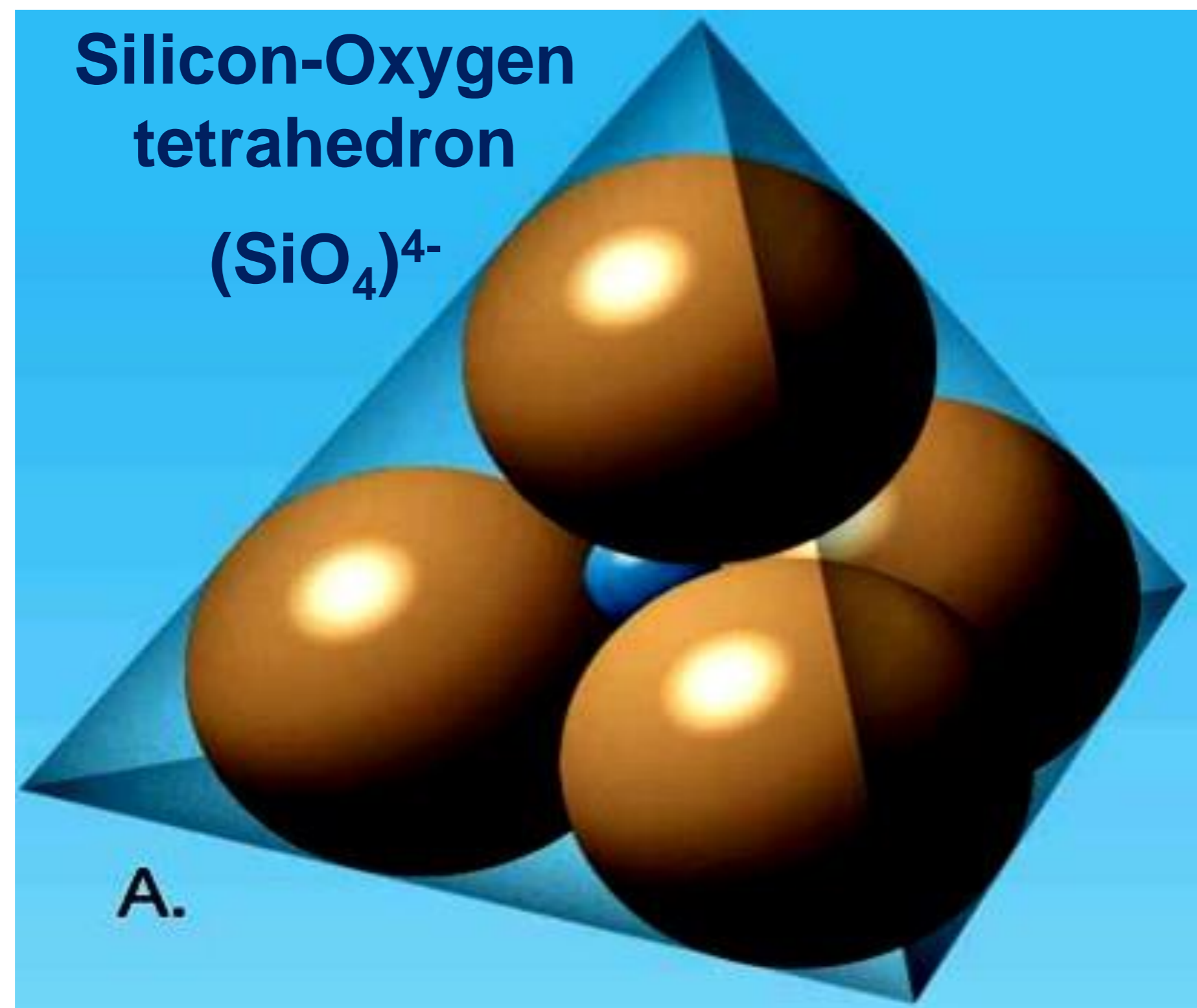
✓ Native elements - single elements; e.g., Au)



## 2.1.1 Silicate Minerals

### Formed from $\text{SiO}_4$ -tetrahedron

- Where Four (4) oxygen ions surround a silicon ion.
- Is a fundamental building block for silicates

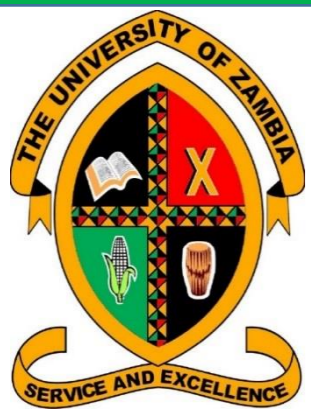




## 2.1.1 Silicate Minerals.....contd.

Silicate Structures occur as:

- independent tetrahedra
- single chains
- double chains
- sheets
- 3-D framework



## 2.1.1.1 Independent Tetrahedra Silicates.....contd.

### Olivine Group

- Dark silicates, rich in Fe & Mg
  - Are thus, called *Ferromagnesian minerals*
- Formed from **Independent Tetrahedra**

