University of Anbar
Collage of Science
Department of Geology
Minerals / 1st stage.

Introduction & Minerals Formation

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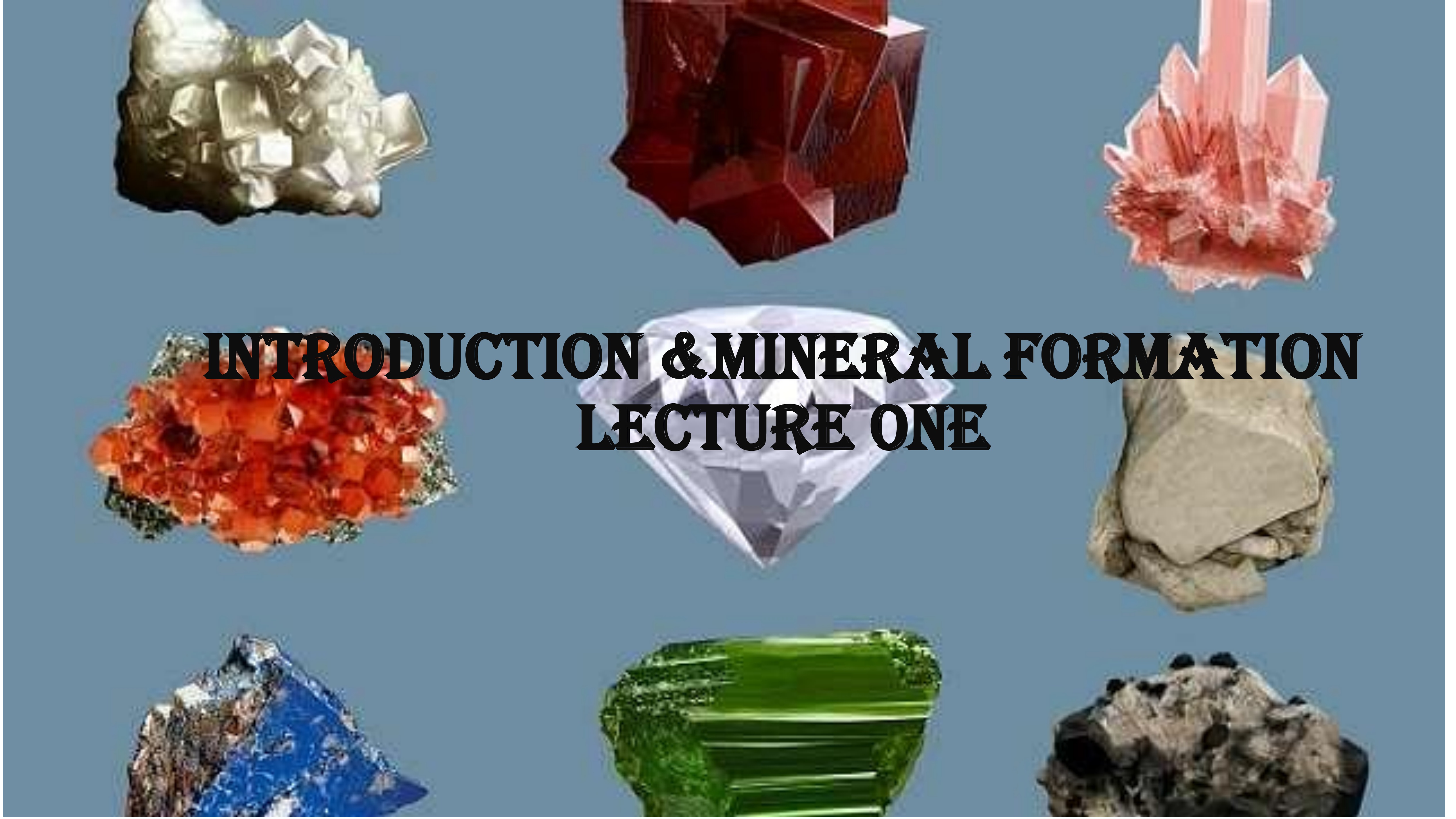


