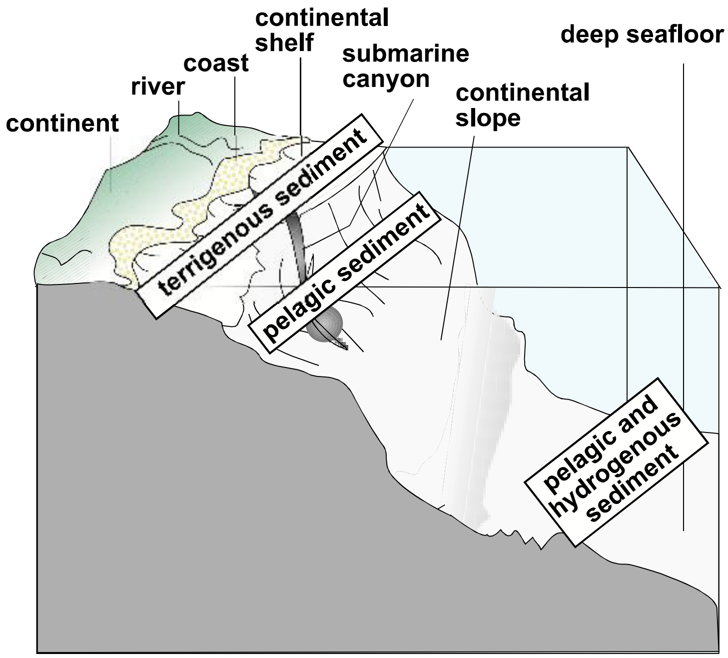
Introduction: Ocean Sediment—Blanketing the Ocean's Floor

If you were to begin walking from your nearby shore and out into the ocean or gulf, your feet would feel a blanket of **sediment** composed of particles from the land, the atmosphere, and the sea. Many of these particles are the remains of once-living organisms. Geological oceanographers have discovered three distinct types of sediment, or deposits, that line the shore and ocean floor: **terrigenous sediment**, **pelagic sediment**, and **hydrogenous sediment**. These three different types of sediment are classified according to their source—where the sediment comes from—and the materials from which they are composed.



Terrigenous Sediment: Building and Covering the Shores and Beaches

Composed of rock or gravel particles, sand, and mud, *terrigenous sediments* build and cover our shores, beaches, and the ocean floor closest to land. Terrigenous sediment comes mostly from the erosion and weathering of land. A lesser amount comes from the activity of land volcanoes. Rivers then carry the sediment to shores, beaches, and the sea. Rivers and the force of waves leave most of these deposits on the continental shelf—near the shore and the mouths of rivers. Beaches form when more sediment is deposited on the shores than is washed away by the action of the waves, tides, and currents.

Terrigenous sediments come in many different sizes, but three sizes are most common and form three different types of beaches. The *rock particles* forming rocky beaches are the largest; *sand particles*, composing sandy beaches, are medium-sized; and *mud*, the smallest particles, form muddy beaches. If you see a rocky beach, you can be reasonably certain that the nearby land also has resistant rocks. Similarly, if you see a sandy beach—quite common in Florida—you can expect the surrounding land to be covered by rocks, such as **quartz**, **feldspar**, and *limestone*, that break down into sand. If you see a muddy beach, the surrounding land will most likely be muddy also.

