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# LATE QUATERNARY GEOLOGY OF SABINE LAKE AND VICINITY, TEXAS AND LOUISIANA


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# LATE QUATERNARY GEOLOGY OF SABINE LAKE AND VICINITY, TEXAS AND LOUISIANA

By Henry E. Kane*

## ABSTRACT

The late Pleistocene and Recent sediments, faunas, and geomorphology were mapped in the vicinity of Sabine Lake, in an area that straddles the Texas-Louisiana state line and extends into the Gulf of Mexico. The former valley of the Neches and Sabine rivers is entrenched into oxidized Pleistocene deposits to a minimum depth of 120 feet at the Gulf of Mexico shoreline. This valley has been filled in by the streams and closed off at its southern end, except for Sabine Pass, by prograding of the Gulf shoreline to form the present lake estuary, Sabine Lake. The erosion and subsequent alluviation were caused by a fall and rise in sea level due to waxing and waning of continental glaciers late in Quaternary time.

Lithology and fauna, especially the Foraminifera, were determined from cores and clam shell samples taken in the Sabine Lake estuary and Gulf of Mexico nearshore neritic environments. No lithologic criteria for distinguishing these two environments were evident in the surface sediments or in core samples taken 3 feet and 6 feet below the surface.

Foraminiferal biofacies, however, do differentiate clearly the estuarine and the nearshore neritic environments. The species and their percentages in the bottom sediments of Sabine Lake differ from those of the Gulf of Mexico, and from those in the core samples from 3 and 6 feet. The biofacies of the core samples from under the Lake are similar to those of the present Gulf, indicating greater circulation of saline waters from the Gulf of Mexico before the south end of Sabine Lake was restricted.

## INTRODUCTION

The evolution of a lake estuary environment has been developed from a study of the geomorphology of the area, cores taken from Sabine Lake and adjacent water bodies, auger samples, and lithologic logs. The criteria which distinguish the two main environments—lake estuary and nearshore neritic—should be useful in recognizing these environments in more ancient rocks.

The area studied includes parts of Orange and Jefferson counties, Texas, and Calcasieu and Cameron parishes, Louisiana, as well as the adjacent portion of the Gulf of Mexico (see fig. 1). The north boundary is 30° 15′ 00″ North latitude; the south, 29° 37′ 30″ North latitude; the east, 93° 40′ 00″ West longitude; the west, 94° 7′ 30″ West longitude. Its area is approximately 1,230 square miles, including a nearshore part of the Gulf of Mexico approximating 126 square miles.

Sabine Lake and Sabine Pass, the region of concentrated study, are located in the southeastern, south-central, and east-central parts of the general area. The mouths of the Neches and Sabine rivers and nearby Old River Cove and Hickory Cove are included.

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Sabine Lake is almost oval in shape and covers approximately 100 square miles. Its long axis is 18 miles in a northeast-southwest direction to the head of Sabine Pass (Mesquite Point), and its short axis is 7½ miles in a northwest-southeast direction. Sabine Pass, the narrow, slightly sinuous outlet of Sabine Lake into the Gulf of Mexico, is almost 6⅓ airline miles long and averages one-half mile in width.

## SURFACE GEOLOGY

The Quaternary geology of the area consists of the Pleistocene deltaic plain of the Neches and Sabine rivers in the northern part and the Pleistocene deltaic plain of the Trinity River in the western part (see fig. 1). These deltaic features with interbedded marine and lagoonal facies form an extensive coastwise plain (Barton 1930), which has been correlated with the Prairie terrace of Louisiana (Bernard 1950) and which can be traced into fluviatile equivalents up the stream valleys. Remnants of this terrace representing dissected stream divides occur in Louisiana near Black Bayou. Other remnants and ridge extensions of the terrace occur in the western part of the area.

