

**ES2013**

# **Minerals, rocks and deformation**

## **Part 1 - Mineralogy**



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# Logistics

- **Instructor (Part-1):** Dr. Tapabrato Sarkar  
Research Complex, Room: E141 (First floor)  
[tapabrato@iiserkol.ac.in](mailto:tapabrato@iiserkol.ac.in)
  - **Class schedule:** Monday (11:00 am)  
Wednesday (03:00 pm)
  - **Tutorial:** Friday (08:00 am)
- **Attendance in the class**

# Introduction

## □ What is a mineral?

A mineral is a naturally occurring crystalline solid.

### Naturally occurring:

- Formed without the benefit of human action or intervention
- Must be possible to find samples of it formed in the natural environment



Quartz

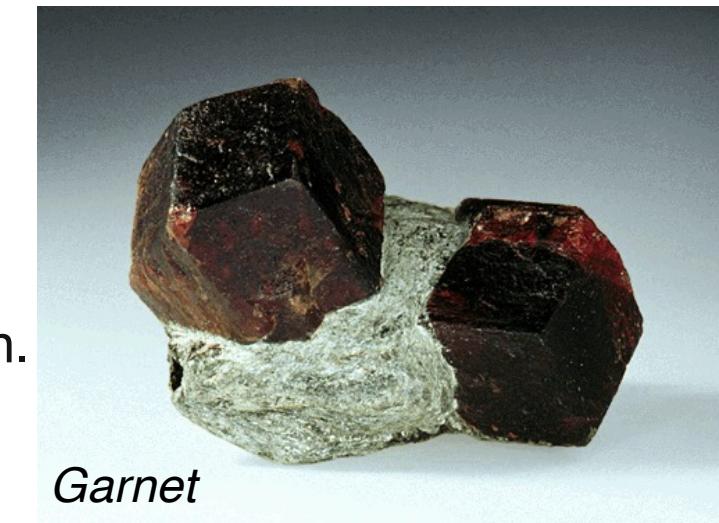


Quartz

### Crystalline solid:

The atoms and/or ions that form crystalline materials are arranged and chemically bonded with a regular and repeating long-range order.

- Minerals have a definite, but not necessarily fixed, chemical composition.
- Because minerals are crystalline and have a **definite** chemical composition, they also have definite physical properties.



Garnet

### Amorphous

Not all solids are crystalline. If the atoms/ions lack long-range atomic order, it is considered amorphous or non-crystalline. E.g. Glass



Is ice a mineral?



Diamond

# Mineralogy

## **Mineralogy is the study of minerals.**

- The beginning of this particular branch of science extends back to prehistoric times, our ancestors surely knew about and used many minerals.
- Evidence of mining and smelting minerals to extract useful metals such as copper, lead, and zinc is found in many ancient civilizations.
- 20th century: Development of new techniques and instruments (e.g. X-ray, XRD). Improved our ability to understand mineral structure and chemical composition.

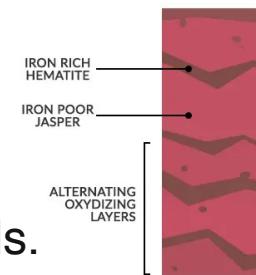
### **□ Why do we care about mineralogy?**

- Almost every human endeavor is influenced by minerals.
- Most things around us are directly or indirectly related to minerals – Integral part of our society
- The earth is made up of rocks – rocks composed of minerals
- The chemical composition, structure, and texture of the minerals that compose the rocks record the history of our planet

