Part 2
COASTAL SEDIMENT PROBLEMS

Chapter 9

RECENT GEOLOGY OF COASTAL LOUISIANA

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Recent, in a technical geological sense, refers to the latest episode of geological time. Definitions vary. Northern European geologists are likely to refer to about the last 10,000 years for the reason that only the sedimentary deposits of such an interval are available for study. Geologists in the United States commonly regard the Recent as a post-glacial period of somewhat longer duration. Studies of materials containing the carbon isotope, C^{14}, are resulting in time determinations in years. Louisiana geologists define Recent as that period of time during which sea level made its last general rise. This may have lasted about 30,000 years. Sedimentary layers deposited during that period are regarded as Recent in age.

The contact between Recent and pre-Recent sedimentary rocks is a distinct and sharp break along the Louisiana Gulf Coast. Offshore, on the continental shelf, and beneath coastal marshes, the Recent is underlain by a reddish oxidized layer of variable thickness. Cores from wells pass from Recent layers of dark and reduced silts, clays, and peats, with minor amounts of coarser sediments, directly into the oxidized zone at the top of the pre-Recent materials upon which they rest. The organic content of the Recent is comparatively high, whereas that of the pre-Recent is much lower. Basal gravels occur inland at various places but are ordinarily absent offshore. The most reliable criterion for determining the uppermost pre-Recent deposits is the oxidized zone at their top. Oxidation developed as a result of exposure to the atmosphere during a time of greatly lowered sea level.

The Recent and pre-Recent are separated farther inland by a topographic break. Recent alluvium fills valleys cut in pre-Recent materials. Toward the coast the pre-Recent deposits incline gently under the Recent. The "Prairie" lands of southern Louisiana are pre-Recent in age. Their surface inclines beneath Recent marsh deposits in the coastal area. The contact dips at rates as low as 3 inches per mile. It is considerably steeper in some areas and shows sharp offsets where displaced by faults at many places.

The pre-Recent topography of Louisiana culminated in an entrenched valley system which has been mapped in detail by Fisk for the U. S. Engineers (1944, 1947, and unpublished reports located in the New Orleans District Offices and Mississippi River Commission Headquarters, Vicksburg). The pre-Recent Mississippi flowed along a

valley over 300 ft. deep where the existing inner boundary of the coastal marshes is now located. Enormous masses of continental ice that covered land areas during the last main glacial stage accounted for subtraction of oceanic waters to such an extent that the universal sea level was lowered to the degree indicated by the entrenched valley system. Low sea level drove shorelines not only downward but southward, as much as 100 miles in southwestern Louisiana. Projection of the entrenched valleys along their probable gradients to the Gulf indicates a lowering of the universal sea level of about 420 ft.

The Recent sediments bottom at a depth of about 550 ft. in several of the wells of the Louisiana shelf. If 420 ft. of the section represents a deposit that accumulated as a result of the last general rise of the oceans, the other 130 ft. represents an additional deposit required by subsidence of the region during the Recent. Indeed this coastal subsidence has been occurring, not only during Recent time but also for such a long interval that a sedimentary section some 30,000 ft. thick underlies coastal Louisiana. Rock layers normally incline Gulfward, steeper dips being characteristic of older layers because they have shared the effects of coastal subsidence for greater lengths of time. Rocks that were formed on flood plains, coastal marshes, deltas, and shallow sea floors now lie below the Louisiana Coast at depths ranging down to almost three times that of the deepest water in the Gulf of Mexico.

RECENT SEDIMENTS

Two main sources account for the materials found in the Recent sediments: (1) adjacent land, and (2) biologic. The Mississippi River and other streams bring most of the mineral and rock fragments that lodge as sedimentary deposits in the coastal region, together with colloidal materials and dissolved salts. The biologic contribution is overwhelmingly that of carbonaceous plant remains in the marshes and primarily that of calcareous animal remains offshore.

