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Faculty of Engineering
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Engineering Geology

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- Peter Link
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Minerals and Rocks

Lecture 2

Outline

- Minerals
- Rock Cycle
- Igneous Rock
- Sedimentary Rock
- Metamorphic Rock

Rock Forming Minerals

Mineral: the units that make up rock

Rock: An assemblage of minerals

Earth Crust

SiO_2	59.1%	Na_2O	3.7%
Al_2O_3	15.2	K_2O	3.1
Fe_2O_3	3.1	H_2O	1.3
FeO	3.7	TiO_2	1.0
MgO	3.6	P_2O_5	0.3
CaO	5.1	rest	0.9

Total: 100.0

2009/12/10/09

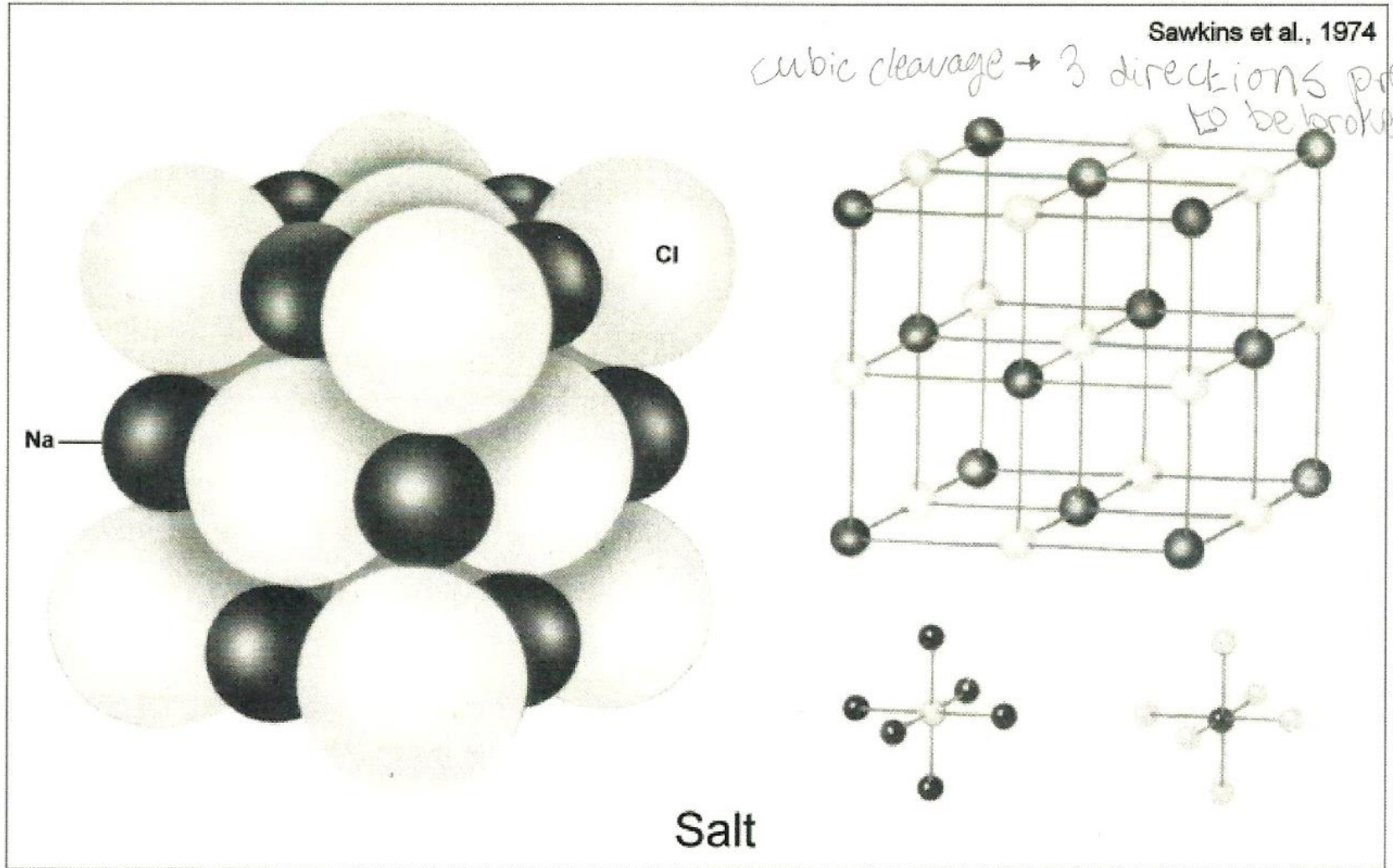
What is a mineral?

Naturally occurring, inorganic, constituent of earth material with definite chemical composition or a range of compositions and a regular atomic structure to which its crystalline form is related.