Associated with the Prairie terrace, in the northern part

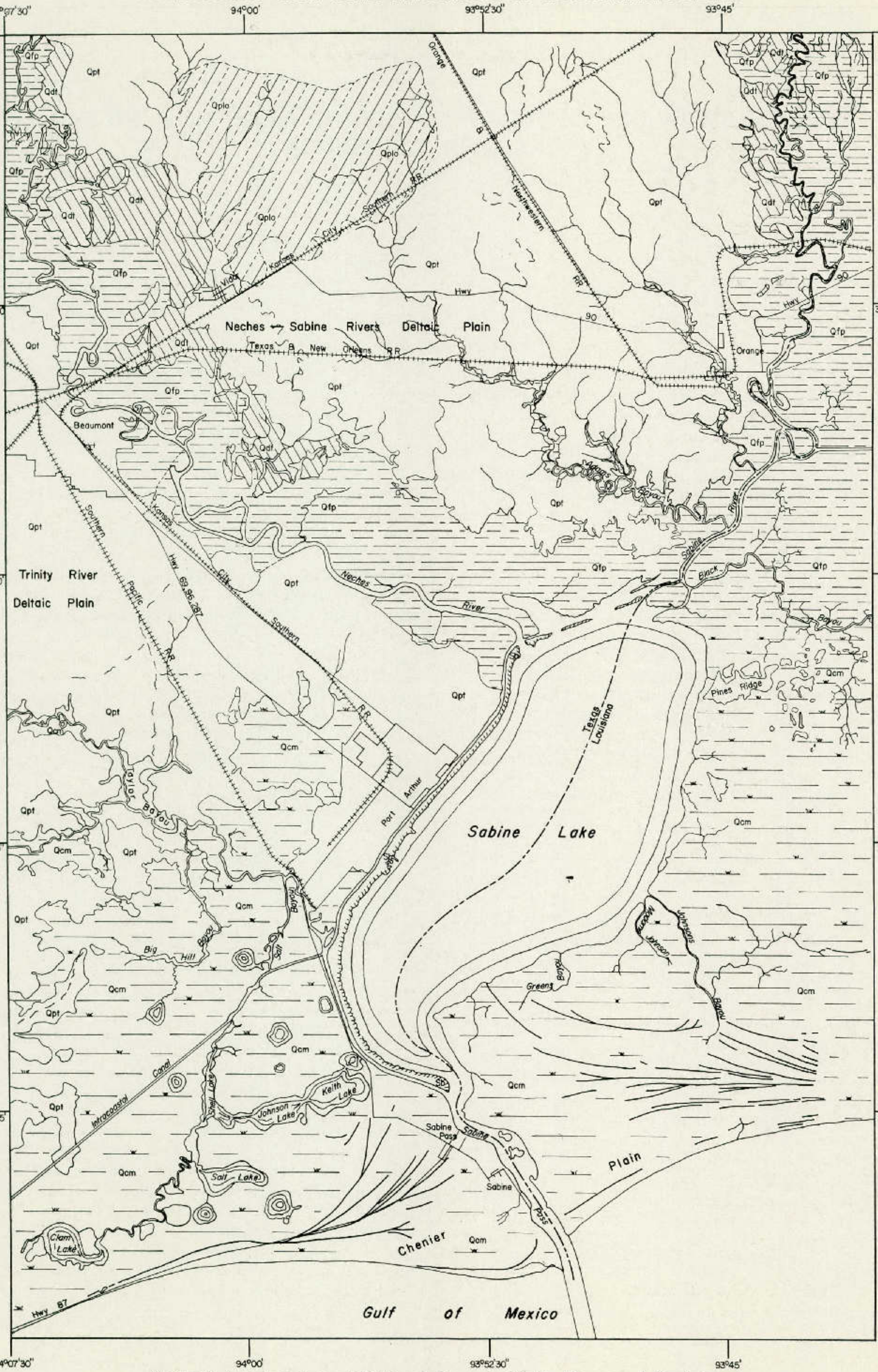
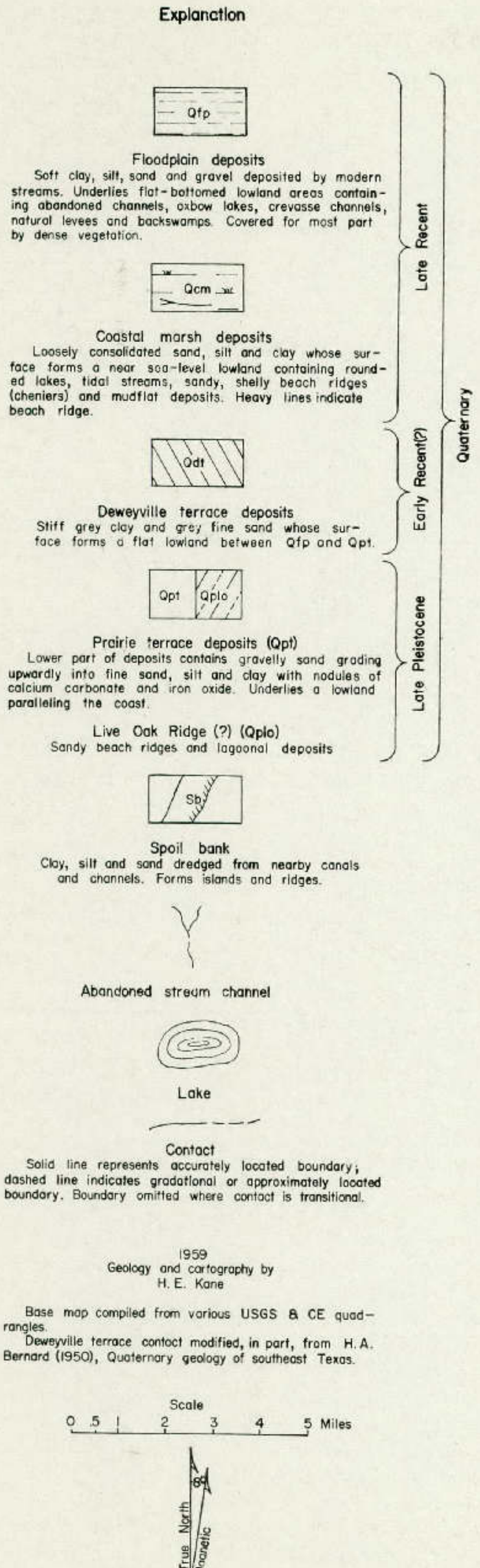



Figure 1. Areal geology of Sabine Lake and vicinity, Texas and Louisiana.




**GEOLOGY OF**
**THE SABINE LAKE AREA**

of Orange County, near Mauriceville, Texas, are sandy beach accretions and associated lagoonal deposits, referred to as the Live Oak Ridge (?) or Ingleside shoreline (Price 1933). These deposits, rising approximately ten feet above the surrounding Prairie terrace level, represent a Late Pleistocene stand of the Gulf of Mexico. Subsequently, this shoreline was bypassed by the regional drainage as deltas were built seaward. According to Price, this shoreline can be traced in discontinuous segments from Matagorda County, Texas, to Calcasieu Parish, Louisiana.[1] Henry (1956) posits a possible correlation with the Pamlico shoreline of Florida which occurs at a 25 foot elevation.

South of the Pleistocene outcrop is the Recent coastal marsh; equivalent fluviatile deposits extend up the valleys of the Neches and Sabine rivers. The fluviatile deposits of the two rivers include the Deweyville terrace and the modern floodplains. The coastal marsh toward the Gulf margin includes the chenier plain (Price 1955), consisting of abandoned sandy and shelly ridges and associated mudflat and marsh deposits.

## SUBSURFACE GEOLOGY

The sedimentary material of the oxidized Pleistocene lying beneath the Recent fluviatile and marsh deposits is a stiff, varicolored clay, bluish-gray, red, brown, yellow, or tan, sometimes containing concentrations of lime or iron nodules. In a few cases, the uppermost material of the oxidized zone consists of whitish, very fine sand or silt. The Pleistocene clays are usually very difficult to penetrate in probing or drilling with an auger.

In contrast, the Recent sediments consist of grayish or blackish soft clays and silts with grayish or whitish compact sands. The clays are penetrated very easily by auger; the thick sands resist penetration. In some logs and borings in Taylor Bayou and Sabine Pass, great thicknesses of sand are encountered in the basal section of the Recent sediments.

Subsurface contours on top of the oxidized Pleistocene reveal the confluence of the Neches and Sabine rivers at the north end of Sabine Lake (see fig. 2). The valley of the combined streams is entrenched to a minimum depth of 120 feet. The axis of the valley trends generally north-south through the eastern part of Sabine Lake, then through the southwestern corner of Cameron Parish, Louisiana, approximately four miles west of Johnsons Bayou. The western side of the valley merges with the Pleistocene outcrop flanking Sabine Lake on the west. The Pleistocene stream divides in Louisiana indicate that tributary streams entered the valley from the east, probably giving an embayed appearance to this part of the valley wall. The same interpretation might apply to the western wall, but effective control is lacking.

A narrow stream divide projects southwardly from the main Pleistocene outcrop on the western side of the entrenched valley of the Neches and Sabine rivers, separating it from the entrenched valley of Sabine Pass.