# Minerals and society

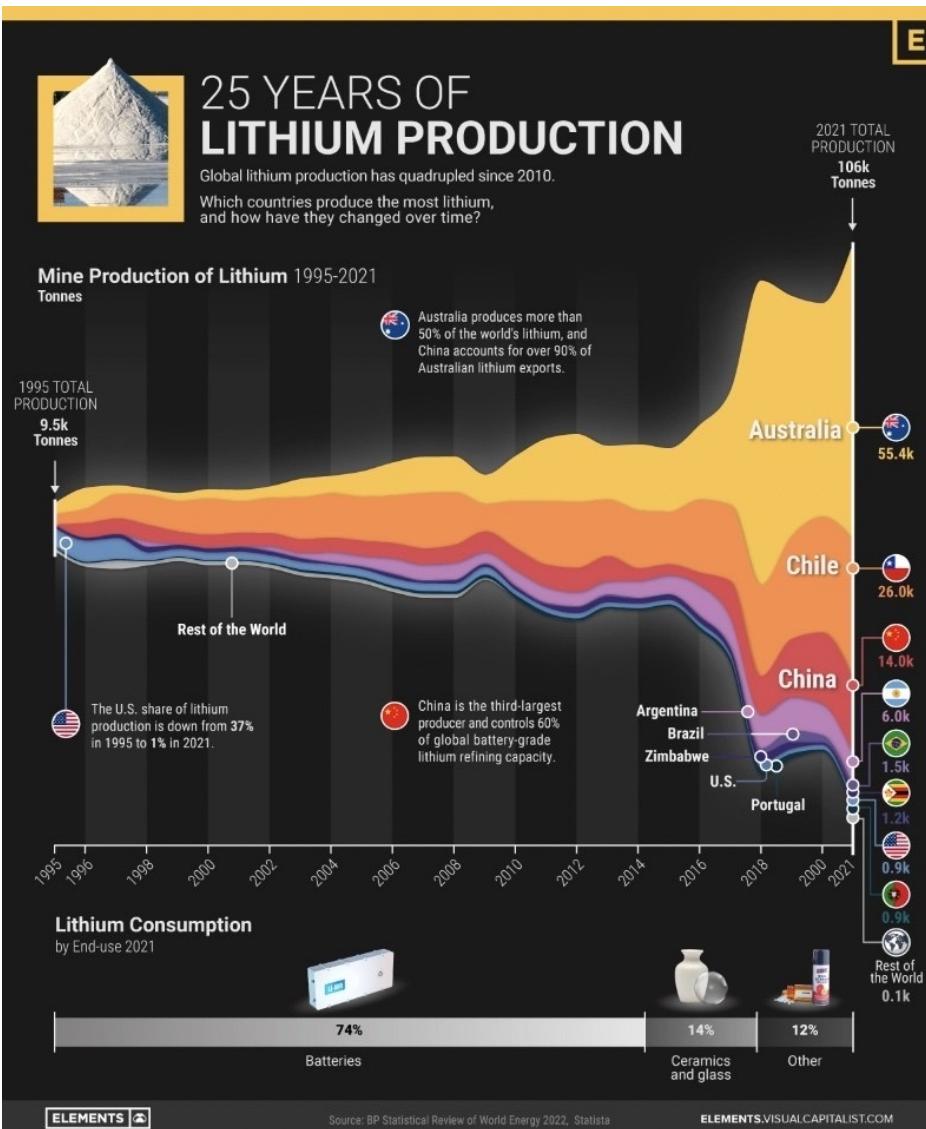
## □ Natural resources

- ✓ Civilization depends very directly on the materials obtained from minerals.
- ✓ From regular metals like iron, copper, zinc etc. to precious metals like gold, silver, platinum – all are derived from minerals
- ✓ From radioactive elements like uranium, thorium to modern day critical elements like lithium and rare earth elements – all derived from minerals.
- ✓ One hand minerals have boosted trade – on the other led to wars.
- ✓ Mineralogy is essential for the discovery of new resources, extraction of usable materials and sustainable use.



# Minerals and society

## □ Natural resources



*Lithium is one of the most essential minerals of the modern world!*

*India is one of the largest importers of Li or Li products*

*But where do you find lithium?*

**Mineralogy and Petrology is the guide..**



$\text{LiAlSi}_2\text{O}_6$



Li bearing mica

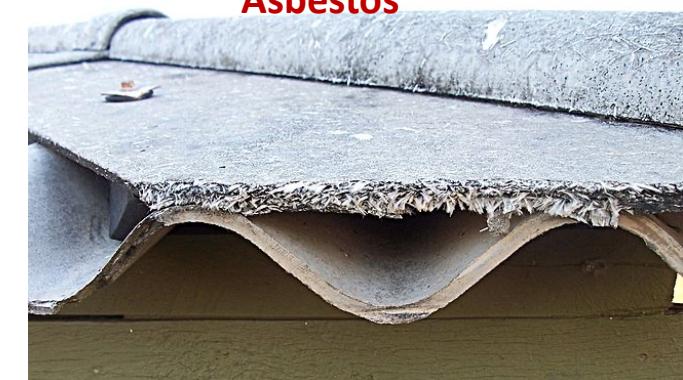
# Minerals and society

## □ Minerals and health

- ✓ Metal poisoning: arsenic, chromium, cobalt,
- ✓ Copper, iron, manganese, molybdenum, nickel etc. – nutrient in small amount but toxic in large amounts
- ✓ Asbestos: group of minerals referred to as asbestos, which form thin flexible fibers that are useful for a number of products and industrial processes.
- ✓ Asbestos poisoning: fibrous mineral particles has been documented to cause cancer and a variety of other lung-related pathologies
- ✓ Inhalation of mineral dust: Chronic lung diseases