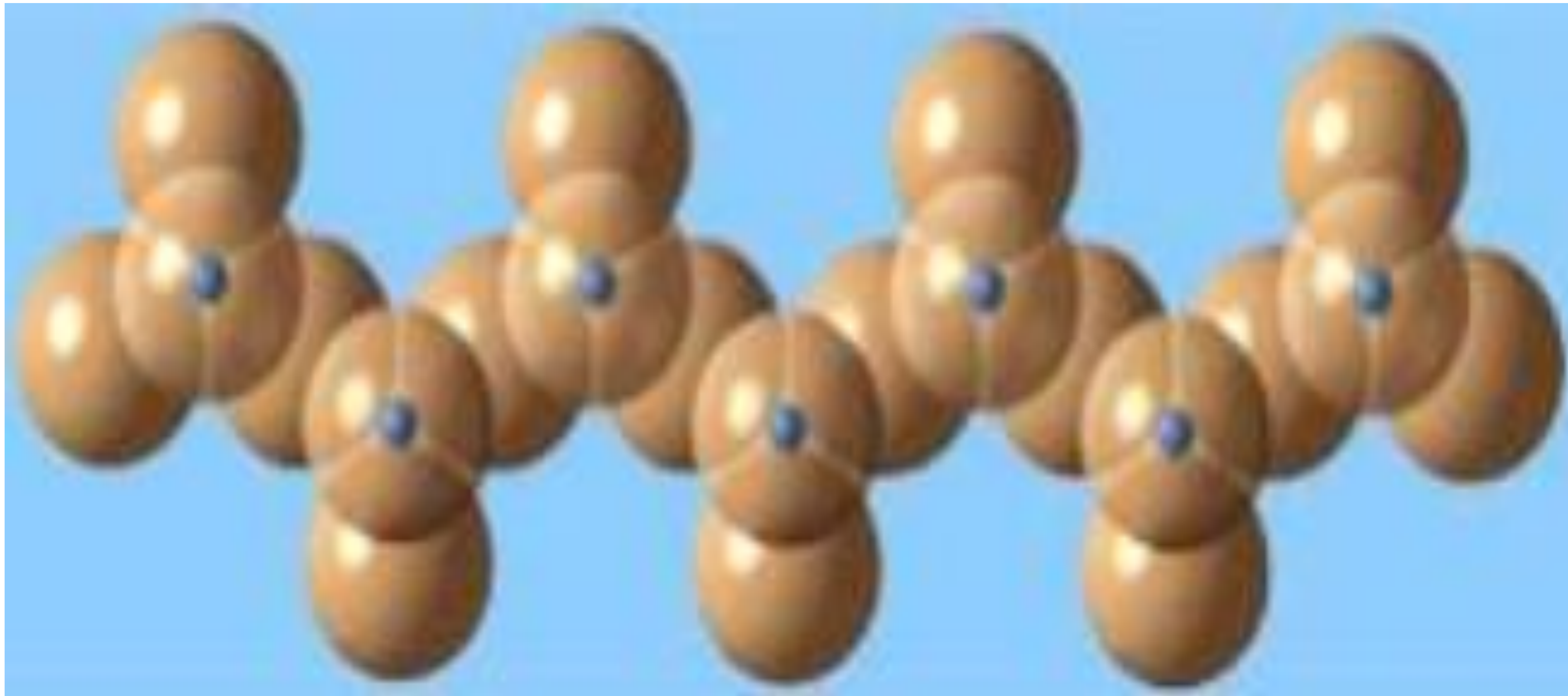




## 2.1.1.2 Single Chain Silicates

### Pyroxene Group

- Ferromagnesian / dark silicates (Fe-Mg)
- Form from **Single Chains**

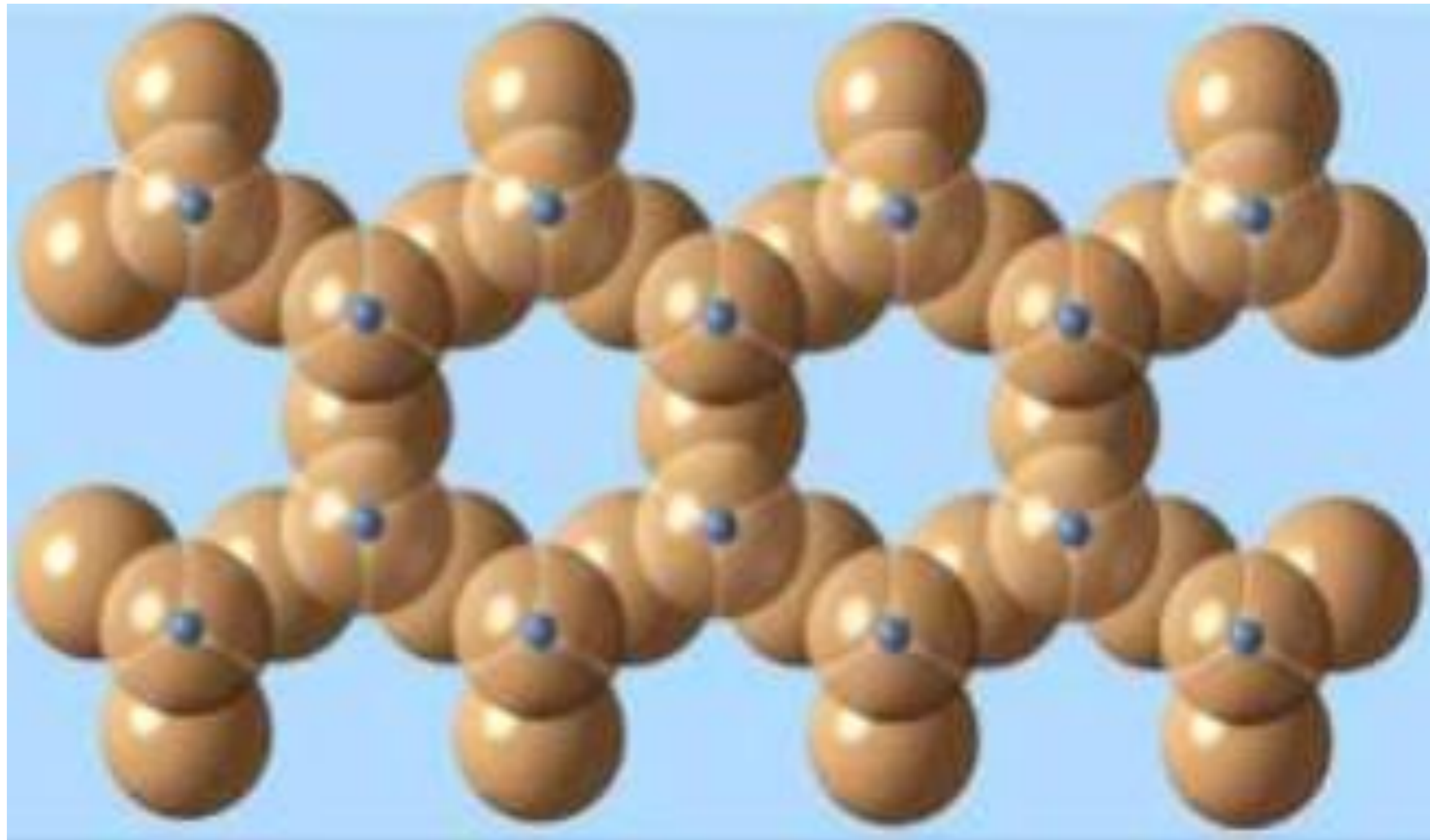




## 2.1.1.3 Double Chain Silicates

### Amphibole Group

- Ferromagnesian / dark silicates (Ca, Fe-Mg)
- Form from **Double Chains**

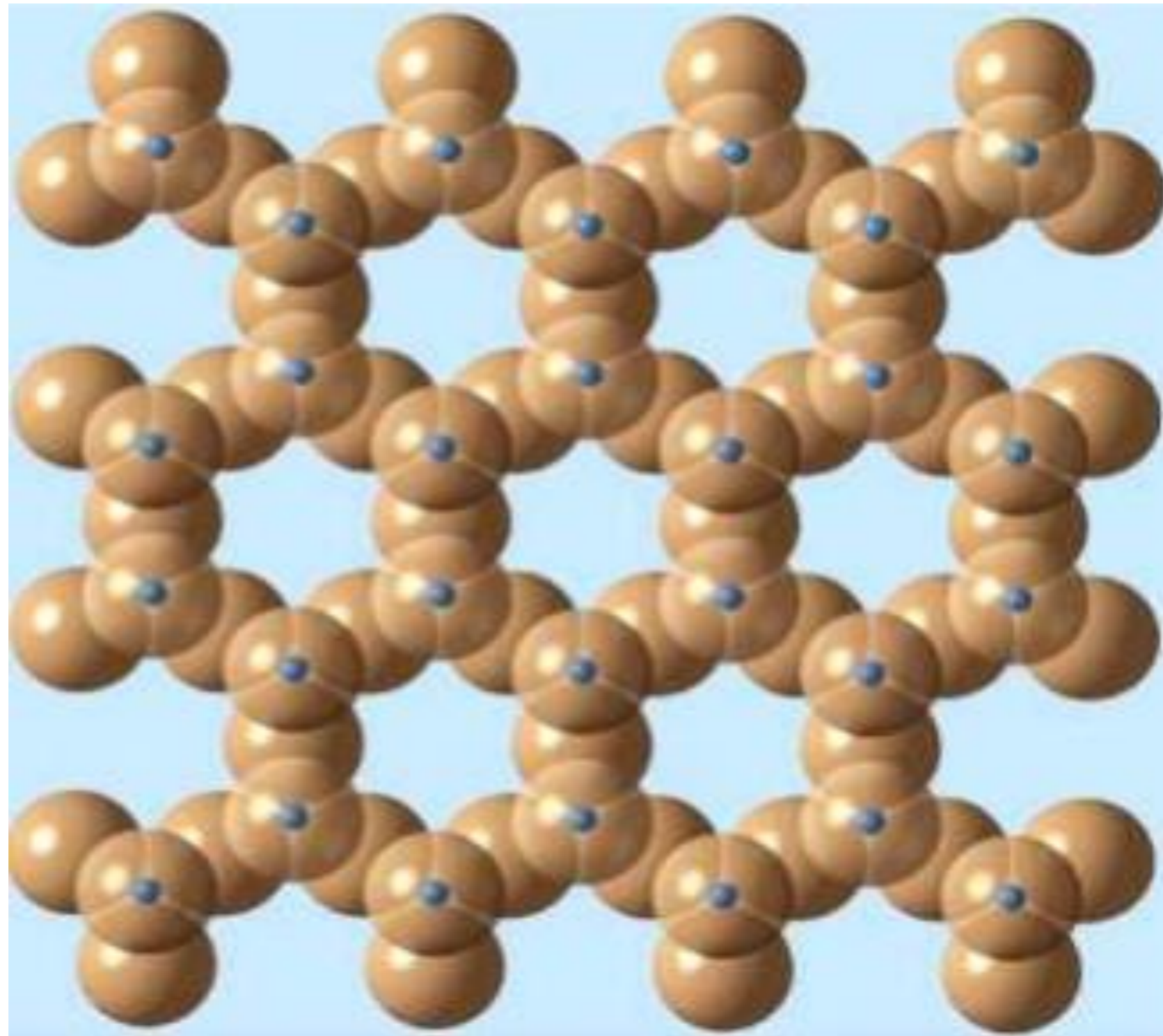




## 2.1.1.4 Sheet Silicates

### Mica Group & Clay Minerals

- Light-coloured silicates, with K & Al Cations
- Are non-ferromagnesian
- Form from **Sheets / Layers**

