Introduction to the Lithosphere: Minerals and Rocks

I. Composition of the Lithosphere - the lithosphere is made up of soil, sand, mud and rock, which are all composed of minerals

A. Minerals - a mineral is a naturally occurring, crystalline, inorganic substance with specific physical and chemical properties.

1. Naturally Occurring - a process by which a material is formed in or on the earth.

2. Crystalline - the atoms and molecules of a mineral are the same throughout, and are joined in a fixed position as a solid in a definite pattern.

3. Inorganic Substance - not living, or formed from a living thing.

4. Chemical Symbol - a chemical symbol or formula can be used to represent a mineral.

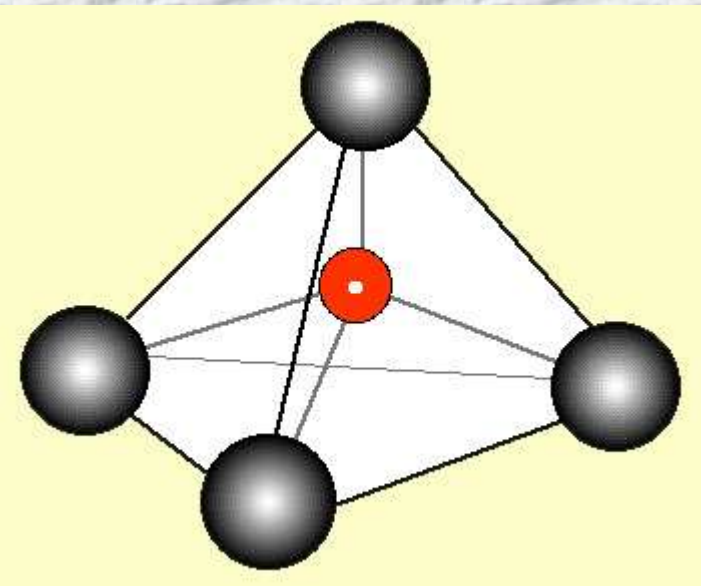
B. Mineral Composition - Most minerals are composed of two or more elements. Oxygen is the most abundant element in the earth's crust by both weight and volume. Silicon is the

second most abundant element by weight.

Average Chemical Composition of Earth's Crust, Hydrosphere, and Troposphere

ELEMENT (symbol)	CRUST		HYDROSPHERE	TROPOSPHERE
	Percent by Mass	Percent by Volume	Percent by Volume	Percent by Volume
Oxygen (O)	46.40	94.04	33.0	21.0
Silicon (Si)	28.15	0.88		
Aluminum (Al)	8.23	0.48		
Iron (Fe)	5.63	0.49		
Calcium (Ca)	4.15	1.18		
Sodium (Na)	2.36	1.11		
Magnesium (Mg)	2.33	0.33		
Potassium (K)	2.09	1.42		
Nitrogen (N)				78.0
Hydrogen (H)			66.0	
Other	0.66	0.07	1.0	1.0

C. Mineral Structure - different minerals can possess different structures. Silicate containing minerals (Silicon and Oxygen) have a structure based on the silicon-oxygen tetrahedron. In this arrangement, four oxygen atoms surround one silicon atom.



D. Mineral Properties - all minerals have their own unique physical and chemical properties that can be used to identify them.

1. Color - all minerals have unique colors. Many minerals share similar colors. Also, some of the minerals come in different colors.

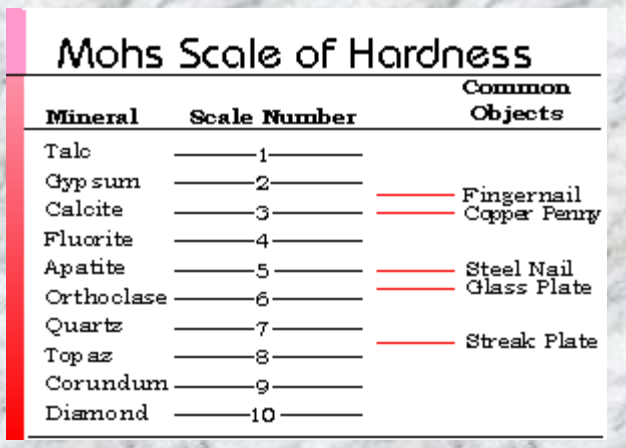
2. Luster - luster is the way the surface of the mineral reflects light. There are two forms of luster, metallic and non-metallic.

