Minerals and Rocks

Chapter 20

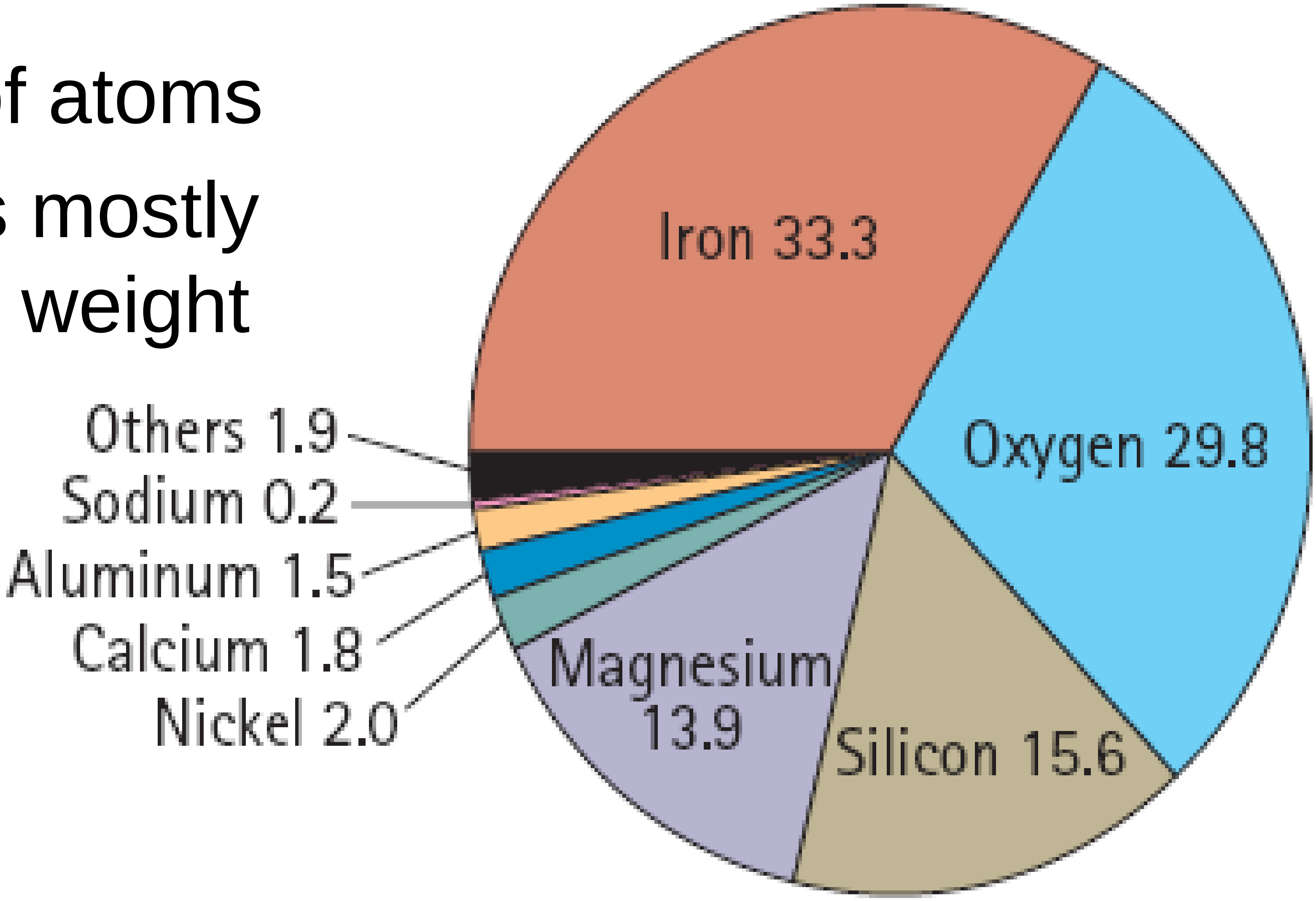

Hey Emily, the seashore is the perfect place to see interactions of the geosphere, hydrosphere, and atmosphere!
You're right, Megan, it is the perfect place. We are standing on the solid geosphere, but all the while, the hydrosphere and atmo-sphere are at work weathering the rock we stand on. The hydrosphere is where life on Earth began, and the atmosphere provides the oxygen animals need and the carbon dioxide plants need. Plus the atmosphere shields us from harmful UV rays. Our planet is unique in our solar system. It is our home and we need to learn more about it to be able to preserve it.