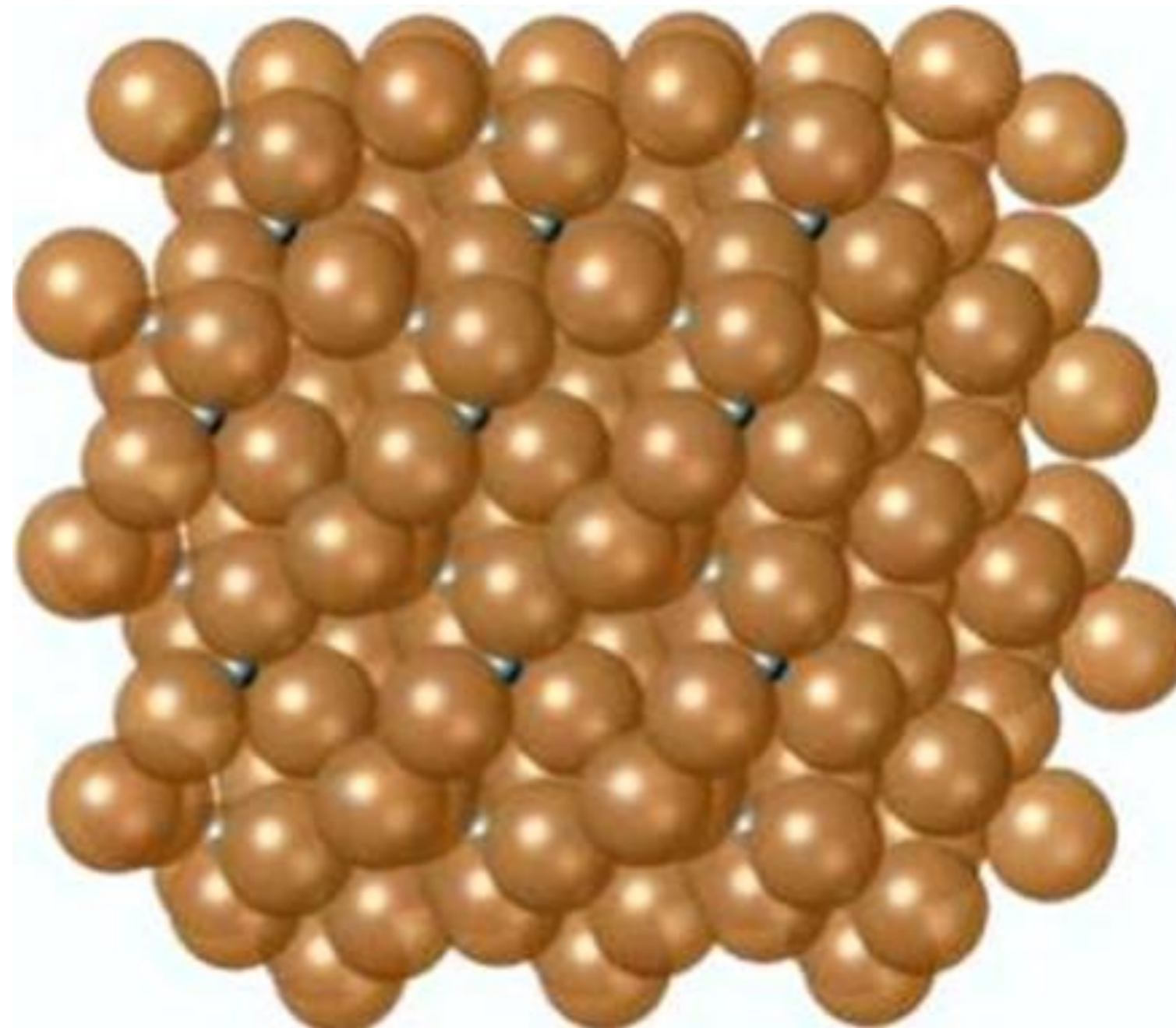




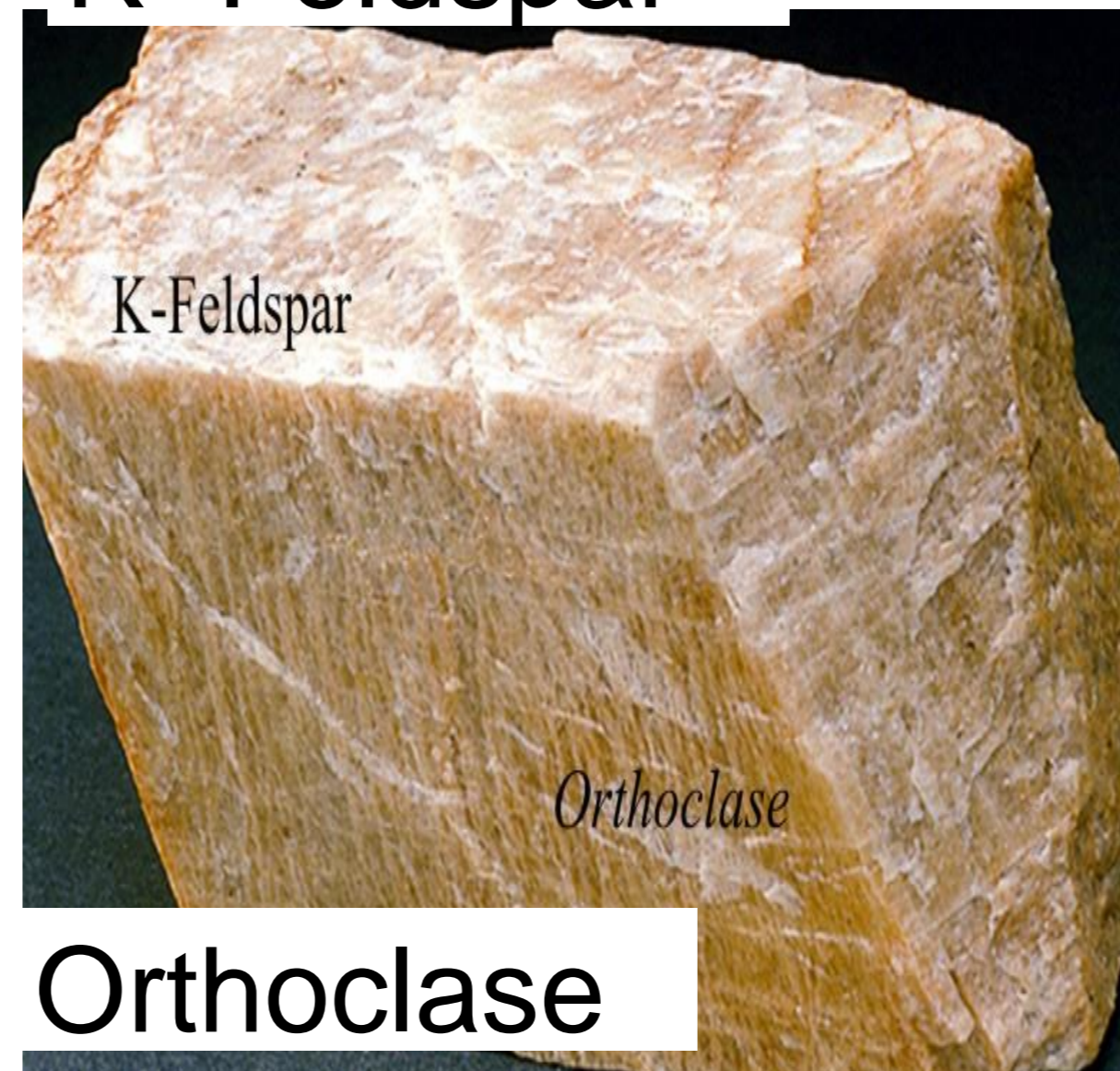
## 2.1.1.5 Framework Silicates

### a) Feldspar Group

- Light-coloured silicates with K-Na-Ca, Al
- Most common mineral group
- Made from 3-dimensional networks



