Sediments ...

- are unconsolidated particulate materials that either precipitate from or are deposited by a fluid (e.g., water, wind);
- provide information about the past depositional environments and climatic and tectonic conditions;
- corroborate inferences from such other data as marine magnetic anomalies; and
- are important in terms of resources (e.g., sand, hydrate gel).
Ages of the oldest sediments based on the DSDP data

- DSDP drilling sites

- Bonin Trough
- Mariana Trench

- Jurassic and older?

- 136 Ma
- 110 Ma

- More than 136 Ma up to the Mariana Trench

- Early Cretaceous
- Middle Cretaceous
- Late Cretaceous

- Oligocene
- Miocene
- Pliocene

- East Pacific Rise
Five primary factors control the distribution of sediments in the oceans:

- Age of the underlying crust
- Tectonic history of the ocean crust
- Structural trends in basement
- Nature and location of sediment source, and
- The nature of the sedimentary processes delivering sediments to depocenters
Total Sediment Thickness of the World's Oceans & Marginal Seas

http://www.ngdc.noaa.gov/mgg/sedthick/sedthick.html

Thicknese in meters
Sediments are classified based on ...

- **particle size**
- **origin**
  - terrigenous or land-derived sediments are neritic
  - Pelagic (or underwater sediments) can be
    - biogenous (they form from the organic debris),
    - hydrogenous (precipitates or evaporates) and
    - cosmogenous

<table>
<thead>
<tr>
<th>Wentworth Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grain diameter</strong></td>
</tr>
<tr>
<td>Boulder</td>
</tr>
<tr>
<td>Cobble</td>
</tr>
<tr>
<td>Pebble</td>
</tr>
<tr>
<td>Granule</td>
</tr>
<tr>
<td>Coarse</td>
</tr>
<tr>
<td>Medium</td>
</tr>
<tr>
<td>Fine</td>
</tr>
<tr>
<td>Silt</td>
</tr>
<tr>
<td>Clay</td>
</tr>
<tr>
<td>Type/Source</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td><strong>Terrigenous</strong></td>
</tr>
<tr>
<td><strong>Biogenous</strong></td>
</tr>
<tr>
<td><strong>Hydrogenous</strong></td>
</tr>
<tr>
<td>(a) Precipitate</td>
</tr>
<tr>
<td><strong>Cosmogenous</strong></td>
</tr>
</tbody>
</table>
Perspective is looking northeast from the Pacific Ocean towards Los Angeles and Palos Verdes.

http://walrus.wr.usgs.gov/pacmaps/la_pers2.html
The world distribution of continental rises ( ) and deep sea trenches ( )
The Grand Canyon of the Colorado River

The Monterey Submarine Canyon

Adapted from
F.P. Shepard: Submarine Geology
(Harper & Row, New York, 1973)
In this image, the viewer has been positioned to the west of the image at an elevation angle of 25° above the ocean (65° from directly above). The topographic relationships between the on-land mountains, ocean shelf, slope and basin are easily seen in this image.
This is the same as the previous image, but with color coded bathymetry.
The beach material is typically classified according to diameter.

- **Boulder**: $2^7 - 2^8$ mm
- **Cobble**: $2^5 - 2^6$ mm
- **Pebble**: $2^2 - 2^4$ mm
- **Granule**: $2^1$ mm
- **Sand**: $2^{-4} - 2^0$ mm
- **Silt**: $2^{-8} - 2^{-4}$ mm
- **Clay**: $2^{-9} - 2^{-12}$ mm

The beach material is typically classified according to diameter.
### Distribution and thickness of world’s sediments

<table>
<thead>
<tr>
<th>Physiographic Province</th>
<th>Proportion of Earth’s surface area</th>
<th>Proportion of total sediment volume</th>
<th>Average sediment thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continents</td>
<td>29%</td>
<td>8%</td>
<td>0.3 Km</td>
</tr>
<tr>
<td>Continental Margins (shelves, slopes, rises)</td>
<td>14%</td>
<td>80%</td>
<td>7.5 Km</td>
</tr>
<tr>
<td>Deep Sea Floor</td>
<td>56%</td>
<td>12%</td>
<td>0.2 Km</td>
</tr>
</tbody>
</table>
Many 'beaches' do not consist of sand but of pebbles or boulders, sometimes with sandy beaches in between. The coarse material here often originates from a fast flowing river nearby. Since pebbles do not move as easily as sand, pebble beaches occur only close to the origin of their material (a river). Only fast water movements in excess of 1m/s are capable of moving pebbles, so pebble beaches form only along very exposed shores. The reason that they are not topped over by sand, is that pebbles are capable of staying put much better than sand, resisting the wave's back-wash much better. As a result, they form steep beaches with strong back wash, too strong for sand to settle out. So the sand remains at the foot of the pebble beach. However, in less exposed places, the process reverses, allowing sand to lay over a deeper bed of pebbles. As a result one may find sand and pebble beaches seemingly 'alternating'. Note that pebbles laying on top of the sand, prevent the formation of dunes.