[1]In personal correspondence, dated September 24, 1949, with Bernard (1950).

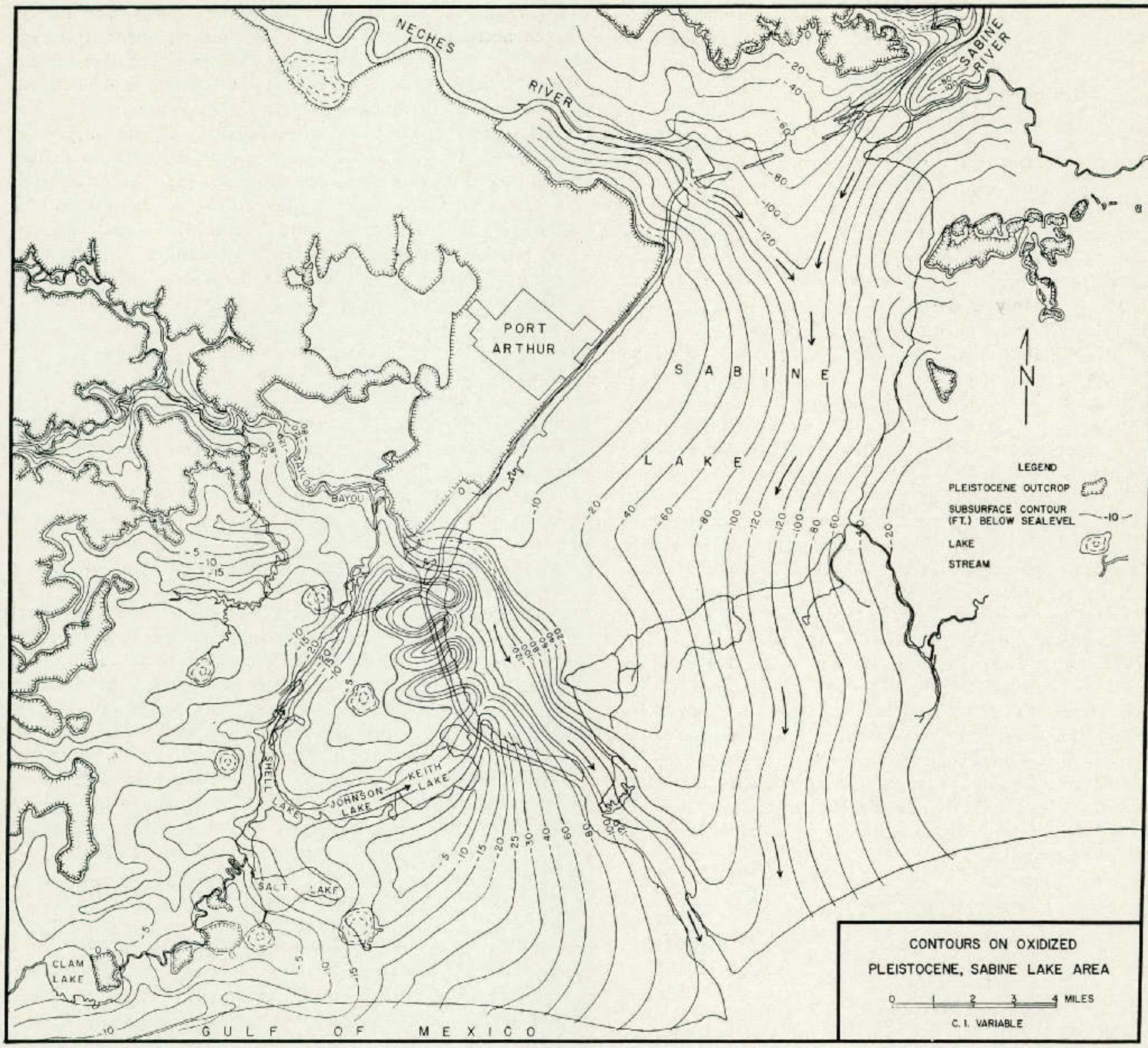



Figure 2. Subsurface contours on top of the oxidized Pleistocene in the vicinity of Sabine Lake, Texas and Louisiana.

The valley of Sabine Pass, with steep and highly embayed walls as indicated by a portion of its western valley wall, is entrenched to a minimum depth of 120 feet. This valley, which trends southeast, represents the southern continuation of the present Taylor Bayou valley. The trend of the valley suggests that it might be tributary to the main entrenched valley of the combined Neches and Sabine rivers. Presently, the valley of Sabine Pass functions as the tidal outlet of Sabine Lake.

Subsurface ridges extend from the Pleistocene outcrop on the extreme western side of the study area. Some Pleistocene outliers also occur. This area is separated from two main subsurface "hills" by the valleys of Shell, Johnson, and Keith Lakes, and Salt Bayou, all of which flow around the flanks of the northernmost of these "hills." The lakes drain into Sabine Pass, and Salt Bayou flows into Taylor Bayou.

## GEOLOGIC HISTORY

The terraces and later deposits can be ascribed to alternate valley-cutting and filling resulting from fluctuations of sea level. These fluctuations were caused by the waxing and waning of the continental ice sheets during the Quaternary period. During the waxing stage of the glacial sheets, sea level was lowered, stream gradients were increased, and the streams cut vigorously into the underlying deposits; this was the valley-cutting stage. Also during this interval, streams were capable of transporting coarser-grained materials. As the ice sheet melted (interglacial stage), sea level rose, causing a diminution of stream gradient and consequent valley-filling. Coarse sediments grading upward into fine-grained sediments were deposited during this stage. The general sequence of the fluviatile deposits is:

Top substratum—fine sands, silts, and clays.
Basal substratum—gravels and coarse sands.

