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Coasts
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River Deltas

Except for coasts that are dominated by glaciers, most of the sand and mud that is contained in the coastal zone arrived at the coast via a river system. These river-borne sediments are transported to different coastal and marine depositional environments depending upon their size (mass) and the strength of the transporting currents. They may be carried out into deep water and never become involved in the coastal zone, they may be transported along the coast and incorporated in various coastal depositional environments, or they may accumulate at or near the mouth of the river in the form of a delta (Fig. 5.1), the topic of this chapter.

The first known application of the Greek letter delta (Δ) for the accumulation of sediment at the mouth a river was by Herodotus in the fifth century B.C. in connection with the Nile River in Egypt. Our detailed knowledge of deltas as a geologic entity has been acquired in a fairly short time, all within the twentieth century. The first significant mention of the deltas was by G. K. Gilbert (1885) in his famous studies for the U.S. Geological Survey on Lake Bonneville, the present reduced version of which is the Great Salt Lake. It is from his work that the terms *topset, foreset,* and *bottomset* for the parts of the delta were first applied. Up until H. N. Fisk began his extensive work on the Mississippi Delta in the 1940s, there were only two or three additional studies of modern river deltas. The work of Fisk and his colleagues, along with the newly recognized importance of deltas as oil and gas producers, stimulated a great deal of research by the petroleum industry beginning in the 1950s. This started on the Mississippi and moved to the Niger in Africa and the Orinoco in Venezuela—all important oil-producing deltas. Unfortunately, because of the great wealth of information on the Mississippi Delta, it became considered a representative delta

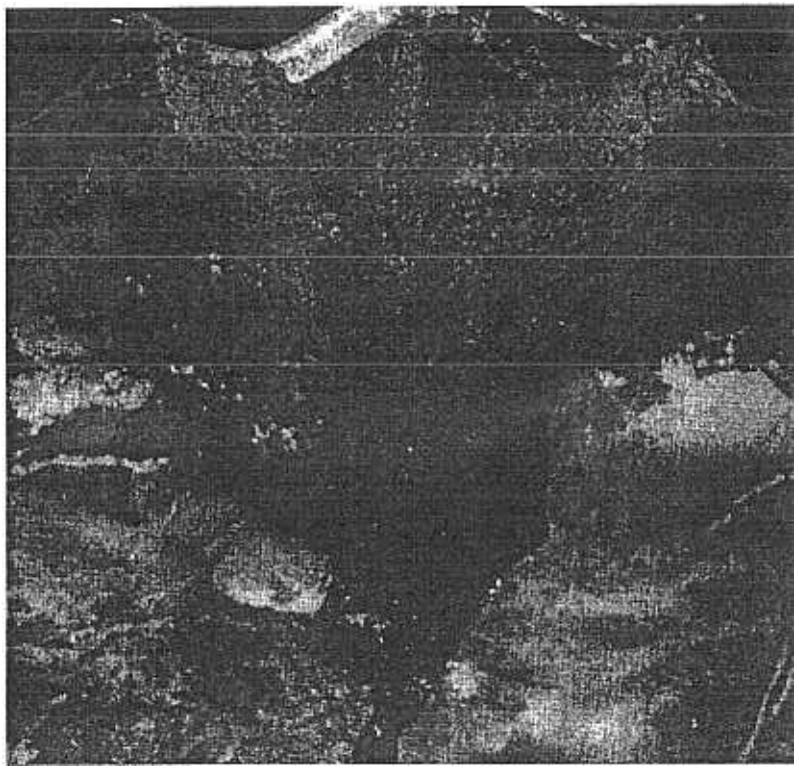

FIGURE 5.1
Satellite photo of the Nile Delta showing the generally triangular shape (Courtesy of EROS Data Center)

for global interpretations. In fact, however, the Mississippi is an end member and essentially one of a kind. We will consider this further in the section on delta classification.

The accumulation of sediments in riverine deltas may be quite temporary or may be permanent. Considerable interaction exists between the riverine processes of sedimentation with those of the open marine system, especially waves, longshore currents, and tidal currents. The interaction of these processes, along with the sediment load of the river and the physical setting at and near the river mouth, determine the presence and the nature of the delta. The first and foremost requirement for the formation of a delta is the delivery of sediment in excess of what is removed and redistributed by waves and currents. This varies greatly from location to location. Places characterized by large waves and/or strong tidal currents require considerably more sediment than those locations in which waves and tidal range are small. The other important variable is the phys-

iography of the continental margin adjacent to the coast. The sediments carried to the coast by the river must have a place on which to accumulate if a significant delta is to be built.

