GEOLOGIC HISTORY

Padre Island is one of several barrier islands along the Gulf coast of Texas. These islands began to form when sea level approached to within 20 or 30 feet of its present position following the relatively rapid rise of sea level that accompanied the melting of the last continental ice sheets (Bernard and LeBlanc, 1965, p. 157–158; Fisk, 1959; Rusnak, 1960, p. 192). Radiocarbon dating of shells found in borings in the central part of Padre Island indicates that the lowermost barrier island sand was deposited about 5,000 years ago (Fisk, 1959, p. 122–123). Drill holes in the South Bird Island quadrangle show that the barrier island sand is about 60 feet thick and overlies a thin shell layer consisting mainly of pelecypods, *Mulinia* sp. The shell layer probably represents a late Pleistocene lagoon. Radiocarbon dates of two samples of shells from the layer are 27,880 ± 1100 and 29,980 ± 1070 years B. P. Underlying the shell layer is clay, sandy clay, and clayey sand of Pleistocene age with shells representing a normal Gulf fauna.

Padre Island has continued to be modified even after it was built up to essentially its present level. Landforms and sediments have shifted rapidly in recent years. Probably all of the landforms of this section of Padre Island have formed or been extensively modified during the past century, and many are undergoing further rapid change at the present time. Likewise, much of the surficial sediment has been deposited during the last hundred years or is undergoing yearly erosion and redeposition. However, somewhat older but still geologically recent sediment may occur at the surface in places. Because of the rapid changes, the mapping presented here must be considered not a final record but rather a datum point from which future changes may be monitored.

Comparison of present mapping with the coastal survey of 1860–1882 (U.S. Coast and Geodetic Survey, 1887), which is the earliest accurate map of the island, shows the changes that have taken place during the last century. That map shows the following landform zones from east to west: (1) the Gulf of Mexico beach, located within 300 feet east or west of its present position; (2) a vegetated foredune ridge similar in width and position to the present one; (3) an irregular pattern of dunes, largely vegetated, in the middle part of the island; (4) a low vegetated flat in the western part of the island; and (5) a Laguna Madre shoreline characterized by small lagoons, bars, and spits. No back-island dune field was present, nor was there a low plain in the middle part of the island such as is found now.

Between the 1880's and the early twentieth century, much of the vegetation on Padre Island was destroyed by overgrazing, by droughts, especially those of the 1880's and 1896 to 1903, or by a combination of the two (Price and Gunter, 1943). The previously vegetated dunes in the middle of the island, and probably the foredunes also, thereby became subject to the sand-transporting power of the wind. The combination of prevailing southeasterly winds and winter northerly winds in the Corpus Christi area results in a westward sand-transport vector (Boker, 1956, p. 19–26). Thus, the devegetated dunes migrated westward to form the present back-island dune field, leaving behind a low deflation plain that became revegetated, largely by grass. As the deflation plain became vegetated, the nourishment of the back-island dune field by sand blown from the beach or foredunes ceased. Moreover, there is no evidence that the back-island dune field in this part of Padre Island is periodically nourished by sand washed over the island during hurricanes; such nourishment is said to occur in some parts of Padre Island (Hayes, 1967, p. 25–27).

As the back-island dune field moved westward, it encroached on Laguna Madre. Aerial photographs show that the last vestiges of the old, relatively stable shoreline were covered soon after 1948. Between 1948 and September 1967, Padre Island has advanced westward an average of 700 feet into Laguna Madre, and the advance can be expected to continue until all the sand in the back-island dunes is in the lagoon or until the dunes become stabilized by vegetation. Cores drilled on the wind-tidal flats in the northern part of the quadrangle have shown that about 5 feet of sand fill overlies dark-gray mud, which probably formed the lagoon bottom prior to 1948.

Much or all of the present foredune ridge in this part of Padre Island probably began to form during the period of revegetation following the droughts in the late nineteenth and early twentieth centuries. Although there is no conclusive evidence that the foredune ridge was largely destroyed and then reformed during the past hundred years, the rapidity with which parts of the foredune ridge can be eroded and then grow again is demonstrated by aerial photographs made at frequent intervals during the past 20 years.