Earth System Science

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

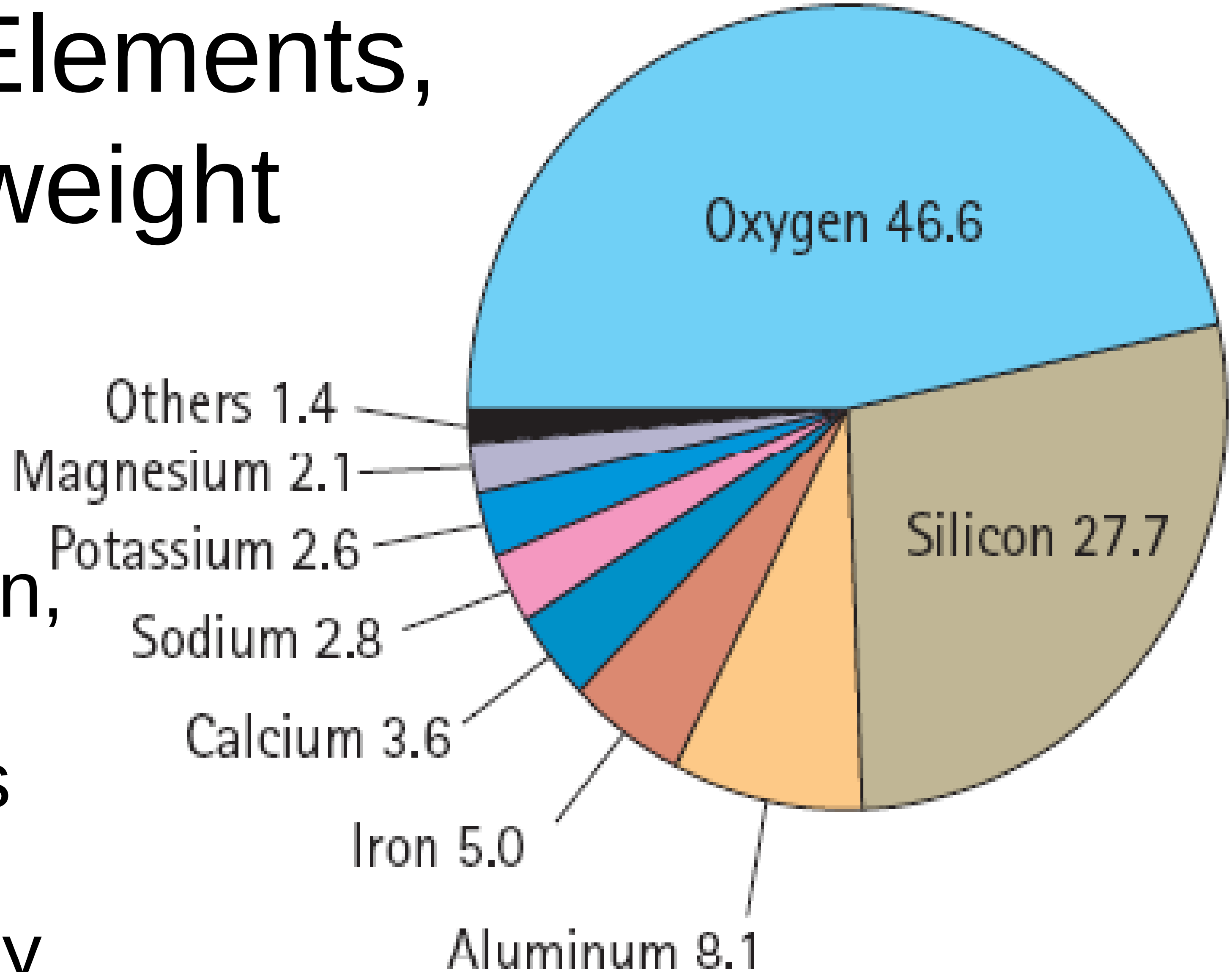
Elements of Earth by weight

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