Metallic Luster - Pyrite

Nonmetallic Luster - Kaolinite

3. Streak - is the color of the powder left by a mineral after it is rubbed against a hard surface. A porcelain plate is often used to reveal a minerals streak.

4. Hardness - is a mineral's resistance to being scratched. Talc is so soft that it can be scratched with a finger nail, and a diamond is so hard, no other mineral can scratch it.



5. Cleavage - is the tendency of a mineral to split along surfaces, or planes of weakness. Minerals that do not show cleavage are classified as fractured.

6. Specific Gravity - minerals can be identified by determining their relative density as compared to water.

7. Chemical Tests - The use of hydrochloric acid to see if a mineral bubbles, or taste tests can help identify a mineral like halite or quartz. Taste tests can be dangerous, because some minerals can be toxic.

8. Special Properties - some minerals possess special

properties like magnetism (magnetite), luminescence (flourite), piezoelectricity (quartz).

E. Relationship of Minerals to Rocks - nearly all rocks are composed of minerals

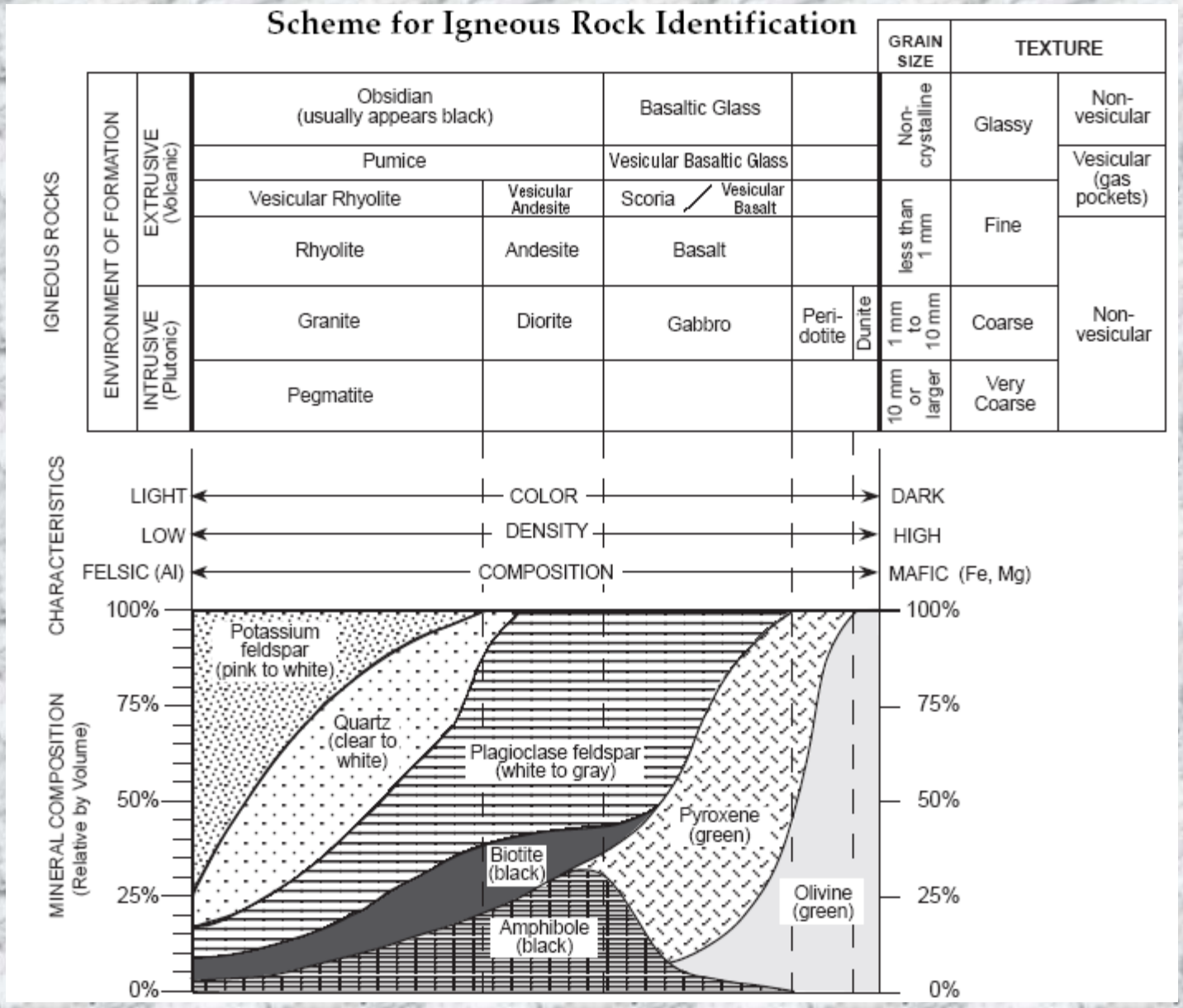
1. Monomineralic - these are rocks formed from only one mineral like rock salt (halite), and limestone (calcite).

