Minerals and Rocks

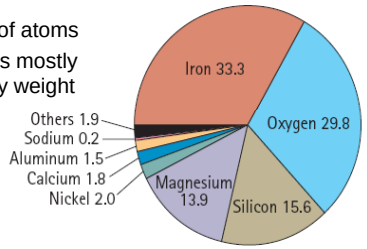
Chapter 20

Earth System Science

- Interconnected
- Rocks and minerals
- Interior processes
- Erosion and deposition
- Water and air

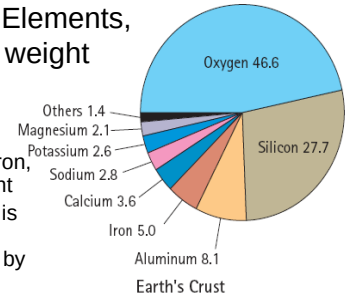
Elements of Earth by weight

- Made of atoms
- Earth is mostly iron, by weight



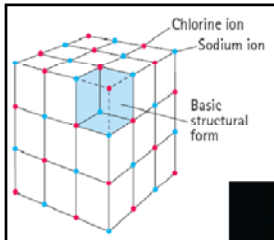
Crust Elements, by weight

- Made of atoms
- Earth is mostly iron, by weight
- Surface is mostly oxygen, by weight



Minerals

- Naturally occurring
- Not composed of 'organic' molecules
- Crystalline solid
- Specific chemical composition



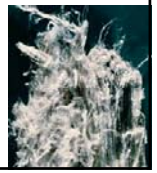
Halite crystals
NaCl

Crystals

- Amethyst quartz
  - Pyrite

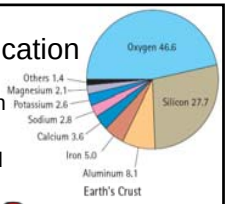
Shape reflects internal arrangement of atoms

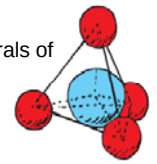
- Rhodochrosite
  - Asbestos



Mineral Classification

- Crust is mostly oxygen and silicon
- Silicon always bonded to oxygen
- 'SILICATES'
- 92% of minerals of crust



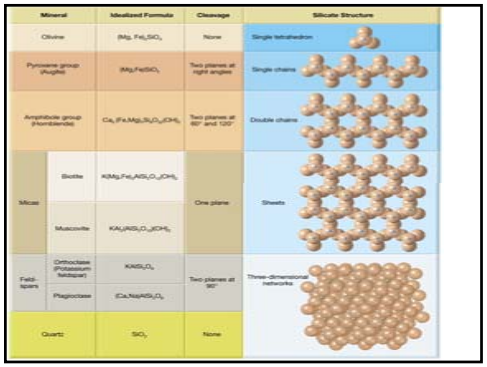


Silicate Minerals

- Silica bonded to metals
- Aluminum, sodium, potassium, calcium
  - Feldspar: Most abundant mineral
  - 'felsic minerals'
  - Pale, average density
- Examples of felsic minerals
  - Feldspar
  - Quartz
  - Muscovite mica

Silicate Minerals

- Silica bonded to metals
- Iron, magnesium
  - Ferromagnesian silicates: 'ferromags'
  - Dark, denser than felsic minerals
- Examples of ferromags
  - Amphibole
  - Pyroxene
  - Biotite mica
  - Olivine

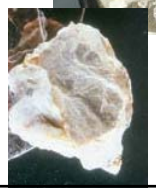


Hardness

- Resistance to scratching
- Compare to glass/steel, penny, fingernail

Breaking minerals

- Strength of bonds within crystals
- Cleavage
  - Some planes with weak bonding
  - Break along these



Breaking minerals

- Strength of bonds within crystals
- Fracture
  - No planar arrangement of weak bonds
  - Conchoidal or irregular

Non-silicates

- Carbonates
  - Calcite: $CaCO_3$
- Oxides
  - Fe_2O_3, Fe_3O_4
  - tin, chromium, uranium
- Sulfides
  - Zinc, lead, mercury
  - Pyrite: FeS_2
- Native elements: Au, Cu

Minerals crystallize

- From liquid (usually) or gas (occasionally)
- Magma: molten rock
- Watery solutions

Crystallization of Magma

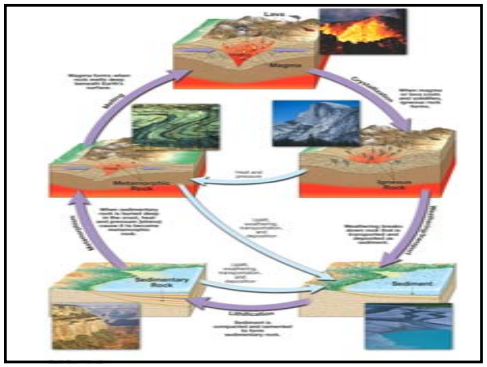
- Cools, atoms attracted to one another
- Arrange in orderly crystalline structures
- When very hot, low-silica forms
- Cooler, greater amounts of silica in them
- Composition of magma changes as crystallization proceeds

Crystallize from watery solutions

- Change solubility by changing physical or chemical conditions in magmatic water left
  - pH, other ion content
  - Temperature, pressure
- Chemical sedimentary rock
  - Carbonates: made by organisms, mostly
  - Increase concentration by evaporation: evaporites

Rock Types

- Igneous
- Sedimentary
- Metamorphic



Sedimentary rocks

- Cover 2/3 of Earth's surface
- Record conditions at time of deposition
- Include remains of organisms preserved as fossils