Crust Elements, by weight

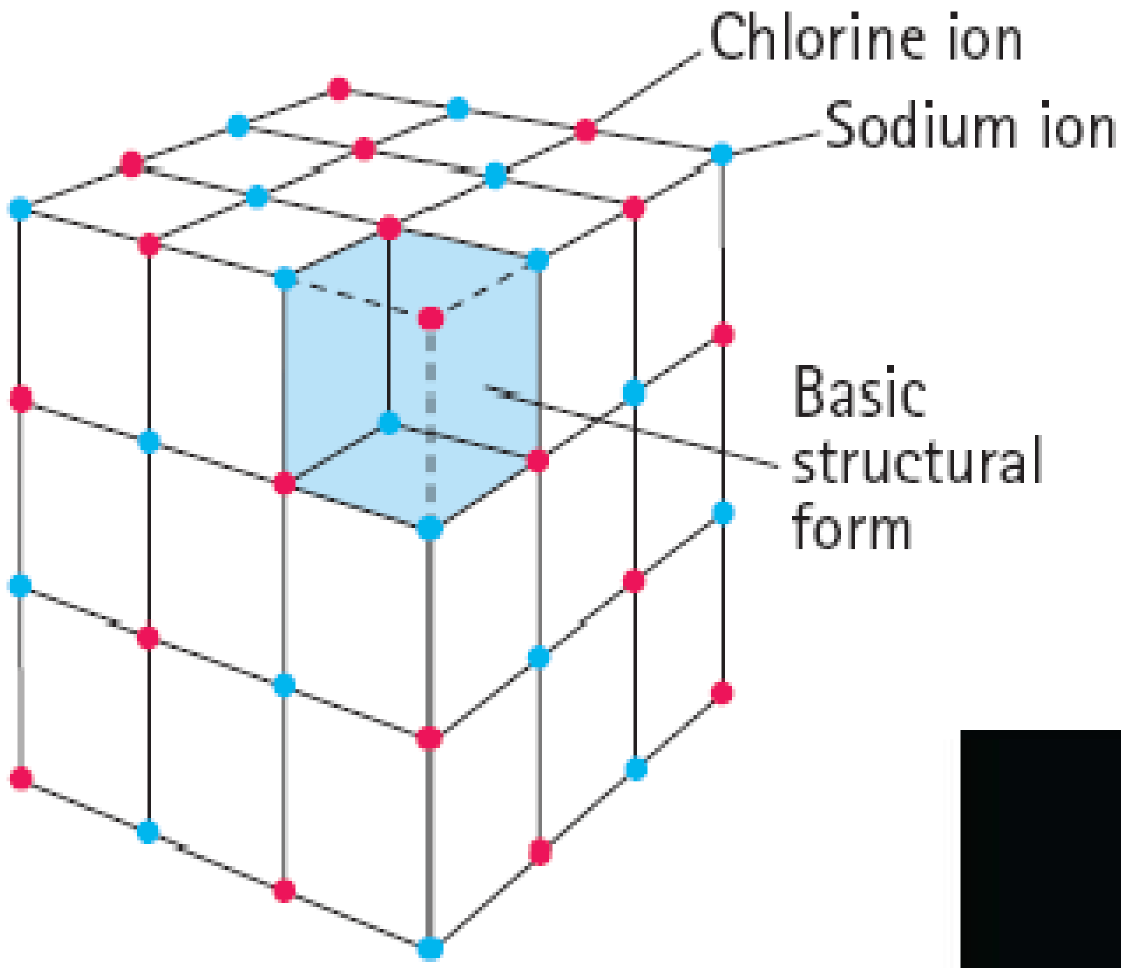
- Made of atoms
- Earth is mostly iron, by weight
- Surface is mostly oxygen, by weight



