Quadrant II – Transcript and Related Materials

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Notes

Introduction to Sedimentary Petrology

Sedimentary rocks are those, which have been derived from the consolidation of sediments. They consist mainly of rock fragments and particles which are derived from the weathering of pre-existing rocks such as igneous, metamorphic or sedimentary itself. The weathered material is transported by water, wind or glaciers. Water is by far the most important agent of transportation of sediments. The material that dissolved in water is transported in solution. Detrital material is transported in suspension or as bed load (rolled or dragged along the river bed). Lighter material may be transported in suspension and heavier material is dragged or rolled along the surface of the river bed. All this material is finally deposited in the basins like ponds, lakes, rivers, seas, and oceans. When detrital material is deposited in the basin, the sedimentation is referred to as **clastic sedimentation**. The material which is transported in solution and when solution encounters supersaturation environment it precipitates. Such type of sedimentation is referred to as **chemical sedimentation**. Another type of sedimentation is due to the activity of the organisms. Living organisms extract ions dissolved in water to make their

shells and bones. After the death of these organisms, the skeletal parts accumulate on the seafloor. This type of sedimentation is called **biochemical sedimentation**. Similarly, the accumulation of plant matter in swamps is referred to as **organic sedimentation**. Thus there are four major types of sedimentary rocks: **Clastic Sedimentary Rocks, Chemical Sedimentary Rocks, Biochemical Sedimentary Rocks and Organic Sedimentary Rocks.**

Types of Sedimentary Rocks and Their Examples:
Clastic Sedimentary Rocks: Sandstone, siltstone, Shale, Grit, Arkose, Conglomerate, Breccia.
Chemical Sedimentary Rocks: Limestone, Gypsum, Halite, Evaporites, Travertine, Dolostone.
Biochemical Sedimentary Rocks: Shelly limestone, Oolitic limestone, Coral limestone.
Organic Sedimentary Rocks: Coal, Peat, Lignite, Anthracite.

Process of Formation of Sedimentary Rocks:

When the rocks (igneous, sedimentary or metamorphic) are at or near the surface of the earth they are exposed to the processes of weathering. Weathering is the process by which the rocks are broken down into finer and finer particles by mechanical disintegration or by chemical decomposition. This process of weathering is due to the action of external agents such as wind, water, rain, temperature fluctuation, plants and bacteria. An essential feature of weathering is that it take place insitu, no transportation is involved.
There are two types of weathering: **Mechanical or physical weathering and Chemical weathering**

Mechanical Weathering: In mechanical weathering rocks are broken down into smaller pieces by frost wedging (the Freezing and thawing of water inside in the pores or cracks in the rocks), root- wedging (Plant roots growing into the cracks), and abrasion caused by blowing sands in the desert (sand blasting) or the scouring of water transported sand, gravel and boulders on the bedrock of a stream. Mechanical weathering break the rocks into smaller and smaller fragments without altering the minerals by chemical action.

Chemical Weathering: In chemical weathering minerals are changed into new minerals and minerals byproducts. Some minerals like halite and calcite may dissolve completely, whereas silicate minerals are altered by a chemical process called Hydrolysis. It is the process by which minerals react with weakly acidic waters. Most surface waters are slightly acidic because CO_2 from the atmosphere dissolved in water. Some of the dissolved CO_2 reacts with the water forming the chemical compound carbonic acid. **Solution, hydration, oxidation, hydrolysis and carbonation** are the processes of chemical weathering. Complete weathering of rocks may yield: clays, quartz (if originally present in rock), soluble silica and metal cations.

Solution: Water is the main agent for chemical weathering because it serves as an active chemical solvent and reagent.

$H_2O + CO_2$ ----------→ H_2CO_3 (Carbonic acid)

The ionisation of carbonic acid leads to the formation of chemically active hydrogen ion (H^{+1}) and bicarbonate (HCO_3^{-1}) ions.

The acids generated by water combining with other molecules can decompose other minerals in the rocks and convert them into soluble products. This is the reason water turns hard when the soluble ions like calcium and magnesium bicarbonates get dissolved in the water. The rocks which get chemically decomposed due to solution processes are the carbonate rocks like marble, dolomite and marls.