K- Feldspar

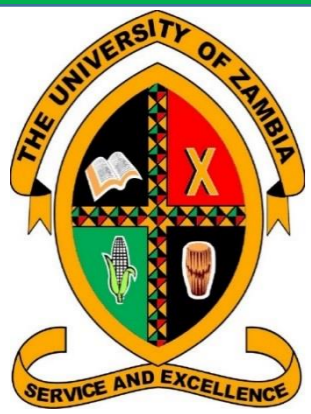


Orthoclase

Ca/Na - Feldspar



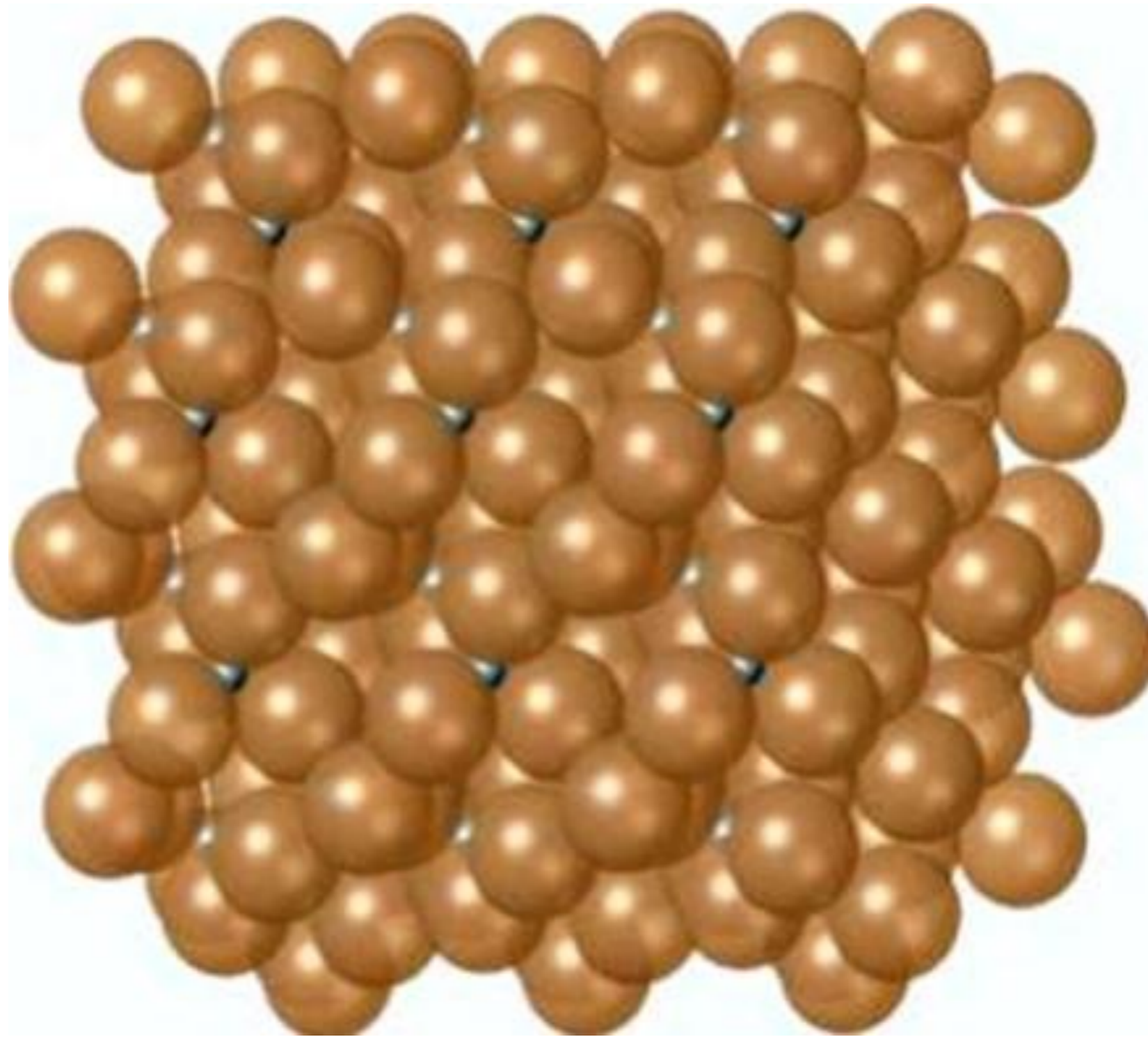
Plagioclase



## 2.1.1.5 Framework Silicates.....contd.

### b) Quartz

- Light-coloured silicates
- Is pure  $\text{SiO}_2$
- Made from 3 dimensional networks



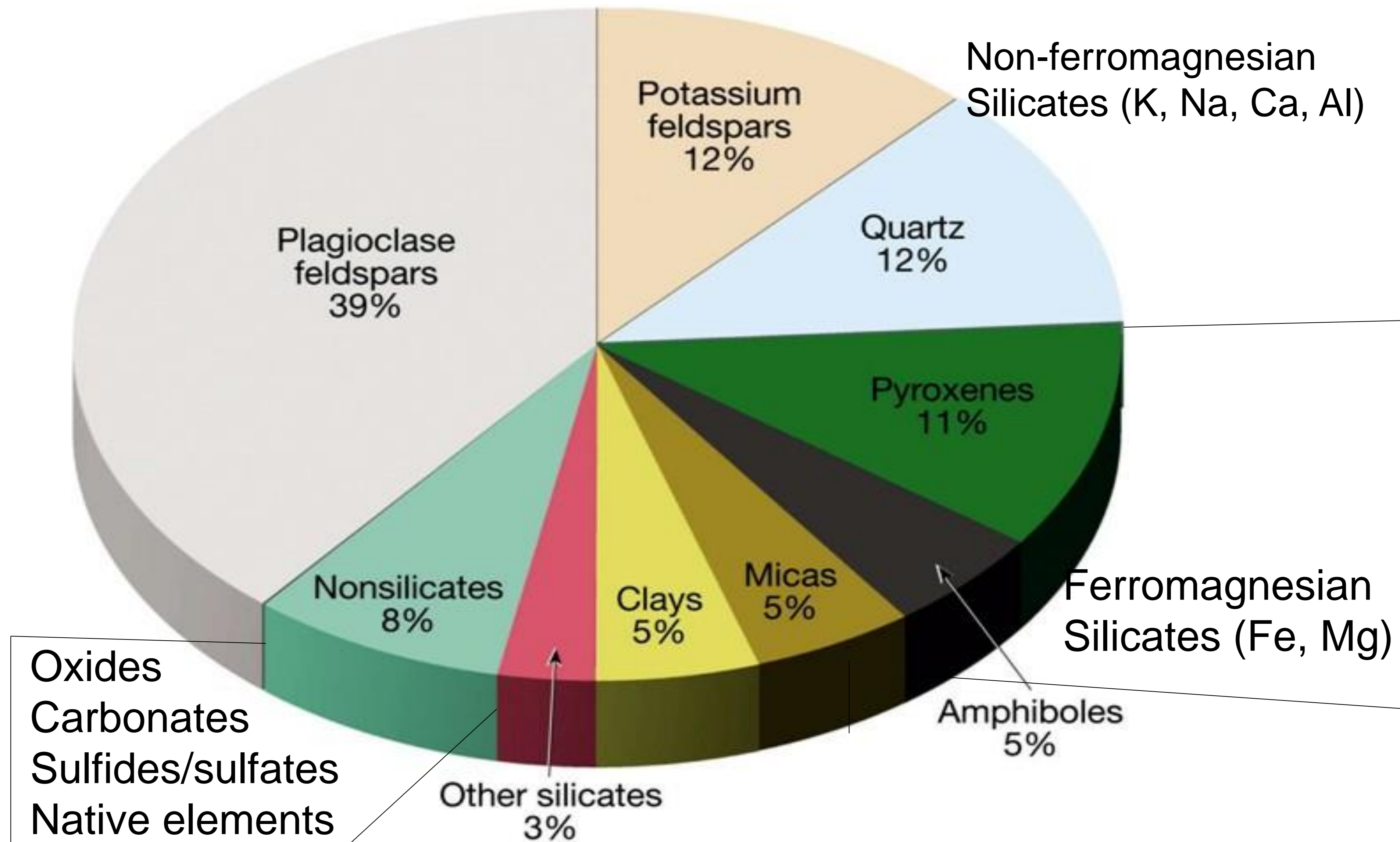


## 2.2 Summary of Rock-Forming Mineral Groups

Mineral Group	Examples	Chemical Formula	Comments
Silicates	Quartz	$\text{SiO}_2$	Common
	Plagioclase feldspars	$(\text{Na, Ca})\text{Al}(\text{Si, Al})_2\text{O}_8$	Very common
	Pyroxene	$(\text{Ca, Mg, Fe})_2\text{Si}_2\text{O}_6$	Ferromagnesian mineral
Carbonates	Calcite	$\text{CaCO}_3$	Main minerals in limestone and marbles
	Dolomite	$(\text{Ca, Mg})\text{CO}_3$	
Oxides	Hematite	$\text{Fe}_2\text{O}_3$	Primary ore of iron
	Bauxite	Hydrous aluminum oxides	Primary ore of aluminum
Sulfides	Pyrite	$\text{FeS}_2$	Major constituent of acid mine drainage
	Galena	$\text{PbS}$	Primary ore of lead
Native elements	Gold	$\text{Au}$	Precious metal, industrial uses
	Diamond	$\text{C}$	Jewelry, industrial uses
	Sulfur	$\text{S}$	Used to produce sulfuric acid



## 2.2 Summary of Rock-Forming Mineral Groups.....contd.





## 2.3 Mineral Diagnostic Properties

- Based mainly on Physical properties:
  - Color
  - Streak
  - Luster
  - Crystal form/shape
  - Cleavage
  - Hardness
  - Special properties – *taste, smell, feel, reaction to acid, magnetism, etc.*