Earth's Crust

Minerals

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



Halite crystals
NaCl

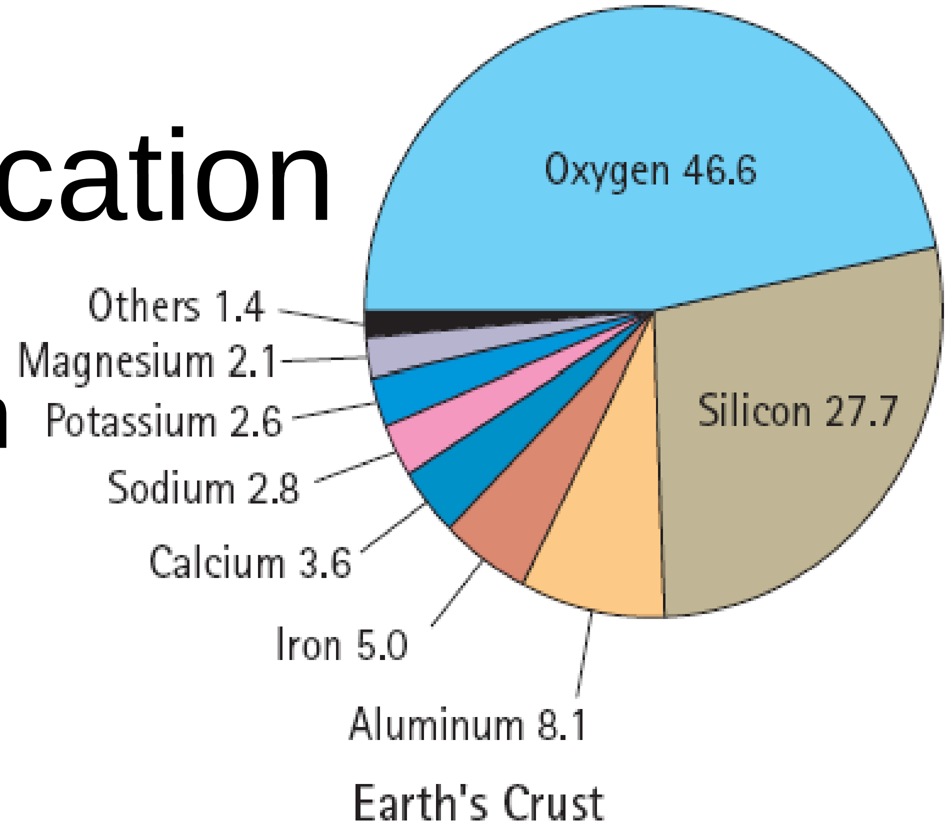
Crystals

- Amethyst quartz
  - Pyrite

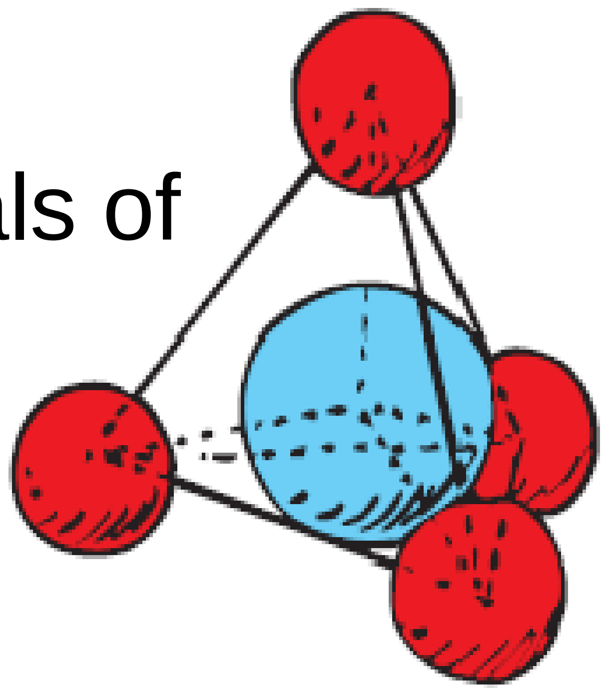
Shape reflects internal arrangement of atoms

- Rhodochrosite
  - Asbestos

Mineral Classification



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

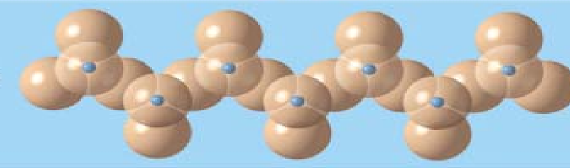
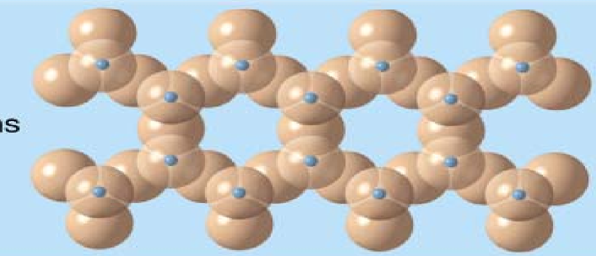
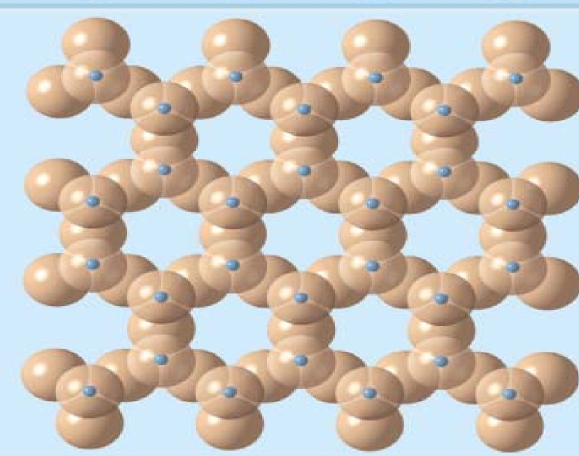
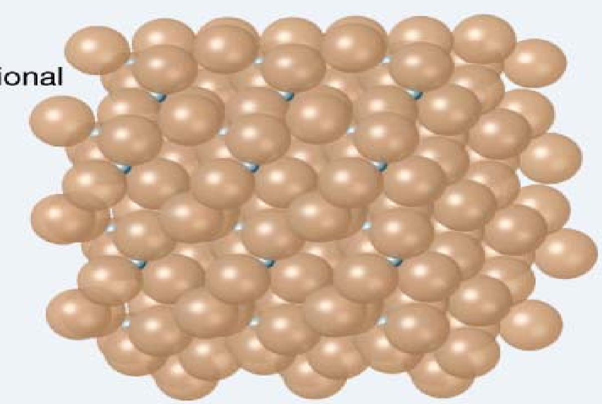