Plate tectonic history and the regional geologic setting are quite important in the development of river deltas (Fig. 5.2). Trailing edge or passive margins are conducive to delta development whereas leading edges or active margins are not. Extensive drainage basins typically form in areas in which there is little relief and no major obstacles such as mountain ranges blocking the path to the coast. Consider, for example, the Mississippi River drainage system in the United States and the Amazon River complex in South America. The Mississippi actually includes the Missouri and Ohio river systems and represents a collection of surface water and sediments from most of the area between the divides of the Rocky Mountains and the Appalachian Mountains, more than half of the country. The Amazon River system drains most of South America with the divide in the Andes on the western side of the continent being the western boundary. Both of these river systems drain huge, relatively stable continental regions and debouch onto a stable, trailing edge margin with a broad, relatively gently sloping continental shelf, a setting highly suitable for deltas to develop.

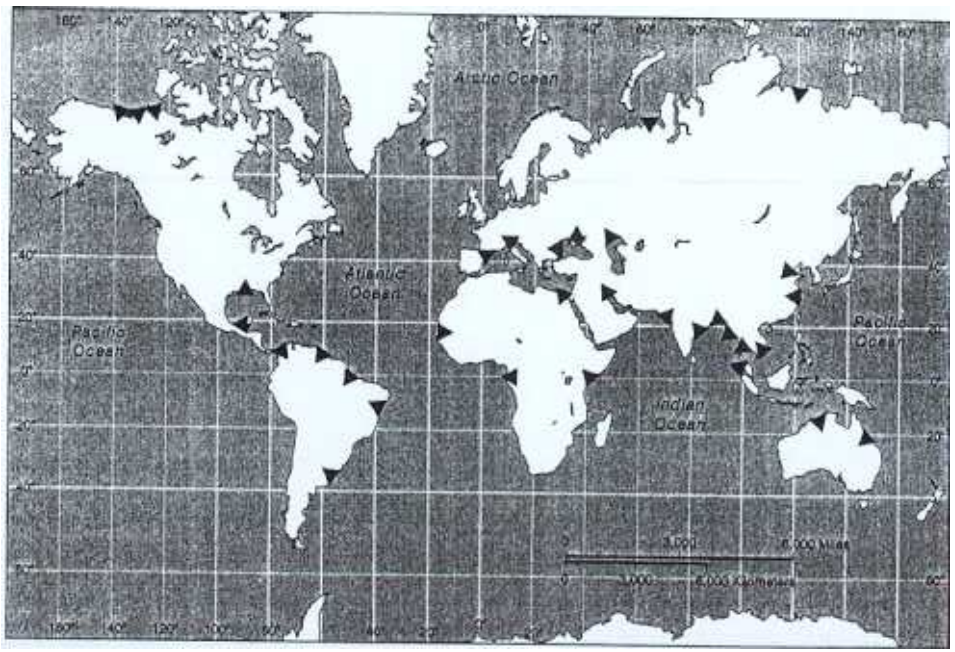

FIGURE 5.2
Map showing the global distribution of major deltas.

Marginal sea coasts also are well suited for delta formation. The Yangtze and Wang Ho rivers of China form large deltas along the South China Sea. Other examples of similar settings where deltas have developed include the North coast of Alaska and the North coast of the Mediterranean Sea.

By contrast, there are no really large river systems and therefore, large deltas, on the western margins of North or South America (Fig. 5.2). These leading edge, active margins are adjacent to high relief, mountainous areas with nearby divides. The result is that drainage systems are quite limited in their geographic extent, and many of the rivers drain terrain that has thin soil cover. These conditions do not produce enough sediment at the mouths of the rivers to form a delta. Additionally, there is no significant, gently sloping, continental shelf on which the deltaic material can accumulate. Another factor that inhibits delta development is the narrow, steep continental shelf that permits large waves to reach the coast with little attenuation. These waves remove and redistribute sediment brought to the coast by rivers. In summary, large deltas, with rare exceptions, can only develop on trailing edge coasts because it is there that abundant sediment, proper site for accumulation, and appropriate physical conditions for their maintenance exist. Global distribution of the major deltas shows this relationship with plate tectonics quite well (Fig. 5.2). There are none around the Pacific except those in China that border marginal seas. There are also some prominent trailing edge coasts that lack significant deltas. A good example is the Atlantic coast of North America where rivers typically empty into estuaries and do not carry their sediment load to the open coast.