Rocky Beaches: West Coast Beaches

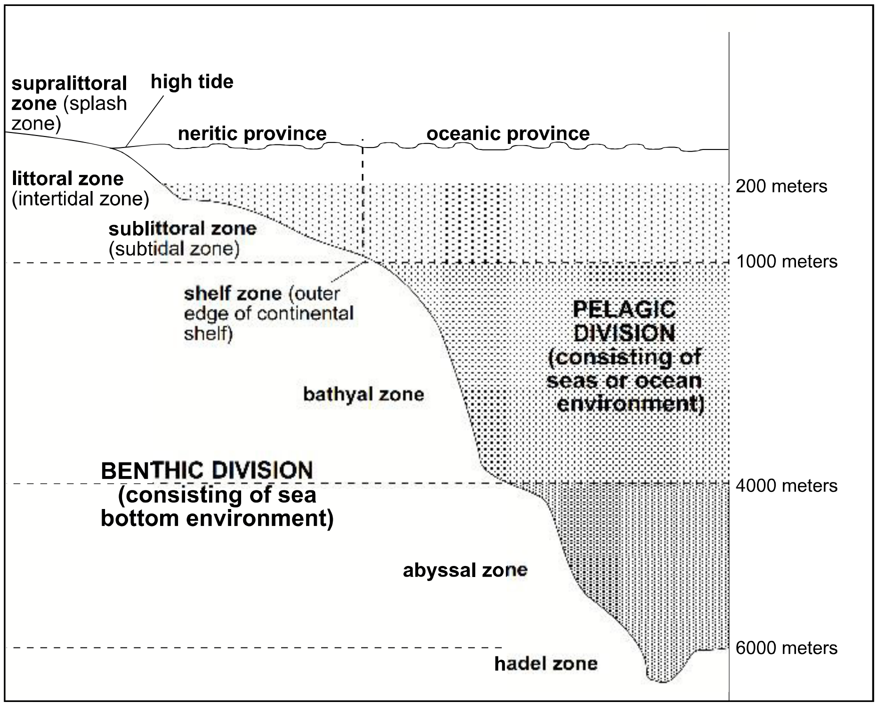
Rocky beaches may be composed of large boulders, medium-sized rocks, or small gravel-sized particles.

Rocky beaches may be composed of large boulders, medium-sized rocks, small gravel-sized particles, or even smaller-sized granules. The beaches on the West Coast of the United States are much rockier than the beaches along the Florida coast. A famous rocky beach is Pebble Beach in California. At Pebble Beach you can see egg-sized smooth rocks that have been carried down from the mountains by fast-moving waters. When you see rocky beaches, you can assume that this *heavier* sediment was carried by forceful waters. Other rocky beaches are common in Alaska and western Canada, as well as in parts of the northeastern United States, such as Maine.

Zones. Zones contain a variety of environments that oceanographers have classified into three major zones: supralittoral, littoral, and sublittoral. (*Littoral* means pertaining to the shore of a lake, sea, or ocean.) Because each zone has its own unique characteristics and environment, certain types of organisms survive and breed in each one.

On a rocky shore, rocks, cracks, and crevices provide shelter for organisms, and circulating water carries oxygen and food particles for their survival. Rocky shores have a higher **permeability**—water passes quickly and easily through the spaces between the sediment particles. This higher permeability allows wave action to wash smaller sediments out to sea. These rocky areas between the land and the ocean are considered **transitional zones** because they are a place where land and ocean meet.

The first zone is the *supralittoral zone*, or high-tide zone, which is very dry. Water only reaches this area at very high tides or when strong waves splash it. (Sometimes this area is called the *splash zone*.) Plants and animals must be very sturdy to **tolerate** this zone, which goes from rushing water to extreme, drying sun. Most organisms in this area attach themselves to rocks and can withstand being dry for long periods of time. The most common animal in the splash zone is the periwinkle snail. Algae and other marine plants are also found here. The algae are dark and crusty and form a line at the high-tide level. This black algae line marks the usual high-tide line on rocky shores all over the world.



zones of the marine environment

Below this zone is the *littoral zone*, or normal intertidal zone. This area is constantly being covered and uncovered by the tides. Animals here must also be able to withstand drying out, but for shorter periods of time. Organisms in this zone need a shell or attachment to survive waves pounding the rocky surface. Barnacles, sea urchins, and flexible algae are common inhabitants of the littoral zone.

The *sublittoral zone*, or low-tide zone, remains under water and is a less harsh and demanding environment than the other zones. It is also called the *subtidal zone*. A variety of plants and animals such as sea palms, algae, starfish, and barnacles are common in this zone. Many fish and other animals, such as sea otters and seals or sea lions, feed on the organisms in this low-tide zone.

Characteristics of Rocky Beaches			
Environmental Conditions	**Description**	**Marine Life**	**Location Examples**
wave action transitional zone good circulation abundant food, shelter, and oxygen	hard surfaces cracks and crevices hiding places exposed areas	most attach to rocks periwinkle snail barnacles starfish sea urchins algae sea palms	beaches in Monterey Bay, California Maine Hawaii most Pacific beaches

Sandy Beaches: Florida Beaches

The **composition** of sandy beaches varies according to the local environment. Hawaii, for example, has black sand beaches composed of **lava** particles that erupted from volcanoes when the islands were formed. Other sandy beaches may be composed of the remains of once-living organisms. Many beaches in the Caribbean, for example, are composed of small particles of coral skeletons. These coral sand beaches may be colored pink or yellow, depending on the type of coral. Other beaches, such as those in southeastern Florida, are composed of sand and small shell fragments.

