BASIC SEDIMENTOLOGY

Process and Transport Mechanisms

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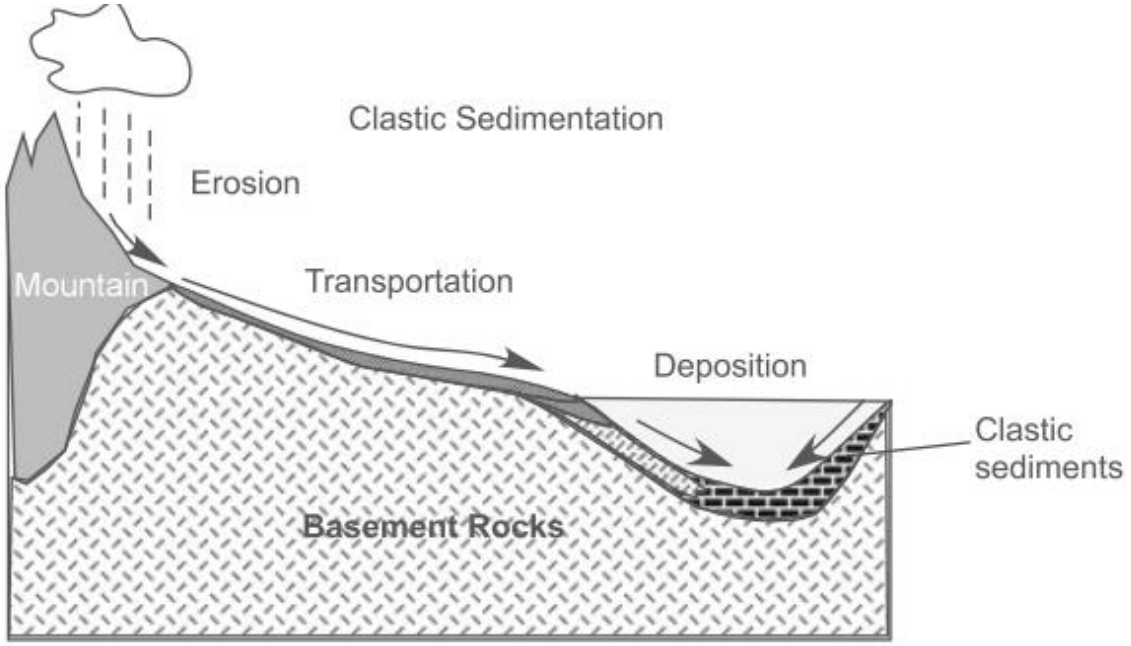
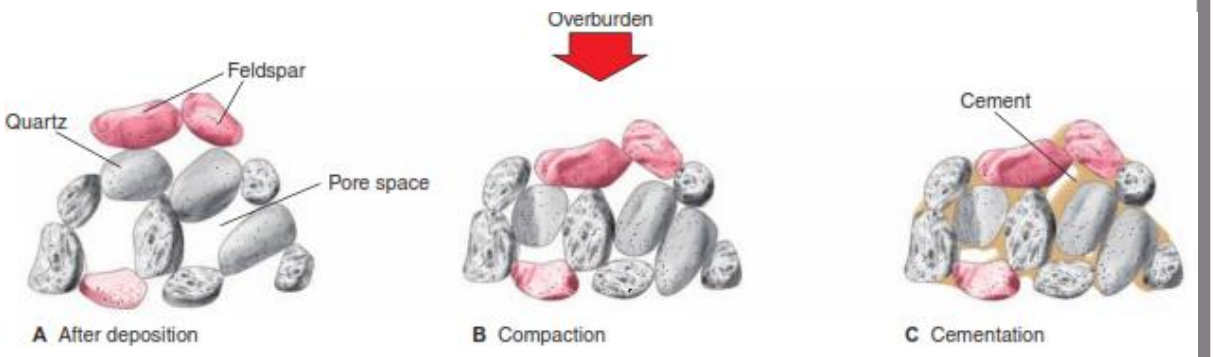
Process and Transport Mechanisms

Sedimentology is the study of the processes of formation, transport and deposition of material that accumulates as sediment in continental and marine environments and eventually forms sedimentary rocks (Garry Nichols, 2009). Sedimentary rocks are formed from pre-existing rocks or pieces of once-living organisms. They form from deposits that accumulate on the Earth's surface. Sedimentary rocks terminology in sedimentology emphasize as the process how the sedimentary rocks forms, meanwhile in petrology emphasize as the composition and the material that formed the sedimentary rocks.

