LECTURE #2: Energy Sources *(con't)*; Elements and Minerals

Date: 25 January 2021

I. Recitations start this week!

- please make sure you attend the class and talk with your TA about what is expected
  - *this is a large percentage of your grade!*
    - and make sure that you have your copy of the recitation manual
    - *you will need this for the first recitation in order to complete the work!*

- also see the note on the main syllabus page about switching your enrollment to a section that's not full or near full

II. From Last Class: *Energy for Disasters*

- *covered external energy (from the Sun) last class*
- *see the end of last class's notes …*
  - *we will cover those first at the start of the lecture*

III. New Topic: Atoms and Minerals

- from the really "big picture" to the VERY small one!
  - *from large-scale hazards to the scale of atoms*

  - we won't spend as much time on this subject as other introductory geology classes
    - you get a good review in the recitation this week
    - we will look at this more next few weeks before talking about Plate Tectonics, earthquakes and later, volcanoes

  - critical for understanding the building blocks of geology
  - next class
    - we'll examine how minerals combine into common rock types
      - important for particular types of disasters

IV. What is a mineral?

- **definition:** a naturally occurring, inorganic solid with a specific chemical composition and a specific regular arrangement of atoms
  - very precise definition and they have specific physical and chemical properties

- identifying minerals and rocks takes practice and experience
  - one of the harder skills to acquire
  - other courses in the Department of Geology devote more time and effort to these details

        - for example, there are five labs devoted to rocks and minerals in the Physical Geology Lab (GEOL 0055) class

- mineral is made up of atoms
    - <u>atom:</u> smallest particle of an element that still retains the properties of that element
        - made up of protons, neutrons and electrons
            - protons (+) and neutrons (o) form the nucleus
            - electrons (-) orbit the nucleus

        - an element/mineral is made up of atoms

- what is atomic structure?
    - atomic structure of minerals
        - all minerals are built from regular, repeating arrangements of atoms
        - this regular structure that makes a crystal a crystal
            - a piece of wood is a solid
            - but it has no regular arrangement of atoms
            - therefore, it is not a crystalline solid

        - glass, bricks, plastic, etc. are also not crystalline solids

- what is an element?
    - <u>element:</u> substance that <u>cannot</u> be broken down into other substances
        - can a mineral be an element??
        - ____

    - atomic number
        - the number of protons in an atom
            - example: hydrogen (H) has 1 proton
            - example: oxygen (O) has 8 proton

- <u>periodic table:</u> arrangement of all elements by their atomic number *(see next page)*

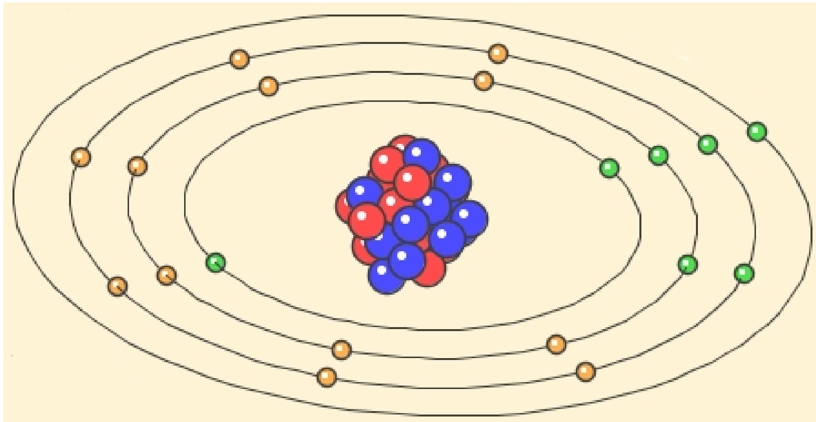
- what is an isotope?
    - <u>isotope:</u> an element with varying amount of neutrons
        - example:
            - most carbon atoms (98.9%) have 6 neutrons (plus 6 protons) → ^{12}C
            - radioactive variety has 8 neutrons (plus 6 protons) → ^{14}C