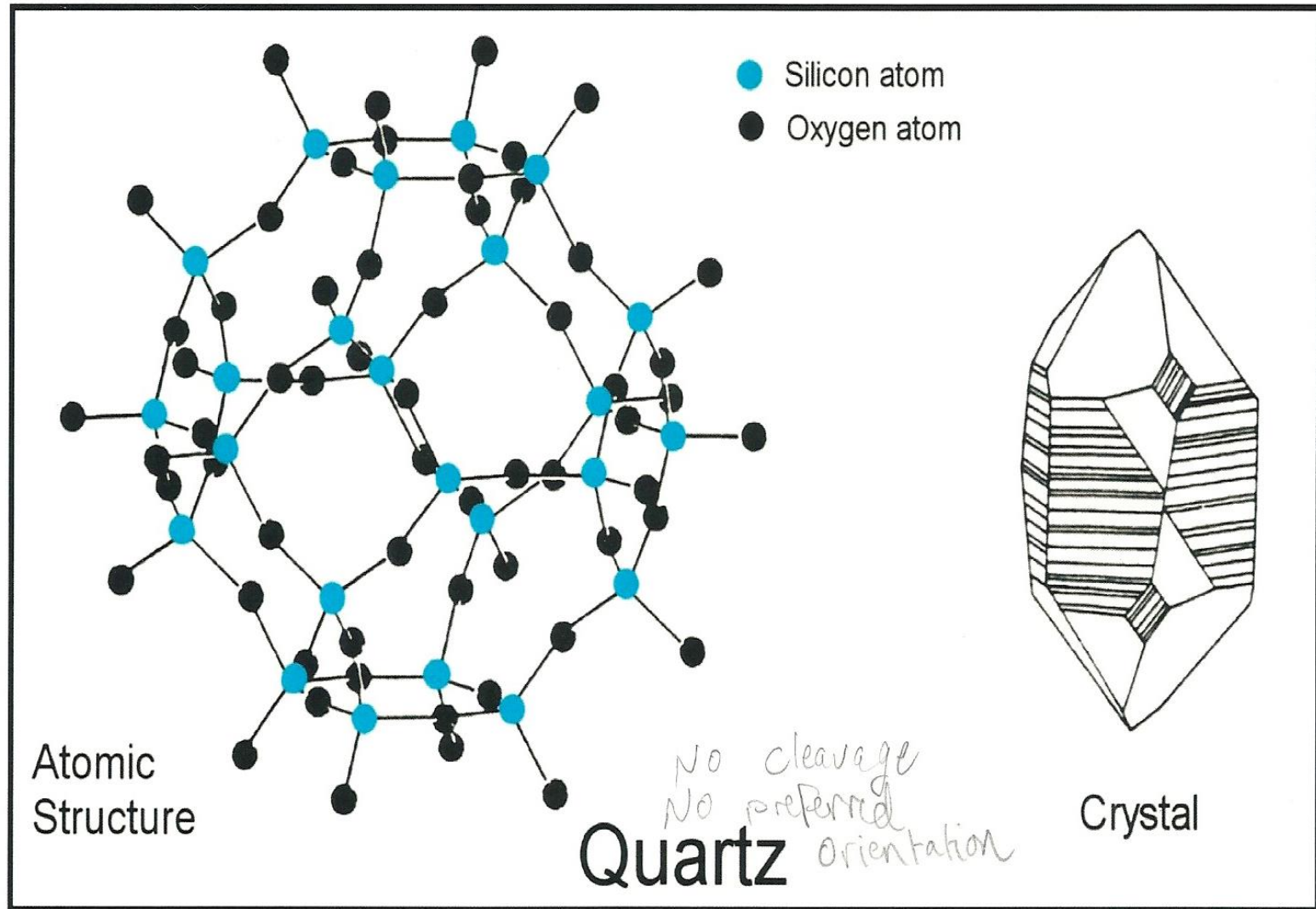
Identifying a mineral

1. Crystal shape
2. Hardness
3. Color
4. Streak
5. Specific Gravity
6. Luster
7. Cleavage

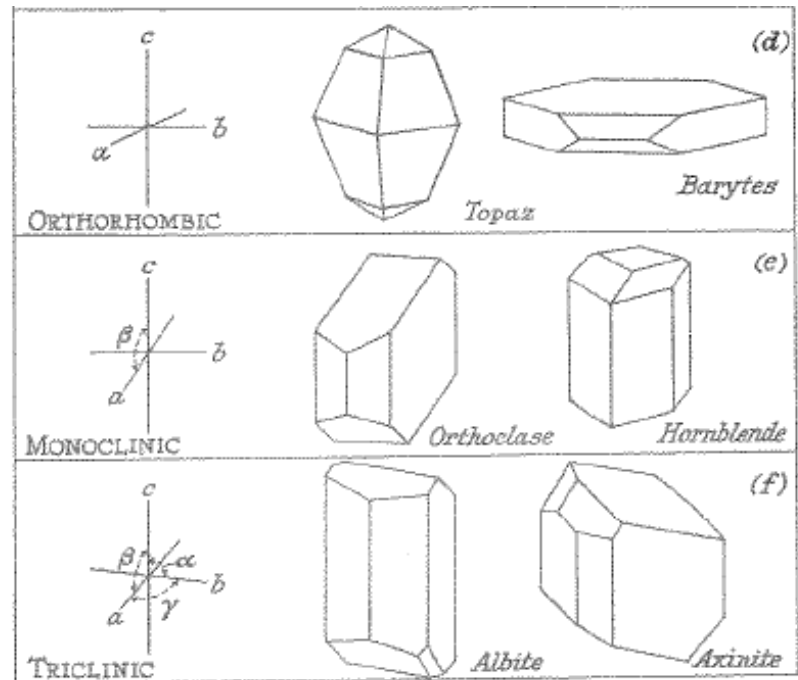
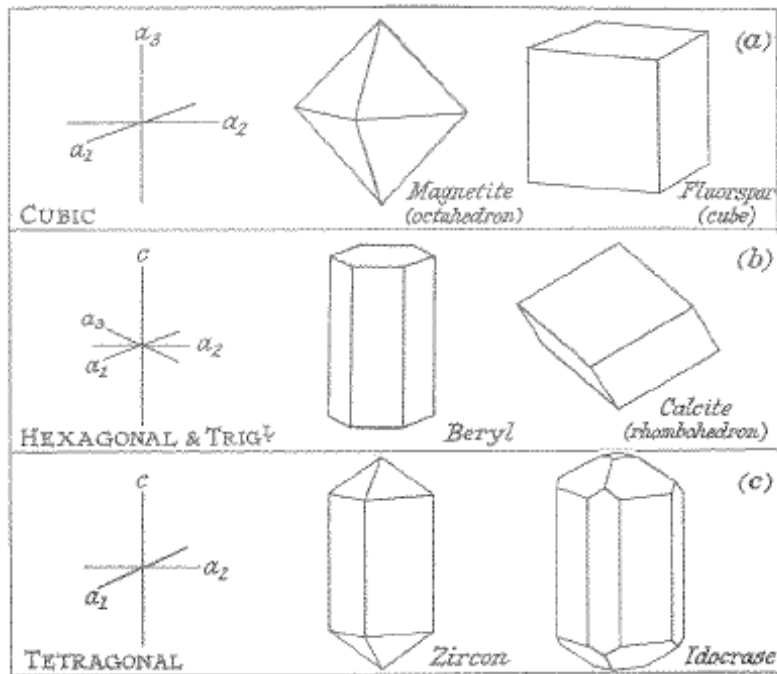
Crystal Shape related to atomic structure