There are several process involves in forming of sedimentary rocks such as :

- Weathering
- Erosion
- Transportation
- Deposition
- Preservation
- Lithification





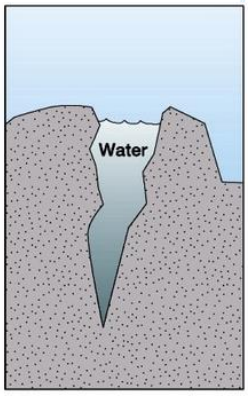
Weathering is a process where the rocks turn into smaller fragments or smaller ions. There are 3 types of weathering :

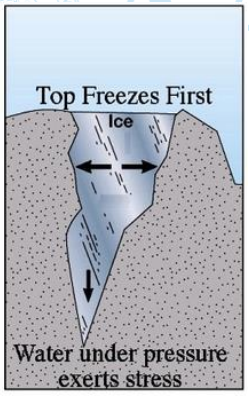
1. Physical Weathering

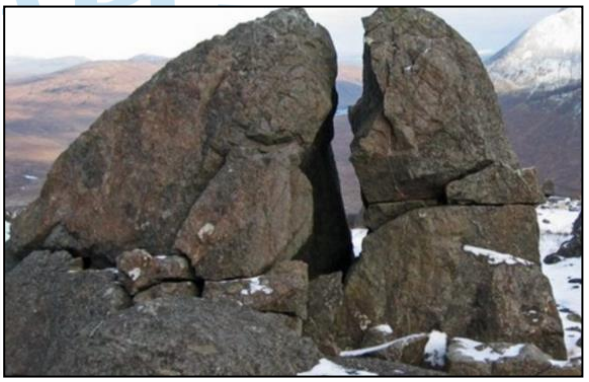
These are processes that break the solid rock into pieces and may separate the different minerals without involving any chemical reactions. The most important agents in this process are as follows :

- Frost Wedging Weathering

Water entering cracks in rock expands upon freezing, forcing the cracks to widen; this process is also known as frost shattering and it is extremely effective in areas that regularly fluctuate around 0^0C, such as high mountains in temperate climates and in polar regions

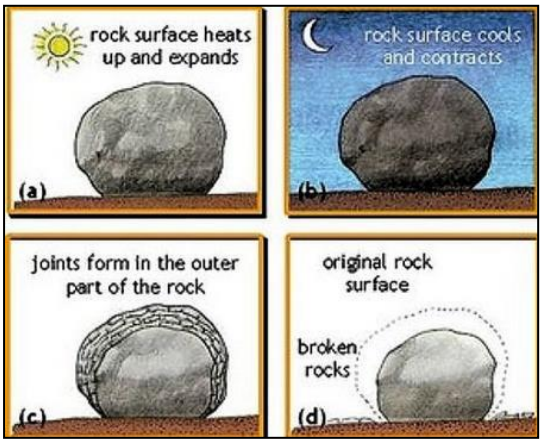






- Insolation Weathering

The process where the rocks goes expanding and shrinking because of the significant changing of the temperature and in the end would make the rocks crack or fracture