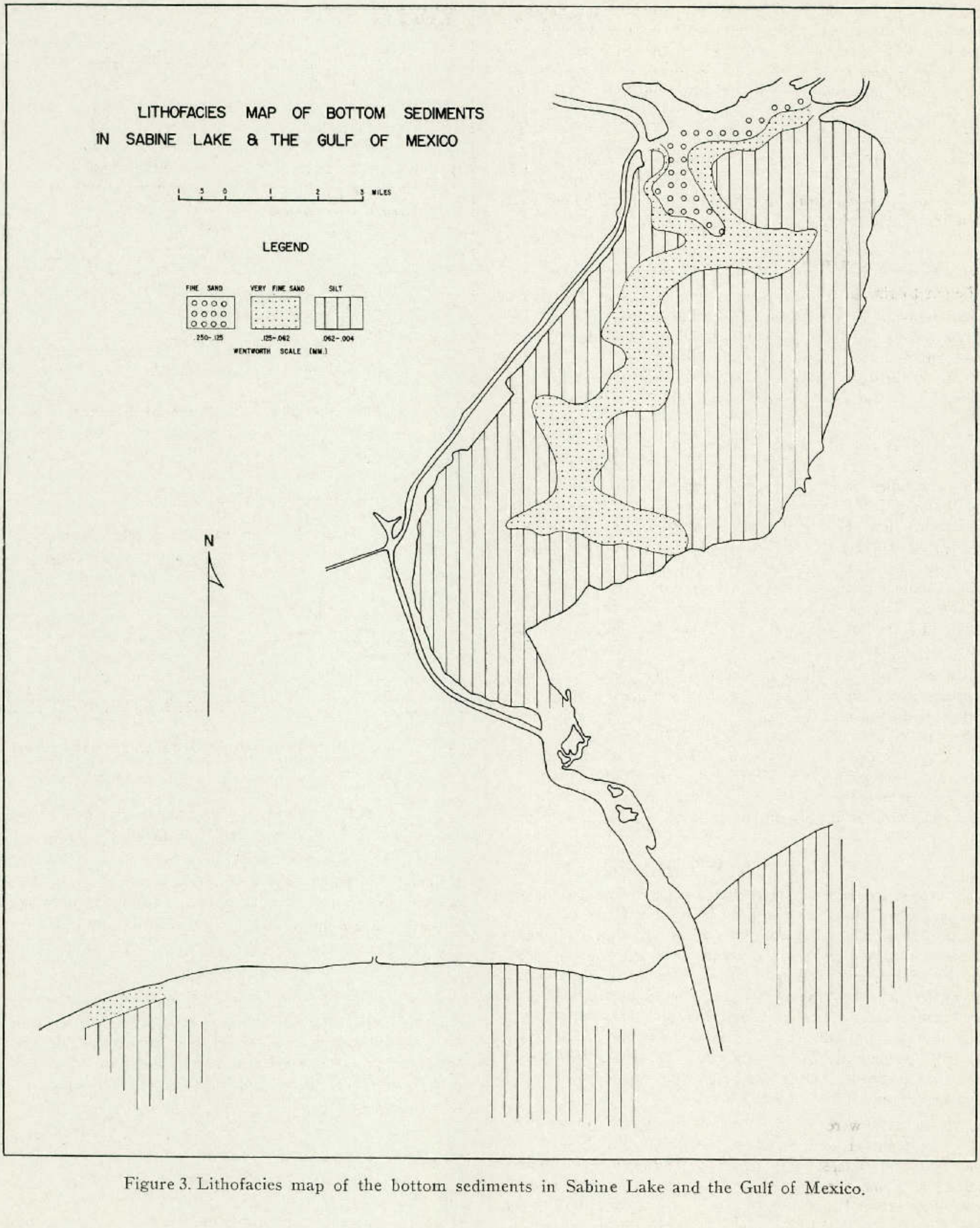



Figure 3. Lithofacies map of the bottom sediments in Sabine Lake and the Gulf of Mexico.

This depositional sequence grades coastwise into a thicker deltaic sequence where, generally, clays and silts are more common and overlie gravelly sands.

Upon completion of each cut-and-fill cycle, the coastwise portions of the depositional surfaces subsided, and the resulting isostatic adjustment uplifted and steepened the interior sections to preserve them in their present-day position and sequence. The oldest terrace surface, exposed beyond the limits of the area, occurs at a higher elevation and has a steeper gradient than the next younger surface, and so on, with the Prairie and Recent surfaces generally showing the least amount of deformation or none at all.

Approximately 25,000 years ago (LeBlanc and Bernard 1954), with the retreat of Late Wisconsin ice, sea level began to rise, marking the beginning of the Recent epoch. Sea level continued to rise, with a probable minor fluctuation in the early Recent (Mankato (?) glacial substage), until some 5,000 years ago when the sea reached its present level. Apparently, no major changes in sea level have occurred in the last 5,000 years (LeBlanc and Bernard 1954).

With the last advance of the sea, the coasts and associated stream valleys were drowned to form bays as well as estuaries such as Sabine Lake. The rise in sea level decreased stream gradients and caused alluviation of the valleys.

Since the maximum inland stand of the Gulf, marked approximately by the cheniers farthest inland, the coastal region around Sabine Pass has generally been built out into the Gulf of Mexico. The record of progradation is interpreted from the features of the chenier plain, such as the stranded sand and shell ridges along with the marsh and mudflat deposits separating the ridges (see fig. 1).

Alluviation from the rivers has resulted in the filling of the entrenched valley of the Neches and Sabine rivers. This valley filling and the prograding of the shoreline have closed the southern segment of the valley and formed the modern Sabine Lake with its tidal outlet, Sabine Pass.

## ENVIRONMENTS

Two main environments, estuarine and neritic, are recognized in the immediate area of Sabine Lake and the Gulf of Mexico.

The estuarine environment includes inlets of the land which have been drowned as the result of the rise of sea level and which are subject to tidal influences. This environment is subdivided into the river estuary—the Neches and Sabine rivers and adjacent coves—and the lake estuary—Sabine Lake.

The neritic environment includes the marine environment which extends from low tide to a depth of 600 feet. This environment to a depth of 24 feet is arbitrarily considered to be nearshore neritic, the term which applies to that portion of the Gulf of Mexico included in the study area.

The tidal pass, Sabine Pass, a narrow connecting channel between Sabine Lake and the Gulf of Mexico, is a transitional environment between the lake estuary and the nearshore neritic.

In this paper, the river estuary environment is referred to as rivers and coves; the lake estuary, as Sabine Lake; the tidal pass, as Sabine Pass; and the nearshore neritic, as the Gulf of Mexico.

## SEDIMENTS

Samples from 72 cores and 20 clam shell samples in Sabine Lake and adjacent water bodies were selected for grain-size analysis. The surface materials representing the uppermost one or two inches of the sample, depending upon the vertical change in sedimentary type, are designated bottom sediments; sediments below the surface materials are called deeper sediments.

In Sabine Lake and Pass, bottom sediments in the wet state, megascopically, consist of very fine sandy and silty mud, or silty and clayey mud, except for certain areas in the northern part of the lake near the mouths of the Neches and Sabine rivers and in some nearshore areas of the pass. In these areas, the bottom sediments have a larger content of very fine sand. The bottom sediments of the nearshore areas of the rivers and coves are closely similar to those of Sabine Lake, while those in the Gulf of Mexico are silty, clayey mud except along the beachline in the western part of the area. Here the sediments are fairly firm, very fine sand.