Crystal Shape



Six Crystal Shapes



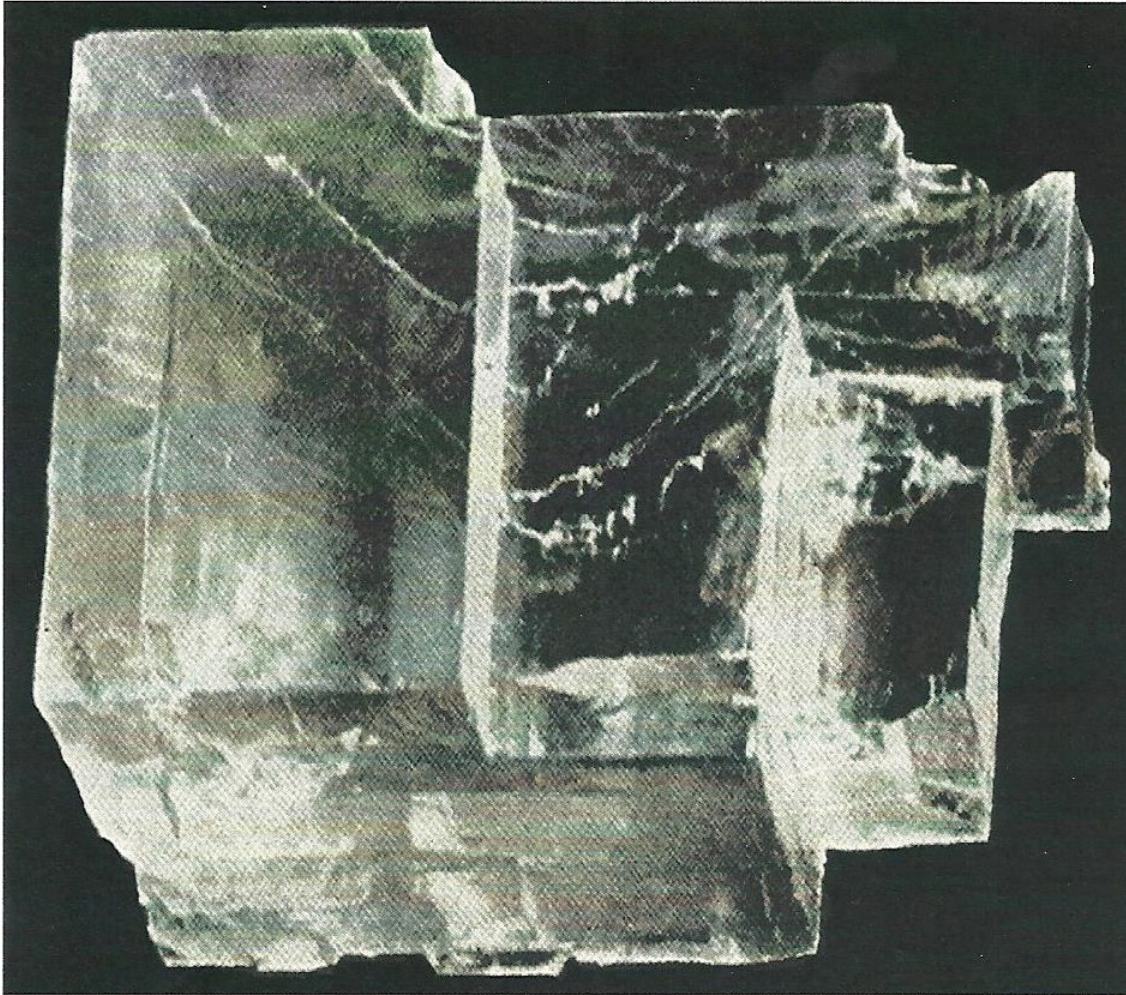
Hardness

Table 8
Hardness Scale

<i>Mineral</i>	<i>Hardness (Increasing Downward)</i>	<i>Reference Materials</i>
Talc	1	baby powder
Gypsum	2	skin associated with lime stone
Calcite	3	Fingernail
Fluorite	4	Copper Penny
Apatite	5	
Orthoclase	6	Pocket Knife
Quartz	7	Glass
Topaz	8	
Corundum	9	
Diamond	10	

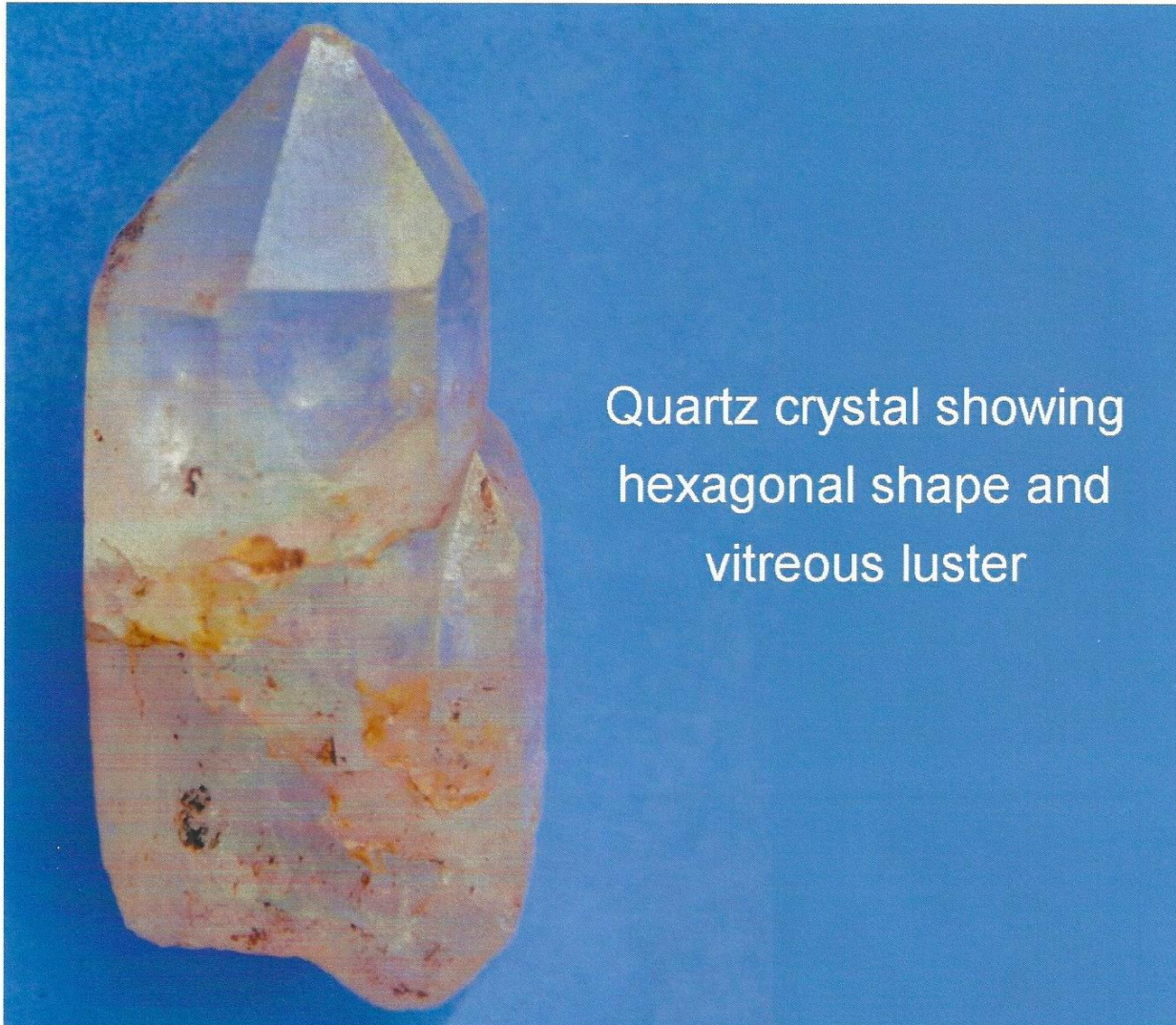
Calcium Carbonate is limestone
Teeth
house dust
Ruby & Sapphire
42 harder than corundum

Cleavage: plane of weakness



Salt crystals have 3 mutually perpendicular faces, producing a cubic or box-like shape. Because of its' internal atomic structure, salt's cleavage is parallel to the crystal faces.

