

Minerals

(Part I of our study of the Lithosphere)

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What's the difference?

- **Rock:** an aggregate of one or more minerals
 - Rocks are *mixtures* – two samples of one type of rock do not always have the same exact composition
- **Mineral:** a naturally occurring inorganic solid with definite chemical structure (a compound)
- To be a mineral, an Earth material MUST
 - Be naturally occurring
 - Be inorganic
 - Be a solid
 - Have a definite chemical structure (be a compound)
- See Fig. 1.1, p. 21 in Earth Science (Tarbuck and Lutgens, 7th Ed.)

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Mineral Structure

- Some are made of elements (gold, sulfur)
- Most are made of compounds (halite = NaCl)
- Recall: a **compound** is a substance composed of 2 or more elements bonded together in definite proportions



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Physical Properties of Minerals – Crystal Form

- **Crystal form:** External structure that reflects internal arrangement of a mineral's atoms or molecules
- Example: Halite (NaCl) forms cubic crystals



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Physical Properties of Minerals – Color

■ **Color** – Unreliable identifier

- Some minerals display *inherent coloration* – color results from chemical makeup and doesn't vary.
 - Example: Sulfur is bright yellow.
- Many minerals display *exotic coloration* (variety of colors) – slight impurities can change the color
 - Example: Quartz (SiO_2) – clear, but with a little iron and aluminum it becomes purple amethyst.



Sulfur



Quartz



Amethyst Quartz

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Physical Properties of Minerals - Streak

■ **Streak**

- Color of mineral in powdered form
- Measured by rubbing the mineral across a *streak plate* (unglazed porcelain)
- More reliable than color



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Physical Properties of Minerals - Luster

■ **Luster**: the appearance or quality of light reflected from the surface of a mineral

- **Metallic luster**: describes minerals that look like metals (whether truly metallic or not)
- **Non-metallic luster**: describes minerals that don't look like metals
 - Glassy (vitreous)
 - Pearly
 - Silky
 - Resinous
 - Earthy (dull)
- See [http://en.wikipedia.org/wiki/Lustre_\(mineralogy\)](http://en.wikipedia.org/wiki/Lustre_(mineralogy)) for more information and great images

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Physical Properties of Minerals - Hardness

■ **Hardness**

- Measure of the resistance of a mineral to abrasion or scratching
- Determined by rubbing a mineral of unknown hardness against one of known hardness (or vice-versa)

- **Mohs scale**: 10 minerals arranged on a scale of 1 (softest) to 10 (hardest)

Mohs Scale	Mineral	Absolute Hardness	Image of Mineral
1	Talc ($\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_2$)	1	
2	Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)	3	
3	Calcite (CaCO_3)	9	
4	Fluorite (CaF_2)	21	
5	Apatite ($\text{Ca}_5(\text{PO}_4)_3(\text{OH}, \text{Cl}, \text{F})$)	48	
6	Feldspar (KAlSi_3O_8)	72	
7	Quartz (SiO_2)	100	
8	Topaz ($\text{Al}_2\text{SiO}_5(\text{OH}, \text{F})_2$)	200	
9	Corundum (Al_2O_3)	400	
10	Diamond (C)	1600	

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Physical Properties of Minerals – Cleavage

- **Cleavage:** tendency of a mineral to break along planes of weak bonding between atoms in the crystalline structure
- Minerals that exhibit cleavage show smooth, flat surfaces
- Examples:



Muscovite Mica
(flat sheets)



Calcite
(rhombohedral
cleavage)



Fluorite
(rhombohedral
cleavage)

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Physical Properties of Minerals - Fracture

- Minerals that don't exhibit cleavage exhibit **fracture**
- Types of fracture:
 - Conchoidal: smooth, curved fracture, similar to broken glass
 - Splinters or fibers
 - Irregular



Conchoidal fracture

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Physical Properties of Minerals - Specific Gravity

- **Specific gravity:** ratio of the density of a mineral to the density of water at room temperature and pressure (1.0 g/mL).
- Example: Galena has a specific gravity of 7.5 (meaning that it's gravity is 7.5 times that of water, or 7.5 g/cm³).

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Physical Properties of Minerals – Other Properties

- Taste and Smell
 - Halite is salty.
 - Sulfur has a pungent, distinctive odor.
- Optical properties
 - Calcite exhibits double refraction (letters appear twice if a transparent sample is placed over them)
 - Ulexite (TV Stone) acts as a set of fiber optic cables (see image above)
- Feel
 - Talc is soapy
 - Graphite is greasy



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Silicate Minerals

- Oxygen and Silicon are the most abundant minerals in the Earth's crust
- **Silicate minerals** all contain Silicon and Oxygen, usually with one or more additional elements:
 - Iron (Fe)
 - Magnesium (Mg)
 - Potassium (K)
 - Sodium (Na)
 - Calcium (Ca)
- Most form when molten rock cools and crystallizes.
- Minerals produced are determined by
 - Temperature
 - Pressure
 - Composition of magma determine

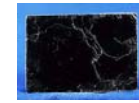
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Silicate Minerals (cont'd)

- Divided into 2 groups based on chemical makeup:
 - "Dark silicates" – iron and/or magnesium ions
 - Hornblende, biotite
 - "Light silicates" – usually do NOT have iron or magnesium
 - Quartz, feldspar



Hornblende



Biotite



Quartz



Feldspar

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Silicate Minerals (cont'd)

Table 1: Common Silicate Minerals

Mineral	Idealized Formula	Cleavage
Olivine	$(\text{Mg,Fe})_2\text{SiO}_4$	None
Pyroxene group (Augite)	$(\text{Mg,Fe})\text{SiO}_3$	Two planes at right angles
Amphibole group (Hornblende)	$(\text{Ca}_2\text{Mg}_5)\text{Si}_8\text{O}_{22}(\text{OH})_2$	Two planes at 60° and 120°
Micas	Biotite	One plane
	Muscovite	
Feldspars	Orthoclase	Two planes at 90°
	Plagioclase	
Quartz	SiO_2	None

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Nonsilicate Minerals

- **Nonsilicate minerals** do not contain silicon.
- Classes of nonsilicate minerals:
 - Oxides – hematite (Fe_2O_3), magnetite (Fe_3O_4)
 - Sulfides – sphalerite (ZnS), galena (PbS)
 - Halides – halite (NaCl), fluorite (CaF_2)
 - Carbonates – calcite (CaCO_3)
 - Native Elements – sulfur (S), graphite (C), gold (Au), silver (Ag)

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Nonsilicate Minerals (cont'd)

Table 2: Common Nonsilicate Minerals

Group	Member	Formula
Oxides	Hematite	Fe_2O_3
	Magnetite	Fe_3O_4
	Corundum	Al_2O_3
Sulfides	Galena	PbS
	Sphalerite	ZnS
	Pyrite	FeS_2
	Chalcopyrite	CuFeS_2
Sulfates	Gypsum	$\text{CaSO}_4 \cdot \text{H}_2\text{O}$
Native Elements	Sulfur	S
	Graphite	C
Halides	Halite	NaCl
	Fluorite	CaF_2
Carbonates	Calcite	CaCO_3

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Minerals



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Minerals (cont'd)



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