In the dry state, megascopically, the bottom sediments are sand, silt, or clay, or some admixture of these components.

When mean grain sizes are interpreted in terms of lithofacies, the greater part of Sabine Lake bottom sediments consists of silt. This interpretation applies also to the coves, parts of the pass, and most of the nearshore areas of the Gulf of Mexico (see fig. 3).

The next most common lithologic type in Sabine Lake is very fine sand which occurs in a narrow strip in the northern part of the lake and in an alternating narrow and wide belt extending from the Neches River mouth to the southeast Louisiana shore of the lake. Very fine sand is also found along the nearshore areas of the Neches and Sabine rivers and Sabine Pass and along a narrow beachline in the Gulf of Mexico in the western part of the area.

Fine sand, the coarsest lithologic type, is found in a small area in the northern part of the lake near the mouth of the Neches River and along the islands adjacent to the Sabine-Neches Canal.

Bottom sediment muds normally are light to dark gray or black in color, and the sands are mainly light gray. In many samples, the uppermost part was covered by a gelatinous layer of reddish-brown iron oxide less than ⅛ inch thick. Most of the bottom sediments are soft with a very high water content; some have a high organic content, especially of plant materials.

Deeper sediments were described megascopically in the dry state only, along with the aid of core photographs. Clay sediments are recognized here on the fineness of grain size and the great degree of shrinkage and cracking caused by dessication.

These sediments are mainly admixtures of clay and silt, such as silty clay or clayey silt. Clay and silt with admixtures of sand occur secondarily. In a few cases, sand, silt, or clay occur as unmixed types. Fine sand occurs in some cores from the northern portion of the lake adjacent to the spoil-islands along the Sabine-Neches Canal.

In the wet state, the color of the sediments is light to dark gray with a yellowish-brown tinge in some of the sediments, particularly the sand. In the dry state, the colors are lighter shades of gray and may show, in some cases, a slightly yellowish or brownish tinge.

Deeper sediments are soft in the wet state, with a high water content. On drying, the clayey and silty elements harden and consolidate and are somewhat difficult to break by hand.

Organic material, both plant and animal, is present in many of the cores. Plant materials, such as rootlets and stem debris, are found in many of the silty and clayey samples. Frequently a zone of yellowish or orange-brown iron oxide surrounds a rootlet or the void left by a rootlet.

Whole shells and fragments of *Rangia cuneata* occur mainly in the sediments of the northern and central part of Sabine Lake, while reeflike masses of *Crassostrea virginica* occur in the southern part of the lake. In Sabine Pass and the Gulf of Mexico, *Mulinia lateralis* occurs in layers interbedded with the rest of the sediments.

## MINOR STRUCTURES IN THE SEDIMENTS

Minor internal sedimentary structures occur in the cored sediments of Sabine Lake and adjacent water bodies. The terminology and criteria for identifying these structures are adapted from Moore and Scruton (1957) with one exception: the term "mixing" has been substituted for "mottling" to avoid any confusion with color terminology (see fig. 4).

Mixed structures, both distinct and indistinct, are the dominant type present among the minor sedimentary structures mapped in the uppermost layer of cored sediments in Sabine Lake and adjacent water bodies (see fig. 5). The next most prevalent type in Sabine Lake is fine homogeneous structures which occur along the southwest shore. Coarse and fine homogeneous structures occur in small areas mainly in the northern and western portions of Sabine Lake as well as in the coves and near the rivers. A small area of irregular layers occurs in the lake just above the head of Sabine Pass.

In the Gulf of Mexico, coarse homogeneous structures appear along the shoreline in the extreme western part. Fine homogeneous structures occur along the shoreline west of Sabine Pass and offshore east of Sabine Pass. Mixed structures occur offshore west of Sabine Pass and along the shoreline east of the pass. Mixed structures appear in Sabine Pass, along with a very small area of regular structures at the mouth of the pass on the west side.

## MICROFAUNA AND BIOFACIES

Samples for micropaleontological investigation were taken in the upper one to two inches of 52 cores and 7 clam shell samples and were designated bottom sediments. These bottom sediments correspond to the bottom sediments of the grain-size analysis. Bottom sediment samples were selected with particular emphasis on the lake estuary and the nearshore neritic environments. Ten cores were sampled at an approximate 3 foot interval and seven cores at an approximate 6 foot interval. These samples were designated deeper sediments and were taken only from Sabine Lake.

All samples were carefully washed and the dry weights recorded both before and after washing. All microforms were identified and counted, with particular emphasis on the Foraminifera. Some types were grouped together for mapping purposes. *Ammobaculites*-like forms were designated *Ammobaculites* sp., which included all recognizable fragments. *"Rotalia" beccarii* vars. included *"Rotalia" beccarii* varieties *tepida* and *parkinsoniana* as well as immature forms. *Elphidium* sp. and miscellaneous Miliolidae included immature forms

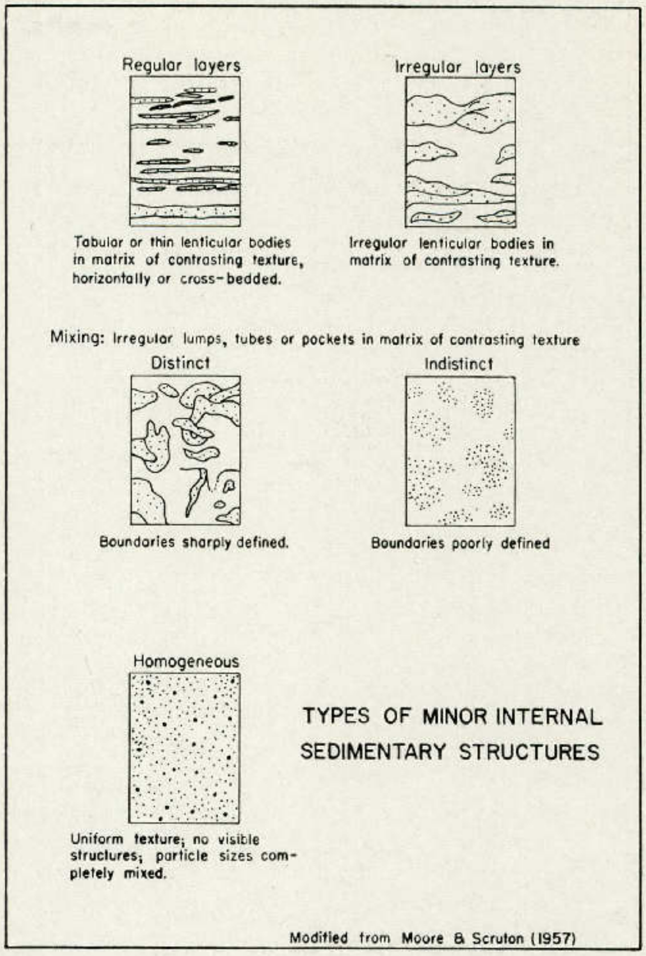



Figure 4. Types of minor internal sedimentary structures.

as well as generically identifiable fragments. Figure 6 shows the percentage distribution of the microfauna by coring stations, geographic locations, and environments.