Asbestos

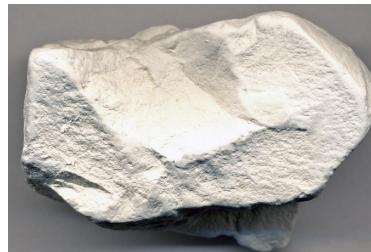


## □ Medical uses of minerals

- ✓ Minerals have probably been used for medical purposes from before the start of recorded history.



Kaolinite  
 $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$



Arsenic poisoning



<https://www.youtube.com/watch?v=FF5NzhpZQ>

# Minerals and society

## □ Astrological uses and precious stones

Gemstone	Composition and properties
Amethyst	Violet; Quartz (Silicon dioxide $\text{SiO}_2$ )
Aquamarine	Pale greenish blue or bluish green Beryl ( $\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$ )
Blue Topaz	Variety of colours; Aluminum silicate containing fluorine ( $\text{Al}_2(\text{F},\text{OH})_2\text{SiO}_4$ )
Citrine	Transparent, pale yellow to brownish orange variety of quartz ( $\text{SiO}_2$ )
Diamond	Transparent; Carbon
Emerald	Green; Beryl ( $\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$ )
Garnet	Variety of colors (commonly pink to red) $\text{X}_3\text{Y}_2(\text{SiO}_4)_3$
Peridot	Light to dark green; Olivine ( $(\text{Fe},\text{Mg})_2\text{SiO}_4$ )
Sapphire	Blue; Corundum ( $\alpha\text{-Al}_2\text{O}_3$ )
Tourmaline	$\text{Na}(\text{Mg},\text{Fe},\text{Li},\text{Al})_3\text{Al}_6[\text{Si}_6\text{O}_{18}](\text{BO}_3)_3(\text{O},\text{OH},\text{F})_4$
Ruby	Pink to Red Corundum (Aluminium oxide $\text{Al}_2\text{O}_3$ )