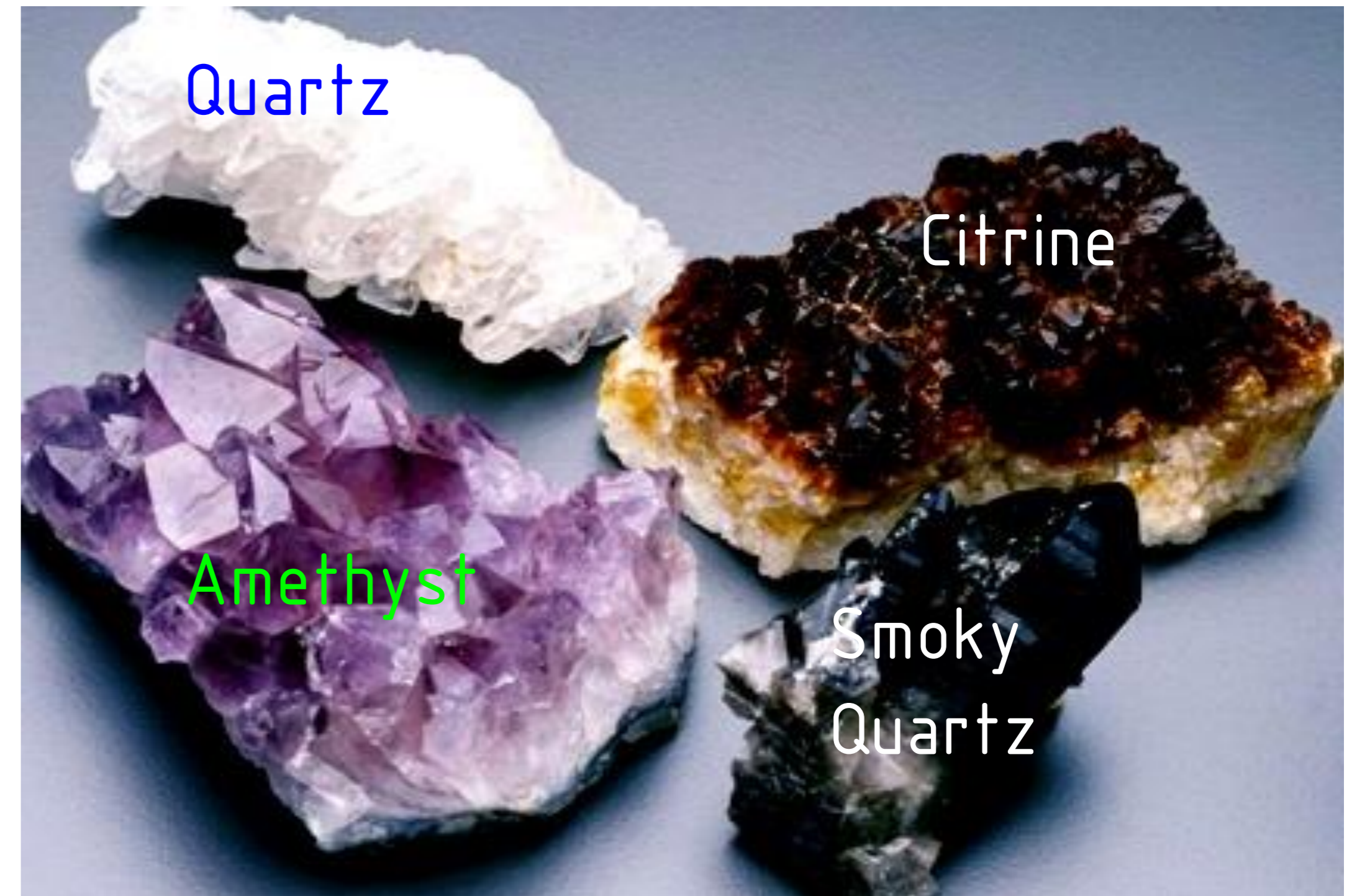
## 2.3.1 Colour

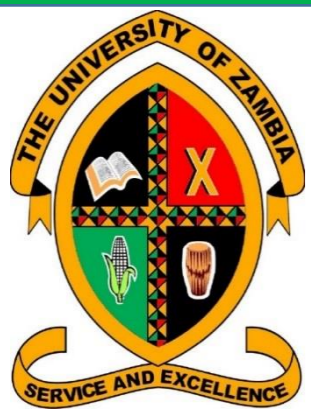
- Most obvious, but often misleading

because:

- Different colors may result from

**impurities**, example, **QUARTZ**



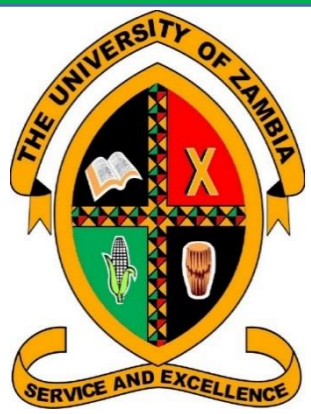


## 2.3.2 Streak

- Color of a mineral in powdered form(used for **metallic** minerals).
- Obtained by scratching a mineral on a piece of unglazed porcelain.

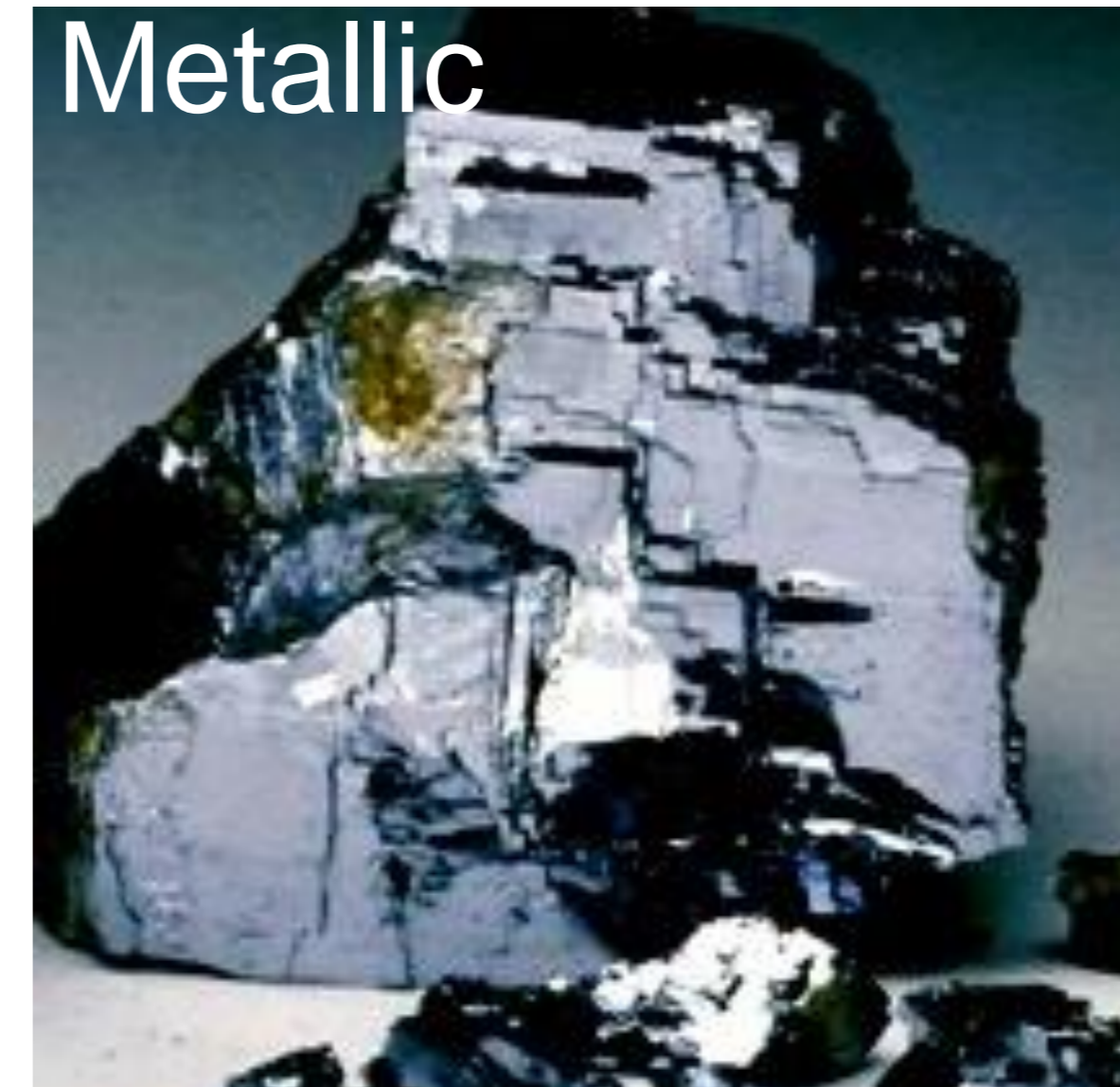


*Example: Hematite*



## 2.3.3 Luster

- How a mineral surface reflects light
- Two major types:
  - **Metallic luster**
  - **Non-metallic luster**