Silicate Minerals

- Silica bonded to metals
- Aluminum, sodium, potassium, calcium
  - Feldspar: Most abundant mineral
  - ‘felsic minerals’
  - Pale, less dense than ferromags
- Examples of felsic minerals
  - Feldspar
  - Quartz
  - Muscovite mica

Silicate Minerals

- Silica bonded to metals
- Iron, magnesium
  - Ferromagnesian silicates: ‘ferromags’
  - Dense, dark
- Examples of ferromags
  - Amphibole
  - Pyroxene
  - Biotite mica
  - Olivine

Mineral		Idealized Formula	Cleavage	Silicate Structure
Olivine		$(Mg, Fe)_2SiO_4$	None	Single tetrahedron 
Pyroxene group (Augite)		$(Mg,Fe)SiO_3$	Two planes at right angles	Single chains 
Amphibole group (Hornblende)		$Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$	Two planes at 60° and 120°	Double chains 
Micas	Biotite	$K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	One plane	Sheets 
	Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$		
Feld-spars	Orthoclase (Potassium feldspar)	$KAlSi_3O_8$	Two planes at 90°	Three-dimensional networks 
	Plagioclase	$(Ca,Na)AlSi_3O_8$		
Quartz		SiO_2	None	

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

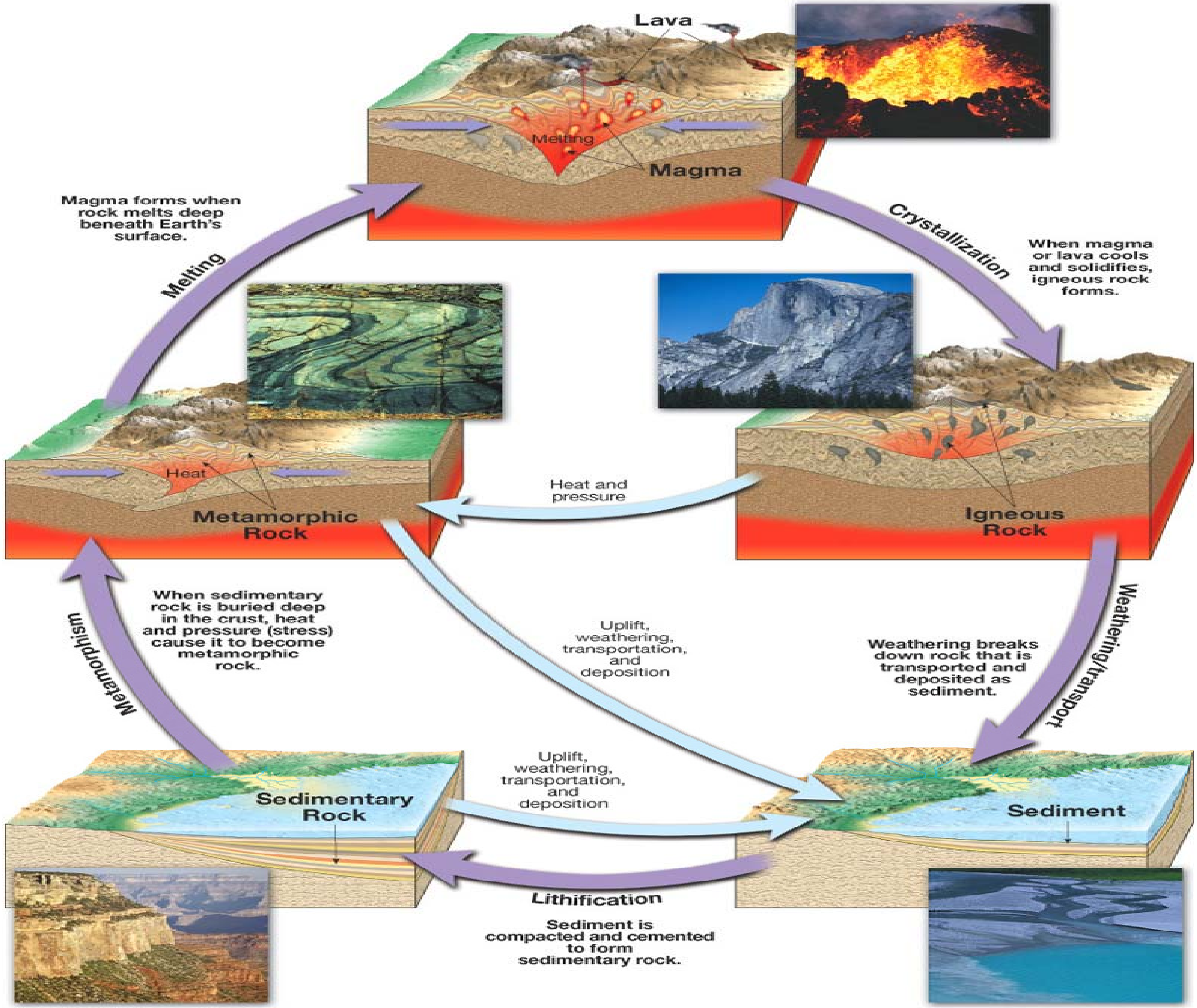
- Cools, atoms attracted to one another
- Arrange in orderly crystalline structures
- When very hot, low-silica forms
- Cooler, greater amounts of silica in them
- Composition of magma changes as crystallization proceeds