Sedimentary rocks

Sediment is derived from weathering

Carried by fluid

Formed at Earth's surface

Important to reconstruct much of Earth's history

Sedimentary rocks

Features of sedimentary rocks

- Strata, or beds (most characteristic)
- Bedding planes separate strata
  May have important characteristics
- Size, shape and distribution of grain sizes
- Fossils

Sedimentary rocks

Two main types

- Rocks formed by deposition of sediment—**Clastic**
- Rocks formed by precipitation from water--**Chemical** (includes rocks formed by organisms)

Clastic Sediment Grains

- Particle loosened from pre-existing rock
- Transported to place of deposition
- Shape, size, and sorting of grains can tell about the environment of deposition

Lithification

Process of becoming stone

- Burial and compaction
- Precipitation of cement
- Each reduces 'pore space'

Cement

- Brought in by water
- Mineral material between grains
- Fills in pore spaces
- Commonly calcite, silica, and sometimes iron oxide

Bedding and bedding planes

- http://www.birdandhike.com/Hike/General_Info/Glossary/Gloss4.htm

Types of Clastic Rocks

- Shale (most abundant)
- Sandstone
- Conglomerate

Fossils

- Traces or remains of prehistoric life
- Are the most important inclusions
- Help determine past environments
- Used as time indicators
- Used for matching rocks from different places

Shale with plant fossils

D

Shale

- Composed of very fine grained sediment
- Shows obvious tendency to split along planes (fissile)
- Usually gray
- Most common type of sedimentary outcrop

Sandstone

C

Sandstone

- Composed of sand-size particles
  - Between 1/16 mm and 2 mm diameter
  - Particles may be individual mineral grains or rock fragments
  - Quartz most common type of grain
- Environments include
  - •Beach,
  - •river,
  - •shallow sea,
  - •sand dunes

Conglomerate

A

Conglomerate

- Composed of particles larger than 2 mm
- Usually particles are rock fragments

Clastic rocks

- Shale is the most common one
- Made from solid particles
- Classified by particle size

Fossiliferous limestone

Coquina

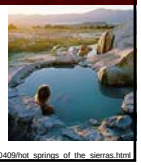
Close up

Chemical rocks

Direct mineral precipitation from water

- Evaporites such as rock salt or gypsum
- Microcrystalline quartz (precipitated quartz) known as chert, flint, jasper, opal or agate
- Travertine (calcite) and sinter (silica) from hotspring deposits

Travertine



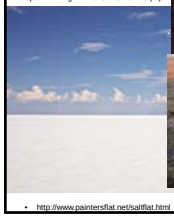
http://www.cis.nctu.edu.tw/~whtsai/World%20Highlights/New%20Side%20Show%20Webpages/imagepages/Turkey%202001---Travertine%20stones%20and%20water%20in%20Pamukale.html

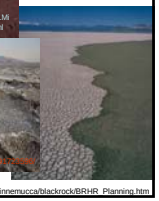
http://www.gonomad.com/destinations/0409/hot_springs_of_the_sierras.html

Evaporites

http://www.img.uni-karlsruhe.de/925.php

http://www.bonnevillehealeyclub.org/





http://www.paintersflat.net/saltflat.html

http://www.nv.blm.gov/Winnemucca/blackrock/BRHR_Planning.htm

Rock salt

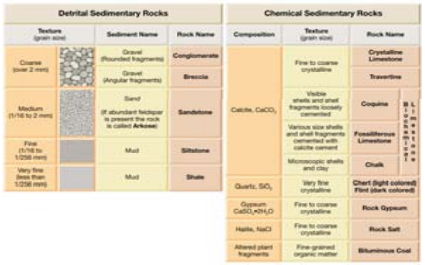
- http://www.mii.org/Minerals/photochert.html

http://geomaps.wr.usgs.gov/sfgeo/geologic/stories/marin_sedimentary.html

Chert

- http://homestake.sdsmt.edu/Photos/Surface_geology_photos.htm

Classification of sedimentary rocks



Detrital Sedimentary Rocks				Chemical Sedimentary Rocks		
Texture (grain size)		Sediment Name	Rock Name	Composition	Texture (grain size)	Rock Name
Coarse (over 2 mm)		Gravel (Rounded fragments)	Conglomerate	Calcite, $CaCO_3$	Fine to coarse crystalline	Crystalline Limestone
		Gravel (Angular fragments)	Breccia			Travertine
Medium (1/16 to 2 mm)		Sand (If abundant feldspar is present the rock is called **Arkose**)	Sandstone		Visible shells and shell fragments loosely cemented	Coquina
					Various size shells and shell fragments cemented with calcite cement	Fossiliferous Limestone
Fine (1/16 to 1/256 mm)		Mud	Siltstone		Microscopic shells and clay	Chalk
Very fine (less than 1/256 mm)		Mud	Shale	Quartz, SiO_2	Very fine crystalline	Chert (light colored) Flint (dark colored)
				Gypsum $CaSO_4 \cdot 2H_2O$	Fine to coarse crystalline	Rock Gypsum
				Halite, NaCl	Fine to coarse crystalline	Rock Salt
				Altered plant fragments	Fine-grained organic matter	Bituminous Coal

Biochemical

Features of sedimentary rocks

- Porosity
- Permeability

Sedimentary rocks

Economic importance

- Coal
- Petroleum and natural gas
- Precipitation of iron and aluminum
- Deposition of gold and tin
- Sand, gravel, clay