    - oxygen dominates the Earth's crust
        - 3 times as abundant as Si
        - Si is much more abundant than the other elements

Group	1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period																			
1	1 H																		2 He
2	3 Li	4 Be												5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg												13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca		21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr		39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	**	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo
*Lanthanoids			*	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb		
**Actinoids			**	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No		

Element	**Weight %**	**Atomic Wt.**
Oxygen	46.60	16
Silicon	27.72	28
Aluminum	8.13	27
Hydrogen	0.14	1
Sodium	2.83	23
Calcium	3.63	40
Iron	5.00	55.8
Magnesium	2.09	24.3
Potassium	2.59	39
Titanium	0.44	49

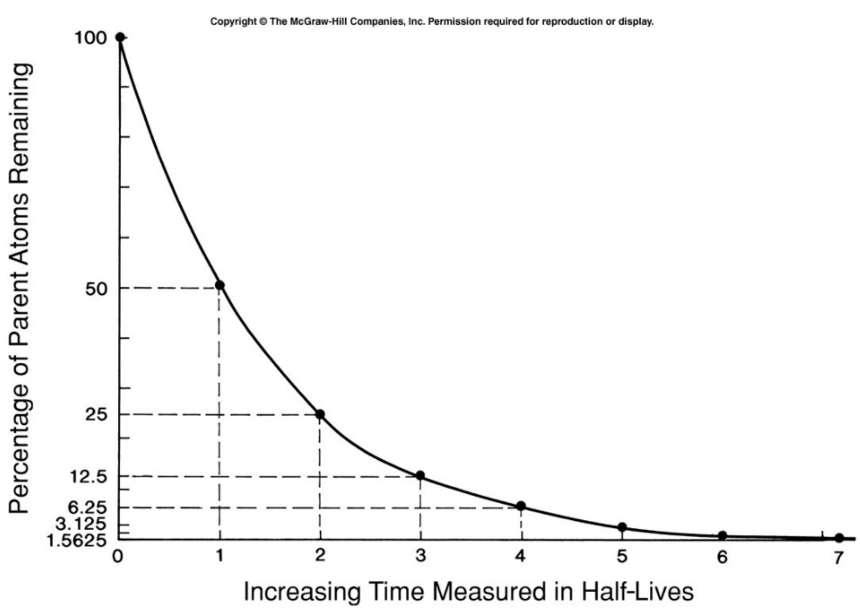
- radioactive minerals
  - unstable and over time decay *(radioactive decay)*
    - Potassium-40, Uranium-238, Thorium-232, many others …
  - releasing neutrons, protons or particles from the atom's nucleus
    - changing the atomic number/isotope and therefore the element
    - particle released is converted into energy
    - heat the surrounding rocks
    - damage/kill living tissue



Potassium-40 (19p + 20n) → Agron-40 (18p + 22n)

- half-life:
  - time required for ½ the number of atoms of the parent element to decay into the daughter element

Parent	**Daughter**	**Half Life**
Aluminum-26	Magnesium-26	720,000
Uranium-235	Lead-207	0.71 billion
Potassium-40	Argon-40	1.3 billion
Uranium-238	Lead-206	4.5 billion
Thorium-232	Lead-208	14 billion
Rubidium-87	Strontium-87	47 billion
Samarium-147	Neodymium-147	106 billion



  - age of the Earth
    - ➢ 4.57 billion years
    - ➢ measuring radioactive elements in lunar rocks
    - ➢ *why moon rocks??*
    - ➢ ______________________________