DELTAS AND SEA LEVEL

The deltas of the present coastal system are geologically quite young. The individual deltaic systems tend to be from a few thousand to hundreds of thousands of years old but the presently active deltaic lobe may be much younger. Deltas depend upon rivers for their existence. River discharge is related, in part, to sea level, and the site of the deltaic accumulation is also related to sea level. Because of these factors, we must consider the role of sea level in the formation and maintenance of deltas.

When there were extensive glaciers, and sea level was much lower than it is now, large rivers were flowing across what is now the continental shelf, dumping their sediment load at near the shelf edge. This resulted in extensive turbid currents and other sediment gravity processes carrying most of the sediment load to the continental rise where it accumulated in thick wedge-like de-

posits. Deltas were not actively being formed, and previously existing deltas near the present position of the coast were being bypassed as rivers flowed across the shelf.

Melting glaciers caused rapid rising sea levels, and the river mouth essentially retreated across the shelf without time for deltas to accumulate. When sea level rise slowed down about 6000 to 7000 years ago, deltas began to develop because there was time enough for large quantities of sediment to accumulate without being dispersed by waves or tidal currents. This is not to say that all deltas are only a few thousand years old. Some have been around for millions of years. These old deltas have not been continuously active because of their abandonment by the shoreline as it moved. The Mississippi Delta and the Niger Delta in Africa are good examples. Both of these present deltas are underlaid by ancestral deltas that are at least 10 million years old.

In the case of the Mississippi Delta, the Holocene portion is only 5000 to 6000 years old but it consists of 16 recognizable lobes. Different lobes are formed when the focus of river deposition shifts due to channel switching, avulsion, or other natural causes. These 16 lobes can be lumped into only a few (Fig. 5.3) based upon radiocarbon dating and location. The present lobe began to form about 600 years ago, not much before the discovery of the New World by Columbus, and the most active portion has developed since the settlement of New Orleans by European settlers (Fig. 5.3). In fact, about one-half of the State of Louisiana has been formed by the Mississippi River during only the past 6000 years.

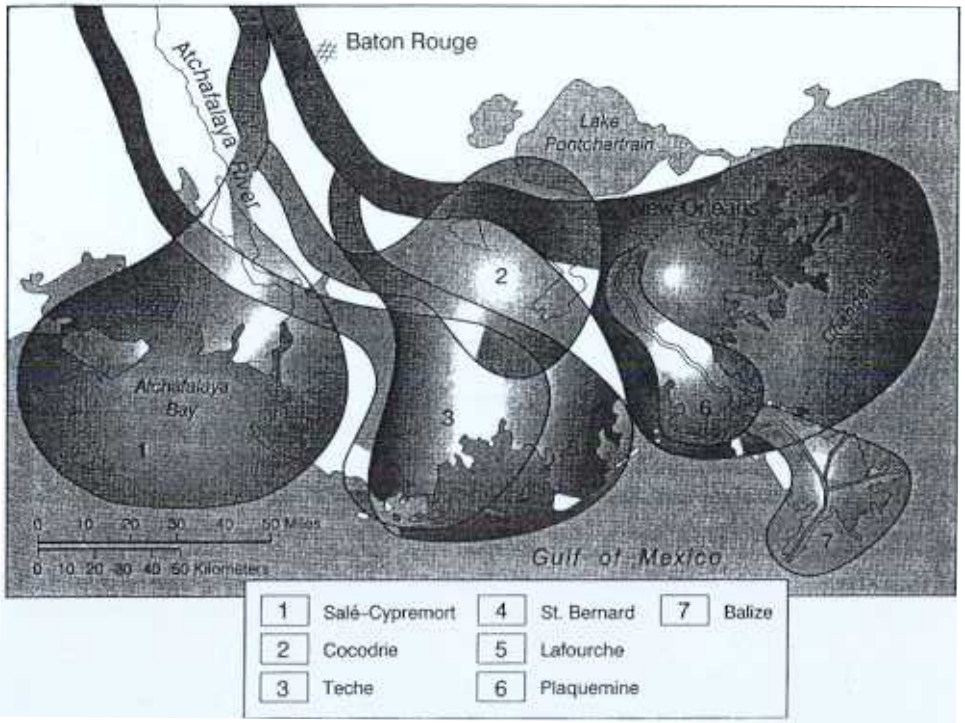

FIGURE 5.3
Holocene deltaic lobes in the Mississippi Delta showing the large number of shifting positions of sediment discharge into the Gulf of Mexico.