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



Earth Sc., 11th ed.

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

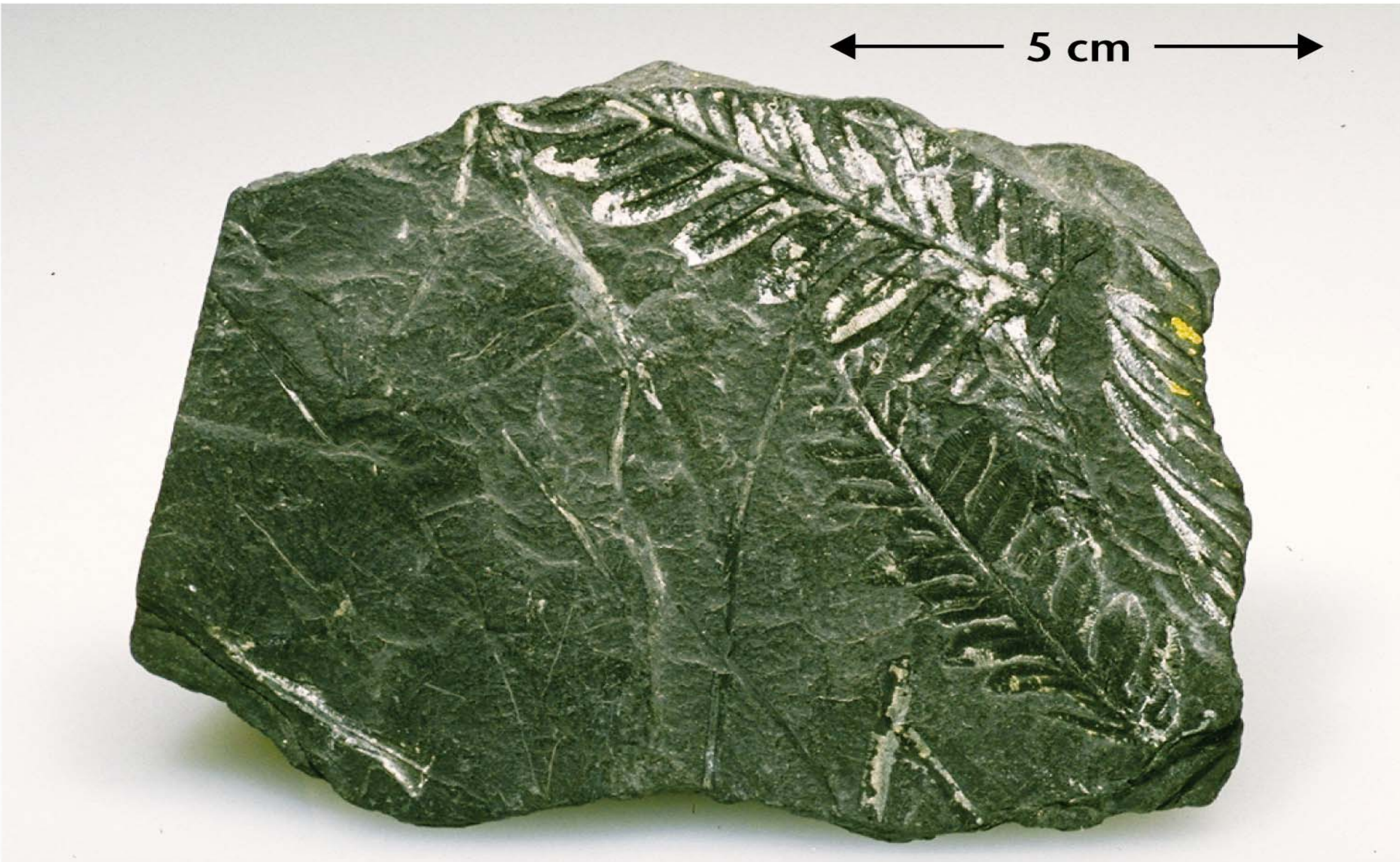
Types of Clastic Rocks

- 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



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Shale

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

Sandstone

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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