No Cleavage: No discontinuity
in crystal growth.



Quartz crystal showing
hexagonal shape and
vitreous luster

What is this mineral?

- Monoclinic Crystal
- Black
- Colorless streak
- Pearly luster
- Hardness = 2.5~3
- 1 cleavage = basal



What is this mineral?

- Triclinic
- Hardness = 6~6.5
- Pink
- Colorless Streak
- Vitreous Luster
- 2 planes of cleavage

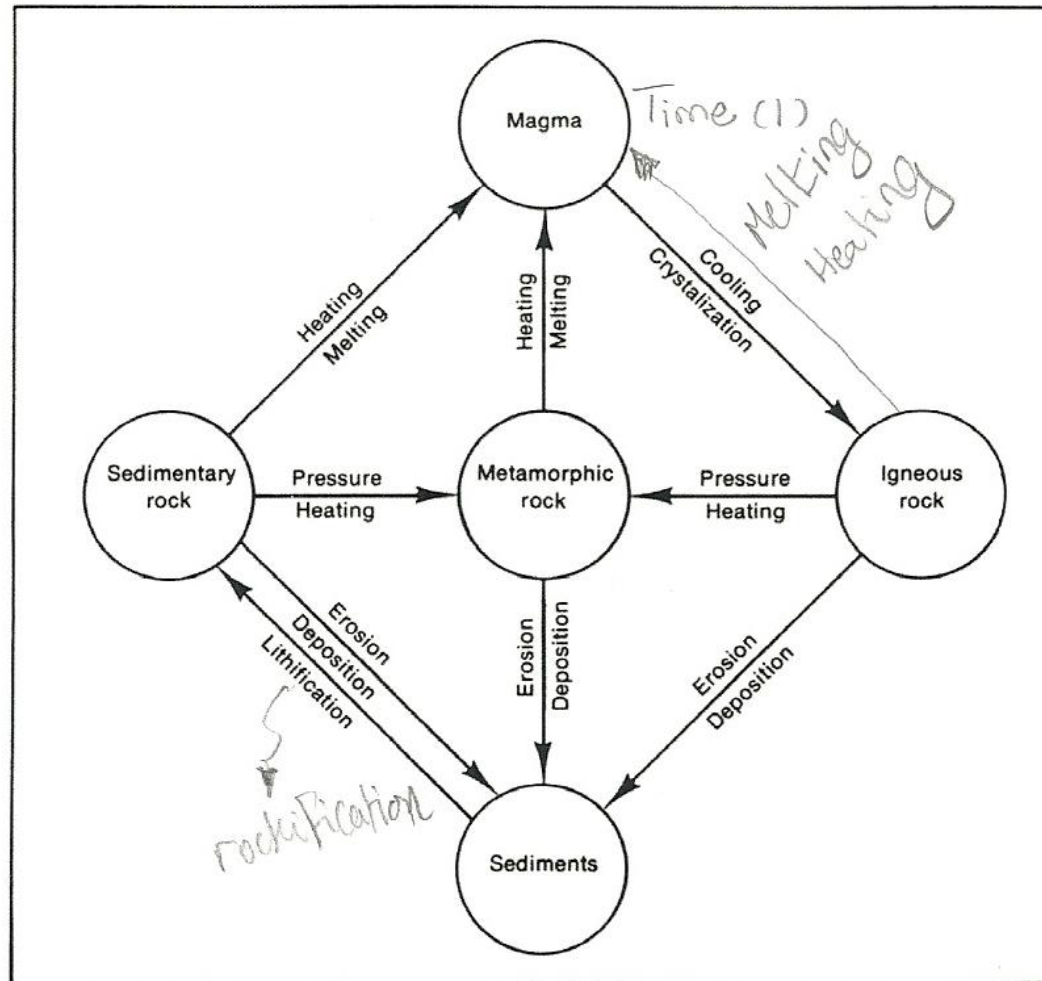


What is this mineral?

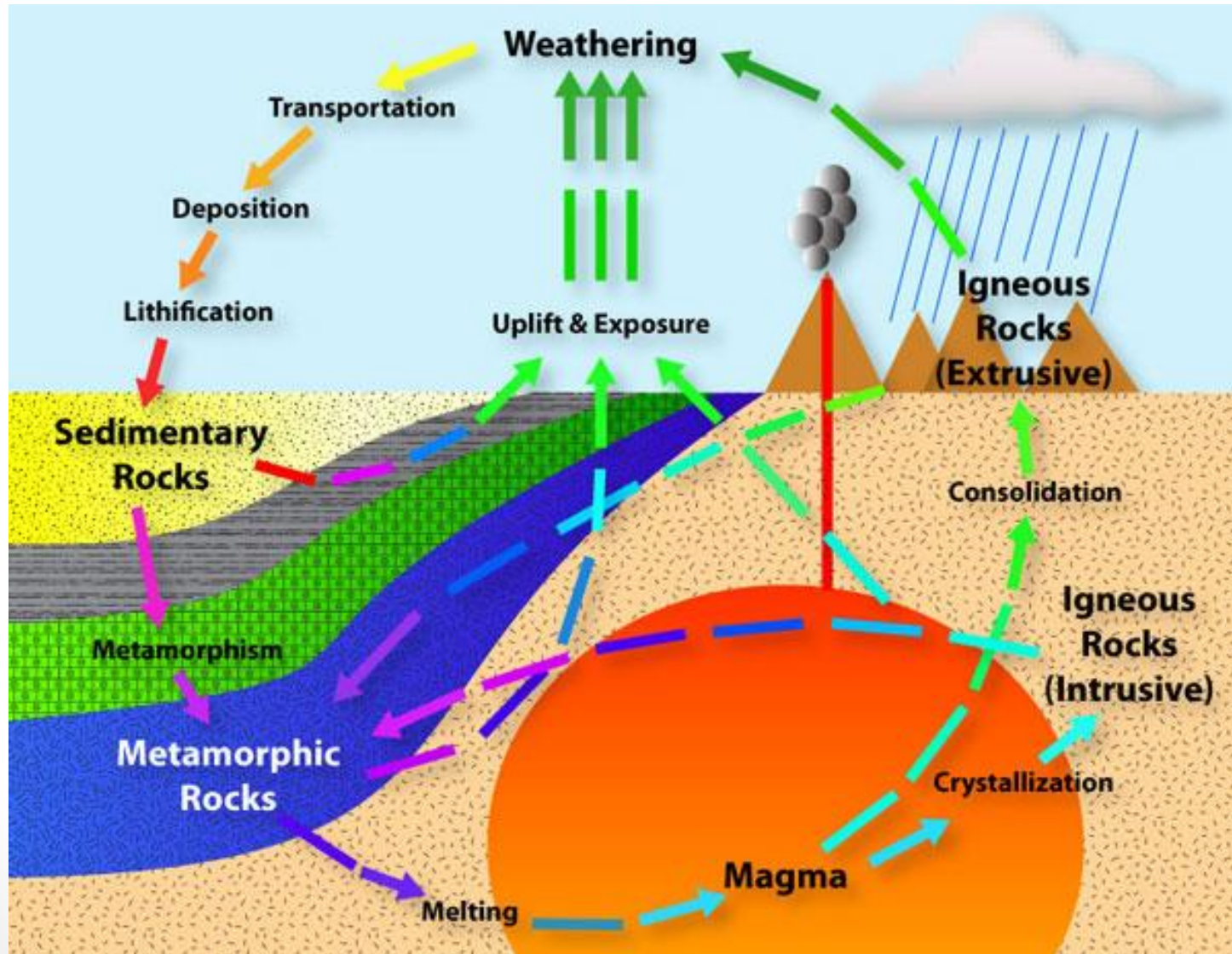
- Hexagonal
- Hardness = 3
- White
- White streak
- Vitreous luster
- Rhombic Cleavage