Amethyst



Aquamarine



Blue Topaz



Citrine



Diamond



Emerald



Garnet



Peridot



Pink  
Sapphire



Pink  
Tourmaline



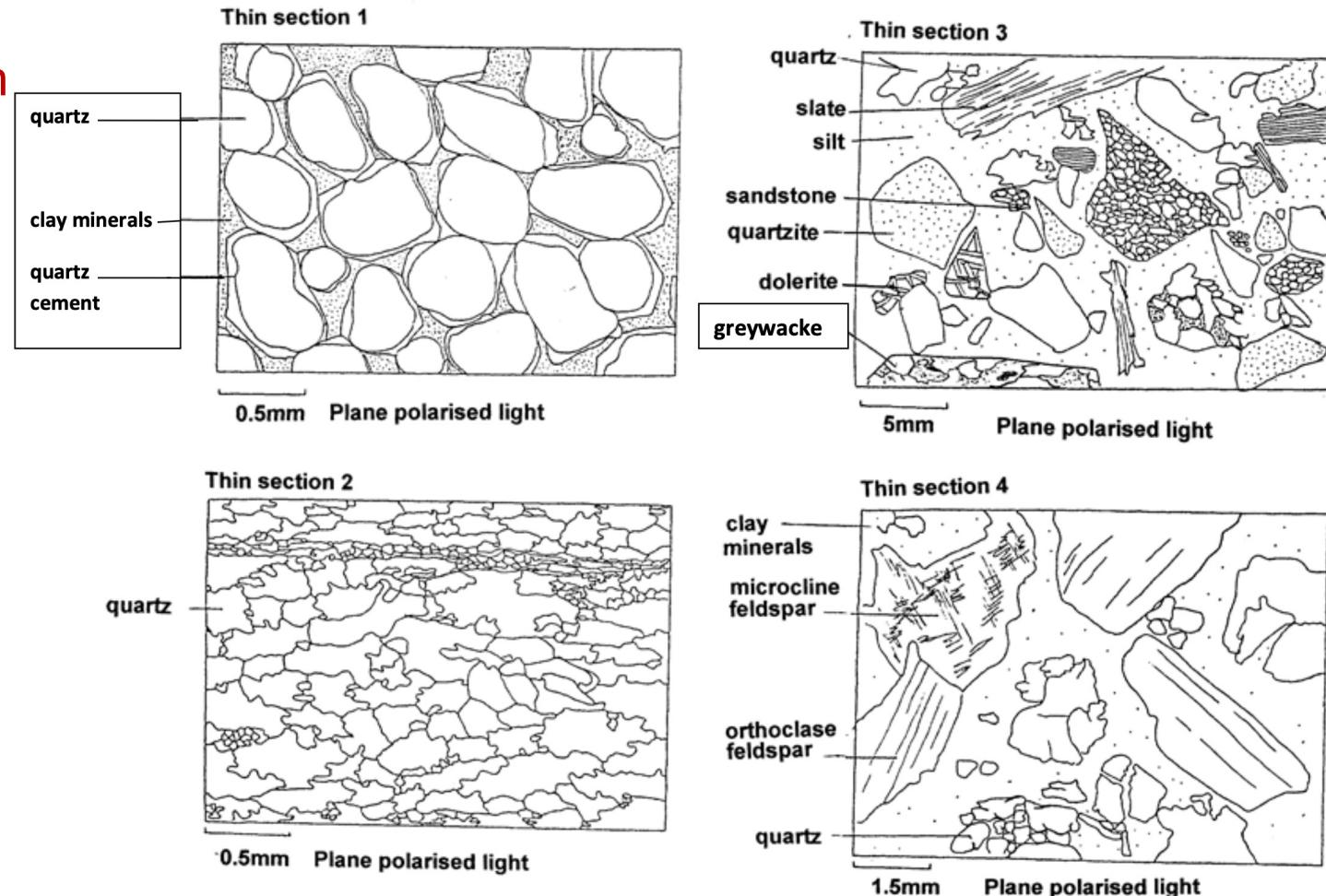
Ruby



Sapphire

# Importance of minerals in Earth Sciences

- Earth's crust and mantle are made of rocks – rocks are composed of minerals.
- Therefore, the history of the earth is recorded in the minerals. *Mineralogy helps to read those records!*
- To reveal Earth's geological history, earth scientists look at:
  - ✓ The rock and its constituent minerals
  - ✓ Mineral composition
  - ✓ Texture
  - ✓ Mineral associations
  - ✓ Relative proportions
  - ✓ Spatial and temporal distributions