*Example:*  
Galena



*Example:*  
Orthoclase



## 2.3.4 Crystal Form / Shape

- external expression of mineral's internal atomic structure
- planar surfaces are called **crystal faces**
- angles between crystal faces are constant for any particular mineral

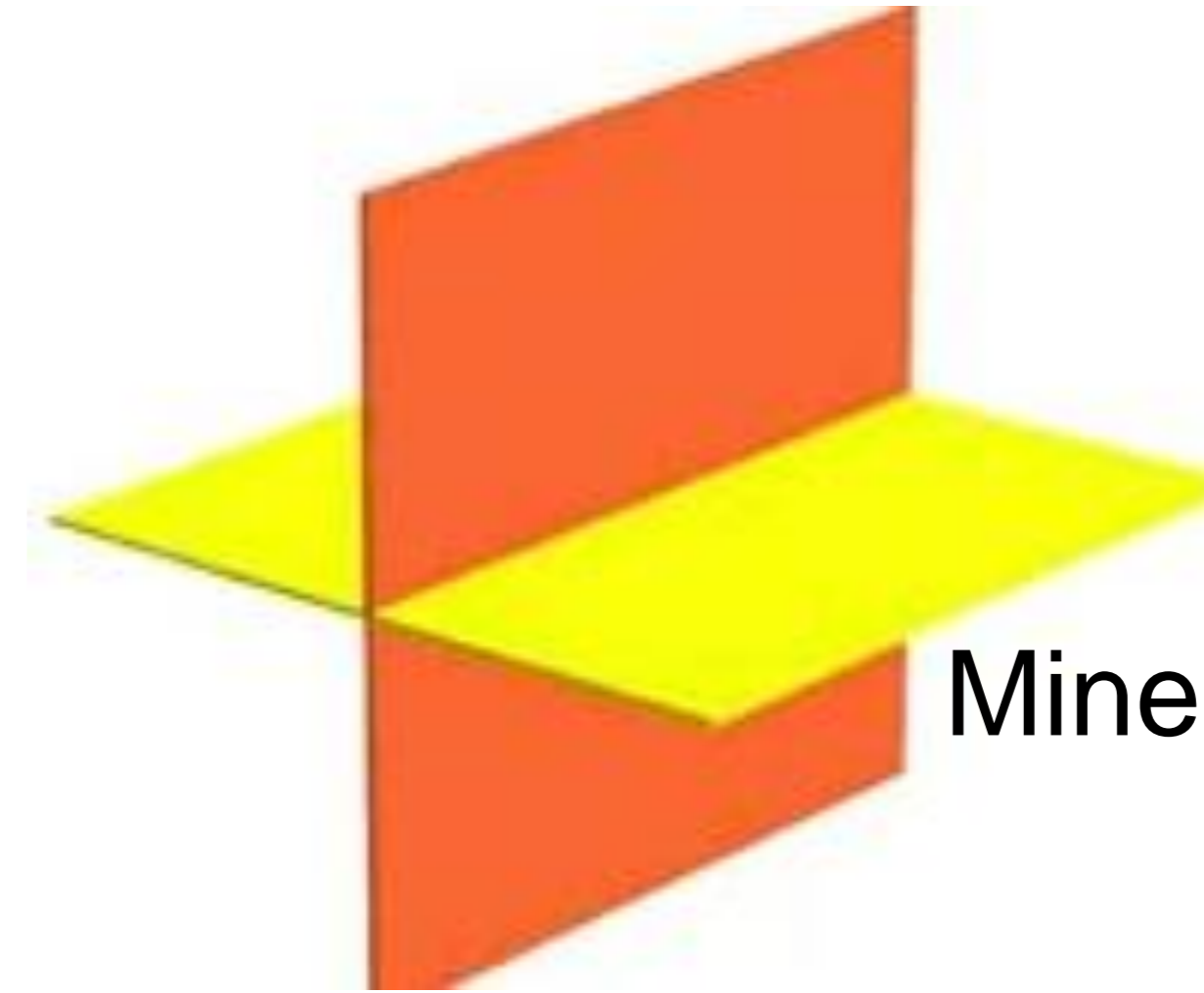




## 2.3.5 Cleavage

Reflects the way a mineral breaks

- **Cleavage** is a mineral's tendency to break along planes of weakness
- Minerals that do not exhibit cleavage are said to **fracture**



Mineral Cleavage



**Conchoidal fracture** – when mineral breaks in glass-like manner



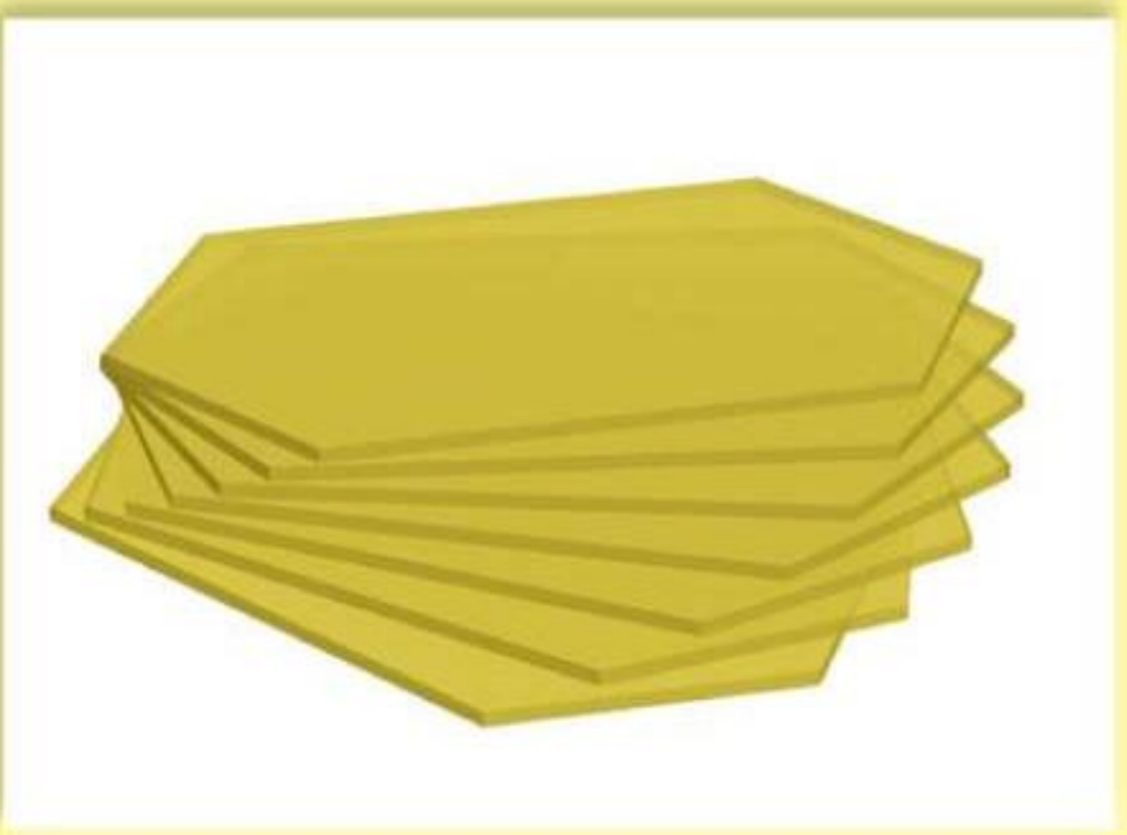
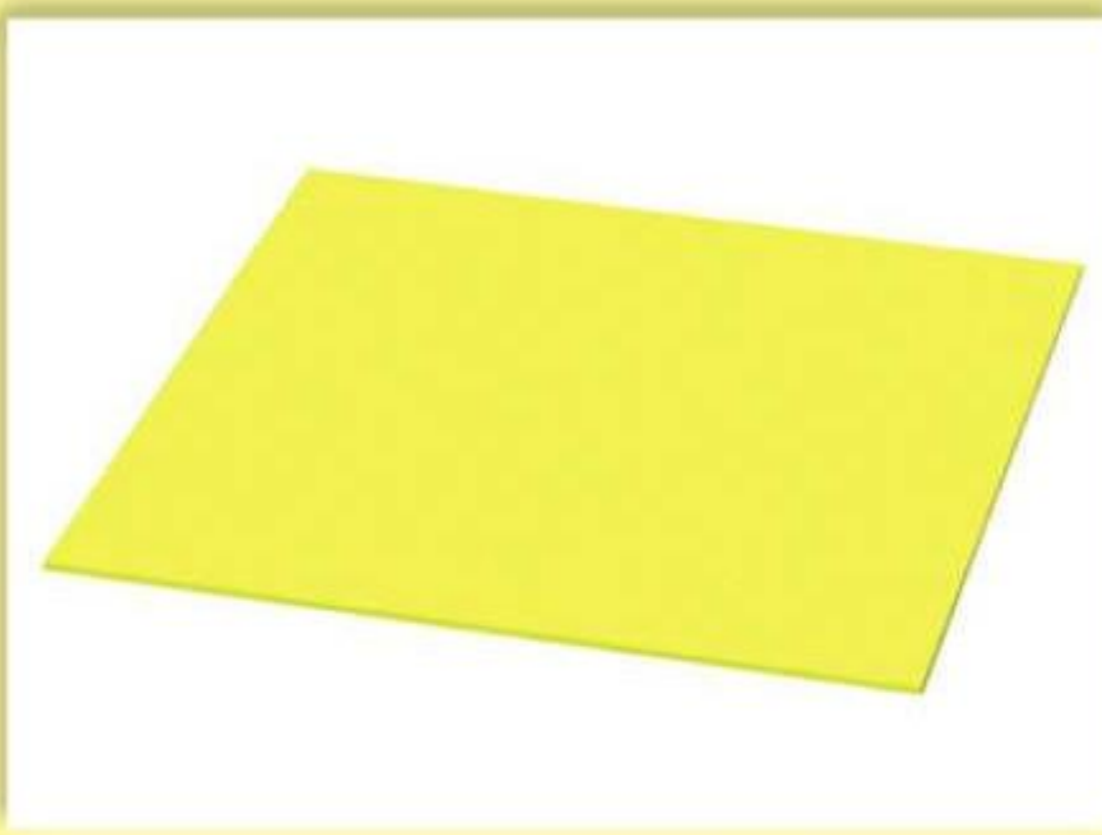