The larger rivers brought enough sedimentary matter to fill not only their own pre-Recent trenches but also to extend their flood plains Gulfward as deltas. Estuarine mouths occur in cases where the rise of sea level was too rapid to be balanced by the sedimentary loads at hand. Mobile Bay is a conspicuous example, as are several indentations along the coast of Texas. The Mississippi lies at the other extreme. During the latter part of Recent time it has had enough surplus sediment to build several deltas. Remnants of its Teche and still older deltas lie somewhat inland and westward of the present-day valley mouth. Later the Terrebonne-Lafourche delta system accounted for an expansion of land area having about

the shape and size of the delta of the Nile. More recently a large delta was built eastward from the site of New Orleans. Finally came the delta which is growing so actively today, the Balize Delta, southeastward from New Orleans. The delta-building period may represent over ten thousand years and during at least its first half the Mississippi generally discharged in a westerly direction.

LAND FORMS

The natural levee is the fundamental depositional form of coastal flood plains and deltas of Louisiana. It is a belt of somewhat elevated land along the side of a channel. Typically it is firm land consisting of silt and other comparatively coarse materials carried by streams and deposited at times when flow occurs across banks. In the coastal marshes pairs of natural levees mark positions of both actively flowing, silt-depositing streams and abandoned streams that once had such characteristics. The system of natural levees associated with each of the modern Mississippi River deltas resembles somewhat the radiating fingers of a spread hand, or the ribs of some leaves. Between the natural levees are basins which typically widen Gulfward. Along the coast these contain shallow bays, such as East Bay and West Bay to the sides of the natural levees of Southwest Pass of the Mississippi. Farther inland they are marsh basins which may still contain conspicuous bodies of water, such as Barataria Bay, Little Lake, Lake Salvador, and Lac des Allemands, all of which lie between the natural levees of the Mississippi and those of Bayou Lafourche and other older courses of the Mississippi. The Atchafalaya and other basins are tree-covered swamps still farther inland. Natural levees rise to levels set by floods under natural conditions. In central Louisiana they stand 15 ft. or more above basin floors and toward the coast as little as a few inches. The general level of land in the coastal marsh basins is that of mean high tide.

Most coastal marsh area is basin. Older basins in western Louisiana are so filled that their surfaces are rather firm over wide areas. Younger basins in and between the various deltas to the east contain greater areas of bay, lake, pond, or soft-surfaced marsh. Silty natural levee deposits are found at various depths in the basins by probing or boring through overlying deposits which are ordinarily highly organic. Layers of silt and fine sand alternate with peats and clays under the marshes both because older and now submerged patterns of delta channels are encountered and because various old lake floors or bay bottoms are present. In detail, the subsurface section is rather complicated. The intricate patterns of today's surface in the vicinity of the Mississippi mouths are

similar to those revealed by detailed subsurface studies in the older areas to the west. Flocculated colloids form deposits of firm blue clay toward the coast. Outer marshes are notably firmer than those inland.

Pitted against the forces of land enlargement are the erosional forces of the Gulf. Wave attack drives shorelines inland, opposing the effects of deposition or accumulation of plant remains. Waves and currents accumulate the coarsest materials available as beaches along the shore. Finer materials are shifted outward, toward deeper waters. Where sand is available beaches are sandy. Such is the case along limited parts of the Louisiana coast. In other cases the coarsest materials are shells, bottles, pieces of iron, and flotsam in general. Predominantly, however, Louisiana beaches are composed of silt and very fine sand. In exposed situations to the east of the Mississippi River many consist almost entirely of coarse shell. Westward, shells are smaller, less conspicuous, and more fragile, excepting on shell reefs where oysters predominate. Most of the reefs are located near the mouths of streams, either active or abandoned.

The main result of delta growth as it affects shoreline patterns is the development of a highly irregular coast. That of erosion is to smooth irregularities and develop long, straight beaches.

FOUR TYPES OF COAST

Louisiana exhibits four distinctly different types of coast. Each is the resultant of the two main controls of shoreline patterns, deposition and erosion.