Hydration: In this process, certain minerals take up water and expand, cause additional stresses within the rocks. For example anhydrite ($CaSO_4$) absorbs water and become Gypsum ($CaSO_4. 2H_2O$). Hydration takes place when hydroxyl or water molecule enters into the mineral structure and in the process decomposes the mineral. Minerals such as feldspars, pyroxenes, amphiboles and micas get converted to clays by this process.

(Anhydrite) $CaSO_4$ + $2H_2O$ --------→ (Gypsum) $CaSO_4. 2H_2O$

(Orthoclase) $K_2O.Al_2O_3.6SiO_2$ + CO_2 + $2H_2O$------→
K_2CO_3 + (Clay) $Al_2O_3.2SiO_2 . 2H_2O$ + (Silica) $4SiO_2$

Hydrolysis: In this process instead of the hydroxyl molecule, the hydrogen ion (H^{+1}) enters into the mineral structure and replaces other positive ions and accelerates the decomposition of rocks.

(Orthoclase) $KalSi_3O_8$ + H^{+1} -------→ (Clay) H $AlSi_3O_8$ + K^{+1} (in solution)

Oxidation: Iron rust when it is exposed to the moisture due to oxidation of the ferrous ion to the ferric ion. Similarly iron bearing minerals like the olivine, pyroxenes and amphiboles oxidise giving rise to hematite in the presence of water.

$4Fe + 3O_2$ ------→ $2 Fe_2O_3$ (hematite)

$FeS + 2O_2$ --------> $FeSO_4$

$4FeO + 3H_2O + O_2$ ----→ $2Fe_2O_3. 3H_2O$

(Olivine) $(MgFe)SiO_4 + H_2O$ ----→ (Brucite)$Mg(OH)_2 + H_2SiO_3 + FeO$

Carbonation: It is the process in which carbon dioxide reacts with the other molecules to form soluble products. For example limestone dissociates to calcium bicarbonate when carbon dioxide reacts with limestone in presence of water.

(limestone)$CaCO_3 + H_2O + CO_2$ -----→ $Ca(HCO)_3$ (calcium bicarbonate)

Similarly feldspar produces clays by carbonation

$2KAlSiO_3O_8 + CO_2 + H_2O$ -------→ $H_4Al_2Si_2O_9 + 4SiO_2 + KCO_3$

Erosion: It is the process which act together with transportation to lower the surface of the earth. This process removes the weathered products from their original location. This can take place by gravity, by running water, by wind or by moving ice. This process overlap the transportation.

Transportation: Sediments can be transported by gravity (sliding down the slopes), by wind, by water or by glaciers. Sediments are transported either in solution, in suspension or as bed load by rolling or sliding on the surface of the earth. It may be transported only when there is sufficient energy in the transporting medium. Depending upon the energy (velocity) of the transporting medium different size particles are transported. For example steep mountain streams can transport large boulders since the energy of the stream in the mountain region is high. Size of the particles decreases during transportation. It also help in sorting of the material into similar sized particles in the transporting medium (wind or water) and rounded by continued abrasion.

Deposition: Sediments are deposited when the energy of the transporting medium becomes too low to continue the transport process. For example

when river flows into the lake or sea, its velocity decreases. The clastic sediments carried by the river starts depositing. Heavier and larger material like gravel dropped first, followed by sand, silt and finally clay. The sediments are deposited layer upon layer and are horizontal or nearly horizontal. In case of dissolved load in water the precipitation takes place when solution encounters a supersaturated environment. For example gypsum, halite, and other salts precipitate out of seawater in arid areas, like the eastern Mediterranean, where evaporation is high.

Diagenesis: Lithification is the process that turns sediments into sedimentary rock. The processes by which the sediments becomes lithified into a hard sedimentary rock is called diagenesis. This includes all physical, chemical and biochemical changes in the sediments which are brought about after its deposition but before final lithification and below temperature of 200^0C. The most important diagenetic processes are compaction, cementation and lithification. The first stage of the process is compaction. Compaction occurs as the weight of the overlying material increases. Compaction forces the grains closer together, reducing pore space and expelling much of pore water. Some of this water may carry mineral components in solution, and these constituents may later precipitate as new minerals in the pore spaces. This causes cementation, which will then start to bind the individual particles together thus forming a rock. The most common cementing materials include calcite, quartz and hematite.