2. Polymineralic - rocks composed of more than one mineral. Granite always contains quartz and feldspar, along with other minerals like mica and hornblende.

II. Rocks - A rock is a naturally formed, solid material that makes up the earth's crust. Rocks are classified on the basis of their origin into three main categories, Igneous, Sedimentary, and Metamorphic.

A. Igneous Rocks - These type of rocks form from the cooling and solidification of liquid rock.

1. Igneous Rock Identification - Igneous rocks are classified by mainly their texture, color, and mineral composition (see reference tables).



2. Sedimentary Rocks - Rocks that form from the accumulation of sediments derived from preexisting rocks and/or organic material.

   a. Formation of Sedimentary Rocks - Lithification is the conversion of sediments into solid rock. Four main processes lithify sedimentary rock:

1. Cementation - Large solid sediments are then bound together by substances like silica, iron oxide and calcium carbonate.

2. Compression and Compaction - fine sediments are compacted together as overlying sediments and water increase the pressure above them.

3. Chemical Action - Dissolved minerals in water may precipitate out of water, or may be left behind as a result of evaporation.

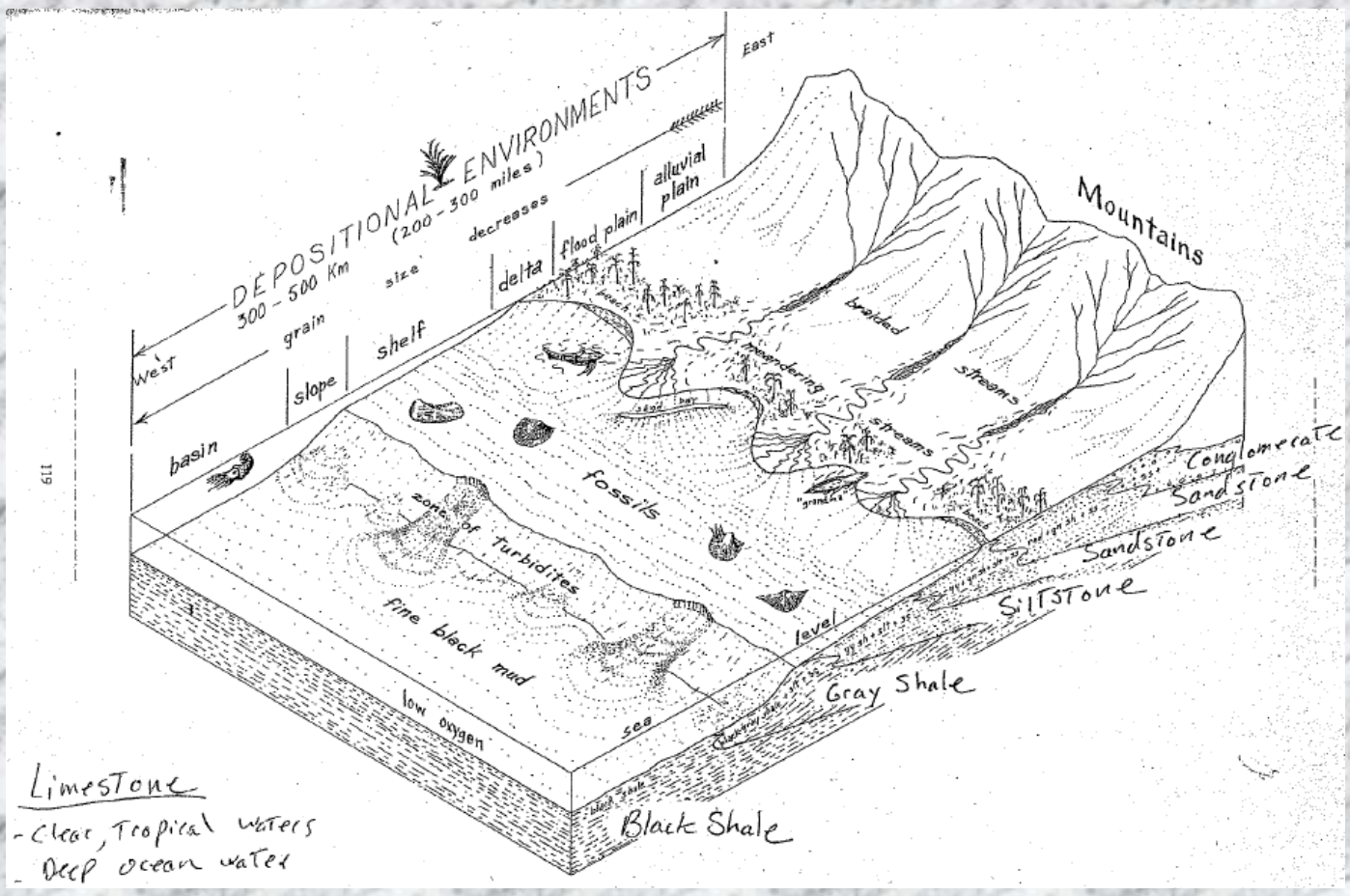
4. Biological Processes - Many forms of aquatic life like clams, coral, and diatoms die and settle to the bottom of the water. Over time they can accumulate and become compressed into a solid mass.