Plaquemines shoreline is the irregular type existing toward the mouth of the Mississippi River. Natural levees protrude out across shallow bottoms to form the radiating passes through which river water reaches the Gulf. Where levees rise a few inches above the level of spring tides they are densely covered by tall grass, willows, and shrubs. Where high enough to escape flooding during intervals of several years large hackberries, oaks, and other trees become firmly established. The natural levees continue beyond the shoreline as submerged features with crests marked by stranded logs and commonly by the presence of myriads of pelicans and other birds standing in shallow water. Main Pass and the passes directed eastward have pronounced underwater natural levees. Jetty construction and deeper waters ahead of South and Southwest Passes discourage the concentration of sedimentary deposits as natural levees.

Wave action and near-shore currents concentrate coarse silt and fine sand both as bars near the outer ends of jetties and as long more or less submerged spits and bars that surround most of the Balize Delta. Exposed parts of spits become beaches that are most conspicuously developed at right-bank pass mouths. The shallowness of the circumferential bar precludes navigation by deep-draft boats into any but the two jettied passes. The bays between passes are sheltered by these outer shallow bottom fringes.

The general plan of bird-foot delta is modified by crevasses which have poured water and sediment into the bays or basins between natural levees. Webs of alluvial deposits are thus formed between the talons of natural levees. The bird-foot pattern grows more and more that of a duck foot. Garden Island Bay, between South and Southeast Passes, has been almost completely filled since 1890. Extensive areas of marsh have been added below The Jump and in the entire territory to the east and north of Head of Passes within recent years.

St. Bernard shoreline is the highly complicated type to the east of New Orleans. Bayou La Loutre, the next older main Mississippi River channel to the one in use today, was abandoned more than a thousand years ago. The extensive delta it built eastward was deprived of supplies of inorganic sediment but continued to be affected by Gulfward tilting, so that more than one half of its original area is now submerged. Patterns of distributary streams and pass ramifications remain in the marshes. Toward their distal ends natural levees have become double-islands; strips of land flanking filled and abandoned channels. Eastward the levees pass below the waters of Chandeleur and Breton sounds. The basins between natural levees are now the large shallow bays and harbors of the region. Wave erosion is modifying their outlines and resulting in a comparatively rapid spread of water surface at the expense of former marsh. Twenty miles and more east of the ragged fringes of the mainland is the beach. Coarse materials originally concentrated around the St. Bernard Delta coast have been driven shoreward to form a continuous arc, the Chandeleur Islands, with southwestward extensions leading to Breton Island and associated bars. The original extent of the St. Bernard Delta is unknown, but Indians lived well beyond the outer face of the Chandeleurs because fragments of their pottery and an abundance of comparatively freshwater shells (Rangias) are lodged by waves among the coarse shell and sandy materials of the beach. Large blocks of peat are detached by waves and carried to the beach.

Centrally within the Chandeleur arc are a few small islands representing remnants of the original marsh of the St. Bernard Delta.

Though the actual silts of natural levees lie about 20 ft. below their surfaces, island shapes reflect channel patterns that originated on marsh surface. This feature is found above many submerged marshes. The more luxuriant vegetation of the natural levee crest tends to perpetuate itself even though its original cause has subsided well below plant roots. The roots themselves form a somewhat more firm base for establishment and maintenance of succeeding vegetation than exists in or above original marsh basins.

Mangrove swamps flank much of the inner part of the Chandeleur arc. The outer beach migrates over and across the mangroves so rapidly that after a short period of burial which results in killing all plants their stubs and roots remain exhumed on the outer beach in density equal to that of the original swamp. Mangrove-held beach is decidedly more resistant to wave attack than beach without such reinforcement. Indentations along the outer beach mark places where bayous ran through the original mangrove swamp.

