

EARTH SCIENCE

INTRODUCTION

COMPONENTS OF STUDY

1. **Geology:** Both physical & historical
2. **Meteorology:** Weather & climate
3. **Oceanography:** The oceans
4. **Astronomy:** What is external to the atmosphere

THE FOUR SPHERES (See The Water Cycle)

1. **Lithosphere:** The solid earth
2. **Hydrosphere:** The liquid earth
3. **Atmosphere:** The gaseous earth
4. **Biosphere:** Where life exists

CONCERNS IN OUR PHYSICAL ENVIRONMENT

1. **Resources:** Water, soil, metallic & non-metallic elements, sunlight, wind, etc.
2. **Per-capita use of metallic and non-metallic elements is 11 tons per year**
3. **Renewable vs. non-renewable resources**
4. **Environmental and population problems**

MINERALS

- A **mineral** is a naturally occurring, inorganic, solid material with a definite atomic structure.
- An **ore** is a useful metallic mineral.

A. Atoms and Forces

1. **Atom:** In ancient Greek, means "un-cut" i.e., the Ancient believed the atom to be the smallest particle of matter.
2. **Atoms** are composed of neutrons, protons and electrons.
 - a. **Atomic number:** Number of protons in nucleus
 - b. **Atomic weight:** Average weight of an atom
 - c. **Isotope:** Forms of an element with identical atomic numbers, but different numbers of neutrons in the nucleus
3. **Forces:** Strong, weak, electromagnetic and gravity

B. Properties of Minerals

1. **Luster:** Appearance or quality of light from surface
 2. **Color:** Nature of light and cause of color
 3. **Streak:** Color of mineral in powdered form
 4. **Hardness:** Moh's Scale (See Figure below)
- Scratch Test: Higher numbered materials can scratch lower numbered materials.
5. **Shape:** is determined by cleavage, crystal form and fracture.
 6. **Specific Gravity:**
 - a. The ratio of the weight of a mineral to the weight of an equal volume of water
 - b. **Density of water = 1 gm/cm³ = 1 gm/ml.**
 $\text{Ex., gold} = 19.3$, aluminum = 2.7, carbon = 2.2

MOH'S SCALE

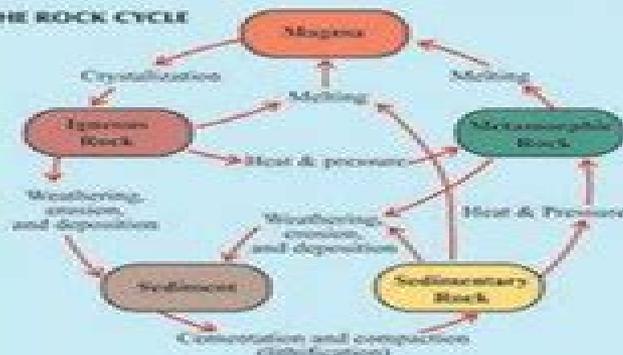
Hardness	Mineral
10	Diamond
9	Corundum
8	Topaz
7	Quartz
6	Feldspar
5	Apatite
4	Fluorite
3	Calcite
2	Gypsum
Softest	Talc

C. Mineral Groups

1. **Silicates:** Minerals with silicon and oxygen
 - a. **Silicon** is a semi-metal which forms a pyramid-shaped structure with oxygen.
 - b. Other forms include single tetrahedrons (olivine), chains (amphibole, asbestos mineral), 3-D structures (feldspar and quartz)
2. **Non-Silicates**
 - a. Make up one-fourth of continental crust
 - b. **Carbonates:** Minerals with carbon and oxygen including calcite, from which we produce limestone (roads) and marble (decorative slabs)
 - c. **Oxides:** Oxygen based solids, i.e., iron
 - d. **Sulfides:** Sulfur (S²⁻), Bismuth (Bi), Fe
 - e. **Sulfates:** Mineral form of salt
 - f. **Gypsum:** Plaster, calcium
 - g. **Noble metals:** Inc, zinc, gold, silver, nickel

ROCK TYPES

THE ROCK CYCLE



IGNEOUS ROCKS

A. Formation

1. **Extrusive igneous rocks** are formed in volcanic eruptions at surface.
2. **Intrusive (or plutonic) igneous rocks** are produced within the earth.
3. **Magma**
 - a. Consists mainly of silicate materials
 - b. Has gases, such as water vapor
 - c. Crystallizes from as deep as 200 km
 - d. Differs in rate of cooling, chemical composition, and amount of gases

c. Produces intrusive (plutonic) igneous rocks

4. Lava

- a. Similar to magma
- b. Most gaseous elements have escaped
- c. Produces extrusive (volcanic) igneous rocks

