

MINERALS & MINERALOGY

Objectives -

Distinguish between elements and compounds, cations and anions, and isotopes and ions.

List the chemical symbol and name of the eight most common elements in the Earth's crust.

List the four most common elements in the Earth's crust in order.

Distinguish silicon, silica, and silicates.

Define a mineral and a rock and state their differences.

State what characteristic is used to assign minerals to their respective groups.

List common rock-forming minerals from each of the major mineral groups.

Distinguish between felsic and mafic silicates minerals.

Distinguish between an empirical classification and a genetic one.

First step*: some basic chemistry terms

- element - the most basic chemical constituent, cannot be further subdivided chemically (90+ elements; e.g. Si, O); elements are composed of atoms
- atom - building blocks of all matter, composed of subatomic particles
- nucleus - the central portion of an atom consisting of one or more neutrally-charged neutrons & one or more positively charged protons
- electron - negatively charged subatomic particle that orbits & balances the + charge of the nucleus of an atom
- ion - an atom or assemblage of atoms that carry an electrical charge
- cation - a positively charged ion (w/o sufficient electrons to balance positive charge of nucleus) produced by lending an electron (Ca^{2+})
- anion - a negatively charged ion (with excess electrons relative to charge of nucleus) produced by borrowing an electron (SO_4^{2-})

D? When an anion and a cation combine, what do you get?

- compound - a neutrally-charged substance composed of two or more elements chemically bonded together, e.g. H_2O
- isotope - atomic variety of an element based on the # of neutrons
 - e.g. C^{12} C^{13} C^{14}
 - some isotopes are radioactive (e.g. U^{235})

* generally, for future classes, I will assume you've already learned the terms before coming to class.

R? What is the difference between an ion and an isotope?

R? What is the charge of a proton? neutron? electron?
cation? anion?

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The "crustal" elements

- Eighty-eight elements occur naturally
- 90 are stable (non-radioactive)
- Only 8 are common* in the crust (know them!)

Element & symbol	Ions	Atomic number	Wt. %	Vol. %
Oxygen	O (2-)	8	46.4	94.27
Silicon	Si (4+)	14	28.2	0.88
Aluminum	Al (3+)	13	8.2	0.47
Iron	Fe (2+, 3+)	26	5.6	0.48
Magnesium	Mg (2+)	12	4.2	0.58
Calcium	Ca (2+)	20	2.4	0.68
Potassium	K (+)	19	2.3	1.65
Sodium	Na (+)	11	2.1	0.99
Totals:			99.4	100.0

*Note: You should also know: C - carbon, S - sulfur, Cl (-) - chlorine

MIN-2

Elements

Si

O

Protons - 14
Neutrons - 14*
Electrons - 14

Protons - 8
Neutrons - 8*
Electrons - 8

*number of neutrons may vary; # of protons is fixed; # P = # E

D? What characteristic distinguishes one element from another?

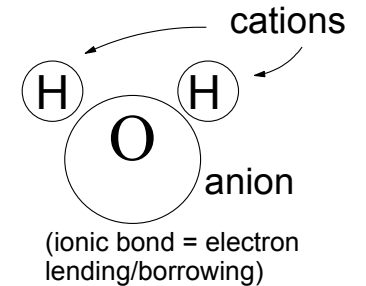
Native elements vs. compounds

D? What mineral is 'C'?

C - C - C

(covalent bonding =
electron sharing)