These aerial photographs show that in 1948, a dry year, a new widespread cycle of wind erosion and dune migration began in the foredunes. Although the devegetation was not as extensive as that of the preceding cycle, numerous blowouts were created in the foredune ridge. A few of the presently active blowout dune fields formed before 1948. Most of the blowout dune fields that formed during 1948 have remained unvegetated, even though many of them are now largely separated from the foredunes by young deflation plains left behind as the dunes passed. These plains have now become revegetated and sand is not being blown across them. The blowout dune fields migrated an average of about 1,500 feet in a west-northwest direction between 1948 and September 1967. They and the back-island dune field made especially rapid advances during the dry periods from 1950 to 1956, from 1962 to 1964, and during the first half of 1967. The pattern of low ridges and troughs in the deflation plains resulting from the intermittent migration of the active dune fields has been called a "corduroy pattern" by Price (1965, p. IV 9).

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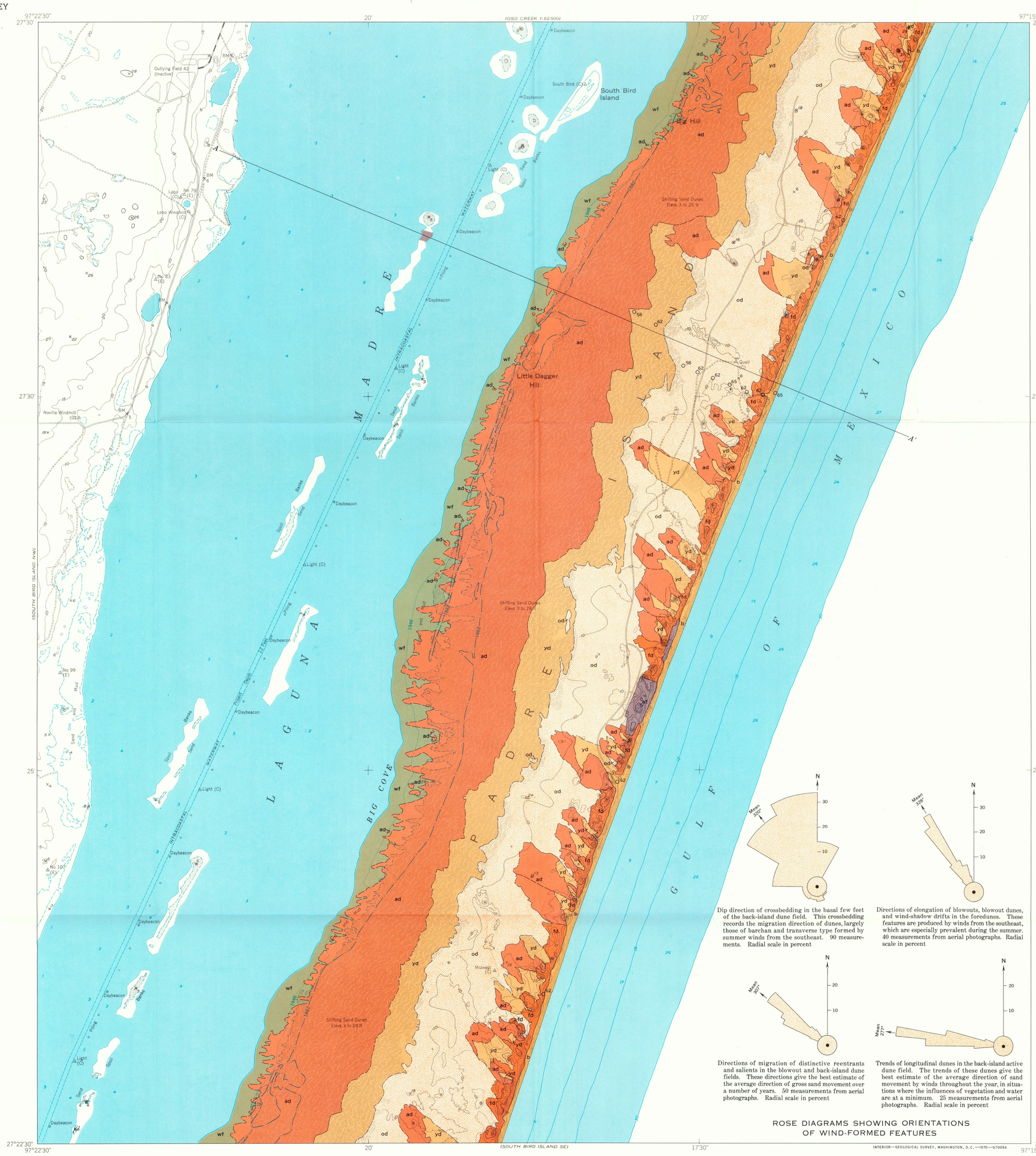
U.S. Coast and Geodetic Survey, 1887, Coast chart no. 210.