INTRODUCTION &MINERAL FORMATION
LECTURE ONE

INTRODUCTION

- The science of mineralogy is a branch of the earth sciences that is concerned with studying minerals and their physical and chemical properties. Within mineralogy there are also those who study how minerals are formed, where they are geographically located, as well as their potential uses. Like many sciences, mineralogy has its origins in several ancient civilizations, and it has been concerned primarily with the various methods of classification of minerals for most of its history. Modern-day mineralogy has been expanded by advances in other sciences, such as biology and chemistry, to shed even more light on the nature of the materials that form the earth we live on.

FORMATION OF MINERALS

In order for a mineral crystal to grow, the elements needed to make it must be present in the appropriate proportions, the physical and chemical conditions must be favorable, and there must be sufficient time for the atoms to become arranged.

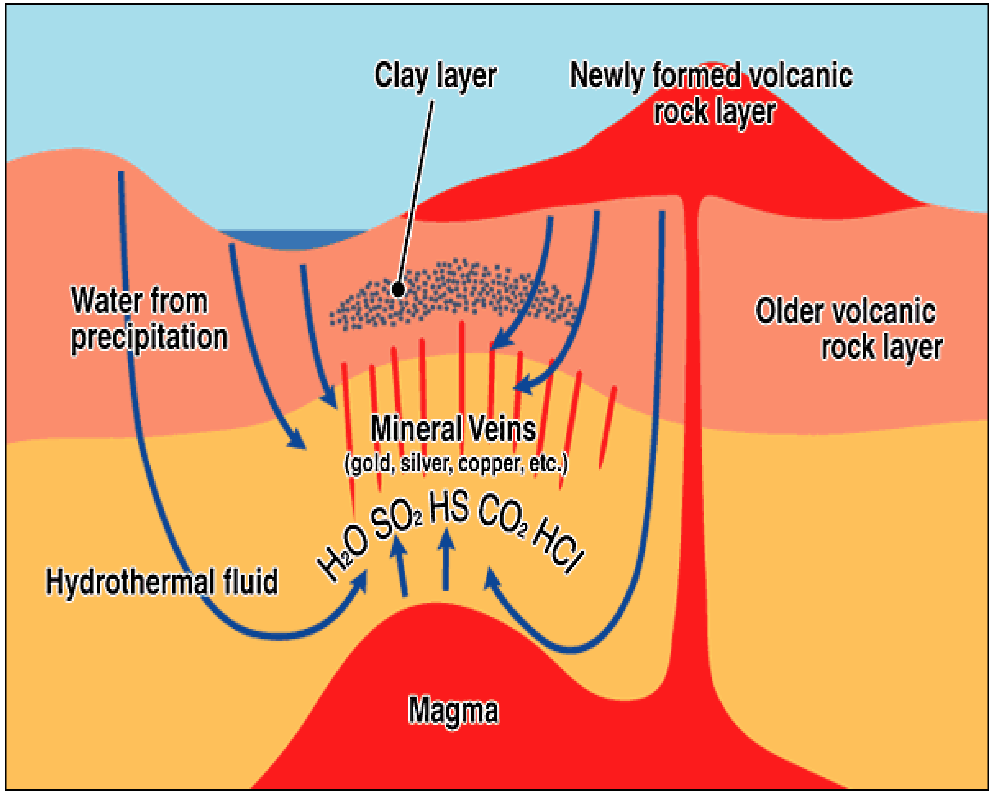
- Physical and chemical conditions include factors such as temperature, pressure, presence of water, pH, and amount of oxygen available. Time is one of the most important factors because it takes time for atoms to become ordered. If time is limited, the mineral grains will remain very small. The presence of water enhances the mobility of ions and can lead to the formation of larger crystals over shorter time periods.

