Sedimentary Rocks

I. Introduction

Sedimentary Rocks are divided into two main groups:

1) Detrital Rocks - composed of detritus or mineral and rock fragments (clastics) of various sizes; and

2) Chemical Sedimentary Rocks - composed of chemical precipitants and animal by-products.

They originate at the earth's surface and are deposited at atmospheric temperatures and pressures, and lithified at low pressures and temperatures.

Sedimentary processes can be easily observed:
Sediment being moved by a stream.
Growth of a coral reef - chemical rock.

II. Clastic Rocks - Why they are studied

A. Give information on the particular sedimentary environment that the sediment was deposited in.
B. Information on climate and sea level changes.
C. Economic Importance - oil, gas, coal
D. Contain fossils - most of earth history is interpreted from sedimentary rocks.

III. Sedimentation

A. What exactly is sedimentation?

1) Sedimentation begins when transportation stops.
2) Transportation is generally downhill (under gravity).
3) Sediment settles out of water
4) Quartz and clay most common sediment.

Note: clay - a weathered silicate.

B. Chemical Sedimentation

Driving force is chemistry. Huge quantities of the chemical substances dissolved from rocks during weathering are carried off to sea.

The ocean is a huge chemical mixing tank.

Dissolved substances are brought in by rivers and rain.
Currents and waves mix these materials with ocean water.

The entry and exit of dissolved materials in the ocean is balanced.

The material that enters the ocean as dissolved substances exit as chemical and biochemical precipitates.

A variety of marine organisms form calcium carbonate shells. When the organisms die they settle on the sea floor as carbonate sediment, and later diagenetically alter into limestone.

IV. Clastic Rocks - detritus or fragments of minerals and rocks.
A. Clastic rocks are subdivided on the size of the clasts (or particles) composing them.

Particle size is the primary mechanism for distinguishing among clastic sedimentary rocks.

B. Particle size - is controlled by the strength of the currents that carry them.
It can provide useful information on the environments of deposition.

The stronger the current, the larger the particle size.

gravels	high energy - streams, beach
sand	middle to high energy - streams, beach, inner shelf
mud	low energy; quiet waters - lakes, deep ocean lagoon, swamp, basins, floodplains.

1. Gravels
deposited by currents strong enough to roll and slide pebbles, cobbles, and boulders. When these currents wane, the gravel is deposited while finer material is carried along.
An abundant supply of course material is common in rapidly flowing rivers in mountainous regions, where erosion is rapid.
indicate the existence of a steep slope or very turbulent currents
Beach gravels are deposited where ocean waves actively erode rocky shorelines.
Glaciers erode and transport gravels.
Landslides

Conglomerates - lithified gravel
If the particles are very angular they are termed a breccia
angularity or roundness is evidence of how far they were transported from the source to deposition.
angular grains implies limited transportation and erosion
Size indicates the strength of the currents
Degree of rounding indicates how far the particles traveled.

2. Sands
laid down by moderately strong currents.
Most rivers have strong enough currents to carry and deposit sand beds in their channels.
Sands can be deposited by winds as dunes.
Sands are transported and deposited by beaches and in the ocean by waves and currents. Beach sands are primarily quartz.

Lithified rock is a sandstone

Can examine *sorting* - degree of similarity of grain size - to make implications about environment of deposition.

range from poor to well sorted

greater degree of sorting - greater length of sediment transport

Can examine *rounding* - shape of sand grains - to make inferences about the length of transport.

Streams, winds, or waves round particles as they collide with other particles.

The degree of rounding indicates the distance or travel time involved in transportation of sediment by air or water currents.

Highly rounded - highly traveled.

Rounded, well sorted, quartzose sandstone traveled a great deal.
Angular, poorly sorted, feldspathic sandstone deposited near source.
Can examine mineralogy to get information on history of sandstone:
Mineral maturity can assist with environmental interpretation.

Quartz is the predominant minerals in sandstone - quartz sandstone.
Quartz is also the most prominent mineral in beach sand.
This is because quartz is the most resistant mineral to weathering at the earth's surface.
If there is a good percentage of feldspar - arkose. Arkoses usually contain mica and quartz, implying rock was underlain by a granitic terrain.
Arkoses are less weathered than quartz sandstones because they still contain feldspars.
Additional weathering transforms feldspars to clay.
Graywacke-dark rock which contains quartz, feldspar, rock fragments, and clay. Limited weathering.