b. Classification of Sedimentary Rocks - sedimentary rocks are classified into two main categories (see reference tables).

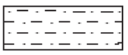
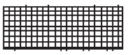
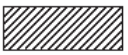
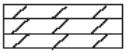
1. Inorganic Land-Derived Sedimentary Rocks - these rocks are formed from weathered rock particles, and are known as clastic.

2. Chemically and/or Organically Formed Sedimentary Rocks - Nonclastic rocks formed from evaporation, compaction, cementation, or precipitation.

Environment of Formation



Scheme for Sedimentary Rock Identification

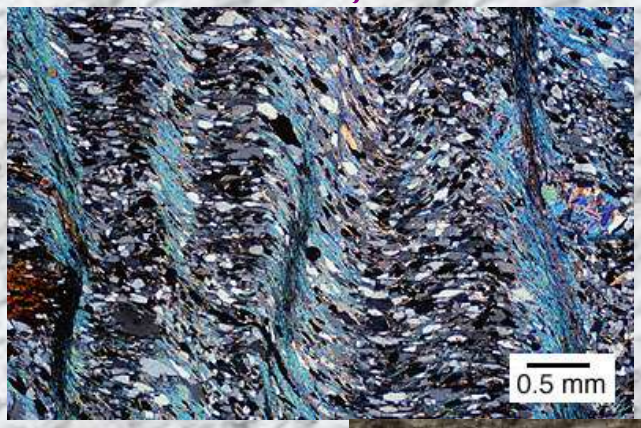
INORGANIC LAND-DERIVED SEDIMENTARY ROCKS					
TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Clastic (fragmental)	Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals	Rounded fragments	Conglomerate	
			Angular fragments	Breccia	
	Sand (0.2 to 0.006 cm)		Fine to coarse	Sandstone	
	Silt (0.006 to 0.0004 cm)		Very fine grain	Siltstone	
	Clay (less than 0.0004 cm)		Compact; may split easily	Shale	
CHEMICALLY AND/OR ORGANICALLY FORMED SEDIMENTARY ROCKS					
TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Crystalline	Varied	Halite	Crystals from chemical precipitates and evaporites	Rock Salt	
	Varied	Gypsum		Rock Gypsum	
	Varied	Dolomite		Dolostone	
Bioclastic	Microscopic to coarse	Calcite	Cemented shell fragments or precipitates of biologic origin	Limestone	
	Varied	Carbon	From plant remains	Coal	

3. Metamorphic Rocks – these rocks form when rocks (parent rocks) undergo a change as a result of exposure to intense heat and pressure.

    1. Recrystallization – as a result of intense heat and pressure, many rocks will form new crystals, without actually melting.