## 2.3.5 Cleavage.....contd.

- **is described by:**
  - Number of planes
  - Angles between adjacent planes
  - These are constant for a particular mineral



## 2.3.5 Cleavage.....contd.

### Cleavage in One-direction

Number of Cleavage Directions	Sketch	Illustration of cleavage directions	Example
1			



*Example: Mica*



## 2.3.5 Cleavage.....contd.

### Cleavage in Two-directions

Number of Cleavage Directions	Sketch	Illustration of cleavage directions	Example
2 at 90°			<p>orthoclase</p>
2 not at 90°			<p>amphibole</p>



## 2.3.5 Cleavage.....contd.


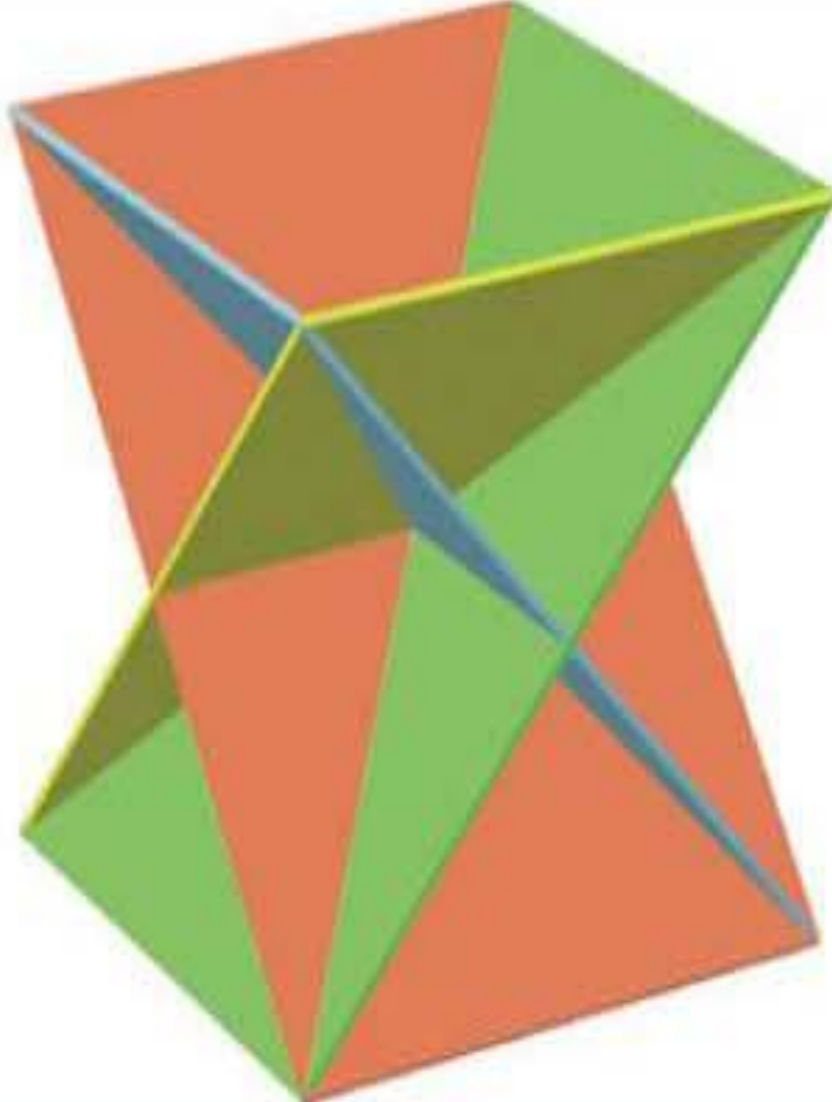

### Cleavage in Three-directions

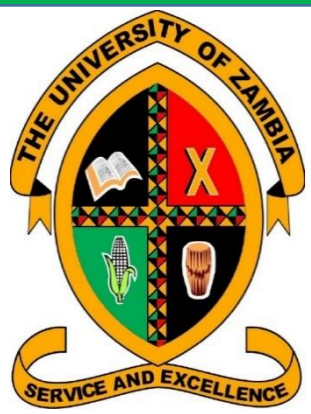
Number of Cleavage Directions	Sketch	Illustration of cleavage directions	Example
3 at 90°			<p>halite</p>
3 not at 90°			<p>calcite</p>



## 2.3.5 Cleavage.....contd.

### Cleavage in Four-directions

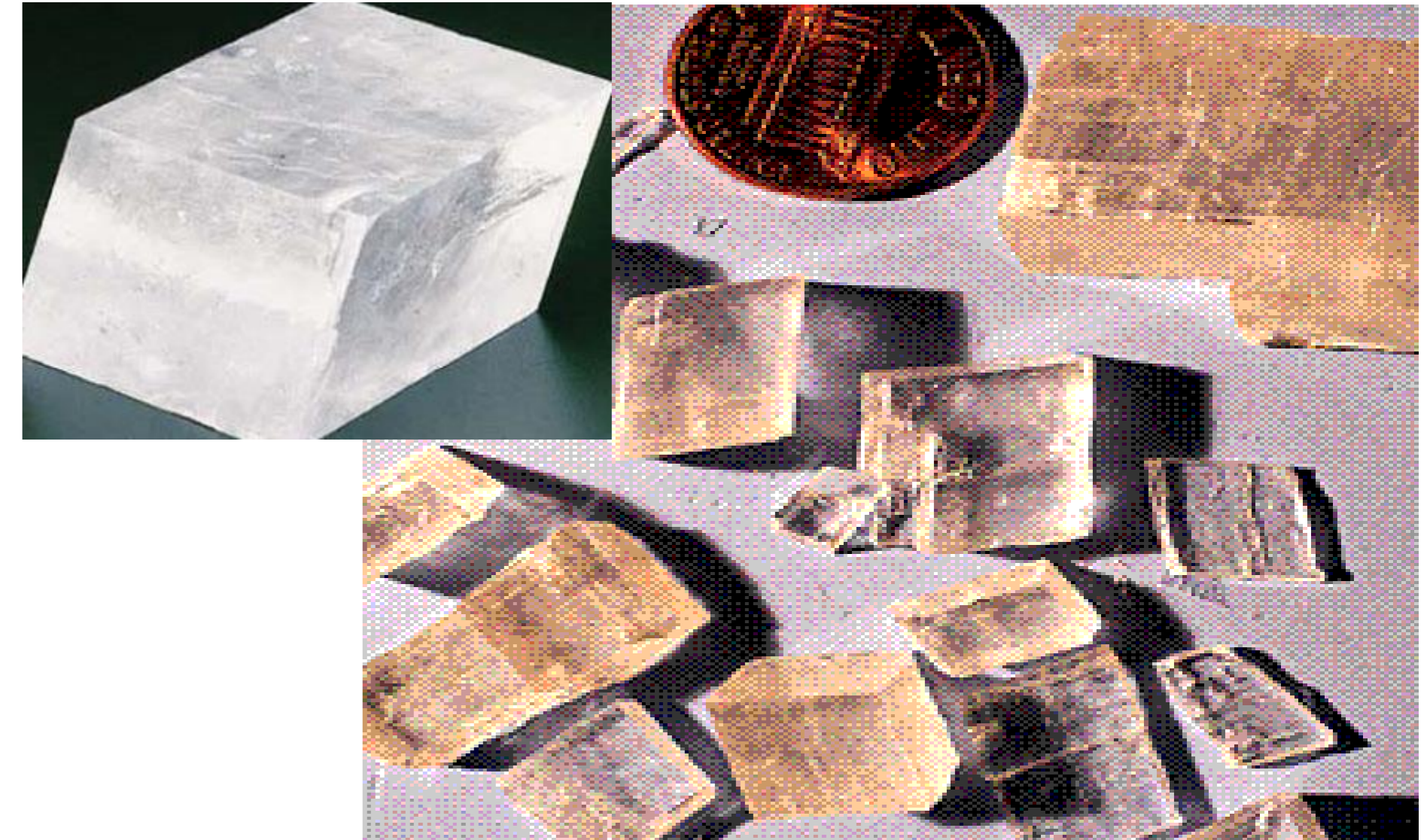
Number of Cleavage Directions	Sketch	Illustration of cleavage directions	Example
4			<p data-bbox="2395 796 2647 864">fluorite</p> 