B. Structure

1. **Crystallization (ordered pattern of ions)**
 - a. The rate of cooling strongly affects crystal size
 - b. slow cooling = large crystals
 - c. quick cooling = small crystals
2. **Amorphous (unordered pattern of ions)**
 - a. occurs with instant cooling (quenching)
 - b. produces rocks referred to as glass

C. Classifying Igneous Rocks

1. **By texture, size and arrangement of interlocking crystals**
 - a. **fine-grained**
 - i. forms at surface or within upper crust
 - ii. openings left by gas bubbles are called vesicles
 - b. **coarse-grained** - formed deep within the interior
 - c. **porphyritic** - large crystals imbedded in matrix of smaller crystals
2. **By mineral composition**
 - a. Depends on composition of magma and cooling
 - b. Some magma can create rocks of varying mineral content.
 - c. As magma cools, certain minerals crystallize first (at very high temperatures).

METAMORPHIC ROCKS

A. Formation

1. **Metamorphic:** To change form
2. **Regional metamorphism:** Material under intense stresses, high temperatures
3. **Contact (thermal) metamorphism:** Changes caused by proximity to magma
4. **Low grade metamorphism:** Shale becomes slate
5. **High grade metamorphism:** Gneiss becomes rock
6. **Diagenesis** during mountain building
7. Most metamorphic rocks are harder than sedimentary rocks.
8. **Metamorphism changes texture.**
9. **Low-grade metamorphism** makes material more compact, more dense.
10. **Foliated texture:** Particles of material are brought into line with one another

B. Agents of Metamorphism

1. **Heat**
 - a. most important agent
 - b. provides energy for chemical reactions
 - c. For example, clay recrystallizes into a mineral at great temperature
2. **Pressure**
3. **Chemical Activity:** Most common chemical agent is water

C. Types of Metamorphic Rocks

1. **Schistite:** Fine grained, dark flinty rock with randomly arranged minerals
2. **Slate:** Fine grained, often gray, foliated rock split easily along cleavage, planes of mica flakes aligned by pressure
3. **Marble:** Granular or sugary-textured rock formed from limestone
4. **Phyllite:** Silty, foliated rock more coarsely grained than slate
5. **Schist:** Foliated rock, more coarsely grained and of higher metamorphic grade than phyllite
6. **Gneiss:** Foliated, banded rock of the highest metamorphic grade
7. **Quartzite:** Very hard, granular quartz rock, formed from sandstone

BOWEN'S REACTION SERIES

If a mineral, which has already formed, remains in the magma, it will react with the remaining magma to produce the next mineral in the sequence. For example, *olivine* forms first; *olivine* then reacts with remaining magma to form *pyroxene*.

A. Right Side of the Bowen Series

1. Calcium rich parts of the magma form small crystals of *olivine*.
2. These react with sodium in the magma to become more and more sodium rich.

B. End of Cooling

1. When everything is almost cool, remaining magma will have high silicate content, and quartz will form.
2. When cooling is complete, everything that cooled at the same time will usually be close to one another (*olivine, mica and quartz cool near one another to make granite*).



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Table of Contents Earth Science High School Essential Question

1. Understanding the eBook Earth Science High School Essential Question
 - The Rise of Digital Reading Earth Science High School Essential Question
 - Advantages of eBooks Over Traditional Books
2. Identifying Earth Science High School Essential Question
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Earth Science High School Essential Question
 - User-Friendly Interface
4. Exploring eBook Recommendations from Earth Science High School Essential Question
 - Personalized Recommendations
 - Earth Science High School Essential Question User Reviews and Ratings
 - Earth Science High School Essential Question and Bestseller Lists
5. Accessing Earth Science High School Essential Question Free and Paid eBooks

- Earth Science High School Essential Question Public Domain eBooks
 - Earth Science High School Essential Question eBook Subscription Services
 - Earth Science High School Essential Question Budget-Friendly Options
6. Navigating Earth Science High School Essential Question eBook Formats
 - ePub, PDF, MOBI, and More
 - Earth Science High School Essential Question Compatibility with Devices
 - Earth Science High School Essential Question Enhanced eBook Features
 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Earth Science High School Essential Question
 - Highlighting and Note-Taking Earth Science High School Essential Question
 - Interactive Elements Earth Science High School Essential Question
 8. Staying Engaged with Earth Science High School Essential Question
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Earth Science High School Essential Question
 9. Balancing eBooks and Physical Books Earth Science High School Essential Question
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Earth Science High School Essential Question
 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
 11. Cultivating a Reading Routine Earth Science High School Essential Question
 - Setting Reading Goals Earth Science High School Essential Question
 - Carving Out Dedicated Reading Time
 12. Sourcing Reliable Information of Earth Science High School Essential Question
 - Fact-Checking eBook Content of Earth Science High School Essential Question
 - Distinguishing Credible Sources
 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development

- Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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