Chemical rocks

Material was once in solution and precipitates to form sediment

- Directly precipitated as the result of physical processes, or
- Through life processes (biochemical origin)

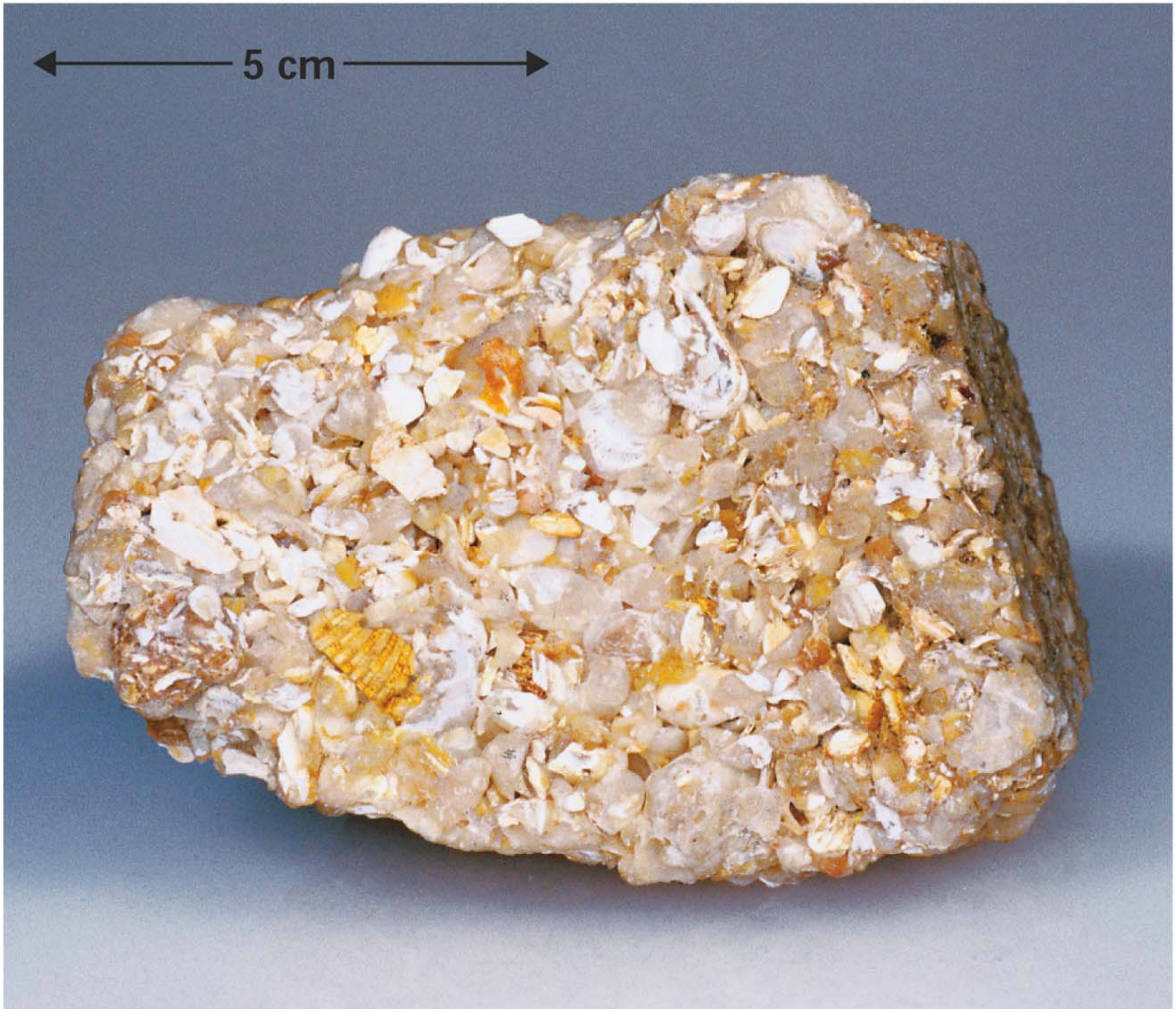
Chemical rocks

Limestone

- Composed of the mineral calcite (calcium carbonate)
- Much of this calcite was precipitated by organisms
- Considered an ‘organic chemical sediment’ if from organisms
- Most common type of chemical rock—
- second most common type of sedimentary rock

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://njminerals.org/travertine.html