## 2.3.5 Cleavage.....contd.

### Note:

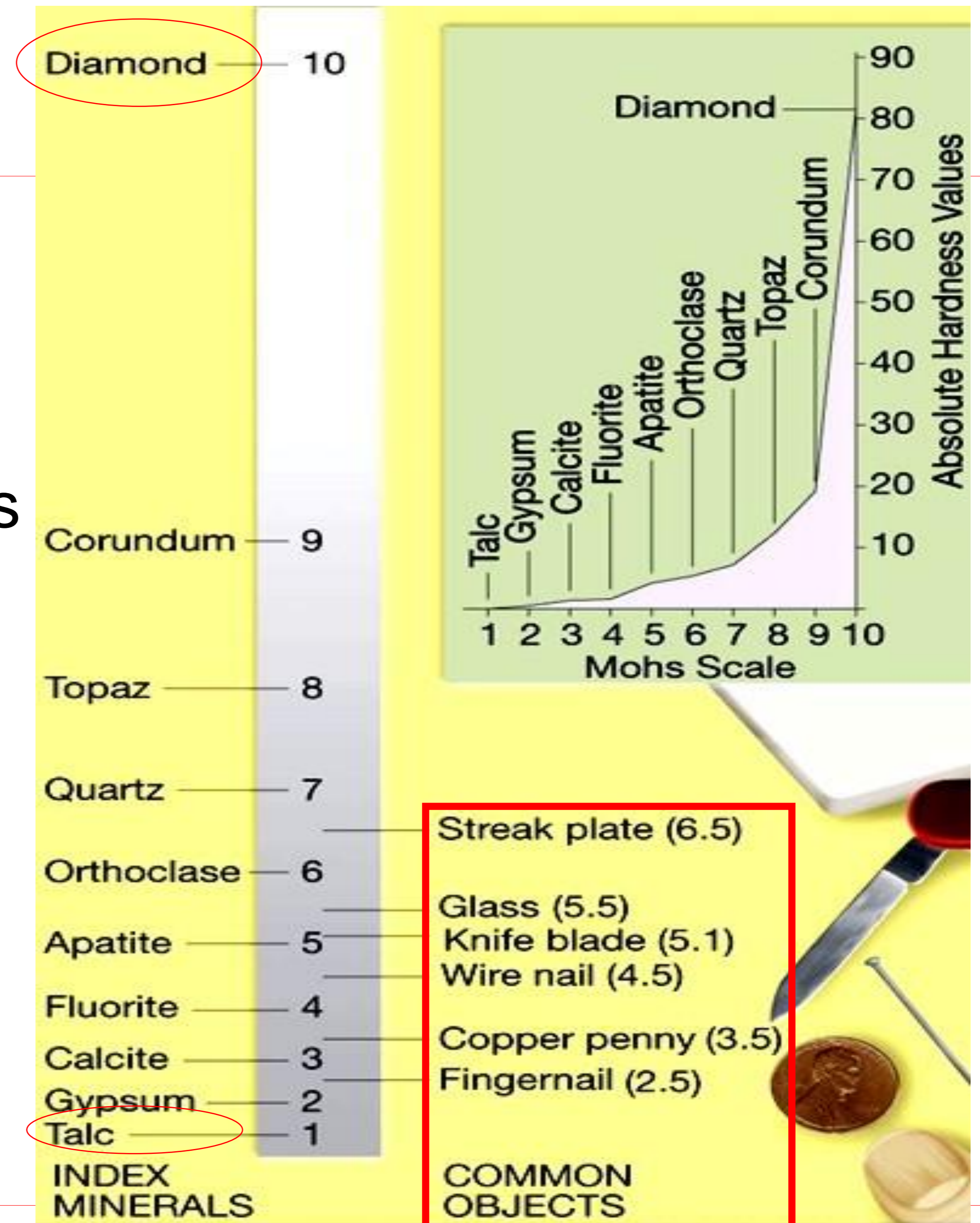
- **Cleavage planes** repeat, when a mineral is broken.
- **cleavage planes must NOT be confused with crystal faces!**
- Crystal faces are just on surface and may NOT repeat, when mineral is broken.

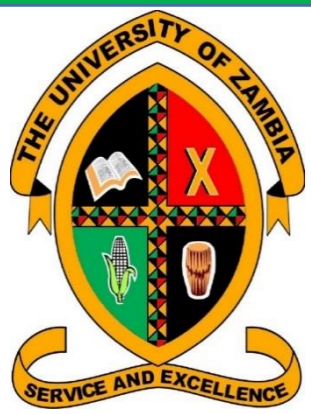




## 2.3.6 Hardness

- How easy it is to scratch a mineral
- Measured on **Mohs Scale** of Hardness
- relative scale
- consists of 10 minerals, ranked from 1 (softest) to 10 (hardest).





## 2.3.7 Specific Gravity

- Is density of a mineral divided by density of water:

$$\text{Specific Gravity} = \frac{\text{density of the object}}{\text{density of water}} = \frac{\rho_{\text{object}}}{\rho_{\text{H}_2\text{O}}}$$

- **metallic minerals** tend to have **higher specific gravity** than non-metallic minerals





## 2.3.8 Other Properties

These include:

- **reaction with hydrochloric acid** (calcite fizzes)
- **taste** (halite tastes salty)
- **feel** (talc feels soapy, graphite feels greasy)
- **magnetism** (magnetite attracts a magnet)



## Summary

- **Minerals** are the substances that make up rocks.
- A mineral is a **naturally occurring inorganic solid with a definite chemical composition and a crystalline structure.**
- Each mineral consists of chemical elements bonded together in definite proportions, and its chemical composition can be given as a chemical formula –  $\text{SiO}_2$ .
- A mineral's **crystalline structure** is an orderly, periodically repeated arrangement of its atoms.



## Summary.....contd.

- Every mineral is distinguished from others by its **chemical composition & crystal structure.**
- Minerals are identified by observing a few of their physical properties – **crystal habit, cleavage, fracture, hardness, specific gravity, colour, streak, & lustre.**
- Although ca. 3500 minerals are known in Earth's crust, only nine **rock-forming mineral groups** are abundant in most rocks – **feldspar, quartz, pyroxene, amphibole, mica, clay minerals, olivine, calcite, and dolomite.**



## Summary.....contd.

- The first seven – *feldspar, quartz, pyroxene, amphibole, mica, clay minerals, olivine* – are **silicates**, whose structures and compositions are based on **silicate tetrahedra**.
- Silicate tetrahedra link together by sharing oxygens to form basic structures of silicate minerals.
- Silicates are most abundant minerals because silicon & oxygen are two most abundant elements in Earth's crust & bond together readily to form silicate tetrahedron.
- Two carbonate minerals – **calcite** & **dolomite** – are also sufficiently abundant to be called rock-forming minerals.



End of Lecture