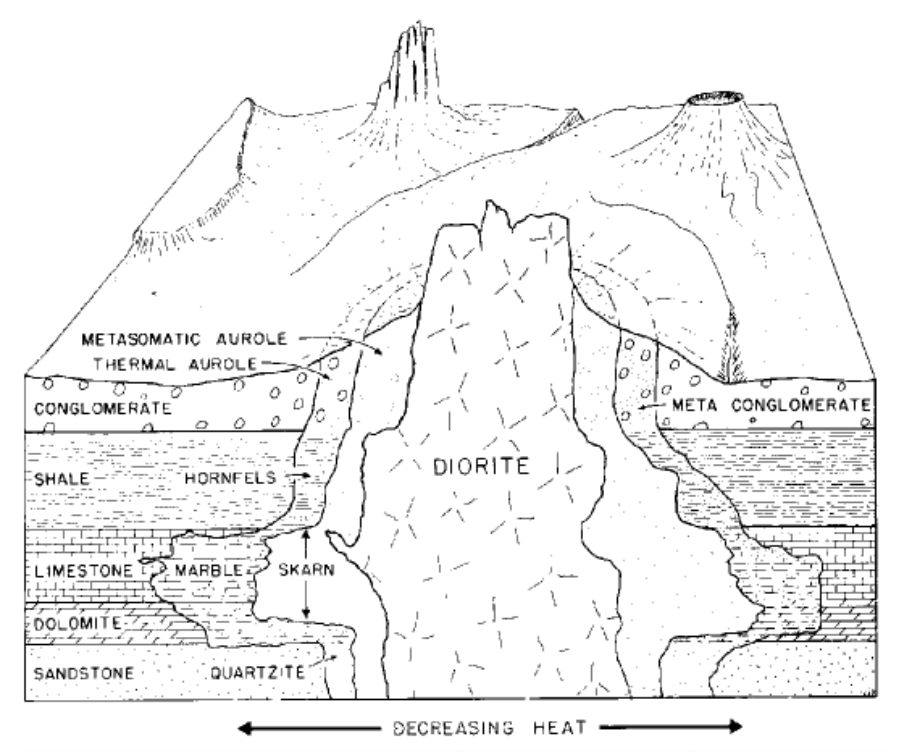
    2. Foliation – this is a layered arrangement of crystals in metamorphic rock. The more intense the heat and pressure, the thicker the foliation.

3. Distorted Structure - many metamorphic rocks display a curving or folding of foliations as a result of exposure to intense pressures.



4. Increased Density - metamorphisized rocks often have a higher density as a result of being exposed to extreme pressures.

5. Contact Metamorphism - when magma (intrusive rock) comes into contact with rock beneath the earth's surface, the heat metamorphisizes the surrounding rocks.



4. Metamorphic Rock Classification – see ESRT

Scheme for Metamorphic Rock Identification

TEXTURE	GRAIN SIZE	COMPOSITION	TYPE OF METAMORPHISM	COMMENTS	ROCK NAME	MAP SYMBOL
FOLIATED – MINERAL ALIGNMENT	Fine	MICA, QUARTZ, FELDSPAR, AMPHIBOLE, GARNET, PYROXENE	Regional (Heat and pressure increase with depth)	Low-grade metamorphism of shale	Slate	
	Fine to medium			Foliation surfaces shiny from microscopic mica crystals	Phyllite	
				Platy mica crystals visible from metamorphism of clay or feldspars	Schist	
FOLIATED – BAND-ING	Medium to coarse			High-grade metamorphism; some mica changed to feldspar; segregated by mineral type into bands	Gneiss	
NONFOLIATED	Fine	Variable	Contact (Heat)	Various rocks changed by heat from nearby magma/lava	Hornfels	
	Fine to coarse	Quartz	Regional or Contact	Metamorphism of quartz sandstone	Quartzite	
		Calcite and/or dolomite		Metamorphism of limestone or dolostone	Marble	
	Coarse	Various minerals in particles and matrix		Pebbles may be distorted or stretched	Metaconglomerate	

III. <u>The Rock Cycle</u>- the rock cycle is a model of the changes in rocks and rock material. It shows how rocks are constantly changing from one type to another.

A. There is no beginning or end in the rock cycle. The processes can begin anywhere.

B. There is no specific sequence of events that occur in the rock cycle. There are many different paths that the formation of rock can take.

C. The rock cycle utilizes specific rock forming processes, like: solidification, uplift, weathering and erosion, deposition, burial, dewatering, compaction, cementation, heat and pressure, metamorphism, and melting.