Poor sorting and angular grains suggest deposited close to source.

3. Mud, Silt, Mudstone, Siltstone and Shale -

consists of silt and clay-sized particles.

The fine grained nature indicates deposition under quiescent conditions - settling from quiet, nonturbulent conditions.

e.g. lakes, flood plains, lagoons, tidal flats, and deep ocean basins.

Particles settle out of suspension.

can be carried even by the weakest currents.

settle to the bottom only when the currents stop.

deposited on the ocean some distance from the shore.

also in flood plains and lagoons.

Shale - rock composed of clay.

Composed of clay minerals.

Tends to form in thin layers called laminae.

Ability to split into thin layers -fissility.

Because of fissile nature weathers more easily to form soils

is not a cliff former.

Mud, mudstone and shales - the most abundant sedimentary rock.

V. Sedimentary Structures
a) bedforms - stratification; expressed by thickness and geometry.
Sedimentary rocks are layered rocks; strata, beds layers.
Internal Organization and Structure of bedforms:
1) graded bedding - sedimentation units marked by variations in grain size, from coarse at the base to fine at the top. - figure
2) cross bedding - is the product of the migration of sand waves; leaves planar or trough type features. Formed by wind and water.
3) ripple marks-small waves of sand that develop on the surface of a sediment layer. by the action of moving water or air. They are asymmetric.

VI. Chemical Sedimentary Rocks
classified according to their mineral composition.
limestone is the most abundant chemical rock.
A. Carbonates- Limestone - $CaCO_3$ (composed of calcite)
Warm water deposits
Quiet, clear waters

Ocean is the most important source of carbonate sediments
Seawater has abundance of
Ca^{+2} and HCO^{3-}.

calcium ion + bicarbonate calcium carbonate + hyd. ion

Sea water is fairly close to being saturated with $CaCO_3$. Several factors can affect precipitation:

1) Ca^{++} and $CO_3^{=}$ ions dissolved in river water is continually being added to the ocean.
2) Higher temperatures of water in tropic are unable to hold as high a concentration of Ca^{++} and $CO_3^{=}$ ions and precipitation takes place.
3) Biological Activity
1) $CaCO_3$ taken up by organisms. Presently found in shells of organisms.
2) $CaCO_3$ secreted by one celled animals; oysters and clams, plants (algae)

Limestone Rock Types
1. Biochemical
chalk - calcareous microfossils
fossiliferous limestone - reefs
coquina - poorly cemented shells and fragments

2. Inorganic travertine - cave deposits
micrite (muddy limestone)
3. Dolostone dolomite Dolomite $CaMg(CO_3)_2$
Magnesium from sea water substitutes for calcium. Found in older rocks where magnesium has time to replace calcium.

Other chemical sediments
Evaporites - minerals precipitate from evaporation.
halite - salt - NaCl -
gypsum - hydrous calcium sulfate
restricted circulation in isolated marine basins produces supersaturation.

B. Biological Sediments
1. Coal - starts as organic matter accumulating in swamps.
peat accumulations become lignite become bituminous coal becomes anthracite coal.
Decomposition of plant material in anoxic environments by bacteria.

VII. Turning Sediment into Rock

Lithification - the process which turns unconsolidated sediments into solid sedimentary rocks
1. Compaction-consolidation by weight of overlying material.
2. Cementation - material in solution can precipitate onto the grains and join them.
Silica, iron oxide, and calcium carbonate are common cements.

VIII. Sedimentary Environments

A sedimentary environment- is a geographic location characterized by a particular combination of environmental conditions and geological processes.
Environmental conditions include:
1) kind and amounts of water (ocean, lake, river, and land)
2) the topography (lowland, coastal plain, mountainous, shallow ocean, deep ocean)
3) biological activity (fossils).
Geological processes include:
1) nature of currents that transport;
2) deposit sediment (water, wind, ice).

Clastic Sedimentary Environments

Environment	Agent of Transportation, Deposition	Sediments
Alluvial	Rivers	Sand, gravel, mud
Lake	lake currents, waves	Sand, mud
Desert	Wind	Sand, dust
Glacial	Ice	Sand, gravel, mud
Delta	River + waves, tides	Sand, mud
Beach	Waves, tides	Quartz Sand, gravel, peat
Shallow shelf	Waves, tides	Sand, mud
Deep Sea	Oceans currents, settling	mud