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.pitt.edu/~cejones/GeoImages/1Minerals/2SedimentaryMineralz/Gypsum.html

- http://www.flickr.com/photos/snogun/191723596/

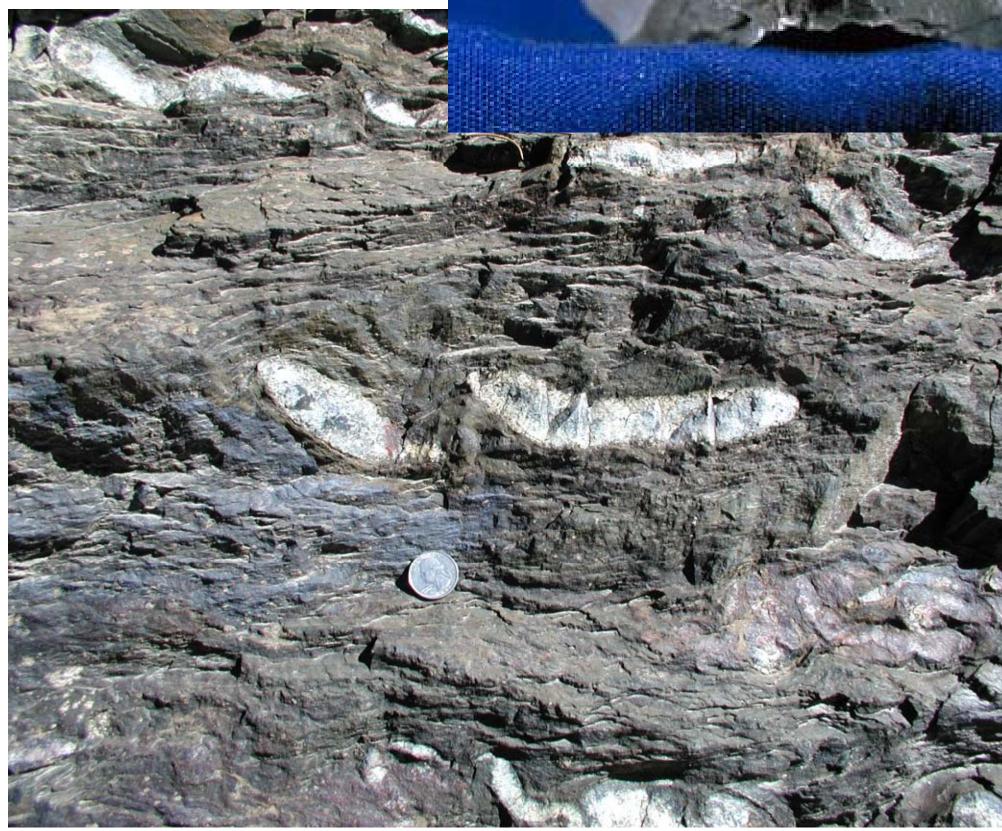
- http://www.paintersflat.net/saltflat.html
- http://www.nv.blm.gov/Winnemucca/blackrock/BRHR_Planning.htm

Rock salt

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

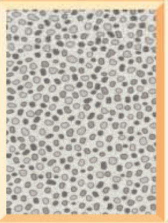
http://geomaps.wr.usgs.gov/sfgeo/geologic/stories/marin_sedimentary.html

Chert



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

Classification of sedimentary rocks

Detrital Sedimentary Rocks			
Texture (grain size)		**Sediment Name**	**Rock Name**
Coarse (over 2 mm)		Gravel (Rounded fragments)	**Conglomerate**
		Gravel (Angular fragments)	**Breccia**
Medium (1/16 to 2 mm)		Sand (If abundant feldspar is present the rock is called **Arkose**)	**Sandstone**
Fine (1/16 to 1/256 mm)		Mud	**Siltstone**
Very fine (less than 1/256 mm)		Mud	**Shale**

Chemical Sedimentary Rocks			
Composition	**Texture** (grain size)	**Rock Name**	
Calcite, $CaCO_3$	Fine to coarse crystalline	**Crystalline Limestone**	
		Travertine	
	Visible shells and shell fragments loosely cemented	**Coquina**	**Biochemical Limestone**
	Various size shells and shell fragments cemented with calcite cement	**Fossiliferous Limestone**	
	Microscopic shells and clay	**Chalk**	
Quartz, SiO_2	Very fine crystalline	**Chert (light colored)** **Flint (dark colored)**	
Gypsum $CaSO_4{\bullet}2H_2O$	Fine to coarse crystalline	**Rock Gypsum**	
Halite, NaCl	Fine to coarse crystalline	**Rock Salt**	
Altered plant fragments	Fine-grained organic matter	**Bituminous Coal**	

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