Types of Rock



Rock Cycle



Igneous Rocks

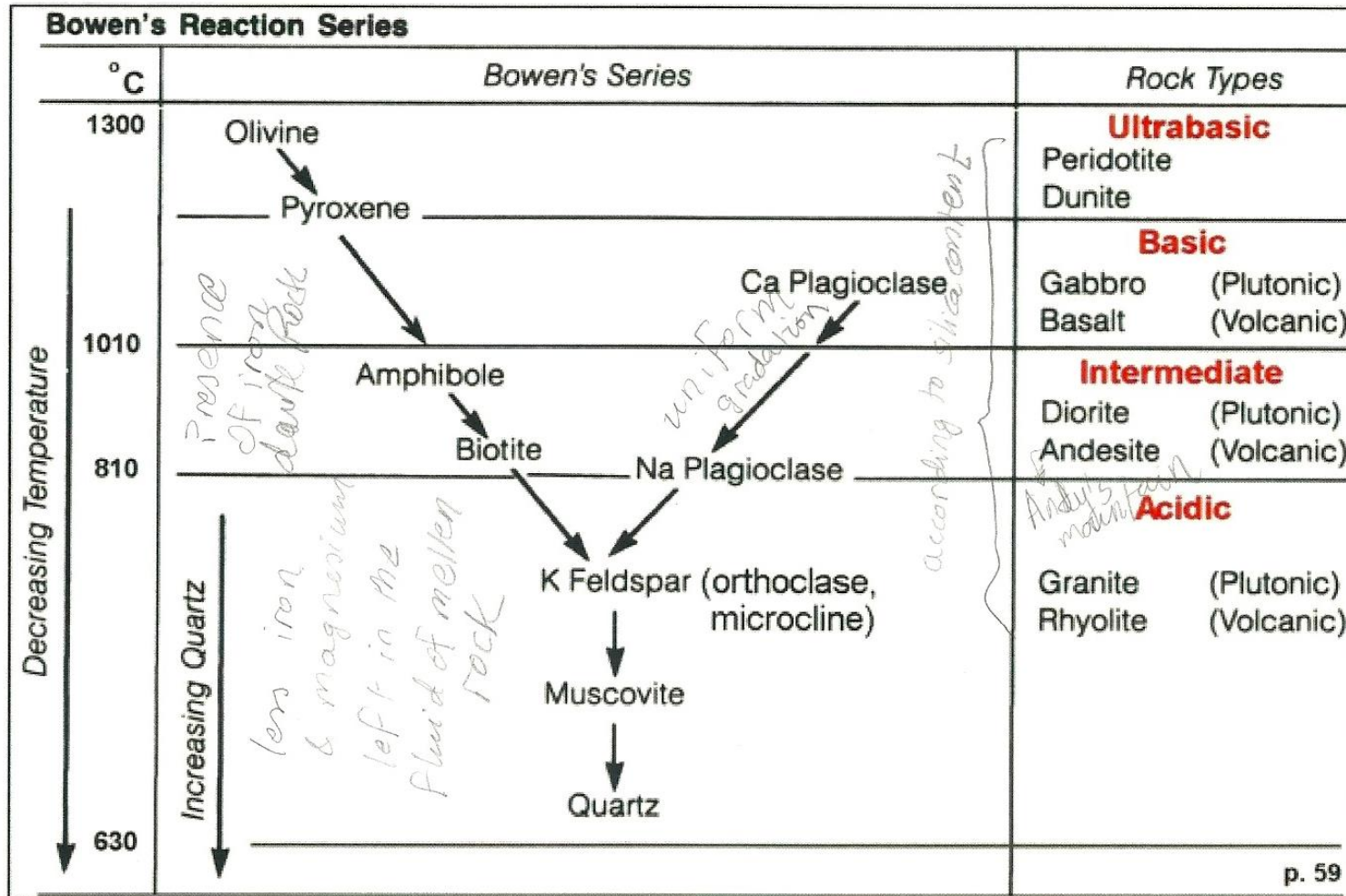
form by the crystallization of molten rock