- Salt Weathering

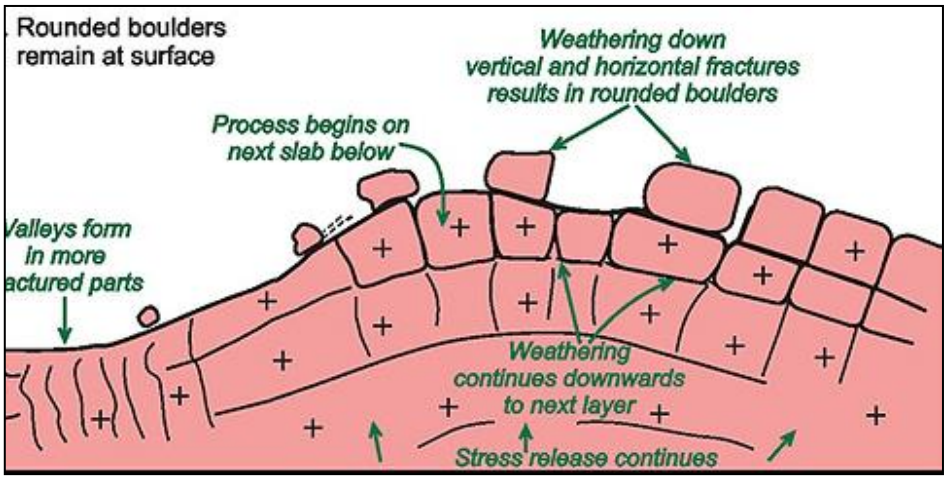
Seawater or other water containing dissolved salts may also penetrate into cracks, especially in coastal areas. Upon evaporation of the water, salt crystals form and their growth generates localised, but significant, forces that can further open cracks in the rock.

- Wetting and Drying Weathering

The process where the rocks got wet by rainfall and suddenly got dried because of the sunlight.

- Stress-Release Weathering

The process where there is a release of stress because the top layer of the rock has been eroded.



2. Chemical Weathering

The weathering process that involves the changing of the chemical composition and the mineral of the rocks

i) Solution

Most rock-forming silicate minerals have very low solubility in pure water at the temperatures at the Earth's surface and so most rock types are not susceptible to rapid solution. It is only under conditions of strongly alkaline waters that silica becomes moderately soluble. Carbonate minerals are moderately soluble, especially if the groundwater (water passing through bedrock close to the surface) is acidic. Most soluble are evaporite minerals such as halite (sodium chloride) and gypsum, which locally can form an important component of sedimentary bedrock.

ii) Hydrolysis

Hydrolysis reactions depend upon the dissociation of H2O into H^+ and OH^- ions that occurs when there is an acidifying agent present. Natural acids that are important in promoting hydrolysis include carbonic acid (formed by the solution of carbon dioxide in water) and humic acids, a range of acids formed by the bacterial breakdown of organic matter in soils. Many silicates undergo hydrolysis reactions, for example the formation of kaolinite (a clay mineral) from orthoclase (a feldspar) by reaction with water.

iii) Hydration

Chemical combination of water molecules with a particular substance or mineral leading to a change in structure.

$CaSO_4$ + $2H_2O$ $CaSO4.2H_2O$

Anhydrite → Gypsum

iv) Oxidation

The most widespread evidence of oxidation is the formation of iron oxides and hydroxides from minerals containing iron. The distinctive

red-orange rust colour of ferric iron oxides may be seen in many rocks exposed at the surface, even though the amount of iron present may be very small.

v) Carbonation

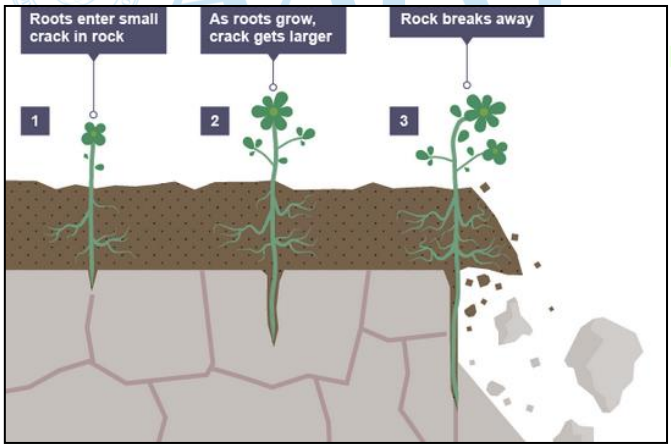
Carbon dioxide when dissolved in water it forms carbonic acid.
$2H_2O + CO_2 \rightarrow H_2CO_3$
This carbonic acid attacks many rocks and minerals and brings them into solution. The carbonated water has an etching effect up on some rocks, especially lime stone. The removal of cement that holds sand particles together leads to their disintegration.

