Sediments (Chapter 5)

The sedimentary rock record of the ocean is very detailed, but short (only the last 180 million years or so is exposed).

Sediments: particles of organic or inorganic matter that accumulates in a loose, unconsolidated form. These particles can come from just about anywhere, including ET.

Sediments are often classified according to grain size (or particle size):
Boulder: Greater than 256 mm (or 10 inches)
Cobble: 64-256 mm (2.5-10 inches)
Pebble: 4-64 mm (1/6-2.5 inches)
Granule: 2-4 mm (1/12-1/6 inch)
Sand: 0.062 (1/16) – 2 mm
Silt: 0.004 (1/256) – 0.062 (1/16) mm
Clay: Less than 0.004 (or 1/256) mm

Most of the particles in the ocean are of the sand, silt or clay sizes.

In general, smaller particles are the easiest to transport.
Figure 5.5-Hjulstrom Diagram

Water often sorts particles, especially if it travels at a certain velocity for a period of time.

1) Well Sorted Sediments: Particles are of similar size. (ex: Beach, Dune)
2) Poorly Sorted Sediments: Particles are of varying sizes. (ex: Glacier, River)

Sediments can also be classified by source (in order of abundance):
(1891: Sir John Murray and A. F. Renard, after a Challenger expedition)

1) Terrigenous Sediments: These sediments originate from the continents from erosion, volcanism and wind transported material. These are the most abundant sediments.
2) Biogenous Sediments: These are sediments derived from critters. *These include calcareous (most skeletons) and silicious (diatoms) compositions.
3) Hydrogenous Sediments: These are minerals that have directly precipitated from seawater, such as sulfides from hydrothermal vents, materials leaching out of the MOR, or stuff from the continents in river runoff.

*Most important: Manganese and Phosphorite Nodules
*Also called authigenic sediments (formed in place, or on the spot)

4) Cosmogenous Sediments: These came from outside our planet. These include interplanetary dust and small meteoroids. Bigger stuff burns up in the atmosphere.
*Sometimes microtektites can be found: shocked glass. Most are smaller than 1.5 mm.

Distribution of Marine Sediments

Most sediments on the ocean floor come from a mixture of sediment types.

1) Continental Shelf Sediments (called neritic): consist mostly of terrigenous tuff from the continents. Comprise 15% of total marine seds. (only 9% of ocean area)
*Currents distribute biggest stuff closest to the continents and carry the fines seaward. Grading: Which is a form of sorting.
*Sorting can be disturbed by sealevel changes (tectonic or climatic), turbidites, and glacial deposits near the poles.
*These sediments always contain biological material.
2) Pelagic Sediments: from the continental slope, rise and deep-ocean floor.
*Slope and rise seds comprise 72% of the total, but only 12% ocean area
*The deep ocean floor makes up 78% of the area, but only 13% of the volume of seds.

These sediments types can then be lithified (turned to rock), and later moved by tectonics.

Examples: Mt. Everest, The Grand Canyon

3) Deep Ocean Sediments: Vary a lot by ocean.
*Atlantic: 1 km (3300 ft)
*Pacific: 0.5 km (1650 ft)
Why? - Atlantic fed by more sediment filled rivers, and the Pacific is bigger, with more destruction areas (convergence)

a) Turbidites: Graded bedded units resulting from underwater avalanches
b) Clays: 38% of the abyss is covered by clays (2 mm/1000 years)
c) Oozes (at least 30 % biogenous material, accumulating slowly, 1 – 6 cm/1000years)
    1) Calcareous: form from amoeba like forams, pteropods (drifting mollusks), coccolithophores (tiny algae). 48% Ocean Floor
    2) Silicious: Radiolarian (Tropical Pacific) and Diatoms (cold waters)

d) Hydrogenous Material: Rarely occur by themselves, typically associated with biogenous and terrigenous seds. Found in areas with slow rates of sedimentation.
    1) Manganese Nodules-found by the HMS Challenger expeditions (typically have a nucleus of shark tooth, bone, alga or crystals; and may contain other metals, such as Co, Ni, Cr, Cu, Mo, and Zn)
    2) Phosphorite Nodules-found in outer continental shelves and upper slopes of CA, Argentina and Japan and the continental rise of South Africa.
    3) Deposits of metal sulfides associated with hydrothermal vents at MOR.
    4) Evaporites-include many salts important to us. They are forming now in the Gulf of CA, the Red Dea, and the Persian Gulf. (Carbonate>>>Sulfate>>>Halite)
    5) Oolite Sands-$CaCO_3$ precipitates around shell frags/particles in critter rich waters where microscopic plants use up the CO_2.

Studying Sediments

Methods:
1) Deep-Water Cameras-first ones lowered by a cable, later used on bottom sleds or submersibles.
2) Clamshell Sampler-for shallow extractions
3) Piston Corer-for deeper ones
4) Rotary Corers-like those that drill for oil (deepest samples: 1100 m or 3600 feet long)
5) Seismic Profilers

These methods have given us knowledge about:
1) Plate Tectonic Theory
2) Evolution of different life forms
3) Paleoclimatic history of the last 100,000 years

Sediments as Historical Records
Even as early as 1899, British geologist W. J. Sollas though the seafloor deposits could reveal much of the Earth's history.

As technology allowed, the new field of ocean stratigraphy and paleooceanography were born, since a relatively uninterrupted record of Earth history (of the last 180 million years) exists on the seafloor. The records of the ocean floor have been correlated and matched with the continental records of the rocks and ice sheets of Antarctica and Greenland.