The picture on the right is that of the Goat Island beach near Leigh, New Zealand. It is a wet beach, located in the shelter of Goat Island (top left) at the base of steep cliffs. There are no dunes here.

The most beautiful and most popular beaches are the soft white coral sand beaches typically found within the National Park on St. John's north shore. Sand beaches like these are found in areas where the water off-shore is relatively shallow, the depth drops off gradually and the coral reefs and headlands are strategically located.

Another type of beach is the cobblestone beach. These are also found where there is deeper reef and higher wave action, but, due to the dynamics of the placement of coral reefs and direction of the incoming waves, coral rubble is not washed ashore. These beaches are covered by rocks that originally came from land and have been broken down, rounded and polished by the continual action of waves. Examples of cobblestone beaches are Great Lameshur Bay, Klein Bay and the beautiful Blue Cobblestone Beach, which you pass through if you walk the Ram Head Trail.
General Sediment Distribution Patterns

Terrigenous deposits:
- Continental margins
- Glacial deposits
- Clays

Biogenous deposits:
- Calcareous oozes
- Siliceous radiolarian oozes
- Siliceous diatom oozes

H Hydrogenous deposits also present
Distribution of sediment types in the world ocean

http://bell.mma.edu/~jbouch/UWMarineGeology/McDuffSediments.html
Continental margins (shelf, slope and rise) carry most (~80%) of the world’s sediments that tend to be …

- fine-grained and well-sorted in the tropics;
- mostly sand at the 30°N and 30°S latitudes; and
- coarse-grained and ill-sorted at the polar latitudes.

<table>
<thead>
<tr>
<th>Fraction of total area</th>
<th>Fraction of all sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continents</td>
<td>29%</td>
</tr>
<tr>
<td>Oceans:</td>
<td></td>
</tr>
<tr>
<td>Continental margins</td>
<td>14%</td>
</tr>
<tr>
<td>(shelf, slope and rise)</td>
<td></td>
</tr>
<tr>
<td>Abyssal sea floor</td>
<td>56%</td>
</tr>
</tbody>
</table>
Sediments of the continental margins

Relative amount of the sediment-type

0% 30% 60% Latitude

Sand

Coral debris

Silt and clay

Rock and gravel

Shell fragments
Hydrate deposits are also found on the continental margins.
Deep ocean sediments comprise

- **biogenic oozes**
  - siliceous oozes that mainly form from diatoms and radiolaria, and
  - calcareous oozes (e.g., form from coccolithophores and foraminifera) below the carbonate compensation depth (CCD); and

- abyssal clays that are often wind-transported, particularly in the tropical oceans.
Topography of the calcium carbonate compensation depth (CCD), i.e., the depth in km below which calcium carbonate is completely dissolved.
Sahara Desert, Africa

Dull opaque surfaces due to erosion from high speed winds. Desert sands tend to have a wider assortment of grain sizes. On the other hand, sand found near water has its sediments constantly sifted, thus depositing grains that are nearly the same size.
Current velocity and grain size determine erosion, transportation and deposition of sediments.
Punalulu, Hawaii

The sand of Hawaii's black beaches is obsidian - volcanic glass created by magma that flowed to the sea and then cooled rapidly. It was eventually reduced to bits of fine black sand by water and waves.
Lifuka Island, Tonga, SW Pacific

Remains of tiny sea animals called crinoids (sea lily) make up part of the sand in this area of the South Pacific. These stony disks which are calcified, wheel-like plates, fall in large numbers to the bottom of the ocean.
Seven Mile Beach, Dongara, Australia

This area, teeming with life from the Indian Ocean, reveals many small corals and shells. In addition, this sand is predominantly made up of some very immature bivalve shells. Most unusual however, are the three-axial, icicle-like sponge points.
Ryukyu Islands, Japan

Some of the southern Japanese islands are famous for their beautiful "star sand." These grains are the shells of microscopic, single-celled animals that are found in abundance throughout our oceans.
Saint-Tropez, French Riviera

The reefs along this shoreline support many different animals whose shells are tossed onto the beach by the waves. This sample shows cone-like mollusks, and tubular mollusks. Below these you can see the horn of a marine ram. You can also see some black and gold mica crystals along with a sponge or sea-urchin spine.
The distribution of various kinds of seafloor sediments

http://www.unf.edu/~gmead/ocbasins/marseds.htm