# Importance of minerals in Earth Sciences

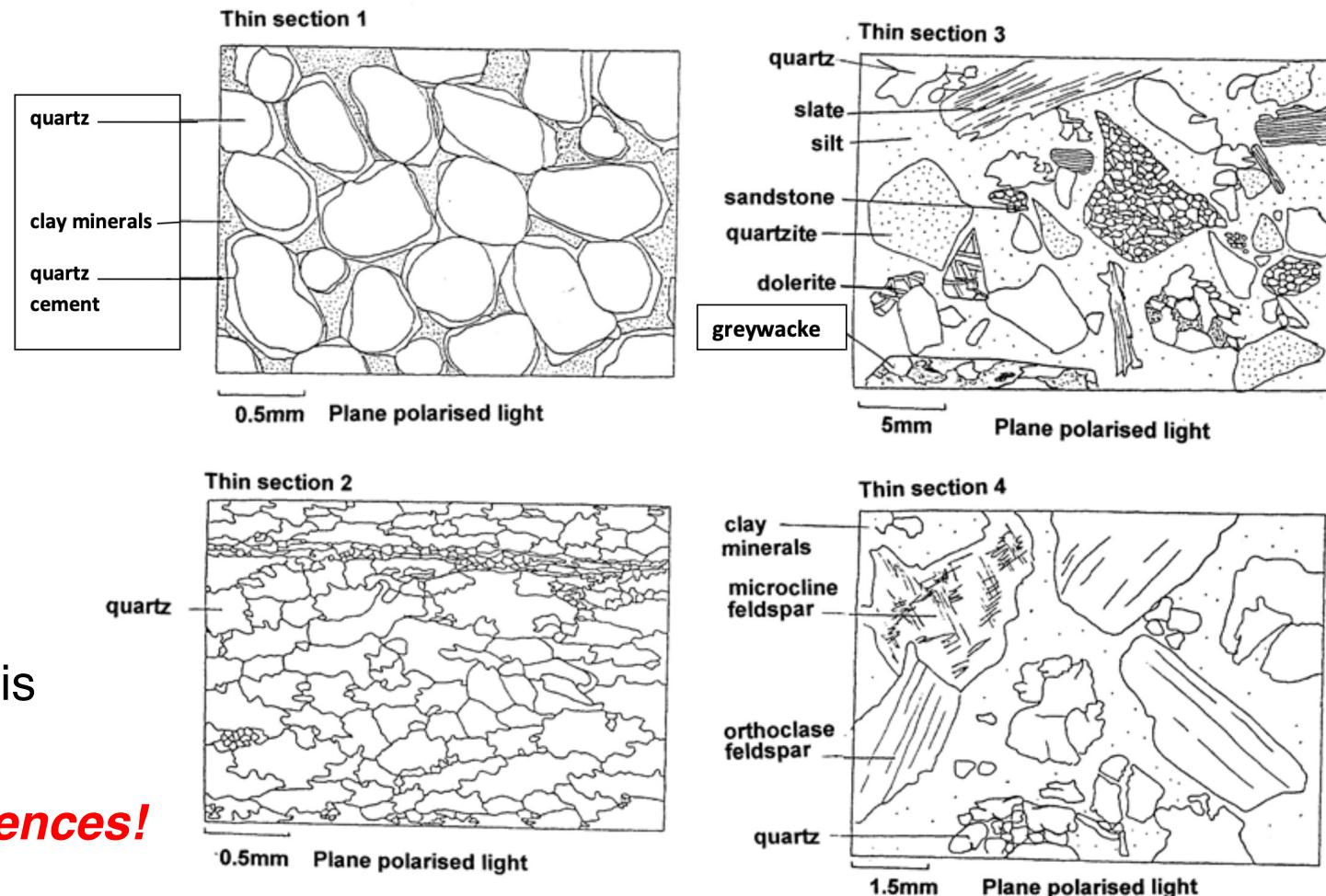
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- **What do earth scientists get?**

- ✓ Conditions in which the minerals/rock formed (temperature, pressure, fluid saturation etc.)
- ✓ Time of formation
- ✓ Region of formation (tectonic regime)
- ✓ How did the minerals/rocks evolve with time

In short– the geological history of the earth is recorded in the minerals.

***Mineralogy is the backbone of Earth Sciences!***



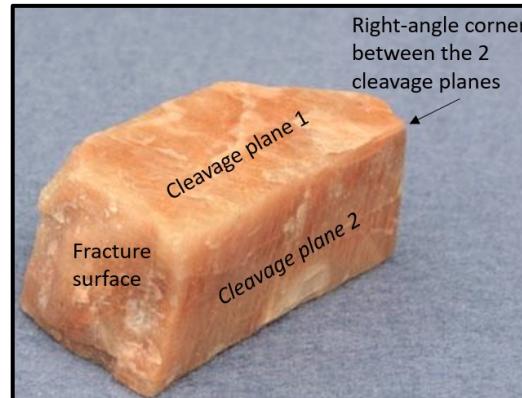
# Properties of minerals

## □ Physical properties

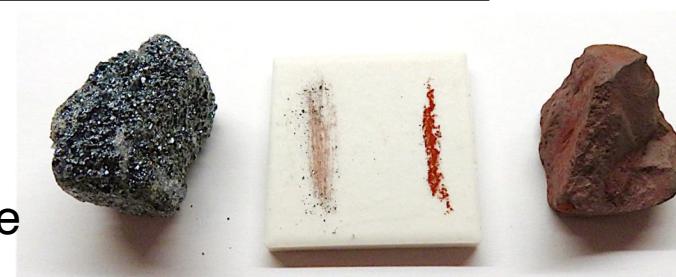
- Mineral shape → depends on crystal structure
- Mass-Related properties:
  - ✓ Density → depends on constituent elements and crystal structure



- Mechanical properties:
  - ✓ Hardness → measure of the resistance of a mineral to being scratched
  - ✓ Cleavage and fracture → refers to the manner in which a mineral breaks.