Native element

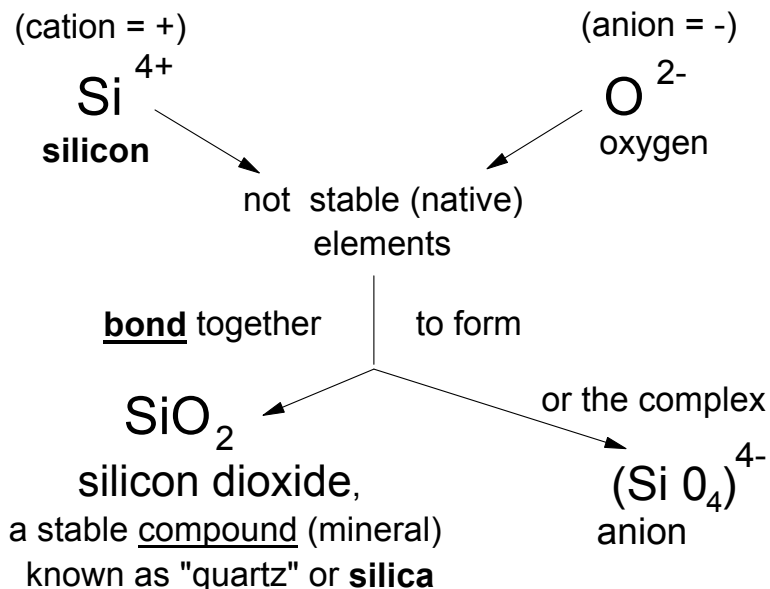


H₂O - Compound

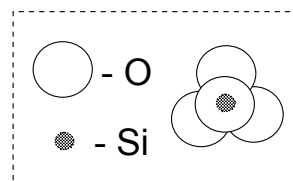
D? What is the difference between a native element and a compound?

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Cations, Anions, silicon, silica, & silicates



- any mineral containing silicon & oxygen (silicon-oxygen tetrahedron) is known as a "**silicate**" mineral



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$(\text{SiO}_4)^{4-}$ tetrahedron

What is a mineral? a rock?

- Basic earth materials
- Minerals compose the bulk of most rock
- Some rocks may contain NO minerals

Mineral definition:

- "a naturally-occurring,
- inorganic,
- solid,
- with a definite range of chemical composition,
- and an ordered atomic arrangement"

D? What do they mean "vitamins & minerals"? What is the difference? Are they essentially the same thing?

Rock definition:

- "An aggregate of one or more minerals as well as non-minerals"
- e.g. most sandstone is composed of sand-sized grains of quartz (a mineral) that are cemented together; whereas, coal is composed primarily of carbonized vegetable matter (a non-mineral.)

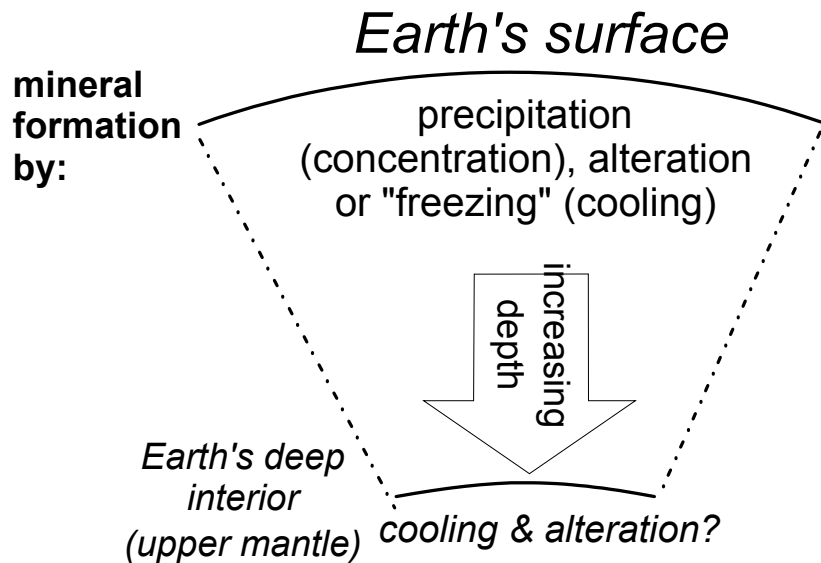
Minerals and non-minerals

D? Instructions: If the substance is a mineral, just place a check in that column, if it is a non-mineral, indicate why.

Substance	mineral	non-mineral
coal		
volcanic glass (obsidian)		
snow		

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How and where do minerals form?



MINERAL CLASSIFICATION BASED ON ORIGIN:

igneous minerals = form by cooling of molten rock ("crystallization")

sedimentary minerals = low-temp. precipitation or chemical alteration

metamorphic minerals = chemical alteration at Hi-P/T

D? We don't typically classify minerals in this way (i.e. genetically). Why not?

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How should we study minerals?

- For classification of a newly discovered mineral: study mineral composition & crystal form
 - every mineral must have a unique combination of chemical composition & crystal structure
 - been going on for centuries
 - over 3500 (?) known
- For identification of individual mineral samples (e.g. in lab):
 - Work methodically! -- must use a method or chaos will ensue.
 - observe and interpret physical traits, e.g.
 - color/streak/luster
 - crystal habit
 - cleavage/fracture
 - hardness
 - specific gravity

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Why use physical traits?

- physical traits or properties result from chemical composition & atomic structure
- this is an easy way of "getting at" the unique properties through more easily observed ones
- empirical classifications -- those based on physical traits -- are usually easier to use than those based on genetic traits

R? What physical traits are commonly used to I.D. minerals?