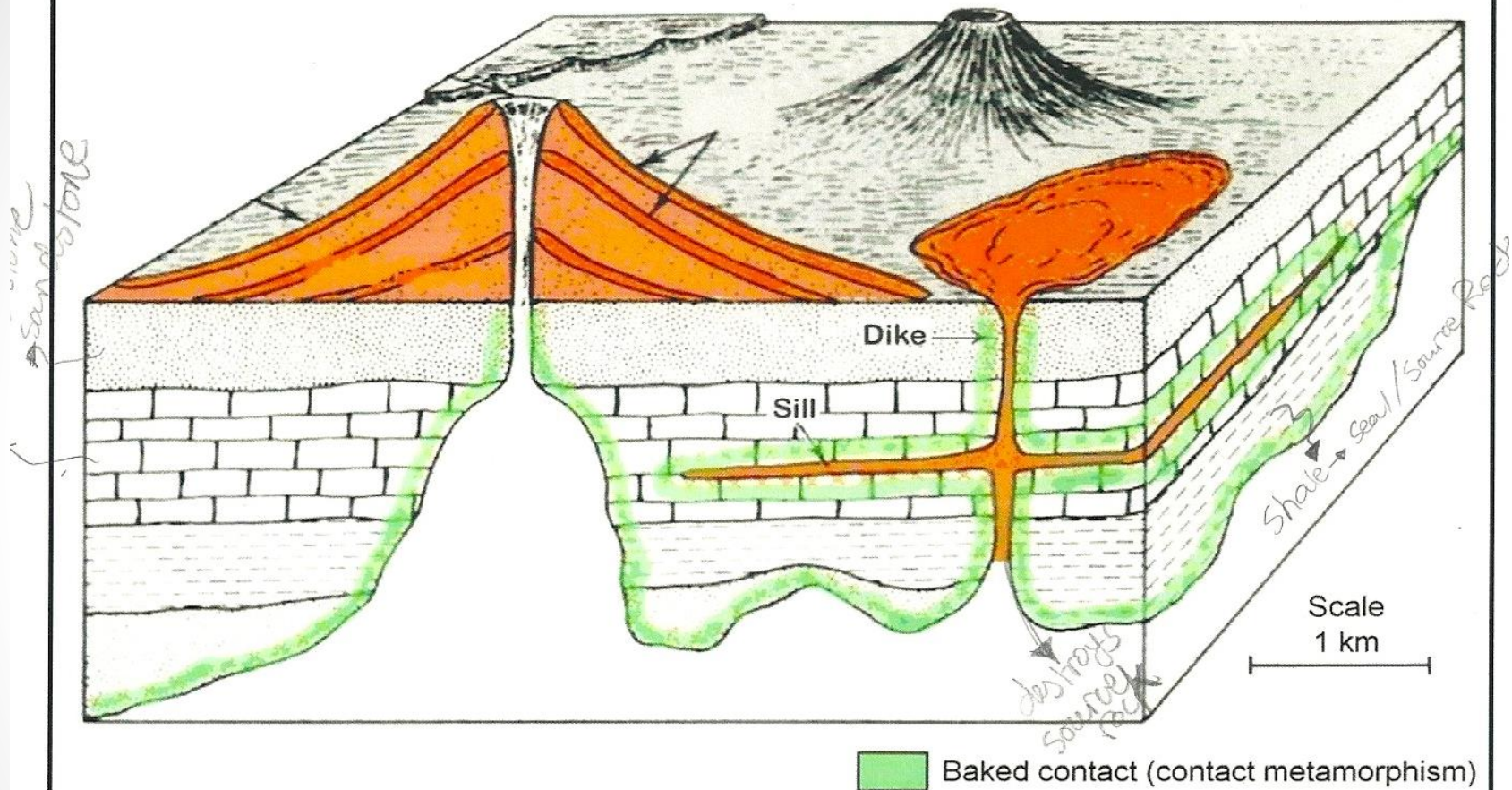
Molten rock in the subsurface (magma) cools slowly because of the insulating effect of the overlying rock and the natural increase in temperature going down into the Earth.

Slow cooling allows time to form large crystals, producing a coarse-grained rock

Molten rock on the surface (lava) cools quickly from exposure to air and water. Fast cooling produces fine-grained rocks by not allowing sufficient time for large crystals to form

Effect of Temperature





Baked contact (contact metamorphism)

Note the relationship between the orientation of the bedding and the orientation of the dike and sill. Dikes cut across the bedding, sills are parallel to the bedding.

What is this Rock

- Fine Grained....look at the texture!
- High Temperature rock



What is this Rock?

- Coarse Grained
- Low temperature



What is this Rock?

- Fine Grained
- Low Temperature
- Very light and has a lot of voids



What is this Rock?

- Coarse Grained
- High Temperature



Mechanical Properties of Igneous Rocks

- Coarse grained are more porous which means more permeable
- Coarse grained are stronger and less deformable

Sedimentary Rocks

Sedimentary rocks form

from (1) pieces of pre-existing rocks like igneous and metamorphic rocks, and (2) precipitation from solution

We assume (dangerous) that sedimentary rocks are deposited horizontally (parallel to sea level) or nearly so, producing layers of rock called strata

Clastic Sedimentary Rocks

Clastic Sedimentary Rocks

<i>Sediment</i>	<i>Size</i>		<i>Rock</i>
	mm	microns	
Gravel	> 2 mm	> 2000 μ	Conglomerate
Sand	2– $\frac{1}{16}$ mm	2000-62 μ	Sandstone
	2 - 1 mm	2000-1000 μ	Very coarse-grained sandstone
	1 - $\frac{1}{2}$ mm	1000-500 μ	Coarse-grained sandstone
	$\frac{1}{2}$ - $\frac{1}{4}$ mm	500-250 μ	Medium-grained sandstone
	$\frac{1}{4}$ - $\frac{1}{8}$ mm	250-125 μ	Fine-grained sandstone
	$\frac{1}{8}$ - $\frac{1}{16}$ mm	125-62 μ	Very fine-grained sandstone
Silt	$\frac{1}{16}$ – $\frac{1}{256}$ mm	62 - 4 μ	Siltstone
Clay	< $\frac{1}{256}$ mm	< 4 μ	Shale