Terrebonne shoreline lies to the west of the Balize Delta and reflects the presence of an abandoned delta system closely resembling that of the Nile. The forces operative in producing the complications of the St. Bernard shoreline have acted so long that the outer beach has migrated landward to become tangentially attached to the mainland fringes. Sandy beach predominates. Between Grand Isle and Timbalier Island the eastern half of the sand beach is now moving into almost continuous marsh. The western part is invading bays and waters between the Lafourche and Terrebonne subdeltas. During the last fifteen years amazing changes have occurred in this area. A few scattered islands of sand have become united into a broad strip about ten miles long which terminates inland and to the west of Timbalier Light. In few places are quadrangle maps issued so recently as 1935 so obsolete. Pottery scattered along this entire coast attests to the fact that Indians were living on lands located several miles out in what is now the Gulf of Mexico. Truncated lakes and stream patterns reflect the rapidity of shoreline advance into marshes. Comparisons of surveys indicate such rates of beach advance as averages of well over 100 feet per year. Great changes mark times of severe storm. The ordinary year commonly witnesses widening of beaches Gulfward even though the general direction of beach movement is landward at a spectacular rate.

Subsidence of the Terrebonne area has resulted in extensive development of flotant; floating marshes overlying either water or soft ooze which are more or less passable to a man on foot. These form in basins extending well inland into areas of fresh-water marsh. During hurricane waves, when broad areas of marsh may be covered to depths such as 6 ft., floating marsh normally rises

intact. Now and then some part breaks away through buoyancy and drifts away. It was thus that Wonder Lake, some 15 mi. southeast of Houma, formed in 1915. This peculiar, somewhat star-shaped, break in the flotant, has axes more than 1.5 miles long.

Cameron shoreline extends westward from Marsh Island into Texas. Processes of erosion have long held the upper hand. The shore is smooth and beach is practically continuous. Coastal sediments are derived principally from marsh which is under erosional attack rather than from supplies furnished by active streams. Waves nearly everywhere are eroding clay or peat. Such silts, sands, or other coarse materials as are available are incorporated into the beach, but they are insufficient in amount to produce the firmness characteristic of outer beaches to the east. Where currents bring large amounts of colloidal and other very fine materials large ooze flats form in front of the beach. A powerful boat with a draft of as much as 6 ft. may churn through such ooze to within a few feet of the land at some places. The development of ooze flats is occurring at a spectacular rate to the west of the artificial Wax Lake outlet of the Atchafalaya Basin.

There is a long and complicated history in the Cameron marshes. Cheniers are inland beaches dating from times when the Gulf beaches advanced into the marshes only to be followed by times when marshes advanced toward the Gulf. Beaches were left stranded behind marshy flats. The alternations between conditions of coastal advance and retreat were caused by alternations between surplus and deficient supplies of sediment along the coast. During Teche-Mississippi times, several thousand years ago, the Cameron coast at times was more than amply supplied by sediments from westward passes of the river. Coasts grew out Gulfward in the manner now characteristic of the Balize Delta. But at other times the river experienced diversions toward the east, so that what is now the central Louisiana coast received most of the sediment and the western coast experienced dominance of wave attack, beach formation, and landward migration. Beaches formed at such times are now cheniers. Later periods of surplus sediment and marsh development account for the deposits south of each chenier. More recent cheniers truncate those of earlier date at several places, just as the present-day shoreline truncates Chenier au Tigre. The last main ridge, Grand Chenier and extensions eastward through Pecan Island and westward to Cameron, reaches elevations nearly 10 ft. above Gulf level and is composed of fresh sand and shell. At a maximum it approaches a distance of nearly 10 mi. from the present-day beach. Older cheniers lie inland and are more altered and submerged in accordance with age. The modern beach is being converted into a chenier in places where Atchafalaya sediments are building ooze flats along the coast. These flats will evolve into marshes extending Gulfward from the chenier.

CHANNEL PATTERNS

The meandering characteristic of the Mississippi River disappears toward the coast and most particularly where the channel is cut in clay. Though many theories have been advanced to account for the "bird-foot" pattern of the Balize Delta, there is little merit in any of them, with the exception of the idea that the river is confined to a single channel for a long distance below New Orleans for the reason that it runs through clay. This clay was deposited offshore during the times when older deltas were forming. The Teche and subsequent deltas, including the St. Bernard, extended into the Gulf across areas without notable clay deposits and for that reason branched freely to form distributary patterns more like those of the Nile Delta.

The patterns of channels below crevasses are anastomotic. Garden Island Bay and other similar areas are characterized by comparatively straight, but freely branching channels that surround lenticular islands. Surplus sedimentary load exists for the low velocities encountered as currents reach bays.