MINERALS CAN FORM IN SEVERAL WAYS:

1. Crystallization from Magma
2. Precipitation
3. Pressure and Temperature (metamorphism)
4. Hydrothermal Solutions

CRYSTALLIZATION FROM MAGMA

- Most of the minerals that make up the rocks around us formed through the cooling of molten rock, known as **magma**. At the high temperatures that exist deep within Earth, some geological materials are liquid. As magma rises up through the crust, either by volcanic eruption or by more gradual processes, it cools and minerals crystallize. If the cooling process is rapid (minutes, hours, days, or years), the components of the minerals will not have time to become ordered and only small crystals can form before the rock becomes solid.



- The resulting rock will be fine-grained (i.e., crystals less than 1 mm). If the cooling is slow (from decades to millions of years), the degree of ordering will be higher and relatively large crystals will form. In some cases, the cooling will be so fast (seconds) that the texture will be glassy, which means that no crystals at all form. **Volcanic glass** is not composed of minerals because the magma has cooled too rapidly for crystals to grow, although over time (millions of years) the volcanic glass may crystallize into various silicate minerals.

- As magma cools, elements combine to form minerals.
- Crystal structure depends on the rate of cooling and pressure.

The mineral formed are called :

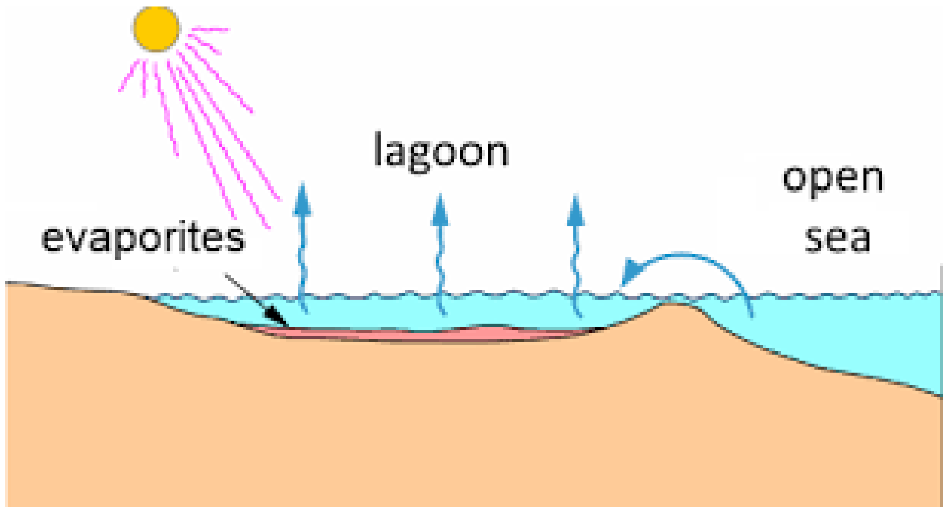
IGNEOUS MINERALS

- Minerals in igneous rocks must have high melting points and be able to co-exist with, or crystallize from, silicate melts at temperatures above 800 ° C. Igneous rocks can be generally classed according to their silica content with low-silica (< 50 % SiO2) igneous rocks being termed basic or mafic, and high-silica igneous rocks being termed silicic or acidic. Basic igneous rocks (BIR) include basalts, dolerites, gabbros, kimberlites, and peridotites, and abundant minerals in such rocks include olivine, pyroxenes, Ca-feldspar (plagioclase), amphiboles, and biotite.