Percentages of individual forms or groups of forms were contoured to determine the distributive patterns. Certain patterns were selected and mapped as biofacies (see fig. 7).

The *Haplophragmoides-Miliammina* biofacies occurs as a narrow band of variable width adjacent to the eastern and western shorelines of Sabine Lake, extending on the east side as far south as the head of Sabine Pass. The biofacies contains primarily concentrations of *Haplophragmoides manilaensis* and *H. wilberti* from 1 to 20 per cent, and *Miliammina fusca* from 7 to 56 percent. Also included in this biofacies are *Ammobaculites* sp., 9 to 84 per cent; *Arenoparella mexicana, Trochammina comprimata, T. inflata, T. macrescens,* and *Trochamminata irregularis* in combined amounts from less than 1 to 18 per cent; *Ammodiscus* sp., less than 1 to 5 per cent; *Ammoastuta inepta* and *A. salsa,* less than 1 to 2 percent; *Elphidium gunteri,* 2 to 15 per cent; *E. poeyanum,* less than 1 to 3 per cent; *E.* sp., less than 1 per cent; *"Rotalia" beccarii* vars., less than 1 to 29 per cent; diatoms, less than 1 to 6 per cent; ostracods, 1 per cent; and reworked Radiolaria, less than 1 to 40 per cent.

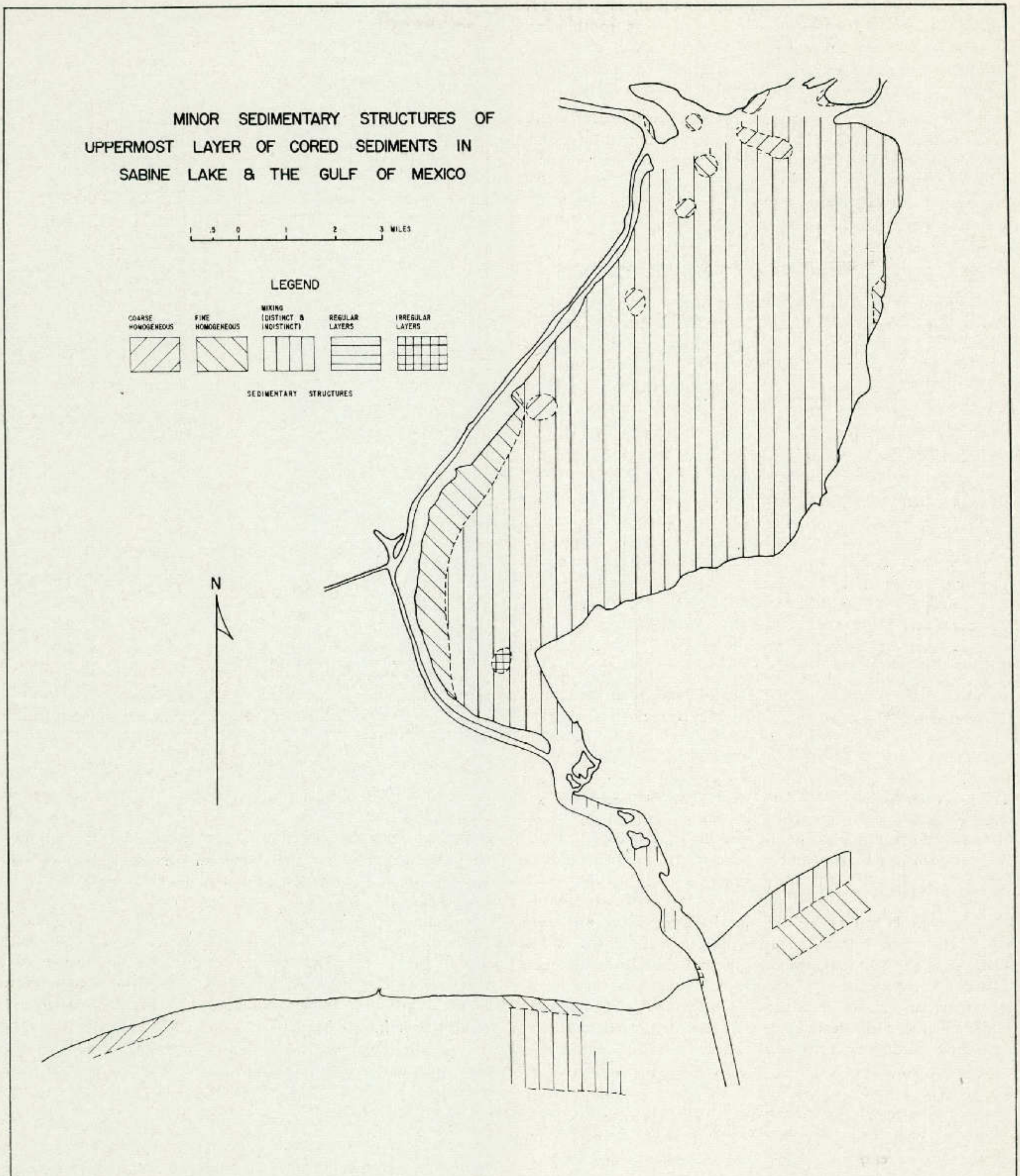



Figure 5. Map of the minor sedimentary structures of the uppermost layer of cored sediments in Sabine Lake and the Gulf of Mexico.