Base from U.S. Geological Survey, 1951
Roads as of 1970

Geology mapped in 1968

SCALE 1:24 000

1 ½ 0 1 MILE

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF THE TIDE IN THE GULF OF MEXICO IS 1 FOOT
AND IN LAGUNA MADRE IS LESS THAN ½ FOOT

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1970

Dip direction of crossbedding in the basal few feet of the back-island dune field. This crossbedding records the migration direction of dunes, largely those of barchan and transverse type formed by summer winds from the southeast. 90 measurements. Radial scale in percent

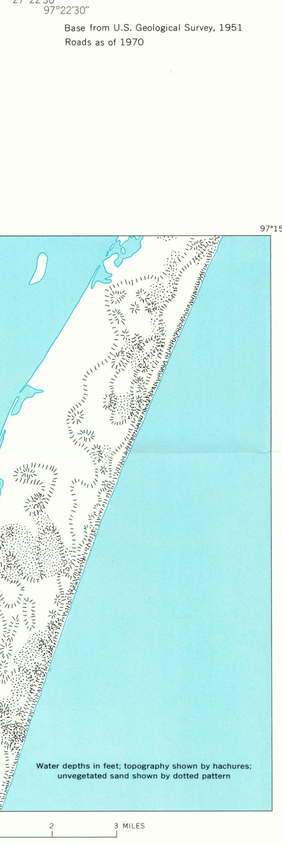
Directions of elongation of blowouts, blowout dunes, and wind-shadow drifts in the foredunes. These features are produced by winds from the southeast, which are especially prevalent during the summer. 40 measurements from aerial photographs. Radial scale in percent

Directions of migration of distinctive reentrants and salients in the blowout and back-island dune fields. These directions give the best estimate of the average direction of gross sand movement over a number of years. 50 measurements from aerial photographs. Radial scale in percent

Trends of longitudinal dunes in the back-island active dune field. The trends of these dunes give the best estimate of the average direction of sand movement by winds throughout the year, in situations where the influences of vegetation and water are at a minimum. 25 measurements from aerial photographs. Radial scale in percent

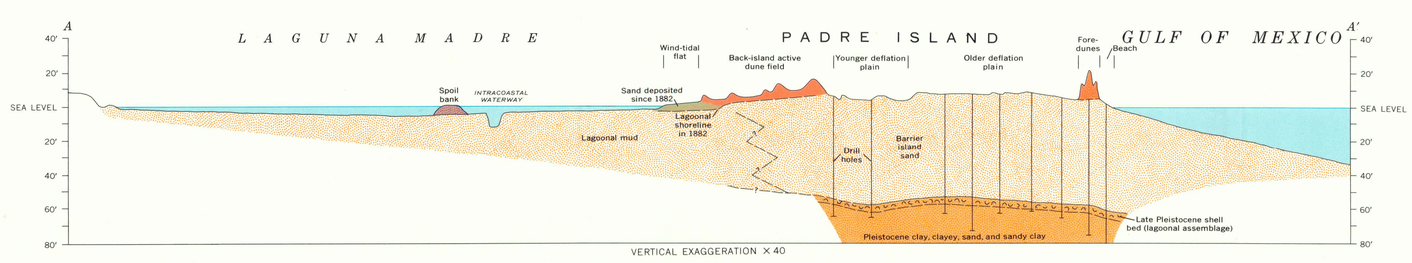
ROSE DIAGRAMS SHOWING ORIENTATIONS OF WIND-FORMED FEATURES

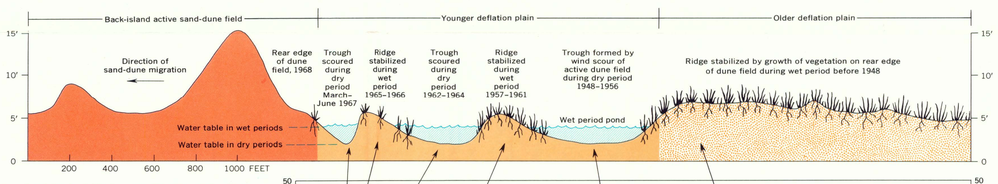
INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1970—G70094