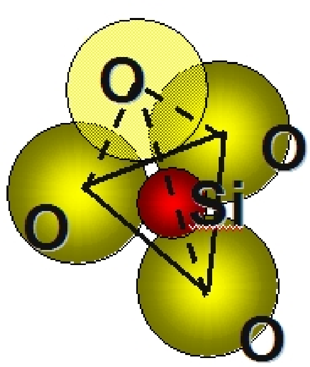
V. Mineral Types and Classes

- top elements in the Earth's crust

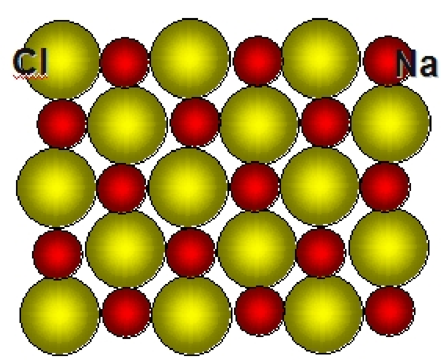
Element	Weight % (Earth)	Atomic Wt.	Atomic #
Oxygen	46.60		16.0
Silicon	27.72		28.1
Aluminum	8.13		27.0
Iron	5.00		55.6
Calcium	3.63		40.1
Sodium	2.83		23.0
Potassium	2.59		39.1
Magnesium	2.09		25.3
Titanium	0.44		47.9
Hydrogen	0.14		1.0

- oxygen dominates the Earth's crust
    - O is nearly twice as abundant as Si
    - Si is much more abundant than the other elements!
    - because minerals naturally grow from whatever elements are available
        - there are a lot of minerals contain O and Si
        - of the several thousand different minerals on earth about 95% contain O and Si
        - these are called the silicate minerals
            - most common silicate: quartz

- Silica Tetrahedra (SiO_4)
    - “building block” of silicate minerals
    - defines the crystal shape, properties, and appearance
    - can have different long range order of the tetrahedra in combination with each other or other atoms
        - single (isolated): “olivine” *(no shared oxygen atoms)*
        - chain structure: “pyroxene” *(2 shared oxygen atoms)*
        - double chain structure: “asbestos” *(2 shared oxygen atoms)*
        - sheet structure: “mica” *(3 shared oxygen atoms)*
        - framework structure: “quartz” *(all 4 shared oxygen atoms)*

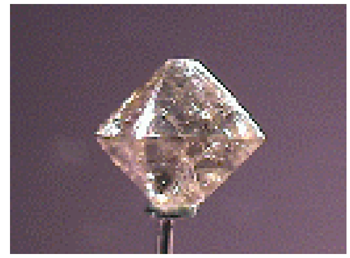
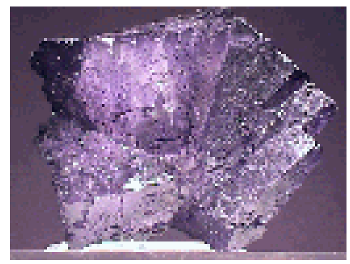
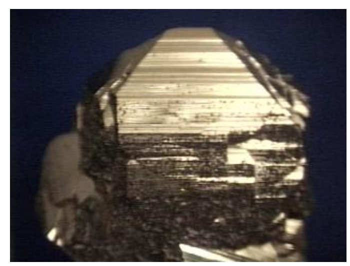


silica tetrahedra (SiO_4)



other classes: sodium chloride (NaCl)

- mineral categories

Native elements	gold (Au), copper (Cu), diamond (C), sulfur (S)	
Oxides/Hydroxides	$Fe_2\mathbf{O_3}$, $Al_2\mathbf{O_3}$, $H_2\mathbf{O}$ (ice)	
Halides	$Na\mathbf{Cl}$, $K\mathbf{Cl}$, $Ca\mathbf{F_2}$	
Sulfides	$Pb\mathbf{S}$, $Zn\mathbf{S}$, $Fe\mathbf{S_2}$	
Sulfates	$Ca\mathbf{SO_4}$, $Ba\mathbf{SO_4}$	
Carbonates	$Ca\mathbf{CO_3}$, $Fe\mathbf{CO_3}$, $(Ca,Mg)(\mathbf{CO_3})_2$	

Phosphates $Ca_5(\mathbf{PO_4})_3(OH,Cl,F)$

- other mineral indicators *(you will see these in recitation in more detail):*
  - color
  - luster
  - transparency
  - crystal system
  - crystal habits
  - cleavage
  - fracture
  - hardness
  - density
  - streak