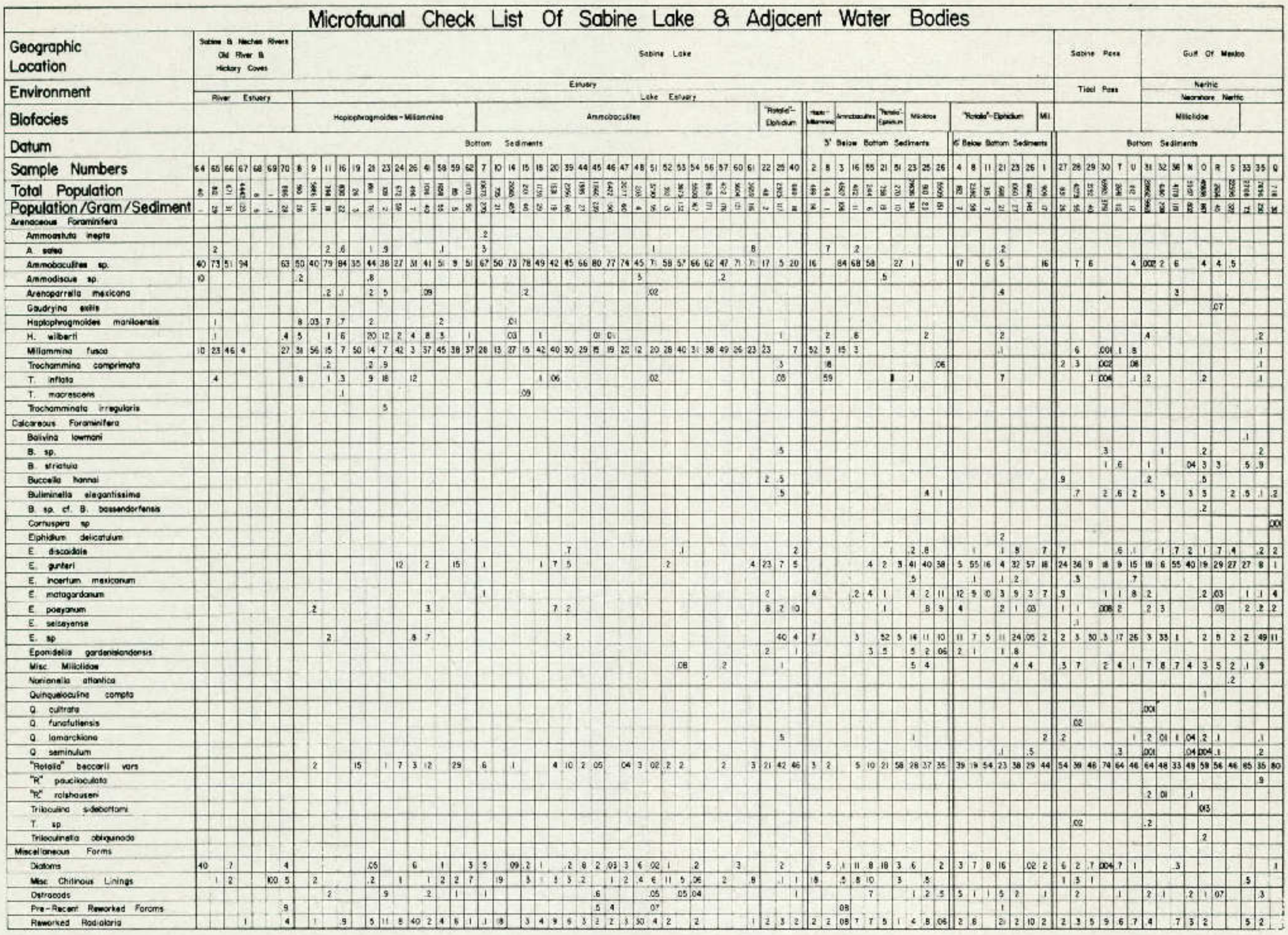



Figure 6. Check list of microfauna from Sabine Lake and adjacent water bodies.

The *Ammobaculites* biofacies covers a widespread area in Sabine Lake. It extends from the extreme north end through the axial portion and gradually diminishes southwestwardly. The biofacies consists mainly of *Ammobaculites* sp., ranging from 42 to 80 per cent. It also contains *Haplophragmoides manilaensis* and *H. wilberti,* less than 1 per cent; *Miliammina fusca,* 13 to 49 per cent; *"Rotalia" beccarii* vars., from less than 1 to 10 per cent; *Ammoastuta inepta* and *A. salsa,* less than 1 to 3 per cent; *Ammodiscus* sp., less than 1 to 3 per cent; *Elphidium discoidale, E. gunteri, E. matagordanum* and *E. poeyanum,* and *E.* sp., less than 1 to 2 per cent; diatoms, from less than 1 to 6 per cent; ostracods, less than 1 per cent; and reworked Radiolaria, from less than 1 to 30 per cent.

The *"Rotalia"-Elphidium* biofacies is localized in the extreme southern portion of the lake. The western part borders the spoilbank along the southwestern margin of the lake. The biofacies consists mainly of *"Rotalia" beccarii* vars., from 21 to 46 per cent, and *Elphidium discoidale,* 2 per cent; *E. gunteri,* 5 to 23 per cent; *E. matagordanum* and *E. poeyanum,* less than 1 to 10 per cent; and *E.* sp., 4 to 40 per cent. Also included are *Ammobaculites* sp., from less than 1 to 20 per cent; *Miliammina fusca,* from 7 to 23 per cent; miscellaneous Miliolidae, 1 per cent; *Bolivina* sp., *Buccella hannai* and *Eponidella gardenislandensis, Buliminella elegantissima,* from less than 1 to 2 per cent; diatoms, 2 per cent; ostracods, 1 per cent; reworked Radiolaria, from 2 to 3 per cent.

The Miliolidae biofacies occurs only in the nearshore area of the Gulf of Mexico. This facies may be more widespread than depicted on the map, where it is confined to the areas of sample control within the percentage limits. The biofacies consists mainly of the family Miliolidae. *Quinqueloculina lamarckiana* and *Q. seminulum* occur up to 1 per cent; *Q. compta, Q. cultrata, Q. funafutiensis, Triloculinella obliquinoda, Triloculina sidebottomi,* and *T.* sp., combined, slightly more than 1 per cent; miscellaneous Miliolidae, less than 1 to 5 per cent. Also included are *"Rotalia" beccarii* vars., from 33 to 59 per cent, evenly distributed throughout the facies; *Elphidium discoidale,* from less than 1 to 2 per cent; *E. gunteri,* from 6 to 55 per cent; *E. matagordanum* and *E. poeyanum,* less than 1 to 3 per cent; *E.* sp., from 2 to 33 per cent; *Bolivina* sp., *B. striatula, Buccella hannai, Buliminella elegantissima,* and *B.* sp. cf. *B. bassendorfensis,* combined, less than 1 to 5 per cent; *"Rotalia" rolshauseni,* less than 1 per cent; *Ammobaculites* sp., less than 1 to 6 per cent; *Arenoparella mexicana,* 3 per cent; ostracods, less than 1 to 2 per cent; reworked Radiolaria, less than 1 to 3 per cent.