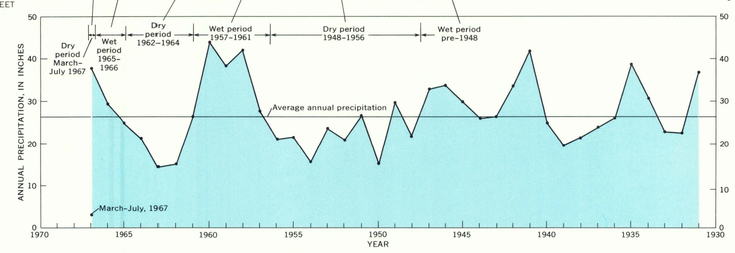
SOUTH BIRD ISLAND QUADRANGLE AS IT WAS IN 1882

This map is slightly modified from the U.S. Coast and Geodetic Survey Coast Chart No. 210, surveyed from 1860 to 1882 and published in 1887





DIAGRAMMATIC SECTION OF YOUNGER DEFLATION PLAIN AND ADJACENT AREAS



RAINFALL AT CORPUS CHRISTI, TEXAS

The graph shows the relation of rainfall to the formation of ridge and trough topography in the younger deflation plains. Data from Environmental Science Services Administration (1968)

EXPLANATION

QUATERNARY — Holocene

b — Beach and related water-laid deposits
The beach is a gently sloping body of sand deposited by waves and currents along the Gulf of Mexico shore. Adjoining the beach and grouped with it for mapping are small washover fans and stream alluvium in gaps through foredune ridge

fd — Foredunes
Vegetated, relatively stabilized dunes immediately landward of the beach, formed of sand blown from the beach by onshore winds

ad — Active dune fields
Areas of unvegetated, actively migrating dunes formed of windblown sand. Active dune fields include (1) blowout dune fields formed by localized wind erosion of vegetated dunes, and (2) a back-island dune field adjoining the wind-tidal flats along Laguna Madre. Contacts between adjacent discrete fields have been mapped where recognizable

wf — Wind-tidal flats
Flats along Laguna Madre, periodically covered by water and composed largely of sand washed or blown from the back-island dunes

yd — Younger deflation plains
Vegetated sandy areas of relatively well-defined low ridges and intermittently ponded shallow troughs left behind the active dune fields as they migrated westward since 1948. Contacts between adjacent discrete plains have been mapped where recognizable

od — Older deflation plains
Vegetated sandy areas of relatively irregular, indistinct low ridges and intermittently ponded shallow troughs left behind the back-island dune field as it migrated westward during the period preceding 1948

af — Artificial fill

Contact
Dashed where approximately located or gradational

1882 — Laguna Madre shoreline of Padre Island in 1882
The 1882 shoreline position is based on the U.S. Coast and Geodetic Survey Coast Chart No. 210, surveyed from 1860 to 1882 and first published in 1887. The chart was positioned on the modern topographic map by correlation of the local shoreline configuration in places where the shoreline had changed little between 1882 and 1948

1948 — Laguna Madre shoreline of Padre Island in 1948
Position from aerial photography

$\circ^{62}$ — Drill hole location, showing depth in feet to the shell layer underlying the barrier island sand

SHORT DESCRIPTION OF LANDFORMS, SEDIMENTS, AND SEDIMENTARY PROCESSES

The surface sediments of the section of Padre Island within the South Bird Island quadrangle are entirely of Holocene (Recent) age. Nearly all the sediments are sands, but the sands have been deposited by several different processes and form a variety of landforms.

The beach (area b on map) along the Gulf of Mexico shore undergoes constant change. During major hurricanes, waves erode the front edge of the foredunes and form a broad, flat beach, whereas in calm weather a steeper beach surface is formed (Hayes, 1967, p. 14–21). Water from the Gulf is driven inland through gaps in the foredune ridge during hurricanes, and as the water spreads out it deposits sand in the form of washover fans. Hurricanes and other storms produce flooding on the lower parts of the island. As the water drains from the ponded areas into the Gulf through the gaps in the foredune ridge, it deposits sandy stream alluvium on the floors of the gaps. In this part of Padre Island, the washover fans and other effects of hurricanes are small because the foredune ridge is high and broken by only a few narrow gaps.