vi) Reduction

The process of removal of oxygen and is the reverse of oxidation and is equally important in changing soil colour to grey, blue or green as ferric iron is converted to ferrous iron compounds. Under the conditions of excess water or water logged condition (less or no oxygen), reduction takes place.
$2Fe_2O_3$ (Hematite) - O_2 -> 4FeO(Ferrous oxide) - reduced form

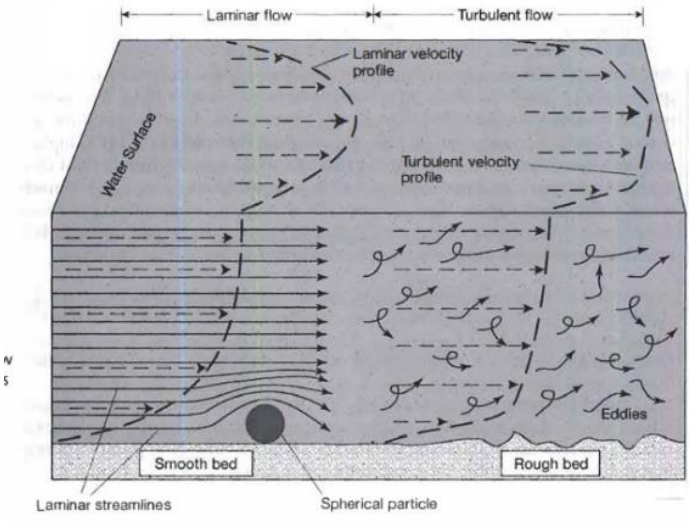
- Biological Weathering

The weathering process that happens because of the organism activities

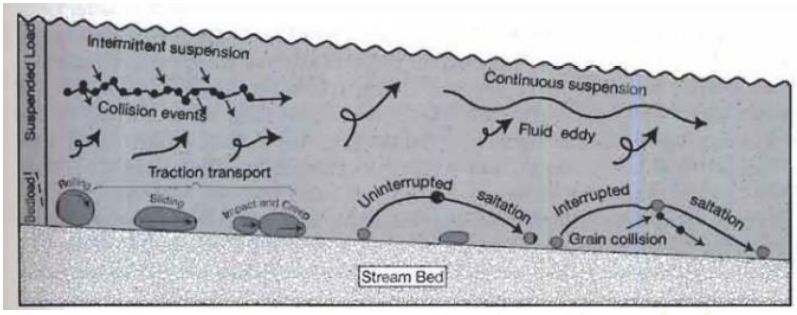


Erosion is the process where the material loose from its source. Transportation is the process of where the sediment carried by the media from it source into lower place. Deposition is the process of where the sediment accumulate into the basin.

The mechanical properties of the flow



The particles movement in the flow



- Saltation

The particles move in a series of jumps, periodically leaving the bed surface, and carried short distances within the body of the fluid before returning to the bed again.

- Rolling

The clasts move by rolling along at the bottom of the air or water flow without losing contact with the bed surface.

- Suspension

Turbulence within the flow produces sufficient upward motion to keep particles in the moving fluid more-or-less continually.

Particles being carried by rolling and saltation are referred to as **bedload,** and the material in suspension is called the **suspended load**. At low current velocities in water only fine particles (fine silt and clay) and low density particles are kept in suspension while sand-size particles move by rolling and some saltation. At higher flow rates all silt and some sand may be kept in suspension with granules and fine pebbles saltating and coarser material rolling. These processes are essentially the same in

air and water but in air higher velocities are required to move particles of a given size because of the lower density and viscosity of air compared with water.

Flow Regime can be related to the sedimentary structures its depend on the grain size and the velocity of the flow. Flow regime can be divided into 2 types which is upper flow regime and lower flow regime. This flow regime also related to the Froud Number.