As a general rule distributary channels of old main river courses are comparatively straight. This pattern is retained after abandonment. As a group they are the channels that deteriorate most rapidly after abandonment. Distributaries shoal rapidly immediately after diversions lead waters elsewhere and they have drainage basins not appreciably wider than their own widths, because the broad slope from each of their natural levee crests is outward into flanking basins. In contemplating a route for a journey by skiff from aerial photographs or detailed maps of the marshes one generally seeks avoidance of straight channels unless they retain inflow from some active source.

Each marsh basin develops its own drainage net. The streams are sinuous and in many cases meander so rapidly that they exhibit numerous cut-offs. These are the waxing and deepening streams of the marshes. The deepest and most developed lead from lakes that fill or empty according to tidal levels in the Gulf. The tidal channels are without appreciable natural levees, though a slight firmness along their banks contrasts with conditions farther out in the marsh basins. Limited segments of straight channels commonly become incorporated in the tidal-channel network and are deepened or widened accordingly.

CANAL LOCATIONS

The history of relocations of the Intracoastal Waterway across Louisiana is illustrative of a need among engineers for geologic

advice. Older routes utilized lakes as far as possible and lay well to the south of the present waterway at most places. Maintenance costs were found to be excessive in lakes, so that canals are now dug around them, even though distance is appreciably increased, as in the case of Lake Salvador. Maintenance costs are also excessive if canals are bottomed in peat or other soft materials. The canals most readily maintained lie well toward the northern boundary of the Recent coastal deposits, where the underlying pre-Recent forms the bottom and fair proportion of excavated bank. The Intracoastal Waterway now approximates the inner boundary of the Recent for long distances.

Canals leading to the Gulf are almost impossible to maintain if they reach a portion of the coast where ooze accumulates in quantity and where the coast is building outward. A proposed canal which would utilize the existing but unuseful Freshwater Bayou Canal at the southernmost projection of the Louisiana coast to the west of Marsh Island represents about the worst possible condition. Long jetties and endless dredging would be required to maintain navigability. The most desirable places for canal mouths to terminate are those where natural agencies maintain deep water, as in the deep passes leading into Barataria and Vermilion bays. Where other sites must be selected the most desirable are places where coastal beaches are moving inland at comparatively rapid rates. Detailed plans should take into account a prevalence of westward drift of debris.

RECLAMATION PROJECTS

Somewhat more than fifty agricultural reclamation projects have been undertaken in the marshes. The general pattern is that of constructing low levees around fields that are ditched to sumps from which water is pumped. Practically all have failed for the reason that plowing and cropping lowers the surface rapidly. Pumping costs increase and drainage difficulties grow more acute until financial failure occurs. Old fields located near highways have been converted into fishing ponds with some success.

One successful undertaking has been the construction of levees protecting higher land against salt water encroachment. The orange groves along the lower Mississippi and various fields in the western part of the state have benefited from such protection, especially at times of high water during storms. The groves lie between artificial levees on Mississippi natural levee crests and a second set of levees toward the marshes.

The principal uses of the marshes are for muskrat and nutria trapping and for cattle grazing. The yield from the best trapping

lands exceeds that of nearby agricultural land. Canals and other engineering structures commonly upset vegetational patterns and thus interfere with pastures. Water bottoms toward the coast with salinities favorable to oyster production are also valuable and are subject to deterioration or improvement when canals and ditches are run through adjacent marshes.

The necessity for extreme caution exists whenever construction projects are likely to affect the water table either within the marshes or in adjacent pre-Recent territory to the north. Industrial and agricultural demands have already lowered water tables to danger points in several places, so that significant salt-water encroachments have occurred. The only considerable area where shallow artesian conditions remain within Louisiana marshes is eastward, in the St. Bernard Delta. The water is somewhat brackish.

It is certain that an increased number of salt-water locks will be necessary for purposes of maintaining adequate trapping and grazing land as well as for protection of more inland places against encroachment of brackish and saline ground water.

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