2:PRECIPITATION

- Precipitation from aqueous solution (i.e., from hot water flowing underground, from evaporation of a lake or inland sea, or in some cases, directly from seawater)

- *Water evaporates, some dissolved substances can react to form minerals*
- Two common examples
- Limestone and Halite
- The minerals formed are called :

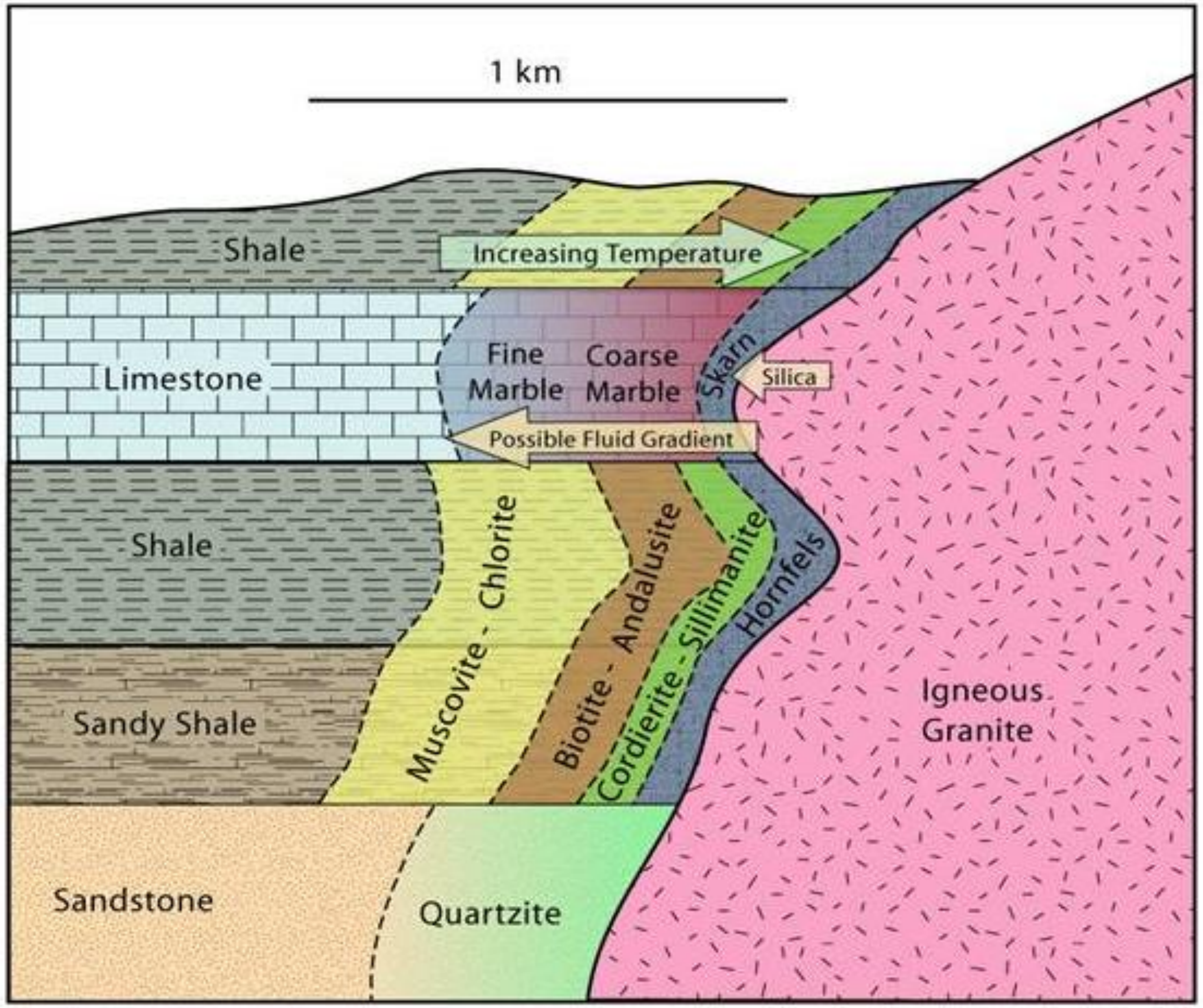


SEDIMENTARY MINERALS

- Minerals in sedimentary rocks are either stable in low-temperature hydrous environments (e.g. clays) or are high temperature minerals that are extremely resistant to chemical weathering (e.g. quartz). One can think of sedimentary minerals as exhibiting a range of solubilities so that the most insoluble minerals such as quartz, gold, and diamond accumulate in the coarsest detrital sedimentary rocks, less resistant minerals such as feldspars, which weather to clays, accumulate in finer grained siltstones and mudstones, and the most soluble minerals such as calcite and halite (rock-salt) are chemically precipitated in evaporite deposits. Sedimentary minerals can classify into detrital sediments (DSD) and evaporites (EVP). Detrital sedimentary minerals include quartz, gold, diamond, apatite and other phosphates, calcite, and clays. Evaporite sedimentary minerals include calcite, gypsum, anhydrite, halite and sylvite, plus some of the borate minerals.

PRESSURE AND TEMPERATURE (METAMORPHISM)

- Metamorphism — formation of new minerals directly from the elements within existing minerals under conditions of elevated temperature and pressure.
- **An increase in pressure** can cause minerals to recrystallize while still solid.
- **Changes in temperature** can also cause certain minerals to become unstable and rearrange into a configuration that is more stable at the new conditions.
- **Common Examples:**
- Muscovite and Talc
- Minerals formed are called:

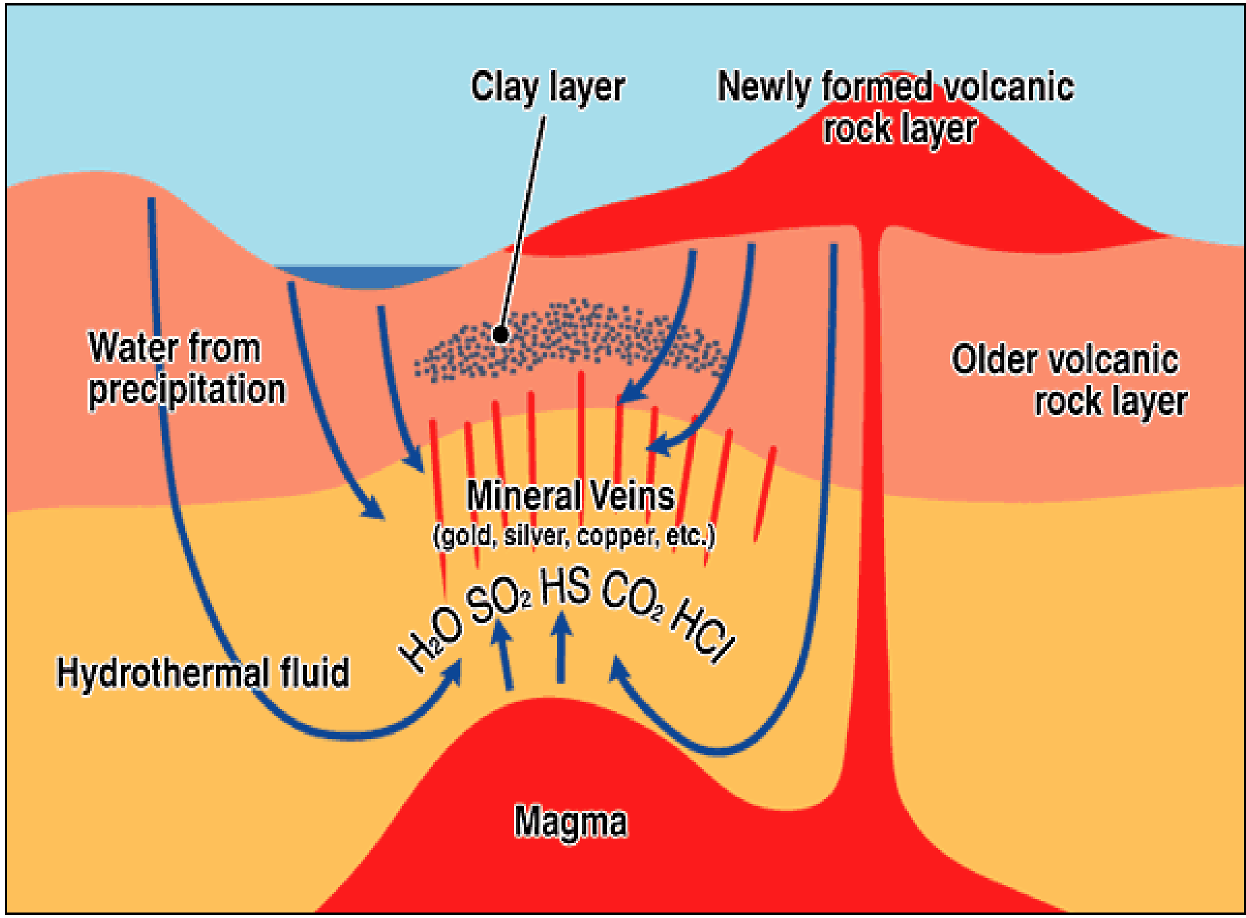


METAMORPHIC MINERALS

- Minerals in metamorphic rocks have crystallized from other minerals rather than from melts and need not be stable to such high temperatures as igneous minerals. In a very general way, metamorphic environments may be classified as low-grade metamorphic (LGM) (temperatures of 60 ° to 400 ° C and pressures < .5 GPa (=15km depth) and high-grade meta morphic (HGM) (temperatures > 400 ° and/or pressures > .5 GPa). Minerals characteristic of low- grade metamorphic environments include the zeolites, chlorites, and andalusite. Minerals characteristic of high grade metamorphic environments include sillimanite, kyanite, staurolite, epidote, and amphiboles.

HYDROTHERMAL SOLUTIONS

- **Hot mixture of water and dissolved substances.**
- Temps. Between 100-300°C
- **When they come into contact with existing minerals, chemical reactions take place to form new minerals.**
- **Examples:**
- Chalcopyrite, bornite, and pyrite
- Minerals formed are called:



HYDROTHERMAL MINERALS

- The fourth major mineral environment is hydrothermal, minerals precipitated from hot aqueous solutions associated with emplacement of intrusive igneous rocks. This environment is commonly grouped with metamorphic environments, but the minerals that form by this process and the elements that they contain are so distinct from contact or regional metamorphic rocks that it us useful to consider them as a separate group. These may be sub-classified as high temperature hydrothermal (HTH), low temperature hydrothermal (LTH), and oxydized hydrothermal (OXH).