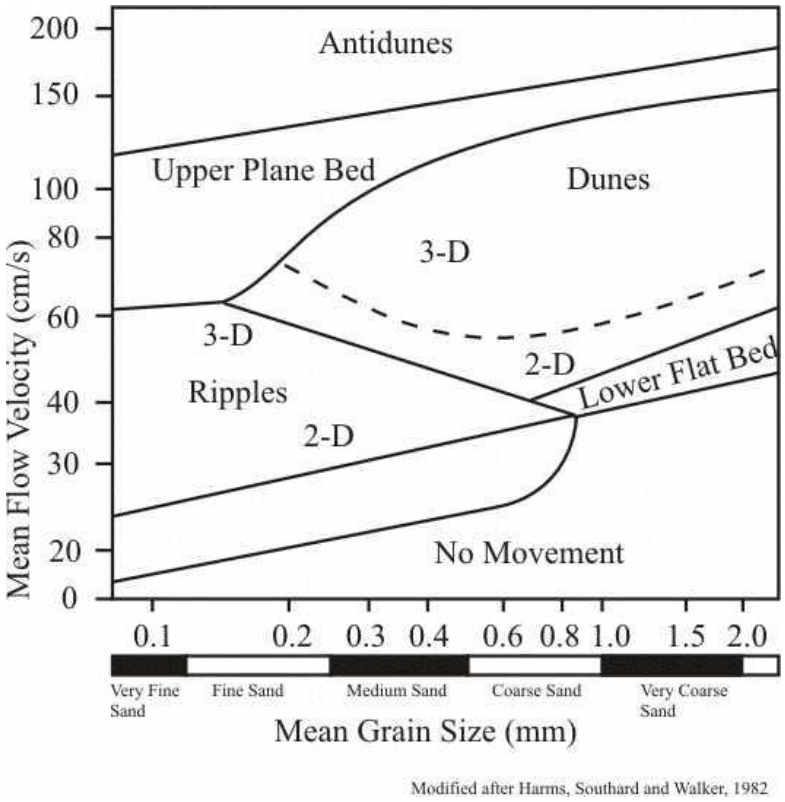
$$\mathrm{Fr} = \frac{V}{\sqrt{gL}},$$

dimana:

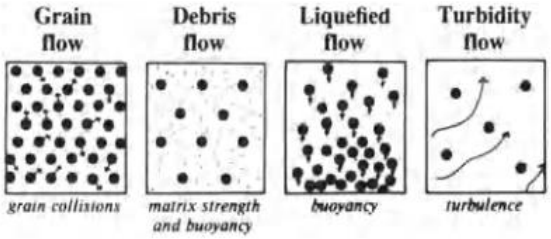
- V=kecepatan partikel
- g=percepatan gravitasi
- L=kedalaman channel

F <1 aliran tenang (regim aliran yang lebih rendah (Lower Flow Regime))

F > 1 aliran cepat (regime aliran atas (upper Flow Regime))



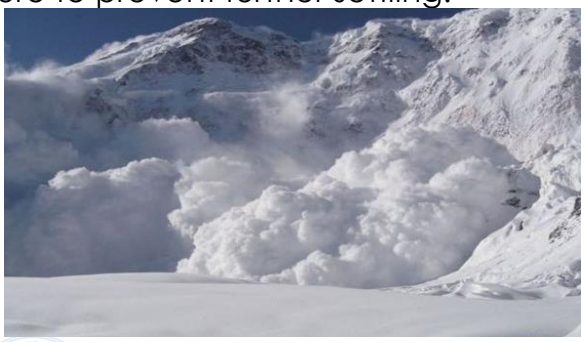
Modified after Harms, Southard and Walker, 1982



The gravity transportation have several type such as :

- Grain Flow

  Type of sediment-gravity flow in which the supporting fluid, which can be either air or water, acts only as a lubricant, and grains within the flow remain in suspension due to grain-to-grain collisions that generate a dispersive pressure to prevent further settling.