In most of the United States, the beach sand is made up of *quartz* and *feldspar*—the two most common minerals on Earth. White sand beaches, like those on the northern coasts of Florida along the Gulf of Mexico, contain only these minerals and do not contain any other minerals or impurities that darken the color.

Sand can be very coarse to very fine. Sand has a fairly high degree of **porosity**—or a large amount of pore space—lots of room—between sediment particles. Water, therefore, circulates between the sand particles, providing plenty of oxygen for organisms to survive.

Like rocky shores, sandy beaches experience wave action. The force of the waves determines the size of sand particles found on the beach. In the winter, when the waves are stronger on many shores, many of the smaller grains of sand on the beach are washed away. This sand is then replaced in the spring and summer when the wave action lessens. The waves are constantly moving the sand particles underneath them. You can feel this grinding action if you stand in the surf area as the waves wash particles of sand past your feet. The larger the particle, the less chance the wave action will erode the beach.

Animals that live on sandy beaches must be able to tolerate, or withstand, this force. Many of these animals have shells to protect their soft bodies or are streamlined to move with the waves. All sand **dwellers** must be able to move with the sand or burrow back into it. These actions keep the organisms from being torn up or washed away by the friction of the sand. Clams, worms, crabs, and sand dollars are common animals on sandy beaches. Many other slow-moving or attached animals sometimes wash up on sandy beaches because of the wave action. Shoal grass is also common in offshore sandy areas.

A sandy beach has three zones like those on a rocky shore. The supralittoral zone, or *high-tide zone*, is very dry, and few animals can survive there. The littoral zone, or normal *intertidal zone*, is very harsh with frequent wave action followed by drying. The sublittoral zone, or *low-tide zone*, is less harsh and provides constant protection for young fish and other soft-bodied animals.

Characteristics of Sandy Beaches

Environmental Conditions	Description	Marine Life	Location Examples
oxygen good circulation regular wave action grinding motion	lava sand coral sand feldspar quartz loosely packed	hard-shelled or streamlined must burrow or move with sand clams crabs worms sand dollars shoal grass	beaches in Hilton Head, South Carolina Panama City, Florida most Atlantic beaches

Muddy Shores: Marked by Their Distinct Smell

Mud is formed when tiny particles of sediment settle in areas of resting water with little or no wave action. The lack of wave action makes mud flats quiet and stable environments. Because of its small particle size, mud is tightly packed and very little oxygen circulates through the particles. Bacteria present in mud flats do not require oxygen. These bacteria help break down decaying plants and animals. However, in doing so, they produce hydrogen sulfide gas, which smells like rotten eggs. These bacteria make mud a very nutrient-rich sediment.

Animals that live in this unique environment must be very well adapted. They usually live on or very near the surface so that they can get oxygen. Most of these animals have special gill systems to prevent the small, tightly packed mud particles from clogging respiratory systems. Some mud dwellers must create currents that bring oxygen and water into their burrows.

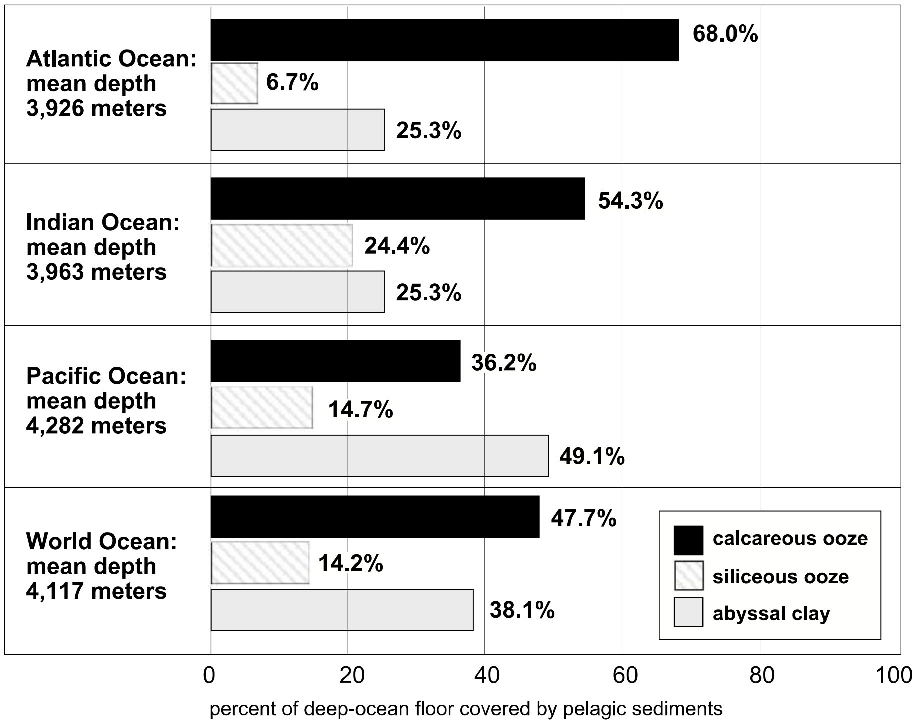
Eel grass, turtle grass, and other grasses are common in muddy areas. The roots of these plants trap particles of mud that build up in these environments. As the area fills in, it is exposed to the sunlight and begins to dry up. Over time, these changes may turn a mud environment into a dry-land environment.

