OCN 201: Shelf Sediments

Rockall Plateau
### Classification by Size

#### Table 5.1 Particle Sizes and Settling Rate in Sediment

<table>
<thead>
<tr>
<th>Type of Particle</th>
<th>Diameter</th>
<th>Settling Velocity in Still Water</th>
<th>Time to Settle 4 km (2.5 mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulder</td>
<td>&gt;256 mm (10 in.)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Cobble</td>
<td>64-256 mm (&gt;2 1/2 in.)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pebble</td>
<td>4-64 mm (1/6-2 1/2 in.)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Granule</td>
<td>2-4 mm (1/12-1/6 in.)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Sand</td>
<td>0.062-2 mm (1 in./sec)</td>
<td>2.5 cm/sec</td>
<td>1.8 days</td>
</tr>
<tr>
<td>Silt</td>
<td>0.004-0.062 mm (1/100 in./sec)</td>
<td>0.025 cm/sec</td>
<td>6 months</td>
</tr>
<tr>
<td>Clay</td>
<td>&lt;0.004 mm</td>
<td>0.00025 cm/sec</td>
<td>50 years*</td>
</tr>
</tbody>
</table>

* Though the theoretical settling time for individual clay particles is usually very long, under certain conditions clay particles in the ocean can interact chemically with seawater, clump together, and fall at a faster rate. Small biogenous particles are often compressed by organisms into fecal pellets that can fall more rapidly than would otherwise be possible. A fecal pellet is shown in Figure 5.16.
Classification by Mode of Formation

• Detrital sediments
  – Transported and deposited as particles
  – Derived from weathering of pre-existing rocks
  – Derived from igneous, metamorphic or sedimentary rocks

• Chemical sediments
  – Sediment that precipitated from solution
Terrigenous Sediment Cycle

• Land (terra) born (-genous)
• Land source **identifiable**
• Participates in sediment cycle…
  – Erosion
  – Transport
  – Deposition
  – Recycling in deep earth
Sedimentary Rocks

Sediments lithified by cementation and/or recrystallization

Detrital or Chemical
Detrital Sedimentary Rocks

- Classified by size:
  - Conglomerate: composed of boulders, cobbles and pebbles (>2mm rocks)
  - Sandstone: composed of sand (1/16 - 2 mm)
  - Siltstone: composed of silt (1/256-1/16 mm)
  - Shale: composed of clay (<1/256 mm), often organic-rich
Chemical Sedimentary Rocks

- **Limestone**: Calcite (CaCO$_3$)
- **Dolomite**: Mixed Ca, Mg carbonate
- **Evaporite Minerals**: chiefly from evaporation of seawater (NaCl, KCl, CaSO$_4$, CaCO$_3$, Borates)
Passive Margins (East USA)

- Faulted blocks of rifted continental crust
- Triassic rift valley sediments in faulted blocks
- Overlain by Jurassic marine sediments/salt
- Overlain by thick (Cretaceous and Cenozoic) sediments (on shelf, slope, & rise) which buried ancient reef
- Whole coastal plain still subsiding and accumulating
Deposition of Sediment Types in Shallow Epeiric Seas during High Sea Level Stands

- Gulf of Mexico (now relatively deep)
- Sediment from Rockies carried by Mississippi
- Overlies salt (~180 Ma)
- Weight of sediment causes domes of salt to rise, spread out and dissolve. Collapsed salt domes create “pockmarks”
Sea Level Changes: I

• Deduced from sediment packets on continental margin using seismic methods
• Use of one or two ships
• Earlier use of dynamite 😊, now use airguns 😞
• Concept of two way travel time (reflection/refraction)
Sequence Stratigraphy

- Assignment of time of deposition to sediment layers
- Objective is to establish time scales for ocean sediments
- Sediment layers can be “correlated” through “litho-” “bio-” “chrono-” or “magneto-” stratigraphy
Lithostratigraphy

• Uses identification of physical boundaries to recognize changes in geologic conditions

• Rocks of different type or character
  – Changes in chemical composition
  – Changes in texture
  – Changes in particle size
  – Changes in mineralogy
Biostratigraphy

• Based on identification of fossil species to date sediment intervals

• Presence or absence of particular “indicator” species whose extant period is known helps constrain time of deposition
  – animal fossils (forams, radiolarians)
  – plant fossils (nannos, diatoms)
  – “land” plants, pollen, etc.
Chronostratigraphy

- Based on age of materials
- Uses radiometric methods for dating

Magnetostratigraphy

- Uses magnetic signatures to obtain time information
- Based on use of magnetic reversals which are recorded in sediment
- Was key in supporting seafloor spreading hypothesis (when applied to seafloor rocks)
Stable Isotope Stratigraphy

- Uses variations in stable isotope composition (often O, C, Sr) to infer changes in:
  - Temperature
  - Weathering rates
  - Sources of materials in sediments
  - Used extensively for Pleistocene (<1.8 Ma) sediments

- Pleistocene sediments deposition patterns reflect record of climate change
  - Latter is evidenced by changes in deposition rates or chemical signatures of the sediments (δ¹⁸O: Ice volume; Sr/Ca: Temperature; Cd/Ca: Upwelling/Productivity)
Sea Level Changes: II

- **Transgression:**
  Progressive flooding of land, high sea level stand

- **Regression:**
  Progressive draining of land, low sea level stand
Sea Level Changes: II

- Transgression: Progressive flooding of land
- Regression: Progressive draining of land
Sea Level Change

• Local causes
  – Water in motion
  – Storm surges, wind driven, currents along shoreline
  – Tectonic uplift or subsidence

• Global causes (eustatic)
  – Change in ice volume on continents
  – Change in mean seafloor spreading rate (fast = younger seafloor, sea level rises, slow = older seafloor, sea level falls)
  – Change in mean ocean T

Q: Would melting of Arctic ice cause a change in sea level?
Sea Level Summary

- Sea level is rising
  - Sea level fell sharply from about 30Ka to ~18 Ka
  - Sea level has been rising steeply for the past 18Ka (evidence from drowned reefs)
  - Eustatic sea level has risen about 20 cm over past century, largely due to melting of glacial ice
  - There is also a local effect of Hawaiian geology on the relative sea level rises of our islands.
Sea Level in Hawaii

- Two causes:
  - Local: Hawaiian Arch
  - Eustatic: overall sea level rise

Every island has its own rate of sea-level rise

As the Pacific Plate moves, every island rides over the bulge causing uplift

The young Big Island is so heavy it bends the lithosphere

Source: NOAA tide gauge network
Effect of Sea Level on Coasts: I
Effects of Sea Level on Low Areas

- Rise of only a few 10’s of cm can be quite critical
- Pacific Atolls (e.g., Marshall, Micronesia, Tuamotu)
- Indian Ocean (e.g., Maldives… background picture)
- Also important for low continental areas (Fla, Tx)
Effect of Sea Level on Coasts: II

Low sea level at about 18 Ka increased dry land (fr. reef banks and continental shelf) as much as 200 km seaward

Future sea level will rise up to 60-70 m if Antarctic, Greenland (and other continental) ice sheets melt. This will flood the relict reef platform and continental shelf of the SE USA
Sediment plume from the Amazon delta
Erosion, Transport, and Deposition of Sediment: Hjulstrom’s Curve

- Faster currents are necessary to transport larger particles.
- Mid-sized particles (sand) are eroded more readily than either finer or coarser particles (cohesion vs gravity).