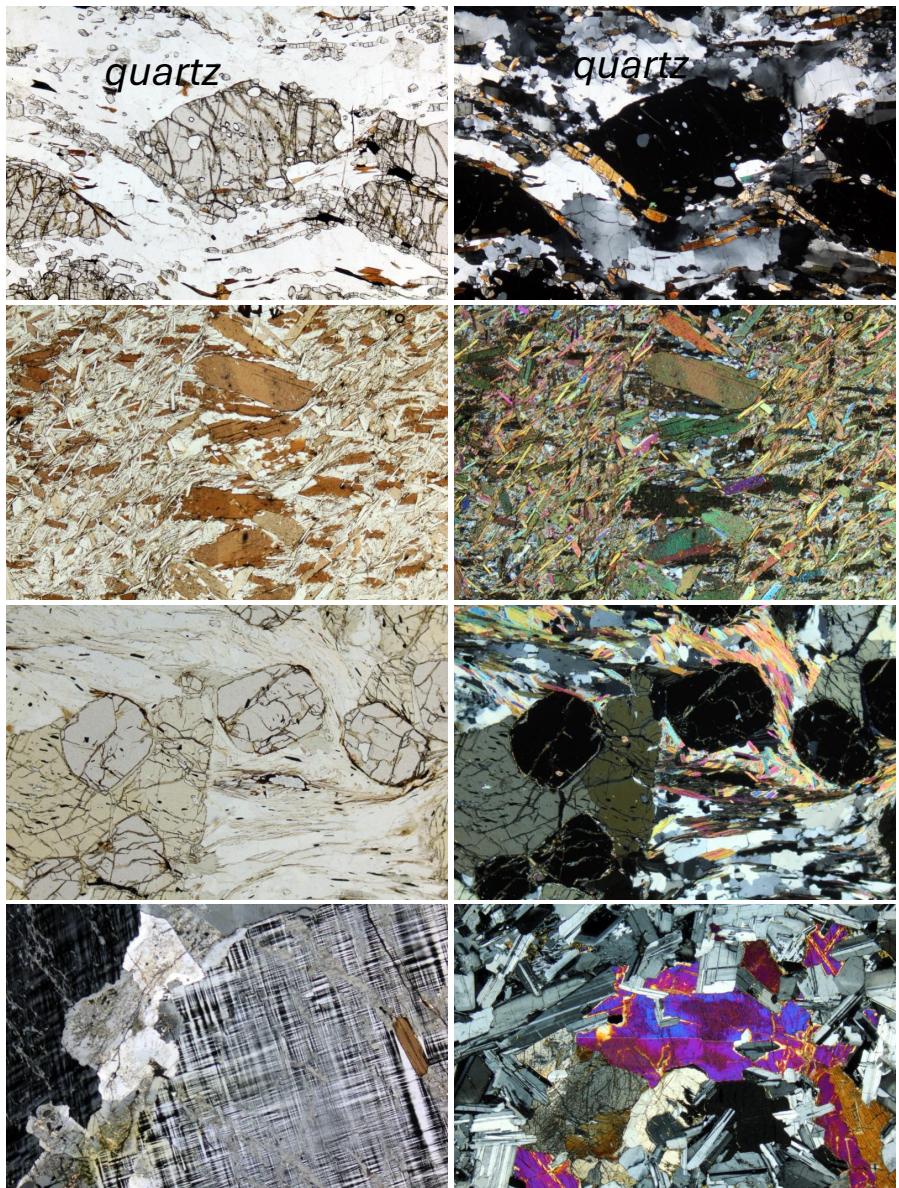


- Color properties:
  - ✓ Color → depends on the interaction of light with the constituent elements and chemical bonding.
  - ✓ Luster → depends on how much the incident light is reflected
  - ✓ Streak color → Color of powdered mineral.



# Properties of minerals

- **Optical properties** → Properties of the mineral when light interacts with a very thin film of mineral.



*Will be covered in detail in later classes*

- **Chemical properties** → chemical composition of the mineral – in turn affects the physical properties.  
(chemical variation in minerals is controlled by substitutions)

*Will be covered in detail in later classes*



Garnet: Same mineral but different chemical compositions



# Outline of the course

- ✓ Crystal chemistry - relationship of chemical composition to atomic structure
- ✓ Optical Mineralogy
- ✓ Structure, classification and properties of silicate minerals.

## References

- ✓ Introduction to Mineralogy, W. Nesse, Oxford University Press
- ✓ Mineralogy, Dexter Perkins, Pearson

## Resources

- ✓ WeLearn
- ✓ Reading assignments
- ✓ Course notes

## Grading

- ✓ Mid and End semester examinations
- ✓ Tutorial assignments
- ✓ Class tests/quiz