- Debris Flow

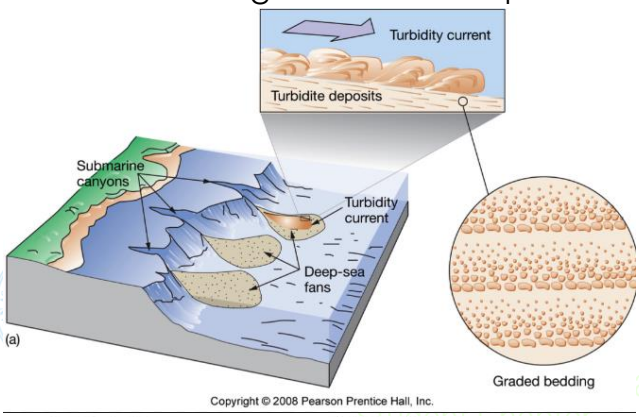
  Debris flow is a moving mass of loose mud, sand, soil, rock, water and air that travels down a slope under the influence of gravity. To be considered a debris flow, the moving material must be loose and capable of "flow",and more than half of the solids in the mass must be larger than sand grains, including gravel, pebble, cobble and boulder sized material.

- Liquefied Flow

  Liquified flows and fluidized flows are types of sediment-gravity flows in which grains within the flow are kept suspension by the upward movement of fluid

- Turbidity Current

A current of highly turbid water carrying large amounts of suspended sediment that increase its density and cause it to flow downward through less dense water along the bottom slope of a sea or lake.



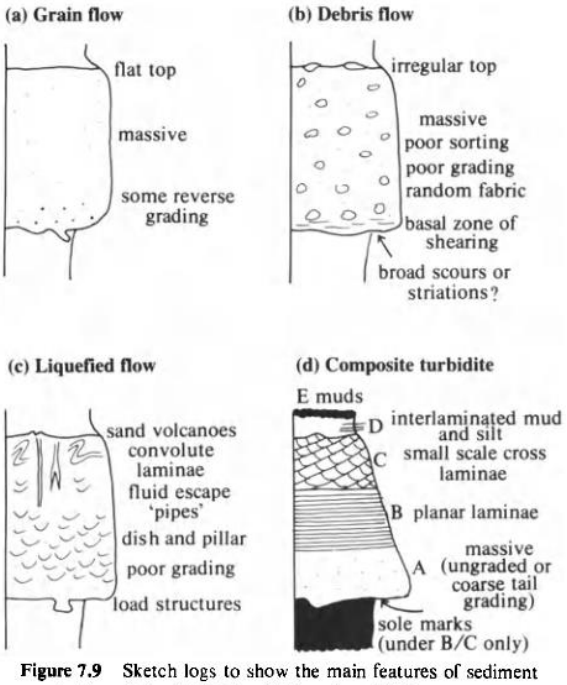
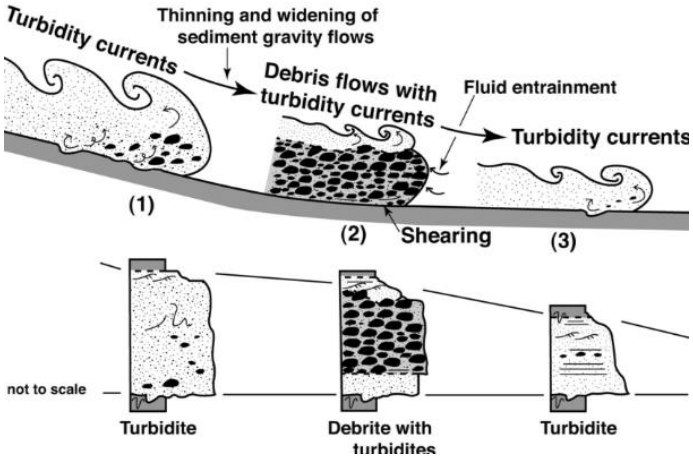


Figure 7.9 Sketch logs to show the main features of sediment gravity flows (after Middleton & Hampton 1973).



Bouma sequence is a characteristic sequence of sedimentary structures occurring in sedimentary rocks deposited in areas of deep water sedimentation by turbidity currents, which form deposits called turbidites. In theory, a complete Bouma sequence comprises sediments that fine upwards, consisting of a lowermost layer of coarse, chaotic clastic sediments deposited under conditions of high depositional energy overlain by successively finer grained and better stratified sediments like sands and muds deposited under calmer conditions that are labeled as Units A though E. In practice, however, the chaotic, high-energy nature of turbidite deposition can alter or remove underlying sediments so that incomplete sequences of sediments typically remain preserved.