R? What is the difference between a genetic and an empirical classification?

Why study minerals?

- Basis of advanced technologies
- Essential component for all life
- Good example of a scientific classification scheme*
- Develop observational skills*
- Good "jumping-off-point" for earth science studies*

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Common, rock-forming minerals*

Mineral name	Composition	Mineral Group (based on anion)
Quartz	SiO ₂	Silicate
Feldspar group	Aluminosilicate ([Na,Ca,K]AlSi ₃ O ₈)	Silicate (anion)
Pyroxene group (e.g. augite)	(Mg,Fe)SiO ₃	Silicate
Amphibole group (e.g. hornblende)	(Ca ₂ Mg ₅)Si ₈ O ₂₂ (OH) ₂	Silicate
Olivine	(Mg,Fe) ₂ SiO ₄	Silicate
Muscovite, Biotite (Micas)	Complex Aluminosilicate	Silicate
Calcite	CaCO ₃	Carbonate (CO ₃)= (anion)
Dolomite	CaMg(CO ₃) ₂	Carbonate
Ice	H ₂ O	Oxide
Gypsum	CaSO ₄	Sulfate (SO ₄)=
Halite	NaCl	Halide
Clay mineral group	highly variable	Silicate

*note: you should know these minerals

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Mafic vs. felsic silicate minerals

- Silicate minerals compose about 90% of the earth's crust
 - All silicates are either mafic or felsic
- Mafic or "ferromagnesian" minerals
 - rich in Fe and/or Mg, Si-poor
- Felsic minerals
 - rich in Si, Fe- and Mg-poor

Know the traits of the following minerals & mineral groups as well as their significance:

- | | |
|-------------|----------------------|
| ■ Quartz | ■ Calcite |
| ■ Feldspar | ■ Carbonate minerals |
| ■ Olivine | ■ Clay minerals |
| ■ Pyroxene | ■ Felsic silicates |
| ■ Amphibole | ■ Mafic silicates |
| ■ Biotite | ■ Native elements |
| ■ Muscovite | ■ Evaporite minerals |

Review questions

Distinguish between a mineral and a rock:

True or False: Not all rocks contain minerals, but any mineral sample can be considered a rock.

Carbonate minerals are an empirical group; evaporite minerals are a genetic group. Explain why.

Why is calcite classified as a carbonate mineral?

Describe the definitive characteristic of a native element and give an example of one.

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Review questions (cont.)

What makes a mineral "mafic" or "felsic"?

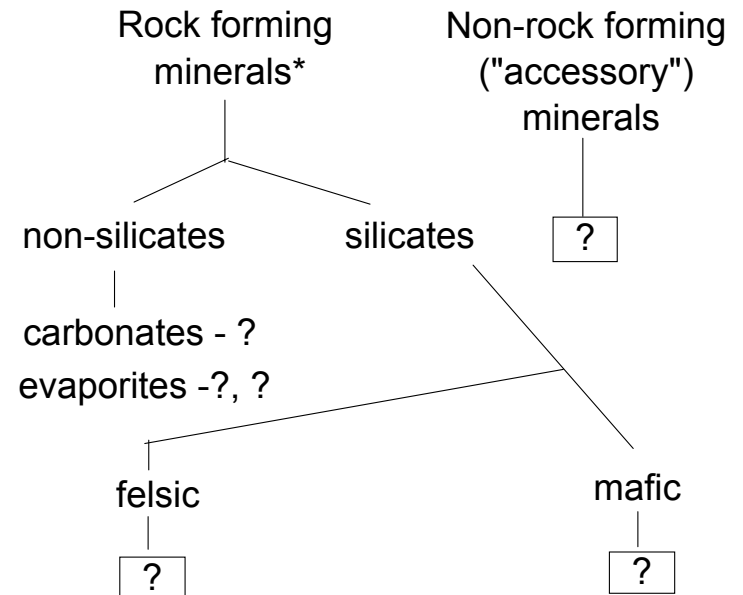
Why are silicate minerals so common in the earth's crust?

Is obsidian a mineral? Explain.

Which of the common, rock-forming minerals discussed is assigned to its mineral group based on its cation rather than its anion?

IMPORTANT MINERAL CATEGORIES

D? Complete the diagram as indicated.



* Rock-forming - def. " those minerals that compose the bulk of rocks and therefore are used for classification."

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