Sample control for establishing biofacies in the deeper sediments at the 3 foot interval is sparse and scattered. Some significant changes do occur in the biofacies as the microfaunas are studied in the vertical dimension. The 3 foot interval tends to indicate a diminution in the geographic occurrence of the *Haplophragmoides-Miliammina* biofacies and the *Ammobacu-*

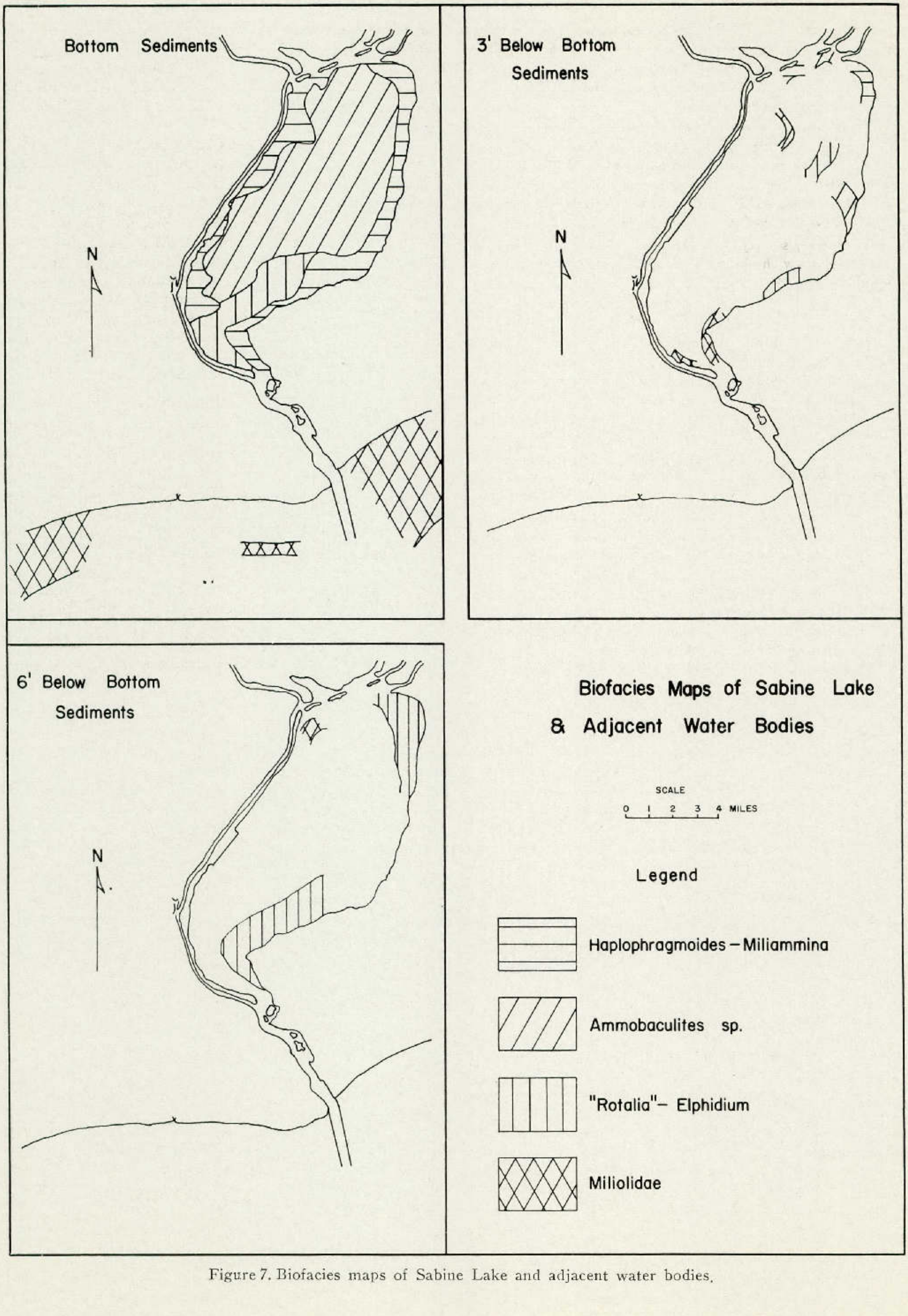



Figure 7. Biofacies maps of Sabine Lake and adjacent water bodies.

*lites* biofacies. The *"Rotalia"-Elphidium* biofacies has extended its occurrence northward in the lake. The Miliolidae biofacies, which in the bottom sediments appeared only in the Gulf of Mexico, now occurs in the extreme southern part of the lake near the head of Sabine Pass.

The conditions of sparse and scattered sample control also apply to the biofacies of the deeper sediments at the 6 foot interval. At this depth, the *Haplophragmoides-Miliammina* and *Ammobaculites* biofacies apparently disappear, while the *"Rotalia"-Elphidium* and Miliolidae biofacies seemingly have expanded and are found farther north in the lake.

Temperature, salinity, and pH measurements are now being collected to show the influence of hydrographic factors on the foraminiferal distribution.

## CONCLUSIONS

No apparent lithologic criteria distinguish the Sabine Lake environment from that of the Gulf of Mexico. However, organic criteria, particularly the foraminiferal biofacies, do differentiate the two environments. The *Haplophragmoides-Miliammina* and *Ammobaculites* biofacies characterize the bottom sediments over most of Sabine Lake except the southern portion, where the *"Rotalia"-Elphidium* biofacies occurs. The Miliolidae biofacies of the bottom sediments occurs only in the Gulf of Mexico.

In the deeper sediments, at 3 foot and 6 foot depths, the *"Rotalia"-Elphidium* and Miliolidae biofacies displace the biofacies that characterize the bottom sediments of Sabine Lake. The *"Rotalia," Elphidium,* and Miliolidae seem to tolerate higher water salinities than the *Haplophragmoides, Miliammina,* and *Ammobaculites.*

At the time the deeper sediments were deposited in Sabine Lake, more open-water conditions evidently prevailed so that the saline waters of the Gulf of Mexico circulated more freely. Since then alluvium has filled the Pleistocene entrenched valley of the Neches and Sabine rivers, and the shoreline along the Gulf of Mexico has prograded, closing off the southern portion of Sabine Lake except for the tidal pass, and thereby restricting the circulation of saline waters from the Gulf of Mexico.

## ACKNOWLEDGMENTS

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