Immediately west of the beach is a hummocky ridge of coalesced foredunes (area fd on map) composed of sand blown inland from the beach by onshore winds, which are active through most of the year (Lohse, 1955; Curray, 1960, p. 229–231). The blown sand would be transported across the island if it were not for the windbaffle and sediment-binding effects of vegetation, largely grass and shrubs, that is especially adapted for growth in the dry, somewhat saline foredune environment. The vegetation is responsible for trapping the blown sand and holding it in place near the beach, thereby allowing the foredunes to grow without migrating rapidly inland. As the vegetated foredunes grow, they form obstacles to the wind, and wind-shadow drifts of blown sand accumulate leeward of some of the dunes. Locally the wind is strong enough to destroy the vegetative cover and cuts blowout depressions in the foredunes. The eroded sand accumulates as blowout dunes leeward of the depressions.

Where wind erosion has been very active, individual blowout dunes have merged to form blowout dune fields or complexes (part of area ad on map). These active dune fields have migrated westward under the influence of the winds and in plan view have assumed parabolic shapes convex in a downwind direction. The individual dunes in the blowout dune fields are largely transverse dunes, which are elongate perpendicular to the prevalent winds from the southeast, and barchan dunes, which are crescent-shaped dunes with the horns of the crescent pointing in a downwind, northwestward direction.

A large active dune field occurs on the back (western) side of the island (part of area ad on map). The dominant dune form in the back-island field is the longitudinal dune, which is elongate parallel to the resultant direction of sand movement by all winds throughout the year (Boker, 1956, p. 52–58). This direction is approximately west along this section of the coast. Dunes of this type have also been called oblique dunes (Cooper, 1958, p. 49–64) because they are not parallel to either of the two main seasonal components that make up the yearly wind pattern, occasional winter winds from the north and winds from the southeast that are prevalent through most of the year (Boker, 1956, p. 19–26). Barchan and transverse dunes are also present in the back-island dune field during much of the year, but these are smaller and more mobile than the longitudinal dunes.

The wind-tidal flats (area wf on map) along Laguna Madre are so named because they are periodically flooded by wind tides in the lagoon. Wind tides, also called wind set-up tides, are fluctuations in water level caused by winds that drive water into the lagoon or from one part of the lagoon to another (Rusnak, 1960, p. 163; Hayes, 1967, p. 21). Hurricane storm surges are less frequent than the ordinary wind tides but produce more extensive flooding, which sometimes extends into the back-island dune field. Although the wind-tidal flats in this quadrangle are composed mainly of sand washed or blown from the back-island dune field, they also contain thin beds of dark-gray lagoonal clay rich in algal remains.

The middle zone of this part of Padre Island, between the foredunes to the east and the back-island dune field to the west, is a low, relatively flat plain vegetated largely by grasses (areas od and part of yd on map). Numerous small dunes stabilized by grass are scattered over the surface, and low ridges and intermittently ponded shallow troughs trend roughly parallel to the trend of the island. This plain is thought to be essentially an erosional landform, in contrast to the wind-tidal flats and washover fans, which are essentially depositional plains. It was produced by wind erosion of the dunes that once covered this part of the island and may therefore be called a deflation plain.

The deflation plain may be separated into younger and older parts by the distinctness of the ridges and troughs, which mark temporary halting places of the dunes as they migrated westward across the island. The older deflation plain contains several old blowout dune fields now stabilized by grass and several large vegetated dune ridges trending in a northwest-southeast direction. In addition to the older and younger deflation plains in the middle zone of the island, young deflation plains (part of area yd on map) occur behind or southeast of the migrating blowout dune fields.

The deflation plains are underlain largely by structureless sand of uncertain origin. The upper few feet of sand may have been reworked during the migration of dunes across the island, but the underlying sand probably predates the dune migration and may have been deposited as washover fans, wind-tidal flats, or beaches. Sand and clayey sediment rich in algal remains have partly filled the troughs on the deflation plain.

MAP SHOWING LANDFORMS AND SEDIMENTARY DEPOSITS OF THE PADRE ISLAND PORTION OF THE SOUTH BIRD ISLAND 7.5-MINUTE QUADRANGLE, TEXAS

By
Ralph E. Hunter and Kendall A. Dickinson

1970

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