$\mu = .001\text{mm}$

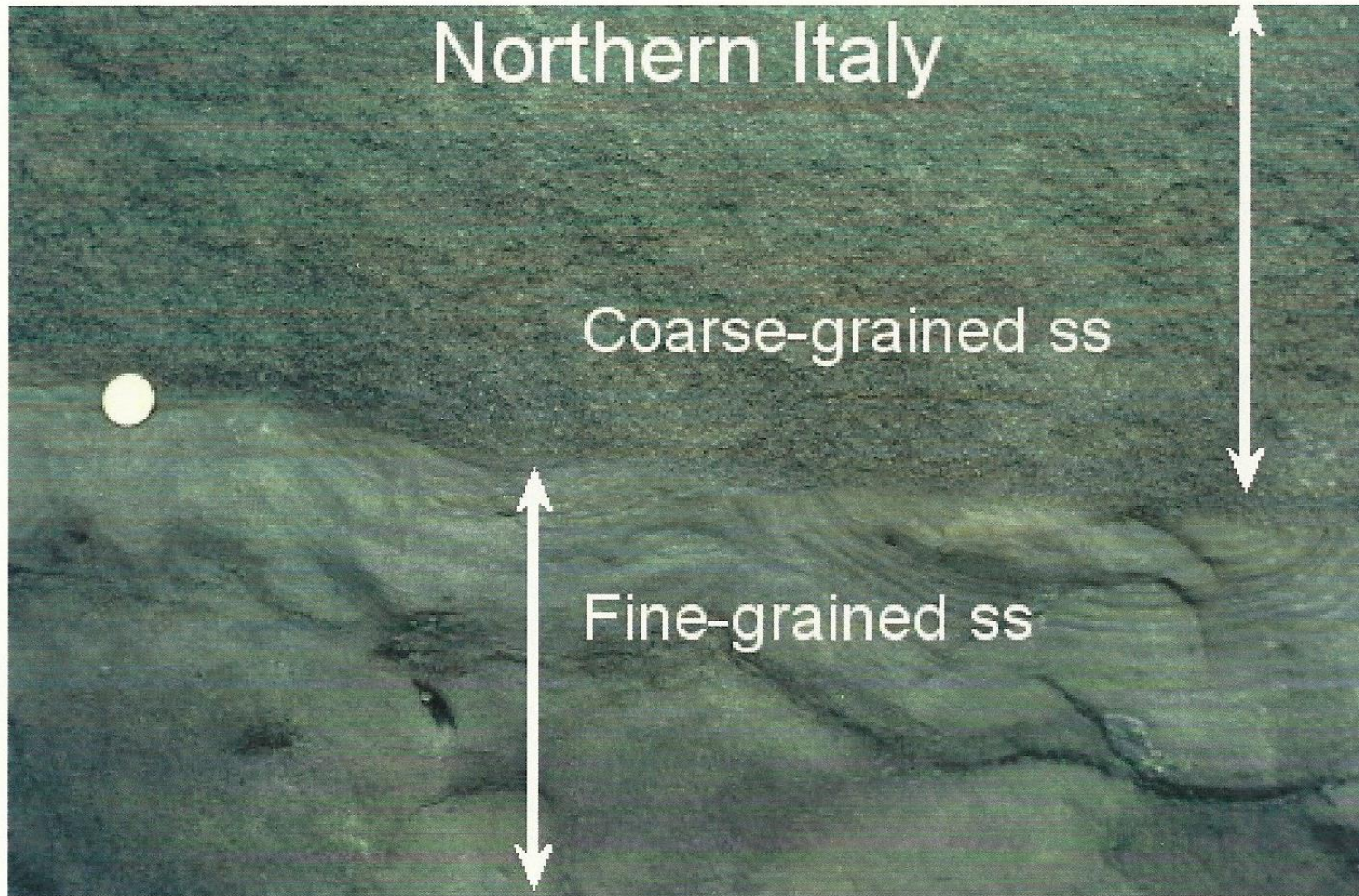
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Conglomerate



Conglomerate, Dana Point, Calif, US

Sandstone



Shale



Non-Clastic Sedimentary rocks

Nonclastic sedimentary rocks form

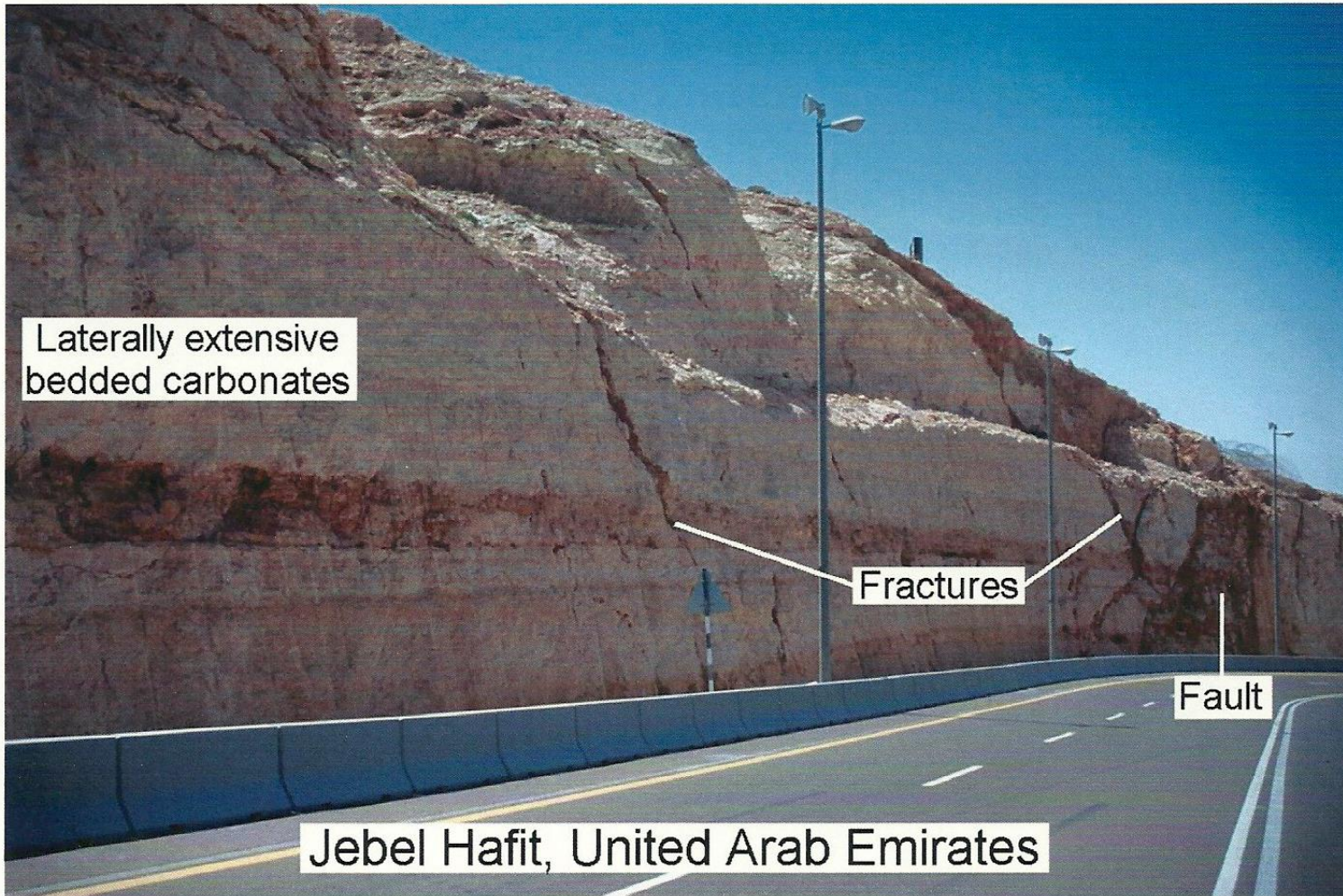
by precipitation from solution. The most common (but not the only) nonclastic sedimentary rocks are carbonates