Characteristics of Muddy Shores			
Environmental Conditions	**Description**	**Marine Life**	**Location Examples**
little oxygen no circulation no wave action quiet area stable soft	fine particles soft tightly packed	special gill systems worms clams bacteria eel grass turtle grass	coastal areas with large estuaries Chesapeake Bay Apalachicola, Florida

Pelagic Sediments: The Ocean-Floor Blanket

Pelagic sediment covers most of the deep-ocean floor where terrigenous sediments cannot reach. The two main types of pelagic sediment are **clay** and **ooze**. Pelagic deposits range in thickness from 60 meters to 3,330 meters. They are thickest in zones of upwelling.

Ooze on the Ocean Basin Floor



Clay is composed of very tiny particles. Some of these particles are blown from land and fall from the atmosphere out at sea. Other pelagic clay includes dust from volcanic eruptions. These inorganic red clay deposits cover 38 percent of the ocean bottom. In some parts of the ocean floor, the clay is hundreds of feet thick. Scientists study these clay deposits to learn about ancient weather and the effects of past volcanoes and meteorites.

Pelagic *ooze* comes from the **organic** remains of tiny plants and animals that once floated near the surface of the ocean. This material was once living and may contain small microscopic fossils. There are two types of ooze. The most abundant type comes from animals that had shells made of calcium. This *calcareous* ooze covers 48 percent of the ocean floor and is mostly associated with warmer, shallow waters. *Siliceous* ooze comes from the remains of animals and plants that had glass-like shells composed of silica. The remains of these silicon-shelled organisms cover 14 percent of the ocean floor and are mostly associated with colder, deep waters.

Hydrogenous Sediments: The Bed of Minerals

Scientists are just discovering a variety of different types of hydrogenous sediments on the deep-ocean floor on places where pelagic sediments typically do not accumulate. *Hydrogenous* means "derived from sea water." These deposits are formed from a chemical action within seawater. Some of these deposits are too difficult and, therefore, expensive to gather, and so their use by industry has been limited. Other deposits have too low a concentration of minerals and so are not yet valuable to industry. *Phosphorite* is one example of a valuable hydrogenous sediment found in high concentration on the ocean floor. Phosphorous is used to produce phosphates—a key ingredient used in fertilizer and the production of other chemicals. As our mineral supplies on land decrease, industry will direct more effort towards extracting these deposits from sediments.

Manganese nodules, lumps of the mineral manganese, are the best known of the hydrogenous deposits. They contain manganese and iron with smaller amounts of nickel, copper, cobalt, and aluminum. Researchers estimate that over one billion tons of these nodules are sitting on the seafloor, mostly in the Pacific Ocean. Because this mineral lies over 3,200 meters down, extracting it is not yet practical. One machine being developed to collect these nodules functions like a giant vacuum cleaner that sucks them up from the sea bed.

Summary

The ocean's floor is blanketed by s*ediment*—particles from the land, atmosphere, and the sea, and often from the remains of once-living organisms. Scientists classify sediment according to its source and where it is deposited. Different kinds of sediment support different organisms. Wave action continually moves sediment onto and off of coastal areas, often sweeping smaller particles away and leaving larger ones. Where there is no or little wave action, mud accumulates.

The composition of sandy beaches varies according to the local environment.