- Sulfides may occur in igneous and metamorphic rocks, but are most typically hydrothermal. High temperature hydrothermal minerals include gold, silver, tungstate minerals, chalcopyrite, bornite, the tellurides, and molybdenite. Low temperature hydrothermal minerals include barite, gold, cinnabar, pyrite, and cassiterite. Sulfide minerals are not stable in atmospheric oxygen and will weather by oxidation to form oxides, sulfates and carbonates of the chalcophile metals, and these minerals are characteristic of oxidized hydrothermal deposits. Such deposits are called gossans and are marked by yellow-red iron oxide stains on rock surfaces. These usually mark mineralized zones at depth.

Other Ways for Minerals Formation

- Weathering — during which minerals unstable at Earth's surface may be altered to other minerals

- Organic formation — formation of minerals within shells (primarily calcite) and teeth and bones (primarily apatite) by organisms (these organically formed minerals are still called minerals because they can also form inorganically)
- Opal is a mineraloid, because although it has all of the other properties of a mineral, it does not have a specific structure. Pearl is not a mineral because it can *only* be produced by organic processes.

IMPORTANCE OF MINERALS

- minerals is around us! It help us to develop new technologies and are used in our everyday lives. Our use of minerals includes as building material, cosmetics, cars, roads, and appliances. In order maintain a healthy lifestyle and strengthen the body, humans need to consume minerals daily.

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