The most common carbonates are

Limestone - calcium carbonate - CaCO_3

Dolomite - calcium magnesium carbonate - $\text{CaMg}(\text{CO}_3)_2$

Carbonates



Non-Clastic Sedimentary Rocks

Other nonclastic sedimentary rocks are salts deposited as water evaporates, including

increasing rate
of evaporation
↓

Gypsum - $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$

Anhydrite - CaSO_4

Halite (table salt) - NaCl

Sylvite - KCl

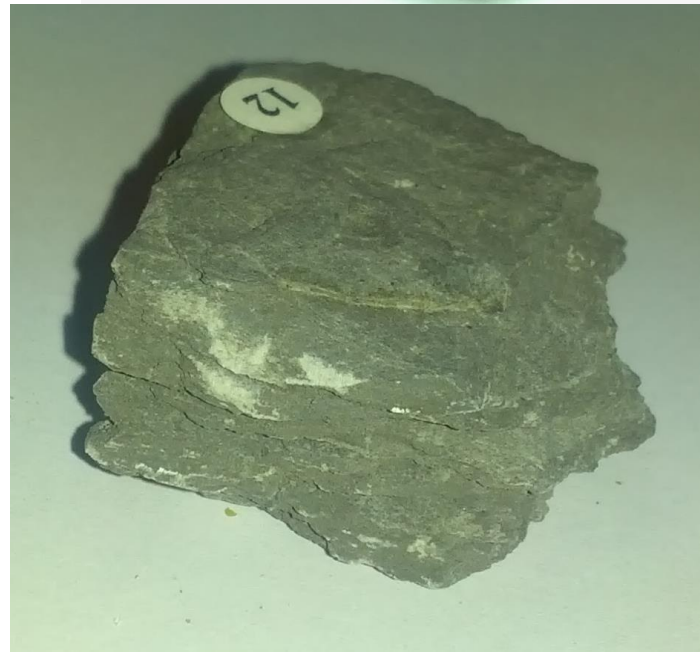
A rock composed of some or all of these salts mixed together is referred to as an evaporite

Evaporites

Evaporites (as salt flats) produced by the evaporation of playa (temporary lake) waters, Death Valley, Calif. USA



Name the rock



Mechanical Properties of Sedimentary Rocks

- Compaction Shale vs Cementation Shale
- Grain size relation to strength
- Grain size relation to permeability
- Carbonates have high strength but greatly affected by water

Metamorphic Rocks

- Formed by alteration of any of the other rock types
- Difficult to differentiate from Igneous Rock (example: Metamorphic Granite)

Agents of metamorphism Temperature - Pressure

- Contact Metamorphism: Temperature only
- Direct Metamorphism: Pressure inside fault zones like Breccia
- Regional Metamorphism: Mainly Stresses but also high temperatures.....foliated rock

Burial Depth: Regional Metamorphism

Metamorphism of Clay Minerals and Silica

Sediments

Low Grade

Medium Grade

High Grade

Clay → Shale → Slate → Phyllite → Schist → Gneiss → Granite

Formed under pressures found at depths of:

Surface

9 km

15 km

22 km

26 km

Temperatures at these depths are:

25°C

200°C

325°C

500°C

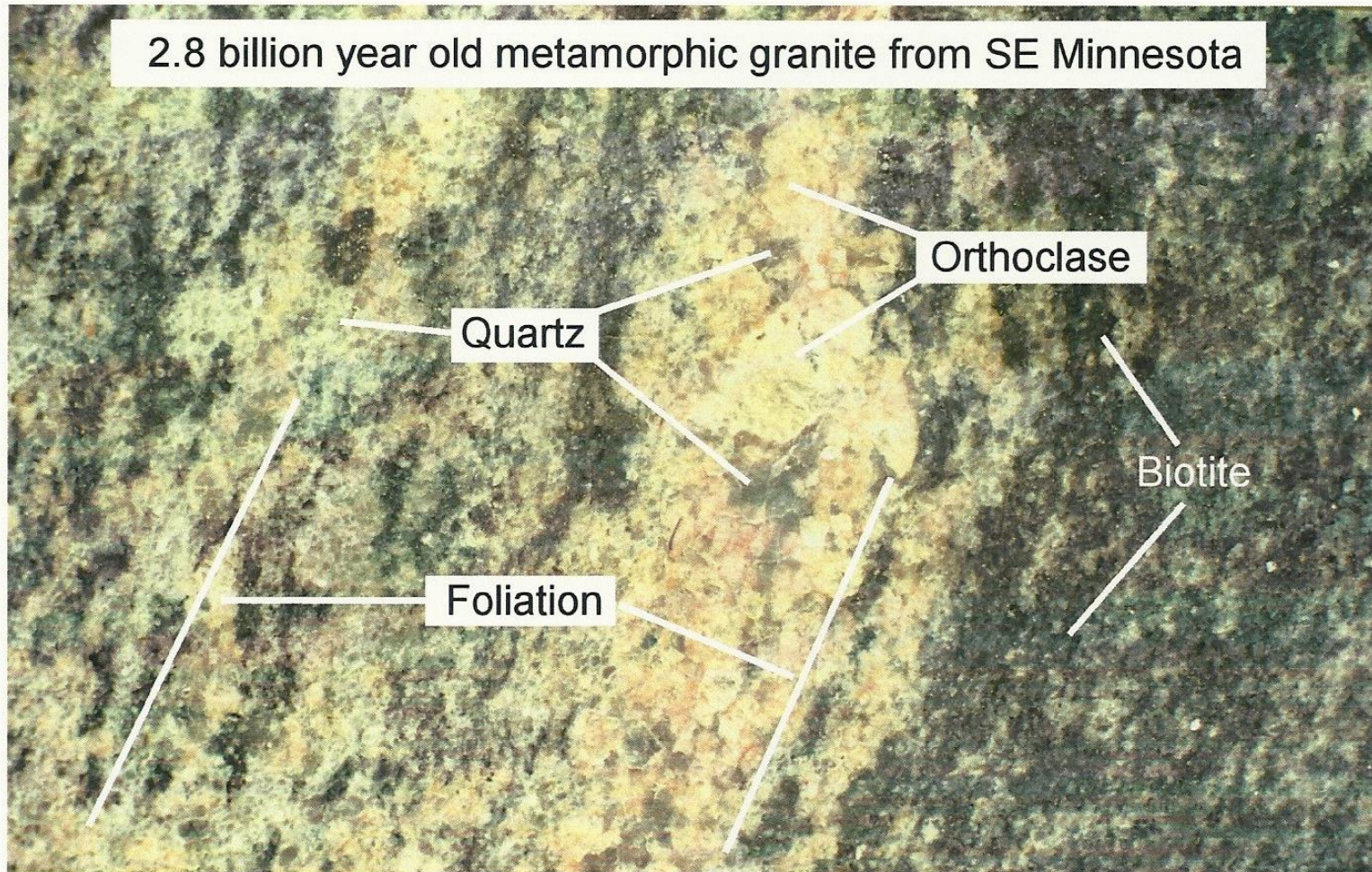
700°C

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————— Rising temperature and pressure —————→

with progressive depth of burial causes increasingly greater degree of recrystallization and progressively larger grain size

Foliation



Foliated Rocks

- Gneiss and Schist
- Non-uniform pressure
- Anisotropic Shear Strength



Non-Foliated Rocks

- Marble might be metamorphism of limestone
- Quartzite might be metamorphism of sandstone
- Heat or Uniform Pressure
- More uniform strength and permeability properties



THANK YOU